UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Health and Safety District B

FINAL REPORT OF MAJOR MINE EXPLOSION DISASTER
MARIANNA NO. 58 MINE
BETHLEHEM MINES CORPORATION
MARIANNA, WASHINGTON COUNTY, PENNSYLVANIA

September 23, 1957

By

F. E. Griffith
Supervising Coal Mine
Fire Control Engineer

G. W. Chastain
Federal Coal-Mine Inspector

and

R. J. Kirk
Federal Coal-Mine Inspector

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INTRODUCTION

An explosion followed by about 25 fires occurred about 7:15 a.m., September 23, 1957, in the Marianna No. 58 mine of the Bethlehem Mines Corporation at Marianna, Washington County, Pennsylvania. Eleven men were underground when the explosion occurred; 5 were killed, and 6 were rescued and hospitalized. Of the 6 injured, 1 died in the hospital 5 days later.

The man-hoisting elevator was destroyed by the explosion forces. The injured men and dead bodies were hoisted and rescue and fire-fighting personnel were lowered in the 581-foot-deep Moore shaft by improvised hoisting facilities shown in figures 1 and 2. This equipment was subsequently replaced by a conventional shaft-sinking hoist and bucket.

The names of the victims, their ages, marital status, occupations, and number of dependents are shown in Appendix A of this report.

Bureau of Mines investigators believe that the explosion originated on 30 mains haulage road between the angle chutes connecting C face west with 30 mains when an explosive mixture of methane and air was ignited by an arc or spark from the trolley pole of an electric-powered utility truck known as a "jeep," or when a trolley-wire cutout switch was opened. Forces of the explosion extended in all of the 30 mains entries, from the entry faces for a distance of 4,400 feet outby, and into C face west for a distance of 900 feet.

A map showing the probable point of origin, the direction and area of forces, and the extent of flame is shown in this report as Appendix D. Some surface structure damage at the Moore shaft of this mine is shown in figure 1.

GENERAL INFORMATION

The Marianna No. 58 mine of the Bethlehem Mines Corporation is at Marianna, Washington County, Pennsylvania, and is served by the Pennsylvania Railroad. The mine was opened in 1903 by the Pittsburgh Buffalo Company and acquired by the present operating company, formerly the Bethlehem Collieries Corporation, in 1923. The operating officials of the Bethlehem Mines Corporation on September 23, 1957, were:

A. F. Peterson	President	Bethlehem, Pennsylvania
T. J. Crocker	Manager	Johnstown, Pennsylvania
C. S. Cressman	Chief Engineer	Johnstown, Pennsylvania
E. A. Steiss	Supervisor of Safety	Johnstown, Pennsylvania
Ebenezer Jenkins	Chief Inspector	Ellsworth, Pennsylvania
K. W. Bartlett	Division Superintendent	Ellsworth, Pennsylvania
J. B. Jones	Division Inspector	Ellsworth, Pennsylvania
T. J. Jones	Superintendent, Marianna No. 58 mine	Marianna, Pennsylvania
A. J. Salvador	Assistant Superintendent, Marianna No. 58 mine	Marianna, Pennsylvania
Michael Barshick	Mine Foreman, Marianna No. 58 mine	Marianna, Pennsylvania

A total of 642 men were employed, 572 underground. The mine was operated 3 shifts a day, 5 days a week, and an average of 4,087 tons of coal was produced daily. In 1956, 769,453 tons of prepared coal was produced. The last Federal inspection of this mine was made January 3-4, 7-11, and 14-16, 1957.

The mine is opened by 8 shafts, 2 of which are used as returns and 6 as intakes. The No. 1 coal-hoisting shaft, equipped with skip hoists, is used as an intake and is 450 feet deep; the No. 2 supply- and man-hoisting shaft, equipped with 2 cages, is used as an intake and is 445 feet deep; the Moore intake shaft is 581.7 feet deep and is equipped with a Westinghouse elevator for lowering and hoisting men. The Hoover and Piper shafts are the main return air shafts and are 744 and 746 feet deep, respectively. Three other shafts are used as intake air shafts, but one of them is in an isolated part of the mine and the air passageways are so obstructed by falls that very little air is drawn through it.

Mining operations are in the high-volatile Pittsburgh coal bed, which averages 72 inches in thickness, and the coal bed rarely exceeds a 2-percent pitch. The immediate roof is a 10- to 18-inch layer of high-sulfur coal overlain by laminated shale and coal of various thicknesses,

Figure 1. - Photo shows some of the damage done to the headframe at the Moore shaft portal by the explosion forces. The arrow designates the truck equipped with winch and A-frame boom that was used in the emergency rescue hoisting and lowering operations.

