J. J. Forbes

FINAL REPORT ON A GAS AND DUST EXPLOSION, JANUARY 10, 1940, IN MINE NO. 1 OF THE POND CREEK POCAHONTAS COMPANY, BARTLEY, McDOWELL COUNTY, WEST VIRGINIA

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UNITED STATES
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BUREAU OF MINES

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CONTENTS

CONTENTS - Cont'd.

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INTRODUCTION

An explosion of gas and coal dust occurred about 2:30 p.m., January 10, 1940, in Mine No. 1 of the Pond Creek Pocahontas Company at Bartley, W. Va., resulting in the death of 91 men from burns, violence, and asphyxiation. A total of 138 men were in the mine at the time of the explosion, of which number 37 escaped uninjured from an unaffected section of the mine and 10 men also escaped uninjured from the vicinity of the two shaft bottoms. Fifteen men gathered in one section of the mine, but were asphyxiated before they could erect barricades. In addition to the first explosion, there was at least one other explosion about 7 hours later after recovery operations had started. No one was injured in the second explosion.

The explosion undoubtedly was initiated by ignition of gas and propagated by gas and coal dust. The exact source and point of ignition were not determined during the investigation due to complexity of conditions; however, a number of possible ignition sources were discovered. The explosion was general throughout the sections of the mine to the north and east of the shafts, but did not affect the section to the west of the shafts. The mine was generally dry and dusty and no water was used to allay the dust. Rock dust had been applied on haulage roads and in working places, but generally trackless entries and return airways had not been rock-dusted.

M. C. McCall of the Bureau of Mines was notified of the explosion at 5:10 p.m. by R. E. Salvati. Mr. McCall notified J. J. Forbes, supervising engineer of the Safety Division of the Bureau, in Pittsburgh, Pa., at 5:20 p.m. Mr. Forbes ordered Mine-Rescue Car 4 to be sent to the mine and directed Messrs. McCall, Park, Ferraro, Furin, Ankeny, Pero, and Brown to proceed to the mine; later Mr. Owings was also sent to Bartley, W. Va. Bureau of Mines Rescue Car 4 left Keystone, W. Va., about 7:15 p.m., arriving at Bartley, W. Va., at 10:15 p.m. W. R. Park and F. J. Furin, who were at Carswell, W. Va., arrived at the mine at 10:45 p.m.; M. C. McCall and J. S. Ferraro arrived about 11:30 p.m.; M. J. Ankeny, J. W. Pero, and T. D. Brown left the Bureau at Pittsburgh, Pa., at 7:00 p.m., arriving at Bartley at 8:30 a.m., January 11; C. W. Owings arrived from the Bureau's Pittsburgh, Pa., office at 12:15 p.m., January 12. The first Bureau of Mines representatives to reach the scene of the disaster entered the mine as soon as possible after arriving; from that time on one or more Bureau of Mines men were underground at all times conferring with company representatives, State inspectors, and State mine-rescue directors. They actively assisted in the recovery work and later in the restoration of ventilation and investigation of the cause of the explosion.

LOCATION

Mine No. 1, located at Bartley, McDowell County, W. Va., on the Norfolk and Western Railway, is owned by the Pond Creek Pocahontas Company, which is an affiliate of the Island Creek Coal Company of Holden, W. Va., and the Mallory Coal Company of Mallory, W. Va.

The principal officials at the time of the explosion were:

James D. Francis	President	Robson-Prichard Bldg., Huntington, W. Va.
R. E. Salvati	Vice President	Holden, W. Va.
G. J. Stollings	General Manager	Bartley, W. Va.
W. M. Largen	Chief Engineer	Bartley, W. Va.
W. A. Haslam	Superintendent	Bartley, W. Va.
H. L. Schweinsberg	Safety Engineer	Bartley, W. Va.
W. D. Combs	Mine Foreman	Bartley, W. Va.

EMPLOYMENT AND PRODUCTION

The mine employed 63 men on the surface and 310 men underground, of whom 160 were loaders and 150 were daymen on two regular shifts. The average daily production was about 3,000 tons and the maximum was 3,265 tons in one day. The production in 1939 was 446,611 tons of coal.

OPENINGS

The mine is opened by two shafts, about 585 feet deep. One is used for hoisting coal and as an air intake; the other as a man and materials shaft, divided by a fireproof partition, to allow the man compartment to be used as an air intake and the other compartment as an upcast to the fans. Each shaft has a steam heating system to preheat intake air in cold weather. No escape stairways are provided in either of the shafts and no other openings have been provided.

COAL BED

The mine is developed in the Pocahontas No. 4 bed, which averages 5-1/2 feet in thickness and ranges from about 4-1/2 to 7 feet. The coal is classed as smokeless coal due to its low volatile-matter content. It is friable and crushes readily, especially in pillar workings. There are a number of local undulations counteracting any definite dip in the coal bed. One predominant bony coal streak or parting occurs generally about 8 inches from the roof ranging in thickness from about 1 inch to 3-1/2 inches. Another bony coal parting occurs near the middle of the bed in some parts of the mine.

The roof is hard micaceous calcareous sandstone and the floor is hard, smooth fireclay.

ANALYSIS OF COAL

Three samples of coal were collected at representative places in the mine. The analyses of these samples are given in table 1.

Table 1. - Analysis of coal, Mine No. 1, Bartley, W. Va.

Lab. No.	Location in mine	Date
B-48893	Pillar room 1, off room 4, 4 right flat	1/30/40
B-48894	Face room 3, No. 3 development	1/26/40
B-48895	Face room 6, No. 6 development	2/ 2/40

Constituent	Coal as received			Coal - moisture - and ash-free		
	B-48893,	B-48894,	B-48895	B-48893,	B-48894,	B-48895
		Percent			Percent	
Moisture	1.0	0.7	1.0			
Volatile matter	16.5	15.0	16.6	17.9	16.1	17.8
Fixed carbon	75.6	78.4	76.9	82.1	83.9	82.2
Ash	6.9	5.9	5.5			
Sulfur	.7	.4	.4	.7	.5	.5
B.t.u.	14,450	14,670	14,700	15,680	15,710	15,730

The volatile matter ranges from 15.0 to 16.6 percent, but the mean is closer to 16.5 percent. The fixed carbon ranges from 75.6 to 78.4, with a mean of 76.9 percent. From the explosibility standpoint, these two constituents are the most important, and in the second set of analyses on the moisture- and ash-free basis the volatile matter is 17.9, 16.1, and 17.8 percent, with a mean of 17.8 percent. Based on this volatile content, at least 63 percent incombustible matter is required to prevent propagation of an explosion with no gas in the air current and 72 percent inert matter with 1 percent of gas in the air. Some of the return air contains more than 1-1/2 percent methane; therefore, the incombustible content of the dust should be above 75 percent to prevent propagation of an explosion.

METHOD OF MINING

The general plan of mining is the Connellsville block system with multiple entries. The shafts are near the center of 25 parallel entries driven roughly north and south for short distances but discontinued, probably because of encountering faults. All of the advance workings have encountered "wants" or faults and practically all working sections of the mine are on the retreat.

Coal is cut with permissible Jeffrey arcwall mining machines, obtaining their power from portable, self-propelling storage-battery power tanks. All but one of these machines cut at the bottom of the bed. One machine cuts at the top of the bed. In pillar workings the coal is soft enough in some sections to mine the top of the bed with a pick, obviating the necessity of cutting with a machine.

The coal is largely hand-loaded into Jeffrey "underground conveyors" and is elevated by a steel chain-flight conveyor and dropped into the mine car at the working place. Twenty of these units were in use. Hand-loading exclusively was used in the No. 3 development section, locally known as No. 6 heading.

The pillar lines are generally well maintained and squeezes are avoided, except in the No. 3 development area where the bottom heaves, probably due to the "pocket" formed by the fault.

The conveyors, although of a permissible type, are rendered nonpermissible by the method of splicing cables, discussed under the section of this report entitled "Machinery and Electrical Equipment". Storage-battery power tanks constructed at the mine supply power for the conveyors. They are nonpermissible.

Timbering in entries varies in extent, considerable support being required in a few places, but only a limited number of posts are used in most back entries and return airways. A definite timbering system has been adopted and each person is given a copy of the plan when he is employed. Posts must be set 6 feet apart and closer if necessary. This distance was exceeded in a number of rooms, although roof in faces in pillar workings appeared to be adequately supported.

VENTILATION AND GASES

Two 12-foot Jeffrey centrifugal fans are placed at right angles at the top of the upcast shaft. Only one fan is used, the other unit being held in reserve. Both fans are electrically driven. A gasoline-driven engine for operating a small generator in case of power failure was not in working order, and little or no dependence is placed on it, as electric power can be obtained from three separate power circuits of the Appalachian Electric Power Company.

On the day of the explosion the company reported that 271,290 cubic feet of air a minute was being exhausted at the upcast shaft at a 5-inch water gage. Suitable doors are provided to change the direction of the air flow and explosion doors are placed over the shaft. The release of pressure through these doors probably prevented the fans from being damaged by the explosion.

Measurement of air and collection of samples were deferred until the mine was in normal operation. These data are included in the appendix to this report. Each section of the mine is on a separate split of air, with small secondary splits on some sections.

Ventilation of 3 development section consisted of coursing the air on Nos. 1 and 2 headings to the pillar line and then directing it to the right across the pillars to the property line room. The air then passes through the rooms to 1st right flats, crosses the overcast, and joins the main return just outby No. 1 haulage left. Part of this split also divides at the pillar line and is directed into the pillared area, thence over the falls to the bleeder at 1st right flat, No. 1 haulage left, and over the overcast to the main return.

The intake air on No. 3 development splits at No. 1 haulage left, passing inby on No. 4 and 5 headings, splitting again at 3rd right flat, part of the air being directed through room 2, 3 right, thence up 4th right, part ventilating the faces of 4th right flat, then passing through 5th right flat to the face of No. 1 haulage left and out No. 1 heading, across the overcast at 4 left and back to the main returns. The remainder of this split sweeps the pillar workings and passes through a regulator in a brick stopping in the bleeder from 2nd right flat, crossing to 1st right and through another bleeder to the overcast on No. 3 development to the main return. On the day before the explosion the regulator on the 3rd right flat overcast had been opened enough to allow about 9,000 cubic feet of air per minute to pass into the return entries.

Air is conducted up No. 1 haulage left to 4th left flat, is made to sweep across the faces of the working places, thence through the two ventilation rooms to 3rd left flat and through the idle workings to the left of No. 1 haulage left, to the main returns.

The No. 6 development section is on one split, air passing up the haulage road, deflected by a door and stoppings to the faces of the workings, and across the pillars to the return entries.

The company has air samples collected and analyzed daily on the main splits and at the upcast shaft bottom. On the day of the explosion the results were:

Location	Cu. ft. air per minute	CO_2, percent	CH_4, percent
4 left	18,000	0.12	0.46
3 development	50,850	.12	1.41
6 development	36,900	.17	1.25
Main return	(152,890) (118,400) (271,290)	.13	1.69

The methane liberated at this time was at the rate of 6,602,113 cubic feet in 24 hours, indicating that the mine is extremely gassy.

Air is coursed by means of overcasts, stoppings, doors, check curtains, and line brattices. Overcasts are constructed of iron rails and concrete with brick or concrete block walls. Stoppings are constructed of bricks or wood and brattice cloth; doors are made of wood and are hung singly rather than in pairs to form air locks; and line brattices are of brattice cloth, which is sometimes nailed to wooden boards at the roof and floor, but in most places investigated boards were not used.

The pillar caves are acknowledged to contain considerable amounts of methane, and when a large fall occurs there is danger of a large quantity of gas being forced out into the active workings.

No outlet is provided at the edge of the property, and no bleeder shafts or entries are used. It is believed that the use of such shafts or entries would help to bleed gas from the gobs. The ventilation should be sufficient to keep the methane on all returns below 0.50 percent.

HAULAGE

Sixty-pound rails are used on main haulage, while on secondary haulage 30-pound rails are employed, laid to a gage of 48 inches. All switches are actuated by parallel switch throws. Wooden ties are used on main haulage and steel ties on some secondary haulage tracks and in rooms. Steel ties are used occasionally on main haulage to maintain a proper gage. A clearance of 38 inches is required by State regulations, but prior to the explosion apparently considerable material was gobbed along the track. During restoration the track is being well cleaned and shelter holes are being constructed at 60-foot intervals.

All-steel cars are used. They are of tight construction and have a capacity of 4 tons. Swivel couplings are required, as a rotary dump is installed at the bottom of the hoisting shaft. A dedusting agent is applied as the coal is dumped and a 16-inch metal pipe leads from the dump to the return shaft, the suction in this pipe drawing some of the dust from the dump.

Permissible-type storage-battery locomotives and power tanks gather coal at the working places and haul cars to the shaft bottom, no power wires being used for haulage purposes. Haulage is on intake air, and in pillar workings the air sweeps across "solid" places to the pillar workings.

The mine was not seen during normal operation by the writers; however, observation of conditions indicates that cars must be pushed from side tracks to working places, and in the past brakemen have ridden the bumper of the front car, although in some cases they ride inside of the car. Low roof, caused in part by heaving bottom, makes this practice impossible in some sections. Undoubtedly cars are, at times, coupled while in motion, as evidenced by several such occurrences during recovery operations.

LIGHTING

No fixed lights are installed underground, except at the shaft bottoms and in the motor barn, as storage batteries are the only source of power elsewhere in the mine.

Miners wear permissible Edison model P electric cap lamps and officials frequently wear model K lamps with polished reflectors. Foremen, fire bosses, shot firers, and machinemen carry permissible Koehler flame safety lamps, except for one Wolf lamp in use at the mine.

MACHINERY AND ELECTRICAL EQUIPMENT

An inspection of electrical equipment in the No. 1 mine of the Pond Creek Pocahontas Company was made January 24 to February 1, 1940, inclusive, for the purpose of determining whether there were any conditions present that might have initiated the explosion in this mine on January 10.

General

The electrical equipment operated in the mine consisted of the following machines:

A. Twenty Jeffrey type 58-C permissible, 2-horsepower, 250-volt pit car loaders, approval No. 250.

B. Five nonpermissible storage-battery "power tanks", each continaing a Philco battery of 108 cells in a box made at the mine and mounted on mine trucks.

C. Three Jeffrey 29-C permissible-type, 250-volt arcwall mining machines, approval No. 112.

D. Two Sullivan WR-26 permissible-type air compressors, approval No. 117.

E. One American Mine Door H permissible-type, 80-volt rock-dust distributor, approval No. 378.

F. Four Jeffrey permissible-type storage-battery "tramming" locomotives with 108-cell batteries.

G. Eight nonpermissible Mancha-Atlas storage-battery gathering locomotives with 48-cell batteries.

H. Four small and one large Mancha permissible-type storage-battery "power tanks" with 108- and 110-cell batteries.

The pit car loaders (underground conveyors) are usually operated in groups up to as many as seven at one time, all receiving energy from a single nonpermissible power tank. The power tank has one Mancha fused switch controlling the current to an Anderson receptacle. A feeder or "mother" cable, which may be as much as 650 feet in length, is tapped off at intervals for connection to the several pit car loaders. The feeder cable is "flat" type Tirex twin with No. 4 conductors. The pit car loader cables are up to 450 feet in length and are Tirex twisted duplex construction with No. 10 conductors.

The Jeffrey mining machines are operated from the 108- and 110-cell power tanks. The rock-dust distributor and air compressors are operated from gathering locomotives equipped with 48 cells.

Condition of Equipment in Explosion Area

At least 20 of the total number of pieces of electrical equipment were in the explosion areas. Some of the damage to this equipment and its wiring undoubtedly was a result of the forces of the explosions.

A. Pit car loaders

Except for the starting switches and trailing cables, the electrical condition of the pit car loaders examined appeared to be very good. The starting switch was incomplete, which made the pit car loaders nonpermissible in that the bar connecting the switch levers was missing on 7 of the machines examined. Without this bar the starter is used as a single- instead of a double-pole switch. Furthermore, the interlocking feature that is designed to prevent opening of the starter for fuse renewals until the switch has first been thrown to the "off" position is defeated by the absence of the bar. Thus it becomes possible to change fuses while the fuse clips are alive.

Instead of being coiled up, the trailing cables for these machines were found strewn about on the mine floor. Permissible pit car loaders of this type are required to have hooks or horns upon which the surplus cable can be coiled to keep it out of the way of cars and locomotives. These cables contained many cuts and splices, none of which were found to be vulcanized. There was also evidence that the splices were not properly made. For example, the cable for the pit car loader in the pillar split between rooms 4 and 5, in 3rd right flat, was found with the ends trimmed as though splicing was in progress at the time of the explosion. A 4-foot piece of cable nearby evidently had been taken out of the main cable. In this short piece of cable there were two splices made by tying the conductors together. On the knots of one of these splices the copper was beaded where the conductors had squeezed together through the insulation. The cable for the machine in room 7, 4 left, was found pulled apart at a splice. The cable for the machine in No. 3 heading, 3 right, was cut and the conductor strands may have been beaded. The cable for the machine in No. 1 airway (heading), 4 right, was found cut off about 4 feet from the clamp on the machine. A piece of cable about 12 feet in length near the machine may have been cut or pulled loose from splices from the rest of the cable. The strands of the conductor at one end appeared to be beaded as though by electric current. The plug connection for this cable was found disconnected from the feeder cable. At 4th right, No. 2 heading, room 4, a concentric cable for a loading machine was found cut in two on top of a fall. The ends of the strands were definitely burned as if a short circuit had occurred in the cable.

The nominal method of connecting the trailing cables of the pit car loaders to the feeder cable was by means of Anderson plugs and sockets. However, this arrangement was not adhered to strictly, as several machine cables were found to be spliced directly to the feeder cable. Stumps of smaller cable were also seen where evidently pit car cables had been cut free from the feeder cable.

The absence of plugs for disconnecting the pit car cable from the feeder cable for splicing tends to encourage the dangerous practice of splicing the smaller cable while "hot", because it would otherwise be necessary to shut down all the other loading machines by opening the switch at the power tank. The nonpermissible plug and socket arrangement is such that the plug may be inserted or withdrawn at will while the contacts in the socket are alive. Removal of the plug while the machine is running would result in dangerous sparking at the contacts in the socket.

The only overload and short-circuit protection afforded the cables for the pit car loaders consists of a single fuse in the switch box on the power tank that serves the several pit car loaders attached thereto. This fuse is in the positive side only of the 2-wire circuit. Examination of a power tank switch box in the motor barn showed that two 200-ampere fuse links are used. The resistance of the No. 10 loading machine cable plus the resistance of splices and plug connections is such that it is very unlikely that the 400-ampere fuse would "blow" if a dead short circuit occurred in the cable near the pit car loaders. The approval plate on these pit car loaders reads, in part, that the cable must be "adequately protected by fuses or other automatic circuit-interrupting devices"; also that "spliced cables must not be used unless the splices are properly made and vulcanized".

It is understood that 30-ampere fuses are used in the starting boxes for protecting the motor and wiring on pit car loaders, but these would not protect the No. 10 conductor trailing cable.

B. Power tanks for loading machines

In general construction these power tanks consist of a nonpermissible battery box of 2-inch lumber on a mine truck. Wooden covers hinged at the center longitudinally and sheathed outside with sheet steel protect the tops of the battery cells. These covers have no locks to prevent their being opened by unauthorized persons: also no provision appears to have been made for ventilating the box to carry off the gases liberated from the cells. Each box is equipped with a single Mancha explosion-proof fused switch box connected to an Anderson receptacle or socket. This switch box, therefore, protects and controls only one side of the battery circuit. The Anderson socket has no provision for keeping the plug in place while the switch is closed, and the plug can be inserted while the contacts in the socket are made alive. In other words, the switch can be closed with the plug removed and the plug can be pulled out while current is flowing to the pit car loaders. No clamp is used to hold the cable in such a way as to prevent strain on the connections in the plug while it is in place in its socket. This in itself is an operating hazard.

The power tank in room 4 off 4th right, No. 2 heading, had 6 cell tops broken, indicating that an ignition of hydrogen had taken place within the cells owing to undetermined source of ignition. The covers of the tank in room 6 off 1st crosscut left, 4 left flat, were damaged in the explosion, but the cells appeared to be in good condition. The plug was found to be in its socket after the explosion and the switch closed.

C. Mining machines

The Jeffrey arcwall machine parked at room 8, 4 left, No. 4 heading, was found with the headlight cable pulled out of its connection box on the main motor. The trailing cable plug and strain clamp with chain were found attached to the cable and lying between ties near the machine. The main switch handle was up, indicating that the switch was partly or completely closed. Another machine seen at room 4 off 4 right had its main switch closed. The trailing cable was fully reeled up with its plug and strain clamp attached. The cable had numerous splices in it.

D. Air compressors

The compressor, formerly a permissible type, examined at 3rd left overcast was used in connection with a gathering locomotive equipped with a 48-cell battery. This compressor was never approved for operation at voltages under 250, nor has the method of connecting the running plug in parallel with the compressor cable been approved. On permissible power tanks the power outlet must be separate and distinct from the receptacle for the running plug of the locomotive, and means must be provided to keep the compressor or other machine plug from being pulled out under load.

The knob and latch for the fuse plug were missing on this compressor. It would be difficult to renew the fuse without first replacing the missing parts and making necessary repairs to the switch box.

E. Rock-dust distributor

The rock-dust distributor examined was new and was not in the explosion area.

F. Haulage ("tramming") locomotives

The motors of two haulage locomotives had been heated to such an extent that the internal insulation was damaged, necessitating rewinding before they can be returned to service.

G. Gathering locomotives

As previously indicated, the gathering locomotive operating the compressor at 3rd left overcast was used in a nonpermissible manner, in that it had no independent fused power outlet for the connection of compressors or other equipment. This locomotive had 11 cell tops broken in the battery, probably by internal explosions of hydrogen in the cells due to electric sparks or flame passing over them. One cell terminal was deeply scarred, but it was uncertain whether the scar was an electrical burn or merely a mechanical abrasion. This locomotive was fitted with one main fused switch, whereas two are required to complete the protection of the wiring. Both headlight lenses appeared to be cracked all the way through.

No. 7 locomotive in room 5, 3rd right, was found with the two battery box covers shifted sideways to the point where one cover was hanging vertically over the side. The exposed cells appeared to be in good condition, as no broken cell tops were visible. The running plug was not locked in place and there was no headlight switch box as is required on permissible locomotives. There was also only one fused switch instead of two as is required for protection of the wiring.

The locomotive next to the power tank in 4th right radius, No. 1 room chute, was found with the battery box covers shifted slightly and no lock for these covers was seen. The running plug was not locked in with padlock as required on permissible equipment.

H. Power tanks

The large power tank found in room 4, No. 3 development, had no lock for the battery box covers, and the lifting mechanism was almost entirely missing. All battery cells had been washed and painted two weeks prior to the explosion and appeared to be in good condition. The cap for closing the power outlet was missing. Two of the three sets of fuses in the power outlet switch had been blown; two 400-ampere links were used in each position. The interlock for preventing the insertion or removal of the power plug while the contacts in the power outlet are alive was missing. One set of fuses was blown in the fused switch for the running plug. The hose conduit for the cables to the running plug was worn through. The exposed cables did not appear to be damaged. The cylindrical sliding ring cover at the commutator end of the motor had been cut off, leaving only about one third of the original cylinder, making the locomotive nonpermissible. The retaining ring was also cut to the same length and was held by two cap screws. Thus the remaining part of the ring cover was not positively bolted in place to prevent exposure of the large opening into the motor.

The power tank found between Nos. 2 and 3 headings, 4th right, had a motor that had been altered in the same way as described above. The power outlet was not protected by a cap and the interlock mechanism was missing.

The motor of the tank in 4th left and that of the tank in 4th right radius, No. 1 room chute, also had been altered by cutting down the ring cover. The power outlets were not capped and interlock mechanisms were missing. The running plugs were not locked in place, nor were the battery box covers locked.

The No. 15-A tank battery in No. 3 development had 21 cell tops broken; also one cell connecting strap was burned in two. Another strap was burned away, leaving about two-thirds of its original width over the entire length. A number of cell terminals were marked as though recently struck.

Motor Barn

The motor barn near the bottom of the air shaft is equipped with charging panels and 17 plugs on flexible cables for connection to the various locomotive and tank battery boxes during charging periods. The gathering locomotive batteries, for example, receive an 8-hour regular charge starting at 95 amperes and finishing at 20 amperes, also a weekly overcharge of 6 to 8 hours. Hydrometer readings are taken every 30 minutes during charge and the cells are watered at least once a week. Washing and painting of the cells is done at regular intervals. The man in charge of batteries in the motor barn checks the seals for headlights and switch boxes every day before the locomotives leave the motor barn. Fuses are checked with a light every day to determine whether replacements are needed.

Current for charging batteries is delivered to the motor barn by cables from surface generators. These cables are suspended in the man-shaft. A balancer set in the motor barn assists in control of charging current. An insulating mat is placed before each charging panel.

EXPLOSIVES

Coal is blasted with permissible Monobel C explosives, in 1-1/8-inch by 8-inch cartridges, and rock with permissible Gelobel. Rock is drilled with an air hammer and then charged with Gelobel, presumably confined with clay according to company regulations, but a shot was found charged to the collar of the hole with explosive in 3rd left flat. Some clay may have been piled on top of the shot and then been blown away by the explosion.

Holes are drilled in the coal to within several inches of the back of the cut. In one room a bootleg was found in the coal, 14 inches on the solid. Shots are fired by shot firers, at any time during the shift, using a permissible single-shot Davis magneto-type blasting unit.

Charges, with a maximum of 3 sticks, are confined in the hole with dry clay in paper "dummies" made from special paper. A No. 6 electric detonator is inserted in a cartridge of explosive and placed in the hole first, with the detonator pointing towards the rest of the charge.

Explosives are taken into the mine at night in wooden, rubber-insulated boxes placed in regular mine cars. A 24-hour supply is distributed to rubber-lined wooden boxes in each section. The shot firer then distributes it to each miner, who stores it in a cloth or rubberized cloth bag, hung on a cap piece a safe distance from the face. Detonators are stored in wooden boxes. Whether these are hung from a post or placed on the gob could not be determined, although none of the containers found was hung on a post or crossbar. All explosives should be stored in a substantial box of wood or other dielectric material in a hole dug in the rib at least 50 feet from the face, and the detonators should be carried by shot firers. Containers should be of dielectric material and so constructed that the detonators will be adequately protected. The present plan of distributing only one day's supply to each miner should be continued. There is evidence that explosives burned in several places and detonation of explosives and detonators may have contributed to the propagation of the explosion.

DRAINAGE

The mine is naturally dry and dusty, but to the north of 3 development a body of water lies in old workings. A pump located near room 6 keeps the water below a definite level. This body of water probably helped to limit the explosion. Water is also found in a low area in 6 development just inby No. 1 haulage right.

DUST

The mine was dry and dusty in all working places and on practically all haulage roads. In the area affected by the explosion, dust was more than an inch thick in most places, and considerable dust was found on the material gobbed beside the track. Where iron rails were used as crossbars, dust had collected on the flanges. Samples of rib and road dust were collected in the explosion zone and in the unaffected 6 development. Analyses of rib-dust samples are given in table 2 and road-dust samples have been tabulated in table 3.

The analyses of the rib dusts show an average ash content of 11.0 percent where no rock dust was present and 34.0 percent in the rock-dusted areas. The highest ash content was 66.4 percent in a sample from a rock-dusted zone. The ash content of samples collected in the explosion area ranged from 5.0 to 8.9 percent ash where no rock dust had been applied and 33.2 percent on the haulage road at the same location. Where the flame died out on this entry the ash was 55.5 percent.