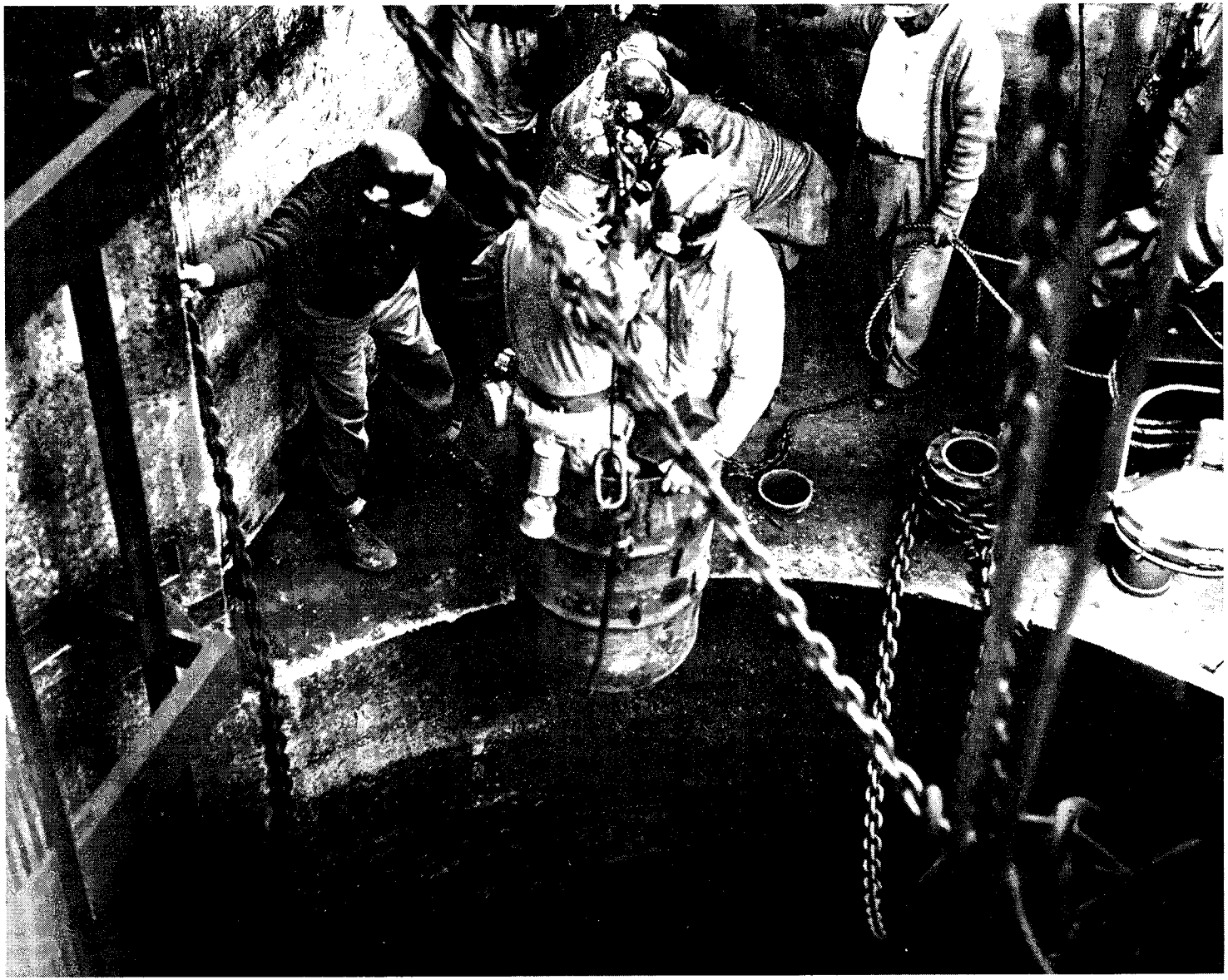

Figure 2. - Rescue officials preparing to enter the 580-foot deep shaft in oil drum rigged for emergency hoisting of injured men and bodies and lowering of rescue and fire-fighting personnel into the mine.

and the main roof is sandstone. Numerous slips and slickenside formations are in the immediate roof. Cover over the coal bed ranges from 435 to 900 feet in thickness, and the floor is limestone. The analyses of coal samples from the Pittsburgh coal bed taken from two adjoining mines, one to the north and the other to the south, are as follows:

	North	South
	Percent	
Moisture	2.7	2.2
Dry basis:		
Volatile matter	35.6	36.1
Fixed carbon	55.7	57.5
Ash	8.7	6.4
	100.0	100.0
Sulfur	1.3	1.1
B.t.u.	13,450	13,880

Numerous tests by the Bureau of Mines have shown that coal dust having a volatile ratio of 0.12 is explosive and that the ignitibility increases as the volatile ratio increases. The volatile ratio of the coal in this vicinity as determined from the above-mentioned analyses is approximately 0.39, indicating that the coal dust from mines in this area is explosive.