Table 2. - Analysis of rib-dust samples, Mine No. 1, Pond Creek Pocahontas Co., Bartley, W. Va., 1940

Laboratory No.	Location in mine	Percent: Moisture	Percent: Volatile matter	Percent: Fixed carbon	Percent: Combustible	Percent: Ash	Percent: Through 200-mesh	Coke, amount	Rock-dusted
48851	5 hdg. 3 development, 30 ft. outby last slant	0.8	14.5	78.5		6.2	42.0	Large	No
48853	4 hdg. 3 development, 20 ft. outby last slant	.6	14.1	80.3		5.0	32.6	Medium	No
48855	3 hdg. do.	.6	14.0	77.8		7.6	53.6	Medium	No
48857	2 hdg. do.	.5	14.8	75.8		8.9	41.4	Large	No
48859	1 hdg. 3 development at last slant	.5			66.3	33.2	37.7	Small	Yes
48861	1 hdg. 3 development at room 12	.7			43.8	55.5	38.8	None	Yes
48863	2 intake 3 development opposite room 12	.8	16.6	54.8		27.8	47.0	None	No
48865	1 hdg. 6 development at R.R. right of way	.5			81.1	18.4	38.8		Yes
48867	2 hdg. do.	.5	16.5	74.6		8.4	29.5		No
48869	3 hdg. do.	1.4	18.0	67.6		13.0	28.2		No
48871	4 hdg. do.	1.1	16.0	69.1		13.8	22.5		No
48873	Slant from No. 6 to No. 5 hdg. 6 development at room 8	1.1			87.1	11.8	21.1		Yes
48875	5 hdg. 6 development opposite room 8	.7	16.7	65.3		17.3	45.8		No
48877	Room 5, 6 development, 100 ft. outby face	.4			90.2	9.4	15.0		Yes
48879	Room 6, do.	.7			54.8	44.5	36.4		Yes
48881	5 hdg. 6 development at 1 haulage right	.8	15.8	73.8		9.6	31.0		No
48883	4 hdg. 6 development at overcast 1 haulage right	.5			66.6	32.9	30.1		Yes
48885	3 hdg. 5-1/2 development	.5	15.2	75.9		8.4	18.7		No
48887	4 hdg. 5-1/2 development	.2			33.4	66.4	68.8		Yes
48889	4 hdg. 3 development opposite room 15	.9	15.5	73.1		10.5	27.8	Small	No
48891	3 hdg. do.	.7	15.5	76.8		7.0	10.3	None	No
	Average, no rock dust applied	.8	15.6	72.6		11.0	33.1		
	Average, rock dust applied	.6			65.4	34.0	35.8		

Table 3. - Analysis of road-dust samples, Mine No. 1, Pond Creek Pocahontas Co., Bartley, W. Va., 1940

Laboratory No.	Location in mine	Percent						Coke, amount	Rock-dusted
		Moisture	Volatile matter	Fixed carbon	Combustible	Ash	Through 200-mesh		
48852	5 hdg. 3 development, 30 ft. outby last slant	0.6	14.9	78.3		6.2	22.2	Large	No
48854	4 hdg. 3 development, 20 ft. outby last slant	1.2	14.2	77.4		7.2	18.2	Medium	No
48856	3 hdg. do.	.6	14.0	78.7		6.7	29.6	Small	No
48858	2 hdg. do.	.5	15.4	70.1		14.0	32.2	Small	No
48860	1 hdg. do.	.4			63.9	35.7	26.0	Small	Yes
48862	1 hdg. 3 development at room 12	.6			54.7	44.7	18.8	Small	Yes
48864	2 hdg. do.	.8	15.7	69.8		13.7	27.6	Small	No
48866	1 hdg. 6 development at R.R. right of way	.5			83.9	15.6	29.6		Yes
48868	2 hdg. do.	.5	14.3	67.2		18.0	27.8		No
48870	3 hdg. do.	.3	12.2	55.7		31.8	18.8		No
48872	4 hdg. do.	.8	15.3	75.7		8.2	20.8		No
48874	Slant, No. 6 to No. 5 hdg. 6 development opposite room 8	.6			69.4	30.0	28.6		Yes
48876	5 hdg. 6 development opposite room 8	.6	15.7	71.9		11.8	26.4		No
48878	Room 5, 6 development, 100 ft. outby face	.2			76.3	23.5	22.2		Yes
48880	Room 6,	.2			43.1	56.7	27.1		Yes
48882	5 hdg. 6 development at 1 haulage right	.7	15.9	74.1		9.3	16.3		No
48884	4 hdg. 6 development at 1 haulage right overcast	.5			55.9	43.6	30.2		Yes
48886	3 hdg. 5-1/2 development	1.2	14.7	76.1		8.0	27.1		No
48888	4 hdg. 5-1/2 development	.4			72.5	27.1	32.3		Yes
48890	4 hdg. 3 development opposite room 15	1.0	14.4	73.4		11.2	18.1	None	No
48892	3 hdg. do.	.8	14.7	71.7		12.8	25.0	None	No
	Average, no rock dust applied	.8	14.7	72.3		12.2	23.9		
	Average, rock dust applied	.4			65.0	34.6	26.9		

Samples 48877 and 48879 were collected in freshly rock-dusted rooms. In room 5 where dust had been piled to within several feet of the roof the ash was 15.0 percent, and in room 6 where large pieces of rock were gobbed against the rib the ash content was 36.4 percent. On the freshly dusted haulage road near room 8 the ash was only 21.1 percent.

The road-dust samples showed an average ash content of 12.2 percent where no rock dust had been applied and 34.6 percent where rock dust had been applied. In the explosion area the ash ranged from 6.2 to 14.0 percent and on the haulage road at the same place 35.7 percent. Outby on the haulage road near where the flame died out the ash content was 44.7 percent, but opposite this point the inert content was 13.7, 18.1, and 25.0 percent.

In the unaffected part of the mine on rock-dusted entries the ash content ranged from 22.2 to 32.3 percent, and on non-dusted entries from 16.3 to 27.8 percent.

The analyses clearly indicate that, in spite of the large amounts of rock dust applied, the combustible dust is present in such large amounts that the inert content is far below that necessary to prevent propagation of an explosion. The need for cleaning excess dust from all entries before applying rock dust is clearly shown.

The feasibility of applying water to the coal during the various mining operations to allay the dust should be carefully investigated. Water sprays should be established on the loaded side track in each section to wet the tops of loaded cars before the trip is hauled to the shaft bottom.

The application of calcium chloride on the haulage roads might also help to allay the dust; and it would be good policy to try out the practice of keeping the floor of haulage roads wet by use of water cars, sprinkling with hose, or by use of suitable water sprays.

The Pocahontas No. 4 coal is generally soft and friable and in pillar workings the dustiness of the coal is increased by the stresses induced when pillars are extracted. Dry dust is readily thrown into suspension and when so suspended is more readily ignited. When water is applied to the coal during cutting and loading, a large part of the dust is prevented from rising into the air or from being thrown into the air by an explosion. The wide extent of the explosion on January 10, 1940, undoubtedly was due to propagation of coal dust aided by explosive gas. If dust at the face had been wet and outby had been adequately mixed with rock dust, the explosion might have been restricted to one section.

If at all feasible, the face region should be thoroughly wetted before and after blasting and at frequent intervals during loading of coal. Mining machines should be provided with means for keeping a stream of water on the cutter bar to wet the machine cuttings and prevent formation of dust. The loaded cars should be wetted before leaving the working places and water sprays should be placed on loaded side tracks to wet the tops of the cars, so that dust will not blow off and contaminate the rock-dusting.

ROCK DUST

The mine has considerable rock dust applied on haulage roads and in rooms, where track is maintained. Once a week rock-dusting is said to be done in the working places and on entries having track in them, but as rock-dusting was not started until many of the entries had been driven, probably at least two-thirds of the entries have not been treated.

The effectiveness of the rock dust has, in most places, been greatly reduced, or practically voided, by the deep layer of coal dust on the floor and the ribs.

During 1939, according to information published by the West Virginia Department of Mines, 785 tons of rock dust were applied, or an average of 3.515 pounds per ton of coal. Only two other mines in the county used more dust and only six mines in West Virginia used more dust per ton of coal. The quantity used was nearly twice as much as the average for the county and nearly three times the average for the State.

No rock-dust barriers have been installed and no map showing the extent of rock-dusting is maintained. It is believed that a record should be maintained of rock dust used, feet of entry treated, pounds applied per foot of entry, and analyses of samples collected at strategic locations.

New stoppings and overcasts built after the explosion are provided with pipes to allow hose to be taken into back entries to apply rock dust. In the room entries the first heading has been fitted with a door 30 inches square, and the No. 4 heading has a 6-inch pipe in it.

All entries should be cleaned before rock dust is applied and all entries that can be reached by a high-pressure rock-dust machine with hose should be thoroughly rock-dusted. Places that cannot be reached with a hose should be protected with suitable barriers or rock-dusted by hand.

The return airways in many parts of the mine contain more than 1 percent methane; hence it is advisable to maintain an incombustible content of 75 percent or over.

Rock dust did not stop the explosion but, as it was not particularly violent, rock dust may have decreased the propagation rate, and on 3 development outby No. 1 haulage left rock dust may have stopped propagation on the haulage road.

FIRST AID AND MINE RESCUE

In 1937 all employees were trained in first aid and at the time of the explosion practically all men had had this training. Approximately 60 men have received mine-rescue training and additional men in the other 3 mines of this company have been trained. Forty men have completed the Bureau of Mines course in accident prevention.

Six Gibbs oxygen breathing apparatus are kept in the mine-rescue room. This equipment is used once a week by at least one of the company's teams and is in safe working condition. Six All-Service gas masks are also available for use in the mine-rescue room. The central mine-rescue stations at Berwind and Logan, W. Va., are also readily available. The system of central mine-rescue stations in West Virginia is described in Bureau of Mines Miners' Circular 39.

Since the disaster, self-rescuers have been ordered for all employees of this and affiliated companies. It is understood that their use will be described and discussed before the men are given them. A regular periodic system of inspection will be instituted.

SAFETY ORGANIZATION

A safety inspector is employed and he spends his entire time inspecting the mine, instructing men in mine rescue and first aid, and helping to formulate the safety policy of the company.

Printed rules are issued to new employees and these rules were being revised by operating officials when the explosion occurred.

Safety meetings of all employees are held monthly and safety bonuses are drawn. A revision of the system was being made and in the future only those who have not been injured will be eligible for drawing. Previously those who had not lost 7 or more days due to an accident were eligible.

SUPERVISION AND DISCIPLINE

Each section foreman has about 22 men under his direction, working in only about 7 places, thus enabling him to visit each working place six to eight times a shift. Whether or not this was done could not be checked. (It was reported that at least one foreman was known to spend a great deal of time near the telephone in his section.) Shot firers are in the places frequently and they should be able to check unsafe conditions.

FIRE-FIGHTING

A 100-gallon soda-acid fire-fighting tank is maintained for underground use and it can be readily transported to any desired location. One pyrene fire extinguisher is placed in a suitable rack on each machine and locomotive; six 2-1/2-gallon soda-acid extinguishers are placed in each section.

MINE CONDITIONS IMMEDIATELY PRIOR TO THE EXPLOSION

The mine was in normal operation on Tuesday, January 9, the day prior to the explosion, and on Wednesday, January 10, the day of the explosion. Two 7-hour shifts were worked per day and the shifts were changed at 3:00 p.m. daily. One hundred and thirty-eight men were in the mine at the time of the explosion. Thirty-seven men, including the section foreman, were on the west side of the mine, which was not affected by the explosion. Ten men, including the mine foreman, were at their posts of duty near the two shaft bottoms. Two men were on the No. 3 development haulage road on their way to the shaft. Twenty-two men, including the section foreman, were on the 4 left flat section; 2 men were cleaning up a fall near the overcast at 3 left flat; 25 men, including a section foreman, were on the 3 right flat section; and 38 men, including a section foreman, were on the No. 3 development section.

According to a statement made by H. L. Schweinsberg, safety inspector of the company, who visited the pillar section on No. 3 development entry the day prior to the explosion, the places to the extreme right end of the pillar line were ready for and expecting a pillar fall. When this section was finally reached during the recovery operations on Sunday, January 14, it was determined that this expected fall had occurred. In speculating upon the possible cause of the explosion the management seems to be of the opinion that this expected pillar fall may have come at the time of the explosion, forcing explosive gas out into the working places. That this pillar fall may have been coincidental with the explosion seems unlikely because the bodies of the two men working in the place nearest the expected pillar fall were found closer to the fall than they would normally be in the event that the fall was imminent. Moreover, if the fall were about to take place at about the time the explosion occurred, it is highly probable that the section foreman would have been on hand. The section foreman's body was found at the shot firers' station near the entrance to the section.

Aside from this expected pillar fall, conditions in all three sections of the mine affected by the explosion appeared to be normal insofar as could be determined by the investigation after the explosion.

Information on barometer readings on January 8, 9, 10, and 11 was obtained from a recording barometer at the Carter Coal Company mine at Caretta, W. Va., about 5 miles from the Bartley mine. The records show:

January 8	12:00 noon	28.40 inches
January 9	12:00 noon	28.72 inches
January 10	12:00 noon	28.71 inches
January 10	2:00 to 4:00 p.m.	28.74 inches
January 11	12:00 noon	28.46 inches

From January 11 the barometer dropped constantly until January 15 when it reached 28.00 inches. Because of the rising barometer from January 8 to January 10 it is concluded from the preceding data that the change in atmospheric pressure bears no relation to the occurrence of gas in the working places of the No. 1 mine on the day of the explosion.

So far as could be determined, the fan was in operation and there were no interruptions on the day of the explosion. The latest report of the fire bosses was made on the morning of the explosion and no standing gas was reported in the active working places.

PREVIOUS EXPLOSIONS IN THIS OR NEARBY MINES

There is no record of any gas ignition or mine explosion ever having occurred in this mine previous to the explosion of January 10, despite the fact that the mine has been operated about 15 years, is extremely gassy, and is regarded by the writers to be exceedingly dry and dusty. Numerous mine explosions have occurred, however, in mines operating in the low-volatile and medium-volatile coals of McDowell County. The following records of such major disasters were taken from the Bureau of Mines files.

Date		Mine	Location	Number killed
1902	Sept. 15	Algoma No. 7	Algoma, W. Va.	17
1905	Feb. 26	Grapevine	Wilcoe, W. Va.	6
1905	Nov. 4	Tidewater	Vivian, W. Va.	7
1908	Dec. 29	Lick Branch	Switchback, W.Va.	50
1911	Nov. 18	Bottom Creek	Vivian, W. Va.	18
1911	Mar. 28	Jed	Jed, W. Va.	81
1916	Mar. 28	King No. 98	Kimball, W. Va.	6
1919	July 18	Carswell No. 3	Kimball, W. Va.	6
1924	Mar. 28	Yukon No. 2	Yukon, W. Va.	24
1927	May 13	Shannon Branch No. 3	Capels, W. Va.	8
1928	Apr. 2	Keystone No. 2	Keystone, W. Va.	8
1928	May 22	Yukon No. 1	Yukon, W. Va.	17

PROPERTY DAMAGE

In summing up the property damage brought about by this explosion it may be stated that the damage to equipment was negligible. On the other hand, much labor and material were expended on the removal of falls from the haulage roads and the reconstruction of stoppings and overcasts.

It is exceedingly difficult to estimate the material and social losses occasioned by this explosion which took the lives of 91 men. In addition to the cost of compensation benefits, which are reported to be from $400,000 to $500,000, the recovery work, the cleaning up of falls, the reconstruction of stoppings and overcasts, the loss of production from the mine for a period of one month or more, the loss of wages to employees, and other incidental items would bring the total cost to a tremendous sum.

STORY OF THE EXPLOSION

At about 2:30 p.m. on the day of the explosion the mine foreman, the dispatcher, and one of the workmen were in the dispatcher's office near the bottom of the manway shaft. Suddenly a rush of air occurred along the entry, the sound of which was described as "like a fire siren". The atmosphere was immediately filled with dust. Men working around the bottom of the coal shaft and the manway shaft also felt the strong rush of air and realized immediately that an explosion had occurred and that the force had evidently come from the northeast portion of the mine. Thirty-seven men working in the west portion of the mine were not aware that an explosion had occurred, but were immediately notified and they came to the shaft unaided. These men, together with the 10 men located at or near the shaft bottoms, were hoisted to the surface. The first indication of any trouble on the surface was a column of dust which rose from each of the shaft openings to a reported height of about 100 feet. The time was noted by the hoisting engineer to be exactly 2:30 p.m.

The operating officials, including the vice president, the general manager, the mine superintendent, and the safety engineer, were holding a safety meeting at the general office located nearby. Upon being notified that there was trouble at the mine, the safety engineer and the superintendent proceeded immediately to the shafts, whereupon it was discovered that the explosion doors on the fan had been blown open. Arrangements were then made to close the explosion doors on the fan and a rescue party entered the mine at about 3:00 p.m. The district inspector of the State Department of Mines arrived at the mine at about 3:30 p.m. and entered the shaft soon thereafter.

RESCUE AND RECOVERY OPERATIONS

The rescue party proceeded in fresh air to the mouth of No. 3 development entries, where they found an overcast damaged by the explosion. After making repairs to this overcast, they traveled in fresh air into No. 3 development entry to about No. 12 room, where they encountered a small fire which was immediately extinguished. Several additional small fires were encountered along the No. 3 development haulage road at No. 15 room. A stopping between the intake and return was blown out at this point and was replaced by a temporary stopping. While this work was in progress a second explosion occurred, which was evidenced by a strong inward and outward movement of the air at the point where the work was being done. When the second explosion occurred, the rescue party returned to the surface to discuss the situation and decide how to cope with a very hazardous problem. The second explosion occurred about 7 hours after the original explosion, at about 9:30 p.m.

M. C. McCall, engineer in charge of Bureau of Mines Rescue Car No. 4, was notified of the explosion at 5:10 p.m. by R. E. Salvati, vice president of the company. Mr. McCall notified J. J. Forbes, supervising engineer of the Safety Division of the Bureau of Mines, at Pittsburgh, Pa., at 5:20 p.m. Mr. Forbes ordered Rescue Car No. 4 of the Bureau of Mines to be sent to the mine. It left Keystone, W. Va., about 7:15 p.m., arriving at Bartley, W. Va., at 10:15 p.m. The following Bureau of Mines men were directed to proceed to the disaster: W. R. Park and F. J. Furin, who were at Carswell, W. Va., and who arrived at the mine at 10:45 p.m.; M. C. McCall and J. S. Ferraro, who arrived at Bartley, W. Va., about 11:30 p.m.; and M. J. Ankeny, J. W. Pero, and T. D. Brown, who were at the Pittsburgh office and drove all night to reach the scene of the disaster at 8:30 the next morning. C. W. Owings left the Pittsburgh, Pa., office of the Bureau on the afternoon of January 11, arriving at the mine at 12:15 p.m., January 12. Meanwhile, additional inspectors of the West Virginia Department of Mines and apparatus crews arrived on the scene from time to time.

Work was resumed in advancing into the explosion area during the night of January 10. The first two bodies were found on the No. 3 development haulage road opposite No. 19 room. These men had been working in the No. 6 heading section and were caught by the explosion while on their way out of the mine. They were evidently asphyxiated and burned. Work was continued throughout the night in advancing into No. 3 development entries in fresh air by erecting temporary stoppings to replace those destroyed by the explosion. On the morning of January 11, the overcast at 1 right flat was reached and repairs to this overcast were made. Shortly thereafter the intersection of No. 1 haulage left and the No. 3 development entries was reached. At this point it was decided to advance into the No. 1 haulage left in an effort to reach the 4 left flat section as quickly as possible, the general opinion being that if there were any survivors they would be located in that section. The indications at the intersection were that the explosion probably came out of the workings on the No. 3 development section, and it was thought unlikely that there would be any survivors in that section. In order to advance into No. 1 haulage left, No. 3 development entries were temporarily sealed off with canvas and the air was carried into No. 1 haulage left.

To guard against moving too much air at a time, apparatus crews were sent ahead to see that break-throughs between the intake and returns were open and to erect temporary brattices across the intakes. This precaution was deemed necessary due to the high concentration of methane encountered and the possibility of fires which might provide an ignition source for additional explosions. Moreover, there were numerous storage-battery power tanks located in both the 3rd right flat and 4 left flat sections which, together with the feeder cables attached to them, constituted a very serious fire and explosion hazard. An additional precaution was to examine the returns frequently, wearing All-Service gas masks, in an effort to detect any smoke in the returns which would indicate possible fires ahead. No smoke was observed in these returns at any time.

As the recovery operations progressed into the No. 1 haulage entries, all openings to the 1st right flat, 2nd right flat, and 3rd right flat were temporarily sealed off with brattice cloth. The bodies of 2 men, a driller and helper, were found near the 3rd left overcast, which had been blown out. Six additional bodies were found on No. 1 haulage entry between 3rd left flat and 4th left flat. Another body was found about 50 feet inby from the overcast on 4 left flat and 2 additional bodies were found about 200 feet inby on No. 1 entry of 4th left flat. The circumstances under which all but one of these 9 bodies were found indicated that they traveled a considerable distance after the explosion and their death was caused by asphyxiation. This left 15 men unaccounted for in the 4 left section. When the working places were explored in this section, no one was found in any of the working places. The following shift explored the 3 return entries of the No. 1 haulage inby from 4th left flat and found the 15 missing bodies. Nine of them were huddled together in one group and 6 others were found outby, as indicated on the accompanying map. It is entirely obvious that these 15 men, including the section foreman, traveled from the working places in 4th left flat into these return entries after the explosion. There is no evidence that these men made any attempt to erect barricades and it is very likely that there was not sufficient time to do so. On the other hand, they may have decided to wait for a while with the hope that the atmosphere would clear up sufficiently to permit them to make their way to the shaft. All 15 of these men died by asphyxiation.

Exploration of the 4th left flat section was completed and a total of 28 bodies were recovered by the morning of January 13. The next move was to drop back to 3rd right flat, erect temporary stoppings across the intakes of No. 1 haulage just inby from 3rd right, and conduct the air into the haulage road of 3rd right flat. The pillar section on 3rd right flat was subsequently ventilated and 25 bodies were recovered from this section. Due to the large volume of explosive gas being moved and a lack of sufficient quantity of air, some of the bodies in this section had to be removed from the working places by oxygen breathing apparatus crews.

Work in the 3rd right flat section was completed by midnight, Saturday, January 13, after which the No. 1 haulage entries were temporarily sealed off at the intersection of No. 3 development entries, and the air was carried into the No. 3 development entries toward the working section. Considerable time was lost in removing a trip of wrecked cars on No. 3 development just inby from No. 1 haulage. The working places of No. 3 development were reached at about 8:30 a.m., Sunday, January 14. The section was explored and all 38 bodies in this section were recovered by 9:30 p.m. of the same day. At the conclusion of the recovery work on Sunday night, January 14, everyone was withdrawn from the mine and plans were made to start reconstructing stoppings and overcasts to permanently restore the ventilation on Tuesday morning, January 16. Obviously no official investigation could be made until after permanent ventilation could be restored because there was not sufficient air to keep the working sections clear of explosive gas due to leakage of air through the temporary stoppings and damaged overcasts.

The recovery work was seriously hampered and slowed down due to numerous large falls along the No. 3 development and No. 1 haulage entries, which made it extremely difficult to obtain supplies. As the recovery work progressed, large crews of men were engaged in cleaning up falls along the haulage roads so that by the time the recovery work was completed the main haulage road was clear to the intersection of No. 1 haulage entry.

The use of trained oxygen breathing apparatus crews aided very materially in expediting the recovery of the mine with much greater safety to those engaged in the work underground than would have been possible without them. Acknowledgment is made to the following mine-rescue teams for the effective service rendered by them:

Pond Creek Pocahontas Co. No. 1 mine	Bartley, W. Va.
Pond Creek Pocahontas Co. No. 4 mine	Bartley, W. Va.
Pond Creek Pocahontas Co. No. 4 mine	Bartley, W. Va.
Pond Creek Pocahontas Co. No. 3 mine	Bartley, W. Va.
Raleigh Wyoming Mining Co.	Glen Rogers, W. Va.
Carter Coal Co.	Coalwood, W. Va.
Island Creek Coal Co.	Holden, W. Va.
American Coal Co.	McComas, W. Va.
Pocahontas Fuel Co.	Jenkinjones, W. Va.
Eastern Coal Co.	Stone, Ky.
Carter Coal Co.	Caretta, W. Va.
New River & Pocahontas Consolidated Co.	Berwind, W. Va.
Koppers Coal Co.	Carswell, W. Va.

The recovery operations progressed continually, 24 hours per day, in 4-hour shifts. Each shift was in charge of a representative of the Pond Creek Pocahontas Company, who was assisted and advised by one or two inspectors of the West Virginia Department of Mines and one or two representatives of the United States Department of the Interior, Bureau of Mines. The Bureau of Mines representatives worked 8-hour shifts, thus overlapping the shifts of the company and Department of Mines representatives. A representative of the engineering department of the Pond Creek Pocahontas Company accompanied each shift to make notations on the map of the location of each body as found and any other evidence that may have a bearing on the explosion.

The company engineers who served at the explosion were C. C. Waldron, W. H. Day, O. C. Casteel, W. M. Largen, Tom Williamson, and Walter De Bard.

The company representatives who were in charge of the shifts were H. L. Schweinsberg, J. M. Holbrook, Jack Bartlett, and C. F. Smith.

Representatives of the West Virginia Department of Mines were N. P. Rhinehart, Chief of the Department; E. L. Chatfield, inspector at large; and Inspectors W. L. Lyons, W. C. Sturgill, W. W. Jones, J. W. Hall, H. D. Lowe, Floyd Houck, Ray Ellis, Robert Lilly, Ivan Shumate, Clinton Meadows, and Young Lawson.

From the time the first Bureau of Mines representative entered the mine at 3:00 a.m. on January 11 to the time the recovery work was completed January 14 at 9:30 p.m., there were at least one and usually two Bureau of Mines men on duty underground ahead of the working crews. The work of the Bureau at this explosion consisted of keeping a check on the quality of the air as the crews advanced, consulting with company officials and mine inspectors as to procedure, preparing, directing, and inspecting apparatus crews at the fresh-air base, and otherwise looking after the safety of the men engaged in the recovery work. A great deal of credit is due the Bureau of Mines and the West Virginia Department of Mines for the fact that the recovery operations, which necessitated the exposure of large crews of men to extremely hazardous conditions of explosive gas, carbon monoxide, and bad roof, were efficiently conducted without injury to anyone.

For the information of the Bureau of Mines, the following is a record of the time spent underground by the personnel of the Bureau during the recovery operations.

McCall and Park	January 11	3:00 a.m. to 7:00 a.m.
	11	7:00 p.m. to 11:00 p.m.
	12	4:00 p.m. to 12:00 p.m.
	13	4:00 p.m. to 12:00 p.m.
Ferraro and Furin	January 11	7:00 a.m. to 11:00 a.m.
	12	11:00 p.m.(11th)to 7:00 a.m.
	13	12:00 midnight to 8:00 a.m.
Ankeny and Pero	January 11	11:00 a.m. to 7:00 p.m.
	12	7:00 a.m. to 4:00 p.m.
	13	8:00 a.m. to 4:00 p.m.

Owings	January 12	8:00 p.m. to 12:00 p.m.
	13	4:00 p.m. to 12:00 p.m.
	14	12:00 midnight to 3:00 a.m.
Ferraro	January 14	1:00 a.m. to 6:30 a.m.
Furin	January 14	5:00 a.m. to 10:30 a.m.
Ankeny and Brown	January 14	8:30 a.m. to 3:15 p.m.
Pero	January 14	1:00 p.m. to 9:30 p.m.

INVESTIGATION OF THE EXPLOSION

J. J. Forbes, supervising engineer of the Bureau of Mines Safety Division, directed M. J. Ankeny, M. C. McCall, and C. W. Owings to investigate and report on the cause or causes of the explosion. M. J. Ankeny, J. W. Pero, T. D. Brown, and C. W. Owings returned to Pittsburgh, Pa., on January 15, 1940, leaving M. C. McCall to assist in restoration of ventilation and cleaning up the mine, to permit a detailed investigation to be made. The investigation was continuous from the time the Bureau representatives arrived on the scene until completion of the investigation on February 2, 1940. C. W. Owings returned to Bartley, W. Va., on January 18 and assisted in the restoration of ventilation and made observations on conditions. On January 24, 1940, M. J. Ankeny, accompanied by E. J. Gleim of the Electrical Section of the Bureau, returned to Bartley, W. Va., arriving there about 2:30 a.m. That afternoon an official investigation was made of the No. 3 development section. The investigating party consisted of Messrs. Salvati, Stollings, Walker, Haslam, and Schweinsberg of the Pond Creek Pocahontas Company; Messrs. Rhinehart, Chatfield, Lyons, and Sturgill of the West Virginia Department of Mines; and M. J. Ankeny, E. J. Gleim, M. C. McCall, and C. W. Owings of the Bureau of Mines.

During the following week the Bureau representatives continued assisting with restoration of the mine and making further investigations. An official investigation was made of the rest of the affected areas on January 31, 1940, by practically the same group which made the investigation on January 24. The Bureau engineers completed their investigation on February 2, 1940.

FORCES

The direction of major forces is shown on the map of the mine. In many places positive evidence of forces in opposite directions was found, indicating that probably more than one explosion occurred.

No. 3 Development

The first evidence of force was indicated by the damage to the explosion doors over the upcast shaft. Men near the shafts indicated that dust was blown from the No. 3 development section. The overcast at the entrance to the section had the top blown downward. Timber legs about room 20 were leaning outby, showing an outward force. At 1 right flat the overcasts were blown downward and the inby walls were blown outby, showing an outward force.

The stoppings in the mouths of the other three headings in this group (1st right flat off No. 3 development) were blown onto the haulage road and all material was blown in the same direction, including rock, brattice cloth, timbers, splinters on posts, and similar material. The three stoppings in the barrier pillar between the No. 1 heading of this group and room 32 were blown outby and forces in these rooms were outby and also towards the haulage road.

Forces inby 1st right flat on No. 1 heading were both inby and outby. A trip of 35 empty cars was being pulled inby by a locomotive on the inby end and pushed by another locomotive on the outby end. The front locomotive was stalled by a large piece of rock, on edge and leaning against the inby locomotive, which continued to run, leaving 4 deep grooves in the rails. A distance of about 5 feet separated the third and fourth cars, and the brakeman was found face down, between these cars, with head outby. The motorman was also found between the third car and the rib with his head outby. The motorman on the outby locomotive had been blown 15 or 20 feet outby, his face striking the roof and his body then being blown 10 or 15 feet farther outby. He was found face up, feet outby. Near the middle of the trip, 5 or 6 cars had been badly damaged, the inby ends having been bent a foot or more inby. These details indicate that a strong outward force blew the men outby, but an equally strong force also blew inby.

The overcast on No. 2 heading at No. 1 haulage left was blown outby, the lower part of a brick stopping between headings 3 and 4 was blown towards No. 4 heading, and in the bleeder from No. 1 heading to 1st right flat, No. 1 haulage left, debris was blown towards 1st right. The bleeder from this same heading near the pillar line showed considerable force into the gobbed area.

The forces to the right of 3 development inby 1st right flat were inby and across the pillars and pillar workings from right to left, as indicated by loose material, coke, and other material blown in the same direction.

Flame was indicated throughout most of this area by coked dust, burnt splinters, charred cloth, and burned explosives and bag in the pillar split in old No. 2 haulage left. In the face region it seemed that the flame burned back and forth with low violence, but in the entries at No. 1 haulage left evidently greater pressure had developed.

No. 1 Haulage Left

Major forces were inby on No. 1 haulage left, indicated by stoppings and overcasts blown inby, loose material carried inby, and by both charred and non-charred splinters pointing inby. On the haulage road a considerable area had fallen between 1 and 2 right flats and at one point inby 3 right. The forces in this entry could not be determined positively. Stoppings in the mouths of the 1st and 2nd right flats were blown into these sections. Stoppings between the haulage road and the return were blown into the return; stoppings just outby the radius curves in 1st and 2nd left were blown inby. The overcasts in 2nd and 3rd left were blown inby, the outby wall being blown inby and the inby wall being practically intact in each case.

1st and 2nd Right Flats

The forces were inby at the mouth of 1st right, through rooms 1 and 2 to 2nd right, inby on 2nd right, and through the bleeder at the face of room 6, into 3rd right flat.

Flame was indicated by coke in both sections and by coke and several burned timbers and cap pieces at the 5th crosscut in room 8 which were charred to a depth of about 1/4 inch.

3rd and 4th Right Flats

Forces were outby on 3rd right from the bleeder leading from 2nd right, from 3rd right to 4th right, and also towards 5th right on rooms 3 and 4, into the mouth of room 2 on 3rd right, but strongly outby from 4th right on room 1 and the larger part of room 2. At the head of 3rd right forces were inby. Forces were greatly confused on the pillar rooms turned from room 4, 3rd right, but definitely outby on all 4th right headings. The clothing of one man near room 2 was blown from his body outby, and the stoppings and gobbed material at the junction with No. 1 haulage left were blown outby onto these entries.

Large deposits of coke and burns on bodies of men in this area indicated the presence of flame.

4th Left Flat

Forces were violently into 4th left at the overcast on No. 1 heading, No. 1 haulage left at the junction with the radius curve, and at the second crosscut on No. 1 heading 4th left. Several of the 90-pound iron rails from the overcast were bent into a crescent, and one rail, together with rock and other parts of the overcast, was blown under the power tank at the second crosscut.

Forces were generally inby on the 4 headings and into the last four rooms. Thick deposits of coke were found in the first 4 rooms, indicating presence of considerable flame, accompanied by forces, mostly outby. In room 7 (the second room, as the number starts from the last room inby) an empty car was blown towards the left rib; the inby end of the car was bowed outby with a post lying against it, indicating that the force had come from the face of the room. The outby end of the car had been torn loose on the left side and bottom and it was pointing outby, parallel to the track.

General

The general direction of force appears to come from No. 3 development and inby on No. 1 haulage left. This appears to indicate that the explosion originated in the No. 3 development section. On the other hand, the violent forces outby from 3rd and 4th right cannot be ignored and 3rd right cannot definitely be eliminated as a point of origin. In both sections forces were in general complex and confused, making it impossible to state definitely the course of the first forces. The few possible sources of ignition in No. 3 development and the larger number of possible sources in 3rd right must not be overlooked.

SUMMARY OF EVIDENCE AS TO CAUSE, ORIGIN, AND PROPAGATION

Generally, in investigating mine explosions it is not difficult to trace the directions of forces and flame as indicated by stoppings and overcasts blown out, piling up of debris, deposits of drifted dust, soot, and coke, and condition of mine timbers with reference to forces and flame, but in this particular case it was found practically impossible to trace the course of the explosion to its origin in working places with any degree of certainty. There are at least two reasons for this: first, because a second explosion which is known to have occurred about 7 hours after the original explosion apparently traversed some of the area that was swept by the first explosion, thus destroying or obliterating evidence left by the first explosion, secondly, since all sections of the mine involved in this explosion were on pillar lines, the explosion must have originated somewhere along one of them, with resultant strong outward pressure through all available openings and a movement of forces across the pillar lines as the explosive gas along the falls mixed with air and burned or exploded. The ultimate result of this situation was such a complexity of evidence of forces and flame that the exact point of ignition or even the section in which the explosion originated could not be definitely ascertained.

The cause of an accumulation of explosive gas in a working place where it could be ignited by any of the common ignition sources, such as open lights, smoking, blasting, or electricity, is not difficult to understand in view of the extremely high rate of emission of methane at this mine, together with the obviously inadequate provisions that were made for the ventilation of the working places. Such an accumulation of methane can occur in the working places along the pillar lines at any time, and the caved areas back of the pillar lines are without question more or less full of methane at all times. No bleeder system, such as openings to the surface or air courses through or around the caved pillar regions, has been provided to cause a movement of air over the caved areas; full dependence was placed upon conducting the air up to and along the pillar line by means of canvas stoppings and check curtains. The destruction of any of these stoppings or check curtains by a fall or other accident would result almost immediately in the presence of explosive gas in the working places. Single wooden doors instead of air locks were used on haulage roads for controlling the circulation of the air, and accidental damage to any one of these doors or failure to keep them closed except when passing through would result in a short circuit of the air and an accumulation of explosive gas in the working places in a very short time. Even without the ventilation being disrupted, a large fall along the pillar line could force a sizable body of explosive gas out into the working places at any time. Any of these things could have happened shortly before the ignition occurred at this mine.

While a study of the evidence of forces and flame failed to indicate the point where the explosion originated, possible ignition sources were found in all three of the sections involved. In order to arrive at some conclusion as to the possible cause or causes of the ignition of gas, the conditions as found in these sections are summarized separately.

4 Left Flat Section

Twenty-four men were working in this section at the time of the explosion. Of these 24 men there is positive evidence that only one man was killed by the flame and violence of the first explosion. His body, which was slightly burned, was found beside the power tank used for supplying power to the cutting machine. The power tank was found about 90 feet inby from the overcast on 4 left flat. "Bumpered" against this power tank on the inby side was the storage-battery locomotive used for gathering coal. This locomotive had probably traveled outby from some point in the section and ran into the power tank. The bodies of the crew of two men who were in charge of this locomotive were found along the No. 1 haulage entry between 3 and 4 left flats. Four other bodies of men who had traveled from the 4 left flat section after the explosion were found along the No. 1 haulage entry between 3 and 4 left flats. The two men who were working in the No. 1 heading, 4 left flat, were found several hundred feet from their working place on the No. 1 heading where they had been asphyxiated on their way out. Fourteen men and the section foreman traveled from the working places in 4 left flat into the return entries of No. 1 haulage inby from 4 left flat where they were asphyxiated. An examination of all working places in the 4 left flat section during the investigation revealed that flame had traversed the entire section and that the greatest indication of heat and flame was found in the first two rooms. The plug connecting the wheel conveyor feeder line to the power tank was in and it is an established fact that there was power on all of the feeder lines leading into all of the working places from sometime before the explosion occurred until the plug was removed during the recovery operations. The switches on all but one of the wheel conveyors in this section were found in the "off" position. A fall had occurred in the second room off 4 left flat and cut the cable leading to the conveyor. It is strongly suspected that the second explosion originated at this point. In view of the evidence as presented here, it is believed that the first explosion did not penetrate into the 4 left flat section and that it could not have originated here because the men vacated the section after the explosion occurred.

3 and 4 Right Flat Section

The 3 and 4 right flat section consists of a pillar line extending diagonally from 3 right flat to 4 right flat and two rooms driven off No. 4 room off 4 right flat. Twenty-two men, including the section foreman, were in this section at the time of the explosion. With the exception of 4 men, all of the others were at or near their working places at the time of the explosion. The 4 men referred to were on No. 1 heading, 4 right flat, just inby from No. 2 room off 3rd right flat. These men were working on the track at this point.

This is a mechanical section in which 6 permissible-type wheel conveyors were used in the working places. These conveyors were connected by means of feeder cable to a main feeder cable which in turn was connected, by means of an Anderson nonpermissible plug, to a storage-battery power tank located in No. 2 heading, 4 right flat, just inby from No. 4 room. In most cases the conveyor feeder cables were connected to the main feeder cable by spliced joints, not vulcanized. At least one of the conveyors was in operation at the time of the explosion, indicating that the power plug was in and that there was power on the entire system of cables with the exception of the cable leading to the conveyor in No. 1 heading, 3 right flat. In this case it was found that the plug connecting this feeder cable to the main cable was out and had apparently been disconnected before the explosion. The plug connecting the main cable to the power tank had apparently been pulled out by the forces of the explosion, as it was found, still attached to the cable, on top of a nearby rock fall that was caused by the explosion. The plug was badly damaged as though it had been struck forcibly against some object. At least two breaks were found in the feeder cable near the rock fall, and beading was noticed on one of the conductors, indicating that an arc had occurred. That this condition may have caused the ignition is doubtful, first, because it was some distance from the pillar line where the gas accumulation is more likely to have been, and second, because the damage to the cable appeared to have been caused by the rock fall which evidently had been brought down by the forces of the explosion.

In the pillar between No. 5 room and the No. 1 entry of 4 right flat, a pillar split had been driven, parallel to the No. 1 entry. The split had been driven through to the pillar fall and a new lift was started to the right. The bodies of two men who were working in this place were found against the rib opposite the entrance to this pillar split or about 60 feet outby from the pillar fall. Part of the excess feeder cable leading to the wheel conveyor had been thrown by the explosion onto the body of one of the men. A piece of cable about 4 feet long was found nearby. The end of the cable leading toward the battery was found to be carefully trimmed with the conductors exposed, strongly indicating that the men were probably in the act of splicing the cable when the explosion occurred. Moreover, the indications are that this cable was being spliced while the power was on the line. According to the company regulations, no person other than the section foreman or the shot firer is permitted to splice a cable, and the regulations prohibit splicing cables when there is power in them. But, in order to comply with these regulations, because junction boxes or connector plugs have not been provided for each conveyor circuit, it would be necessary to interrupt the operation of the entire section in order to cut power off any one of the conveyor circuits. It is strongly suspected that it is common practice to splice cables without cutting off the power. A careful examination of the exposed ends of the conductor failed to reveal any indications of beading or fusing of the metal; however, this would not preclude the possibility of gas being ignited at this point. Moreover, there was no evidence in the surrounding conditions that the explosion could not have originated at the location under discussion. The writers are of the opinion that this constitutes the most likely ignition source in the 3 and 4 right flat section.

The possibility of the ignition having been caused by explosives or blasting in this section does not merit consideration, because the body of the shot firer was found in the entrance to the break-through from No. 4 to No. 3 room. The shot firer's cable was rolled up and it is reasonably certain that no shots were being fired in this section at the time of the explosion.

In addition to the electrical equipment already referred to, a storage-battery power tank used to supply power to the mining machine and for shifting cars, with one empty and one partially loaded car attached, was found in No. 3 heading, 4 right flat, and there was some brattice cloth between the wheels of the power tank and the rails. The cutter's body was found in the car next to the locomotive and the cutter's helper was found in the cab of the power tank. An examination of the switch points of the haulage road led to the conclusion that the power tank was in No. 1 room off No. 4 room off 4 right flat when the explosion occurred, and that it traveled to the point where it was found after the explosion. The controller was in the "off" position and the front end of the power tank was lodged against some debris, including a part of the cover plate which was blown off the nearby power tank previously referred to. There is no suspicion that this power tank may have ignited the gas. The mining machine was not connected to the power tank at the time of the explosion and therefore could not have been involved.

The only other electrical equipment in the section was a storage-battery gathering locomotive located in the break-through between No. 5 and No. 4 rooms. While this locomotive was close to the pillar line, no evidence was found that would cast a suspicion on this piece of equipment as a possible ignition source.

While nothing was found in this section that could definitely be pointed to as the ignition source of the explosion, the conditions in the section, particularly with reference to electrical equipment, were such that an ignition could easily occur at any time when there is explosive gas present. Under the present operating practice, a small fall of rock on a live cable, of which there are many strewn about the floor, a cable being run over by a car or locomotive, the pulling of a plug under load, or the splicing of cables "hot" are all potential ignition sources.

No. 3 Development Section

The No. 3 development section consists of a pillar line extending diagonally from rooms on the right of No. 3 development entries, across these entries to a caved area on the left, and two short rooms driven into the barrier pillar between No. 3 development entries and 1st right flat. Thirty-six men, including the section foreman, were in the section at the time of the explosion. All coal in this section was loaded by hand and the only electrical equipment in the section at the time of the explosion was a mining machine parked in the entrance to No. 3 room, a power tank used for supplying power to the mining machine in No. 4 room, and a storage-battery gathering locomotive in No. 1 entry of No. 2 haulage left near the left end of the pillar line.

The bodies of the section foreman and shot firer were found at the section foreman's station on No. 3 development haulage road about 200 feet outby from the nearest working place, indicating that the shot firer could not have been blasting when the explosion occurred. There was no other indication that any shots were being fired on the section at the time of the explosion. The storage-battery gathering locomotive at No. 2 haulage left was examined and there was no indication that this piece of equipment may have caused the explosion. A flame safety lamp was taken from the machine in No. 3 room and carefully examined on the surface. The lamp was in good condition with no parts damaged or missing. The power tank in No. 4 room was examined on the section and a more complete examination was made after the machine was taken to the motor barn. This examination revealed that the flameproof housing had been altered so as to destroy its permissibility, but whether flame could be transmitted through the joints could not be determined by visual inspection. One of the battery terminal connectors on this power tank was fused so as to break the connection and another terminal connector showed evidence of arcing. The cause of this condition could not be determined and it is not known whether the fusing occurred before the explosion or whether it was caused by the explosion. It is conceivable that the fusing of these terminal connections could have been the cause of the ignition. The controller of this machine was in the "off" position when found, but the machine may have been in the act of shifting cars when the explosion occurred. This power tank was located about 150 feet from the pillar falls. As previously referred to in the report, a pillar fall was expected at the right end of this pillar line the day before the explosion. A pillar fall coming at the time of the explosion could have forced explosive gas out into the workings as far as the point where this power tank was found. Most of the men in the section were apparently engaged in loading coal when the explosion occurred. The location of the bodies as found indicated that in most instances the men generally moved a short distance during the explosion in an effort to get away. They were killed by violence and burns.

As stated before in this report, the evidence of forces and flame is too confusing to trace this explosion to its point of origin, or even positively to the section in which it originated. A careful study of the forces, however, indicates more strongly that the explosion originated in this section rather than on 3rd and 4th right flats. The only possible ignition source found on this section was, as previously mentioned, the power tank in No. 4 room, while numerous possible electrical ignition sources were found in the 3 and 4 right flat section.

Smoking as a Possible Ignition Source

While smoking is prohibited in this mine, the theory has been advanced that the ignition may have been caused by smoking or matches. That two cigarettes were found in a miner's jacket in No. 3 development strengthens this belief; however, no matches were found. On the other hand, the miners were searched for matches and smokers' articles on the surface before each shift entered the mine every day. The employees knew that should matches or smokers' articles be found on any person, that person would be prosecuted. Moreover, the miners were fully aware of the fact that this was an extremely gassy mine and that smoking would be dangerous. It is believed that miners were so conscious of this fact that should any of them observe one of his fellow workmen smoking or even carrying matches into the mine or having matches in his possession, he would immediately report the fact to the foreman. The writers were unable to learn of any instance where anyone had ever been caught smoking in this mine and, while smoking could have been the cause of the ignition of this explosion, the writers are exceedingly doubtful that this was the case.

STATE INSPECTORS' CONCLUSIONS

The West Virginia Department of Mines had reached no conclusion on the cause or point of origin of this explosion upon the Bureau's completion of its investigation on February 2, 1940.

PROBABLE CAUSE OF THE EXPLOSION

There are four common ignition sources which cause mine explosions. They are (1) explosives, (2) open lights including smoking, (3) defective flame safety lamps, and (4) electric arcs and sparks.

(1) The investigation disclosed no evidence that any shots were being fired at the time of the explosion, or that any fires had been started by blasting.

(2) No open lights were used. Although two cigarettes were found in the jacket of one man, no matches were found and no evidence was discovered to indicate that anyone was smoking.

(3) All flame safety lamps found near the working places were examined by a committee of one company representative, one Bureau of Mines representative, and one State mine inspector, and no defects were found.

(4) Several possible electrical ignition sources were found. The surrounding circumstances failed to indicate the point of ignition; however, it is probable that the explosion was of electrical origin.

The Bureau of Mines recommends that if the air in the split which ventilates any group of workings contains more than 1-1/2 percent of inflammable gas, these workings shall be considered to be in a dangerous condition, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said workings. Company records show that this maximum is sometimes exceeded in the returns from splits. Moreover, company representatives stated that explosive mixtures were frequently found in the last working place on pillar lines. Therefore, it is the opinion of the investigators that the quantity of air circulated was not sufficient to dilute, render harmless, and carry away the methane generated in this mine. It is also believed that adequate provisions were not made to control circulation of air and to prevent interruption of ventilation, as evidenced by single doors and lack of bleeder entries extending into or around caved areas.

The extent of flame and violence of this explosion was greatly augmented by coal dust. The mine was not adequately rock-dusted, notwithstanding the use of considerable quantities of rock dust, and no provision was made to allay the dust at its source. It is possible that had adequate protection been afforded against the propagation of flame by coal dust, one or possibly two of the affected sections might have escaped the explosion and numerous additional lives might have been saved.

Among the possible sources of ignition that might have caused this disaster, the condition of the electrical equipment and of the cables connected thereto leads the investigators to believe that the probable source was an electric spark or arc. This belief is based upon the multiplicity of substandard electrical conditions rather than upon the findings on any specific machine or cable.

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

In very gassy mines ordinary precautions in the use of electrical equipment are not sufficient. The elimination of all trolley and feed wires by the use of portable power tanks, and the use of permissible equipment as originally planned indicate that more than ordinary precautions were intended. The mistake seems to have been a lack of understanding as to the necessity of the proper maintenance of this equipment to keep it safe; also the possible hazards resulting from the modification of such equipment were apparently not realized. Had none but strictly permissible equipment been used, and had the safety precautions that are given on the approval plate of each permissible machine been followed, practically all of the criticism of the electrical installation would have been avoided. Therefore, the lesson to be learned from this explosion is that permissible equipment not carefully maintained introduces unsuspected hazards, thus giving rise to a false sense of security.

Another lesson is the need for taking extraordinary precautions against possible gas accumulations and ignitions in extremely gassy mines. The operation of numerous pieces of electrical equipment from a single storage-battery power tank, necessitating the installation of thousands of feet of trailing cable, is too great a risk to take in extremely gassy mines. While hand-loading methods may not be as efficient as the conveyors used in this mine, there is no doubt that hand-loading would be safer, especially in a mine as dangerously gassy and dusty as this one.

Analysis of air samples in the main returns of 275 mines taken at random throughout the United States indicated that the average methane content in these 275 mines was 0.18 percent. A sample of air taken at the No. 1 mine of the Pond Creek Pocahontas Company more than one month after the explosion, but before the mine had fully resumed normal operation, showed 1.03 percent methane. These figures are quoted to indicate that, comparatively speaking, this mine is extremely gassy. One of the lessons that comes from this disaster is that extraordinary precautions should be taken in the ventilation and inspection of extremely gassy mines. In mines of this character provision should be made to keep the caved areas as free of standing gas as possible by means of bleeder rooms and entries. Moreover, careful and frequent inspections should be made in the working places, on the pillar falls, and in the bleeder returns, and air samples should be taken at these places at least once each week in order to keep a constant check on the conditions.

Another lesson is the necessity for making adequate provisions so as to insure, insofar as possible, that no interruptions to ventilation will occur.

Doors should be eliminated except where they are absolutely necessary, and where doors are used they should be erected in pairs forming an air lock; temporary doors should be used in place of check curtains; temporary stoppings should be substantially built and extreme care should be exercised to see that the air is made to sweep the pillar lines as closely as possible.

Application of rock dust, even in large amounts, over thick accumulations of combustible dust, as has been done largely in this mine, does not afford adequate protection; samples collected where rock dust had been freshly applied contained a relatively low percentage of incombustible matter. Rock-dusting only where track is laid and leaving back entries unprotected allows an explosion to travel along the nondusted entries, practically voiding the effect of rock-dusted entries.

The need for collecting rock-dust samples was clearly shown by the fact that apparently the incombustible content of the dust where rock dust had been applied was too low to prevent propagation of flame. Evidently the company believed that, by applying nearly twice as much rock dust per ton of coal as the average for mines in the same county, adequate protection was afforded. If samples had been collected the deficiency of inert matter would have been realized.

The fallacy of the opinion of many operators that low-volatile coal is nonexplosive or only mildly so was clearly demonstrated in this explosion, because the coal dust did aid materially in the propagation of the flame. Actually, the Pocahontas No. 4 coal is practically as explosive as many high-volatile coals, if the source of ignition is violent.

The Bureau of Mines advocates the use of water to allay dust at its source. If water had been applied on the cutter bar of mining machines, directed into the kerf where hand-mining was done, and had been used freely during loading of coal, it seems possible that there would have been considerably less dust in the working sections and the dust might not have entered appreciably into the explosion.

The method of storing explosives was probably responsible, in part, for the extension and propagation of the explosion; hence, it is believed that hanging explosives from timber in fabric bags is not safe, and niches should be cut in the coal for storing the day's supply of explosives. Detonators were found scattered by the explosion at a number of points in the explosion area, teaching the lesson that the shot firer should carry the detonators with him at all times.

Drilling holes on the solid evidently was practiced in at least one section of the mine, and a blown-out shot was suspected in one room, although this was not substantiated. The lesson learned is that shot firers should carefully examine all shot holes and refuse to fire dependent shots.

COMMENDABLE SAFETY PRACTICES

The Pond Creek Pocahontas Company had many commendable safety practices at its No. 1 mine. All men were checked into and out of the mine, this practice enabling the company to tell definitely what men were in the mine and approximately where they were working. Many of the men had their check numbers riveted to their lamp belts, thus insuring that the checks would be on their persons at all times.

A safety inspector was employed and he spent all of his time on safety work at the four mines of the company. He instructed the men from the four mines in mine rescue and use of gas masks and oxygen breathing apparatus.

Men were searched before they entered the mine to prevent smoking materials from being carried underground.

Monthly safety meetings were held for all employees and safety bonuses were distributed at these meetings. Safety meetings were held for officials, and when the explosion occurred the officials were convened for the purpose of revising the printed safety rules. These printed rules are distributed to employees when they are hired.

In 1937 all employees were trained in first aid and many of those employed since have also been trained. In the same year the accident-prevention course of the Bureau of Mines was given to 76 officials, of whom 26 completed the full course.

The use of permissible equipment, the elimination of trolley wires, and application of rock dust are commendable practices, although the maintenance of the equipment and application of rock dust were not adequate.

Each section is on a separate split of air, with a maximum of 38 men on a split, and haulage roads are on intake air even in sections as far as possible, the intake air first sweeping the "solid" workings. The air from main splits and the full return is sampled daily.

The intake air at both shafts is preheated in winter by steam coils, preventing formation of ice in the shafts.

The practice of placing a foreman on each section and keeping the sections small allows the foreman to make frequent inspections of each working place.

Permissible explosives are used exclusively and shots are fired by shot firers, using permissible blasting units and cables 125 feet long. The ends of the cables are kept short-circuited and the ends of detonators are twisted together until the cable is to be attached. Large pieces of rock are drilled and the explosive is placed in the hole, rather than using "adobe" shots.

Miners wear permissible electric cap lamps, and permissible flame safety lamps are used to test for gas by foremen, fire bosses, shot firers, and machinemen.

All men underground are required to wear hard hats and safety-toe shoes. Goggles are required for use during certain operations, but men are not required to wear them all the time.

Whenever men meet underground, each man repeats the slogan, "Be Careful!"

RECOMMENDATIONS

In view of the explosion at this mine with its resultant heavy loss of life, and in view of the extremely gassy and dusty condition of the mine, the following recommendations are made with the belief that their adoption would permit safer operation of the mine.

Ventilation

1. Sufficient air should be provided along the pillar lines and in the working places so that the methane content in any working place should not exceed 1-1/2 percent.

2. Whenever methane in the air in any working place exceeds 1-1/2 percent, all electric power should be cut off the affected place or places, as well as on the return air from the split; and the men should be immediately removed from said working place or return air from the split until it has been made safe by increased ventilation.

3. For safe operation of mines, the methane in split returns or the main returns should not exceed 0.5 percent. When the methane content exceeds this figure, steps should be taken to improve the ventilation.

4. When more than 1-1/2 percent of inflammable gas is found in any return, the men in the mine or affected portion of the mine should be withdrawn and all power should be cut off the regions taking this return air. Storage-battery power tanks also should be withdrawn from the affected portion of the mine.

5. Each working place and all places adjacent to working places should be examined for gas by a competent mine official at least every 2 hours during the working shift. A permissible flame safety lamp or other approved methane detecting device should be used for this purpose.

6. Falls in airways should be removed or leveled and approaches to overcasts should be graded to obtain greater ventilating efficiency and an increased quantity of air.

7. Bleeder rooms or entries should be left, extending into the caved areas, to create a definite flow of air over them and to keep the pillar lines and caved areas as free of accumulations of explosive gas as possible.

8. The major air currents should be made to sweep the pillar lines as closely as possible by keeping temporary stoppings close to the pillar falls.

9. Wooden doors instead of check curtains should be used on haulage roads to deflect the air into pillar workings and into brattice lines in solid working places.

10. Where doors are used to control the circulation of air in a split, they should be erected in pairs forming an air lock, so that when one door is open, the other, having the same effect upon the ventilating current, will be closed.

11. Latches should not be allowed on doors to hold them open and doors should be hung in such a manner as to insure positive self-closing.

12. Temporary stoppings should be constructed of wood or some other rigid material rather than brattice cloth.

13. A warning device that will give both visual and audible warning in case of stoppage or slowing down of the fan should be provided.

14. The recording ventilation pressure gage installed at the fan should be placed in service and the fan charts should be changed daily.

Dust

1. Provision should be made for applying water on the cutter bars of all mining machines, and the machine coal cuttings should be wetted 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. The tops of loaded cars should be thoroughly wetted in the working places to avoid distribution of coal dust along haulage roads.

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

5. To prevent the coal from shaking off the cars along the haulage road and being ground to dust, the coal cars should not be overloaded.

6. Haulage entries should be kept free from spillage of coal and deposition of float dust. To aid in this, it is suggested that the floor of haulage entries be kept wet.

7. Rock dust should be applied to every mine surface, including haulage entries, trackless entries, return airways, rooms, and pillar workings to within 40 feet of the working faces if water is used. If water is not used in working places, rock dust should be maintained to within one cut of the face.

8. The rock dust should be applied to the roof, ribs, floors, timbers, and other mine surfaces in such quantities that the incombustible content will be at least 63 percent if there is no methane present in the air current. If there is gas present in the air current, the incombustible content of the dust should be increased. When 1-1/2 percent of methane is or is likely to be present in the air current, 75 percent incombustible is required to prevent propagation of an explosion.

9. Dust samples should be collected at frequent intervals at designated points in the mine to maintain a check on the condition of the dust as to explosibility. Entries and airways should be redusted before the incombustible content falls below a safe limit, as stated in the preceding recommendation.

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

11. Provision should be made in stoppings between the intake and return airways to convey rock dust into the returns by means of the hose of a high-pressure rock-dusting machine. Airtight doors or capped pipes in the stoppings are suggested.

Explosives

1. The explosives distributing magazine on each section should be constructed of masonry and equipped with an iron door. This magazine should be kept locked and the key should be kept in the possession of the section foreman or shot firer. The region adjacent to the distributing magazine should be well ventilated and heavily rock-dusted.

2. No more explosives should be taken into the mine or stored in any sectional distributing magazine than is necessary for one day's operation.

3. Rigid boxes made of wood or some other dielectric material should be used for carrying explosives to the working places from the sectional distribution point.

4. The explosives in each working place should be stored in a niche cut in the rib at least 50 feet from the face and out of direct line from the face.

5. Detonators should be carried into the mine by the shot firers in rigid wooden containers or containers constructed of some other rigid dielectric material.

6. No detonators should be stored in the mine at any time, but they should be kept continuously in the possession of the shot firers.

7. The shot firer should be required to keep a record of all shots fired, all misfires, all blown-out shots, and all places which he refused to fire, and he should make a complete report on these items at the close of the shift. Every detonator taken into the mine should be accounted for in the shot firer's report.

8. Holes that have been placed on the solid should not be fired; this is important and rigid inspection should be instituted to make this rule effective.

9. When block holes in rock are being blasted, the explosive should be confined in the hole with incombustible stemming, and preferably the surrounding region should be either well rock-dusted or well wetted before blasting.

Electricity

1. The trailing cables for the conveyors should be kept as short as feasible and the amount not needed to reach the connecting point at any one time should be coiled on hooks on the machine. The cable should be hung on insulators about midway between the roof and floor rather than left lying on the mine floor. The method of connecting the cable to its source of power should be such that sparks will not result when making or breaking the connection under load; this can be accomplished by using permissible junction boxes. The cable should be adequately protected by fuses or equivalent overload protective devices at every point of connection to the power source. "Hot" splicing of cables should be strictly prohibited. Splices should be mechanically strong, thoroughly insulated, and vulcanized. The bar which connects the switch levers of the starting switch on these loaders should be kept in place.

2. Power tanks serving conveyors should be of permissible type, equipped with fuses for both positive and negative sides of the battery. The fuses should be of no larger capacity than necessary to give adequate protection to cables connected to these tanks. The power outlet should be equipped with an interlocking mechanism to prevent the plug from being withdrawn under load and causing electrical sparking.

3. Gathering locomotives should not be used as power tanks unless fully equipped with all protective features required on permissible power tanks.

4. Permissible-type storage-battery gathering and haulage locomotives, also power tanks, should be completely restored to permissible condition. The following are essential points:

(a) Lifting mechanism, hinges, and locks should be used to secure battery box covers in place.

(b) Headlight circuits should be provided with switches and fuses.

(c) Both positive and negative sides of the main battery circuit should be fused.

(d) Running plugs should be provided with padlocks to keep the plugs in place and to prevent use of the socket as a power outlet.

(e) Power outlets should have interlocking devices to insure that the power switch is open before the plug can be inserted or withdrawn.

(f) Alteration or substitution of parts not authorized by permissibility requirements should be strictly prohibited.

5. Adequate inspection of all permissible electrical equipment traveling or operating in gassy sections of the mine should be rigidly enforced to insure (1) that such equipment is maintained in a permissible condition and (2) that it is not used in a nonpermissible manner.

6. Sufficient clearance should be maintained wherever storage-battery locomotives and power tanks are moved to prevent the battery box covers from striking the roof. If covers are dislodged by striking the roof, short circuits of the cells will produce electric arcs and flashes.

7. Federal Government approval of power tanks does not authorize the operation of several machines simultaneously from one power outlet. Therefore, to increase safety by minimizing the length of cable exposed to damage from falls and moving equipment, it is recommended that a separate permissible power tank be provided for each conveyor or other mechanical loading unit. If this is not feasible, hand-loading should be substituted for mechanical loading.

8. On account of the increasing use of electrically operated equipment with advances in mechanization, also because of many technical questions continually arising as to safety features of such equipment, it is recommended that electrical inspectors specially trained in the construction and upkeep of permissible machines be added to the inspection force of the State Department of Mines. Furthermore, the chief electrician at every gassy mine should be required by the State to have a certificate attesting to his competency in the maintenance and care of electrical equipment.

General

1. Self-rescuers should be carried at all times by all persons underground.

2. Employees should be instructed in the use and care of the self-rescuers and each self-rescuer should be tested once a month according to recommendations of the manufacturer. A copy of Miners' Circular 30, "Use of the Miners' Self-Rescuer", is appended to this report.

3. The recording pressure gage in the fan house should be repaired and maintained in working condition.

4. Stairs should be maintained in the shafts as a means of escape.

ACKNOWLEDGMENT

The writers of this report desire to acknowledge the valuable cooperation of Mr. N. P. Rhinehart, Chief of the West Virginia Department of Mines, and members of the State inspection department in the investigation of this explosion and in the rescue and recovery operations.

The cooperation of Mr. R. E. Salvati, vice president of the Pond Creek Pocahontas Company, and other officials of the company is also hereby acknowledged.

Respectfully submitted

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Approved:

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*See Appendix 1.

APPENDIX 1

COMMENTS ON THE REPORT AND ITS RECOMMENDATIONS

By

D. HARRINGTON
Chief, Health and Safety Branch

I concur generally with the conclusions and recommendations in this report but do not concur in the recommendations as to explosives or as to the so-called self rescuers; the ventilation recommendations are inadequate and the report should have recommended that an inquiry or inquest should have been held to inquire into the circumstances surrounding the disaster.

I agree that the evidences given in the report do not justify the drawing of definite conclusions as to the ignition cause or place of origin of the first explosion and that the probable igniting agency was an electric arc, though the fact that cigarettes were found in the clothing of a worker in this mine, one of the most gassy in the United States, justifies a strong suspicion that smoking cannot be ruled out as a possible cause of the ignition. Also, while blasting has been absolved of blame, the practices with regard to explosives were such that failure to cause explosions because of blasting can be considered almost a dispensation of Providence.

This mine is one of the most gassy in the United States; it is probable that not more than half a dozen coal mines in the United States give off as much explosive gas per 24 hours as the 6,600,000 cubic feet shown by the gas sampling and analyses by the company on the morning of the day of the explosion. Moreover, the fact that the main return air current carried 1.69 percent of methane and two main splits had 1.41 and 1.25 percent in their returns, indicates that the approximately 271,000 cubic feet of air per minute, as measured by employees of the company, was but about one third of the quantity of air which safety required for this property. Most certainly the amount of air coursed through the mine should have been at least doubled and even then the main return would have held around or over 0.8 percent methane, which is far greater than the 0.5 percent generally considered the safe maximum methane content of a mine air split or return.

The present ventilation system causes less than 280,000 cubic feet of air per minute to circulate through the mine with a water gauge of about 5 inches, this pressure being considered about the maximum (as measured by a water gauge) that should be used in ventilating a coal mine. Hence the present two shafts and the airways leading to and from them, very evidently are inadequate to handle much additional air and about the only feasible remedy to the deficient air supply is the placing of additional openings (shafts) to the surface. Reference to the mine map indicates that at least two additional shafts, with probably also at least one additional fan on the surface, should be provided; one for the region north and west of the present shafts and one (or preferably two) for the region north and east of the present shafts. Or possibly a better method would be the sinking of several relatively small circular shaft openings from the surface for air purposes as is now done to some extent in metal mining. The expenditure need not be prohibitive if up-to-date circular core shaft sinking methods are used by which 5 foot diameter shafts cost less than $25. per foot, or for the 600 or 700 foot depth in this region, a total of about $15,000 to $17,500 per shaft. Another possible alternative is the sinking of 3 foot diameter openings from the surface at key points to "bleed off" methane accumulations from caved regions.

If it is not feasible to sink new shafts, then provision should be made to have "bleeder" air courses of adequate area around or outside of the caved regions of this mine to exhaust explosive gas from the pillared regions and thereby tend to prevent accumulations of explosive gas in the caved, and at present inadequately ventilated, regions of the mine which almost entirely surround the working places and constitute an ever-present menace to the safety of the property and its workers.

These suggestions may seem drastic when it is considered that the mine is on the retreat and almost necessarily the proposed new shaft installations and to some extent the proposed bleeder return air courses, would be in regions from which the coal is soon to be taken and the region allowed to cave. However, the mine most certainly needs more air (at least double the amount now available) and drastic changes must be made in ventilating this property if a repetition of the disaster of January 10, 1940 is to be avoided. Certainly something should be done to try to prevent the heavy accumulations of methane which unquestionably now occur in the unsealed, partly open, pillared or caved territory and also to reduce the methane content of the air returns far below the 1.69 percent which apparently was carried in the main return on the morning of the day of the explosion.

While blasting was given a clean bill of health as to causing this disaster, this mine is too dangerously gassy and dusty to allow of blasting during the working shift or even of allowing any explosive in the mine while the working shift is in the mine. Even if all features in connection with the transportation, storage and use of explosives should be very carefully safeguarded (and evidently there were numerous relaxations from careful procedure in at least some phases of blasting), and even if the safest kind of explosives and explosives' appurtenances should be kept in use and effect at all times, it should be kept in mind that in a mine as gassy as this, the breaking down of the coal by blasting operations undoubtedly releases large quantities of explosive gas as well as considerable amounts of finely divided dust, and unless utmost precautions are always kept in effect (a very difficult matter to guarantee) there are always possibilities for gas or dust ignitions and subsequent disasters. It is true that this mine uses the safest kind of explosives (permissible types as approved by the Bureau of Mines) and electric blasting (also approved and advocated by the Bureau) and the blasting is done by shot-firers (as advocated by the Bureau) but conditions here are so exceptionally hazardous that no "chances" should be taken with having explosives in the mine during the working shift and certainly no blasting of any kind should be done in this mine during the working shift. Blasting should be done between shifts and even then safeguarded in the most rigorous manner possible.

To the argument that blasting apparently did not cause the recent disaster, and that blasting has apparently been done without trouble for about 15 years in this mine, the answer is that the mine has been fortunate much more fortunate than several other mechanized coal mines in the United States. For the past three years, the worst disaster of each year (1937 - 34 killed, 1938 - 45 killed, and 1939 - 28 killed) was caused by blasting during the working shift in mechanized mines such as this one, and in all three instances permissible explosives were used, and the explosion was caused by some relaxation from safe procedure. These three disasters were in different States and none of them occurred in West Virginia. Unquestionably this property is far too hazardous to allow of any blasting during the working shift or even of having explosives in the mine while the working shift is in the mine, even if the most drastic, precautionary procedures are used.

The so-called rescuer is definitely unsafe rather than contributing to the safeguarding of life, this being especially true in the event the device is placed in the hands of persons (as it would be in this case) who are utterly unfamiliar with its limitations or its use. Theoretically, the self rescuer is a piece of safety equipment; in actuality it is very likely to be a menace to the lives of the vast majority of those who try to use it. The recommendation favoring the furnishing of self rescuers is one in which I do not concur.

That smoking is "ruled out" as a possible cause of the original ignition is unfortunate and this conclusion is definitely supported by the fact that in an explosion on March 1, 1940, in Tazewell County, Virginia (only a few miles from the Bartley Mine) a coal-mine worker was burned to death when he ignited some gas while smoking. The fact that the report shows that on the day of the disaster a man smuggled cigarettes into the Bartley Mine with its desperately hazardous gassy conditions (certainly known to all of its employees) means that that man (and possibly others as well) smoked in the mine on the day of the explosion, and if smoking was done at all, the smoker would most probably go to some out of the way place to do it, such a place as the gob region where gas accumulations were most likely to be found. There is good reason for a strong suspicion that smoking was involved in the origin of this disaster, even though neither matches nor burned cigarette butts were found and even though no evidence was obtained from bosses or workers that the no-smoking rule was disobeyed either habitually or occasionally.

It is very unfortunate that a formal inquiry or inquest was not held in connection with this disaster.1/ A properly conducted inquest might bring out facts which would lead to the solution of the cause of the explosion and even as to the place of origin.

The owners or operators of this mine had probably gone farther in the taking of precautions against explosion disasters than at least 99 percent of the coal mines of the United States, yet had relaxed in connection with

1/ An inquest was held after this report was completed but no conclusion was reached as to the cause of the explosion other than that explosive gas was involved.

such details as maintenance or safe use of its permissible electrical equipment; its ventilation practices failed to take adequate care of the large amounts of explosive gas given off; and while much rock dust was used (at least three times as much as the average of rock-dusted mines in the United States per ton of coal produced), the rock dusting was not done or kept in effect in a manner which would insure its being effective; and essentially nothing was done to try to suppress the formation and dissemination of coal dust by using watering methods at the face and elsewhere, though the coal is inherently friable and produces maximum amounts of very fine dust.

The desires of the operating organization in the opening and equipping of this mine very evidently were along the lines of taking the utmost precautionary efforts to avoid a mine disaster. This is shown by the summation of a score or more good practices and ultra-safe types of equipment in use as given in the report (and at least another score of other commendable safety features are mentioned at various places in the report) but familiarity breeds contempt and too many relaxations intervened with dire results. This disaster furnishes a good example of the truth of the old saying that a chain is no stronger than its weakest link.

This occurrence emphasizes that the mere purchase and use of equipment or adoption of methods or mining laws or regulations found relatively safe in laboratory experiments or even in other mines, does not prevent a mine from having accidents; nor is it sufficient for the owners of a mine to rely too implicitly upon the immunization of its property from accidents or disasters merely by adopting recommended procedures without accompanying them with more or less frequent and efficient follow-up checking measures to make certain that the adopted procedures are kept in effect; or if altered, that the changes are in the direction of greater rather than less safety as well as increased efficiency and lowered costs.

In the exclusion of power lines (including the death dealing electric trolley haulage system) from this mine, with substitution of permissible power tanks and permissible storage battery locomotives, this mine went farther towards trying to prevent accidents including disasters due to electricity than any other coal mine in the United States except possibly three or four (and the efforts of these three or four in this direction merely equalled rather than excelled that of this mine.)

In view of the rapid extension of mechanized equipment and devices in mines, not only State mine inspectors but mining operating officials should be technically trained in addition to being physically fit and long experienced in mining. This is becoming of greatly increased importance due to the rapid mechanization of mines and "rule of thumb" methods no longer are sufficient to keep our mines or our mine workers safe and healthful.

D. HARRINGTON,
Chief, Health and Safety Branch.

A P P E N D I X 2

ANALYSIS OF AIR SAMPLES IN MINE NO. 1, POND CREEK POCAHONTAS COMPANY, BARTLEY, WEST VIRGINIA

By M. J. Ankeny and C. W. Owings

Air samples were collected on February 14, 1940, by M. C. McCall in Mine No. 1, Pond Creek Pocahontas Company, at Bartley, West Virginia, to obtain information on average ventilation conditions. Only 2 sections were working, 4 left and 3 right flats off No. 1 haulage left, and these sections had only been working for several days. The entire mine had been idle since the explosion on January 10, 1940. The samples, therefore, do not represent true operating conditions; in fact, they probably were taken under the most favorable conditions of ventilation and liberation of explosive gas.

The gas has a definite, characteristic petroleum odor, but what causes this odor was not determined. Men familiar with making tests for this gas with flame safety lamps expressed the belief that it was quicker acting than methane; however, during analysis the ratios obtained were typically methane and so, if any heavy hydrocarbons were present, they formed too small a percentage to be detected by the present method of analysis.

The analyses are given in the accompanying table. The carbon dioxide ranges from 0.04 to 0.12 percent, with the larger figure representing the full return. Sample 65311, containing considerable air from idle workings, shows the highest percentage of carbon dioxide, with the exception of the samples collected in the fan duct.

The average air from the return of 275 bituminous mines in the United States, according to Yant and Berger, contained 0.17 percent carbon dioxide, 20.53 percent oxygen, 0.18 percent methane, and 79.12 percent nitrogen. In comparison, the carbon dioxide in this mine is considerably below average, the oxygen is about average, the methane is considerably above average, and the nitrogen is lower than average.

Samples 65316 and 65317 represent the return from 4 left flats off No. 1 haulage left. The methane content in room 1 is not exceptionally high, but the 1.03 percent found in room 2 is too high. The total methane being liberated in 4 left was 145,421 cubic feet in 24 hours, or more than 6,000 cubic feet an hour. This is sufficient to make an explosive mixture of 6 percent in an entry more than 1,000 feet long.

No perceptible air was flowing in the bleeder from 2 right to 3 right flats, No. 1 haulage left, and the methane content was 0.28 percent. On the overcast leading from this section only 0.11 percent methane was found in 19,440 cubic feet of air a minute, equivalent to a liberation of 30,793 cubic feet of methane in 24 hours. This appears to be abnormally low and it probably represents unusual conditions. On the day before the explosion 9,000 cubic feet of air per minute was reported to have been traveling over this overcast.

On the overcast on No. 5 heading, No. 1 haulage left, at No. 3 development, 1.38 percent methane was found in 46,400 cubic feet of air. This split contains air from 1 and 2 right flats off No. 1 haulage left and the pillars on the left of No. 3 development. This split contains the highest percentage and quantity of methane and represents liberation of methane at a rate of 922,061 cubic feet in 24 hours.

A sample was taken at the face of the last working place on the right side of the pillar line on No. 3 development. The content, 1.17 percent, appears to be high considering that the section had been idle for more than a month. The full return from this section, sample No. 65310, contained 0.97 percent methane. The liberation of methane in 24 hours, based on this analysis and an air current of 33,000 cubic feet per minute, was 460,944 cubic feet.

The full return from the No. 3 development and the No. 1 haulage left section is contained in samples 65307 and 65309, in which the methane content was 1.31 and 1.07 percent, respectively. The total methane liberated from these sections was 3,490,020 cubic feet in 24 hours. If ventilation were interrupted for even one hour, enough methane could be liberated to make a mixture, near the lower explosive limit, sufficient to fill about 5 miles of entries.

The return from the No. 6 development section (sample 65308) contained 1.20 percent methane in 62,400 cubic feet of air a minute, indicating liberation of methane at a rate of 1,078,272 cubic feet in 24 hours.

The full mine return contained 0.83 and 1.03 percent methane in duplicate samples collected. The liberation of methane in the entire mine at the time of sampling was 3,336,329 and 4,140,264 cubic feet in 24 hours. The larger figure is less than two-thirds of the normal liberation when the mine is in full operation, and therefore the samples apparently do not represent true conditions, but, even so, practically all of the returns show more than 0.5 percent methane, which is believed to be the safe maximum limit in any bituminous mine.

While these samples were collected and the results compiled after the final report was written, the results do not alter the conclusions and recommendations made in that report.

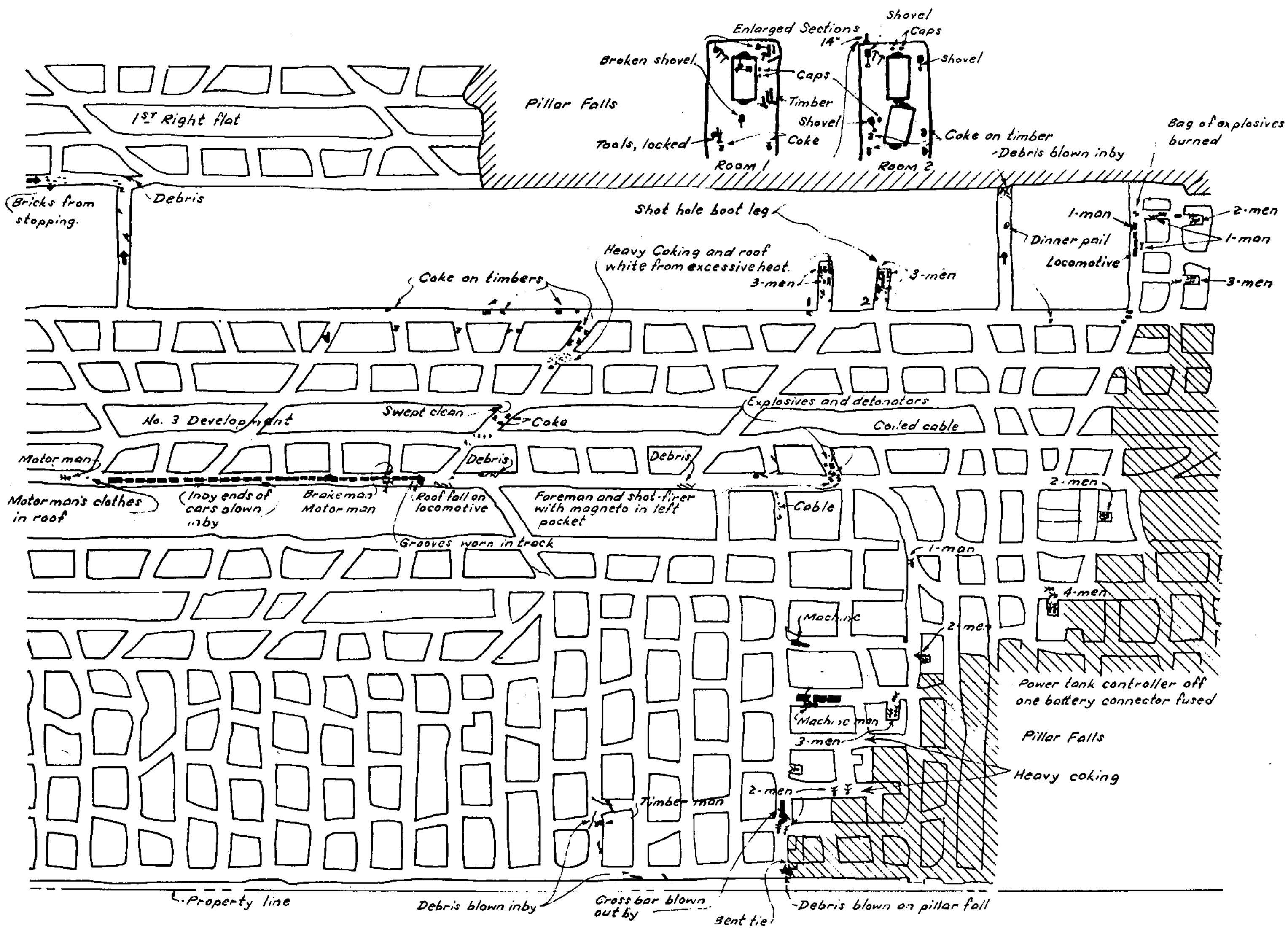
Respectfully submitted

M. J. ANKENY
Mining Engineer

C. W. OWINGS
Mining Engineer

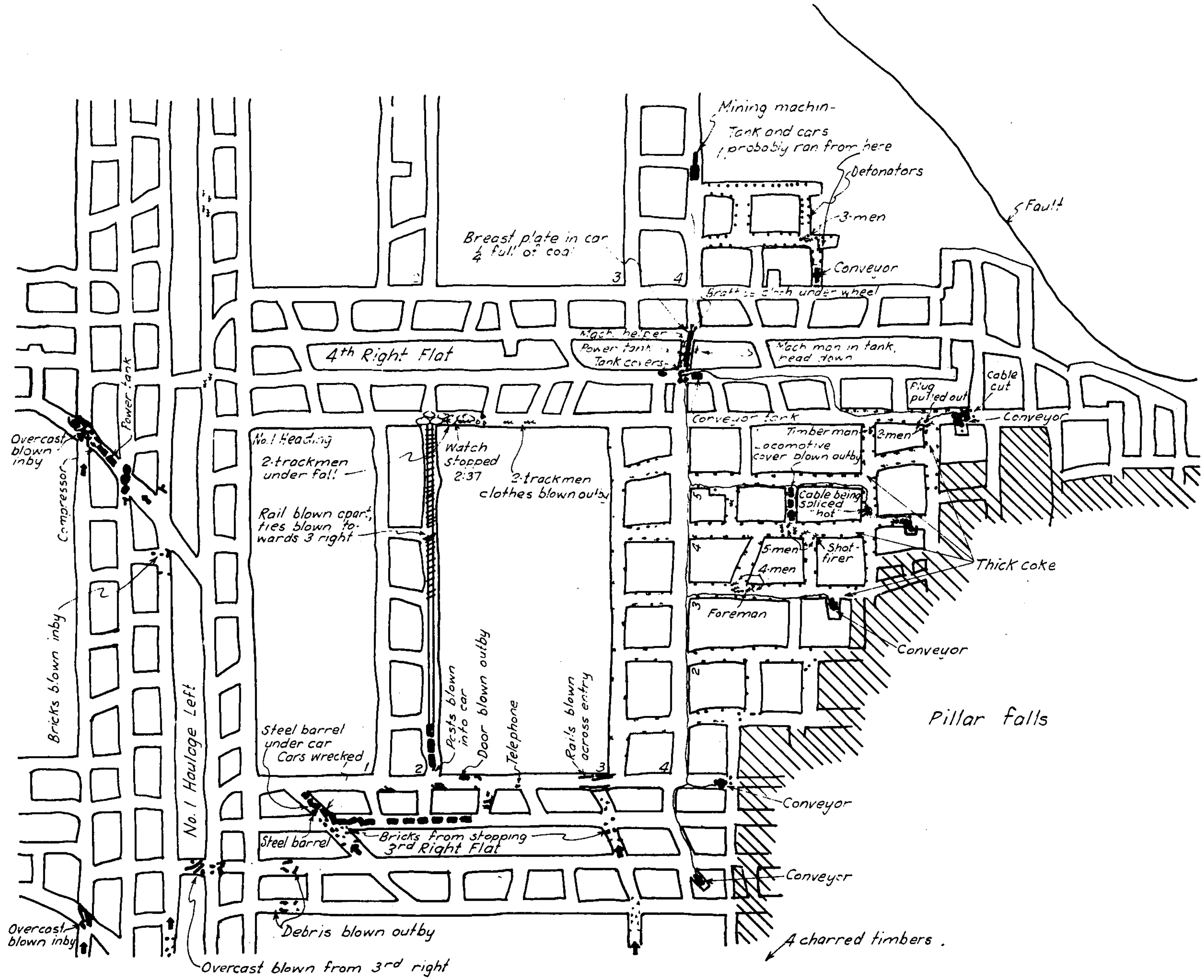
Analysis of air samples collected February 14, 1940, in Mine No. 1, Pond Creek Pocahontas Company, by M. C. McCall

Laboratory No.	Location in mine	Percent				Cu. ft. air per minute	Cu. ft. methane in 24 hrs.
		CO_2	O_2	CH_4	N_2		
65317	1st line room, 4 left to 3 left, No. 1 haulage left	0.07	20.65	0.32	78.96	13,125	64,260
65316	2nd line room, 4 left to 3 left, No. 1 haulage left	.05	20.65	1.03	78.27	5,472	81,161
65314	Bleeder room, No. 2 rt. to No. 3 rt., No. 1 haulage left	.04	20.85	0.28	78.83	-	
65313	On overcast, No. 1 haulage left at 3 right	.06	20.74	.11	79.09	19,440	30,793
65311	On overcast, No. 1 haulage left at No. 3 development	.10	20.44	1.38	78.08	46,400	922,061
65312	Last working face, right side, No. 3 development	.04	20.65	1.17	78.14	-	
65310	On overcast, No. 3 development at No. 1 right	.04	20.65	0.97	78.34	33,000	460,944
65307	1st overcast, No. 3 development and mains	.05	20.61	1.31	78.03	123,750	2,334,420
65309	2nd overcast, No. 3 development and mains	.09	20.49	1.07	78.35	75,000	1,155,600
65308	At overcast, No. 4 development and mains (return from 6 development)	.07	20.52	1.20	78.21	62,400	1,078,272
65305	In fan duct, full return	.10	20.53	.83	78.54	279,144	3,336,329
65306	In fan duct (duplicate)	.12	20.51	1.03	78.34	279,144	4,140,264



SKETCH SHOWING DETAILS OF EXPLOSION IN NO. 3 DEVELOPMENT


Probable limit of flame in first explosion
Limit of flame
Limit of violence
3 cars, men in car, coupled to machine power tank
Drillman & helper
Compressor
Section boss, cap box, shooting cable, shot fireman, with magneto in left pocket
Skip Shaft
Air Shaft
Fires
Loaders from 6 heading
No. 3 Development
Charred cloth
Bratticeman
Mach. power tank
2 loaded cars
Note: This section all hand loading
4-timbers charred
48895
48883-4
48881-2
48877-8
48879-80
48875-6
48873-4
48869-70
48871-2
48885-6
48887-8
48891-2
48889-90
48863-4
48865-6
48867-8
48861-2
48851-2
48853-4
48855-6
48857-8
48859-60
LEGEND
Direction of air currents
Direction of forces
48851-92 Dust samples
48883-95 Face samples of coal
2 Bodies
POND CREEK POCAHONTAS CO.
BARTLEY, W. VA.
MINE NO. 1
0 200 400 600
SCALE, FEET
Jan. 10, 1940



Sketch showing details of explosion in 3RD right section.