The mine records indicate that an explosion which occurred in this mine November 25, 1908, killed 154 men. Other major mine explosions that have occurred in nearby mines include:

Date	Mine	Location	Lives Lost
July 25, 1924	Gates No. 1	Brownsville, Pa.	10
April 26, 1925	Hutchinson	West Newton, Pa.	5
February 3, 1926	Horning No. 4	Horning, Pa.	20
April 2, 1927	No. 53	Cokeburg, Pa.	6
May 19, 1928	Mather No. 1	Mather, Pa.	195
February 2, 1952	Carpentertown	Carpentertown, Pa.	6

MINING METHODS, CONDITIONS, AND EQUIPMENT

Mining Methods

An entry-and-block system of mining was followed. Main entries were driven in sets of 8, face entries in sets of 6 or 7, and butt entries in sets of 5. All places were driven on 90-foot centers; this included crosscuts. Entries were driven 14 feet wide, and pillar lifts were 16 feet wide. Nine track-loading units, 2 continuous mining machines,

and a caterpillar-mounted loading machine were used to produce coal from 12 active sections. The entry faces in 30 mains were stopped December 19, 1954. The Moore shaft portal was completed in June 1955, and the elevator in this shaft was approved for use on May 20, 1957.

Bolts were used for roof support in all active working sections. Where abnormal roof conditions were encountered, conventional timbers were used to supplement the roof bolts, and the roof-support plan required at least two rows of posts to be set along the gob side during pillar extraction.

Explosives

Permissible Liberty AA explosives and instantaneous electric detonators were used for blasting. The explosives and detonators were stored in isolated well-constructed magazines on the surface and transported by autotruck to the Marianna No. 2 shaft, where they were taken into the mine in specially constructed explosives cars during the second shift and stored temporarily in suitable section boxes. Coal was topcut about 10 to 20 inches below the draw rock and sheared vertically off-center to a depth of about 9 feet. It was then blasted on shift with permissible blasting devices by certified shot firers. From 5 to 6 shotholes were drilled, 3 in the draw rock above the kerf and 2 or 3 in the coal below the kerf. Incombustible material was used for stemming, and during the last Federal inspection gas tests were made before blasting.

Ventilation and Gases

Air circulation through the mine was induced by two axial-flow fans installed on the surface and operated exhausting. About 557,700 cubic feet of air a minute was circulated during normal operation. The fans were run continuously unless mechanical defects necessitated stoppage, as was the case with the Piper fan prior to the explosion. The fans were housed in fireproof structures, offset from the mine openings, equipped with explosion doors, recording pressure gage, water gage, and failure-warning signals. Overcasts and permanent stoppings were constructed of incombustible material. Some checks and line curtains of brattice cloth and temporary stoppings of wood were used.

The fans draw air from common intake shafts; thus numerous regulators and strict control are necessary to prevent one fan from taking air from the other. At best, airflow is very sluggish in certain areas at the junction or natural separation points of the fan circuits. If one fan is stopped, a reversal of airflow usually results in certain splits, such as occurred with the split ventilating the north side of 30 mains prior to the explosion when the Piper fan was stopped. See ventilation map, Appendix C. Normally, as shown on the map, intake air from the Moore shaft was split at the face of 30 mains, one split passing across the faces of Nos. 5 through 11 entries and returning through the extreme north entries to Piper fan; the other split ventilated the

entries south of No. 5 entry and returned to Hoover fan. Also, intake air from Moore shaft flowed outby along 30 mains, with the major portion going through C face west to the 46 mains section and the remainder to B face north and outby. When the Piper fan was stopped the airflow reversed, and both intake and return flowed from B face north toward the face of 30 mains to C face west. These volumes as measured near B face west after the explosion were as follows:

Both fans in operation and flow through 30 mains from Moore shaft toward B face north

12,000 cubic feet a minute through Nos. 4, 5, and 6 entries
11,580 cubic feet a minute through 7 and 8 entries

Piper fan stopped and the flow reversed, flowing through 30 mains from B face north toward C face west

7,480 cubic feet a minute through Nos. 4, 5, and 6 entries
4,150 cubic feet a minute through 7 and 8 entries

Since there were two possible sources of gas to the explosion area, first, the face of 30 mains where explosive mixtures were present along No. 11 entry from the face outby for several crosscuts 24 hours after the explosion, and second, from the old workings outby B face north when airflow was reversed, it was decided to check these sources carefully. A check of the old workings north of 30 mains and outby B face north disclosed that, with the quantity of air (in excess of 100,000 cubic feet a minute) normally moving from the Shidler and Nos. 1 and 2 shaft intakes through these areas, the possibility of gas accumulating would be remote. Also, had the gas come from this source, it is believed that the explosion would have extended farther toward these old workings. Moreover, if high concentrations of methane had been given off from the old workings of B face north when the airflow interruptions occurred, it would have been detected by assistant foremen on the day of and the day before the explosion. According to the testimony given by two assistant foremen who made an inspection and took air measurements in certain parts of the mine on Sunday, September 22, and a general assistant foreman who came out of the mine about 15 minutes before the explosion on Monday morning, September 23, the flow of air had reversed itself and was coming out of air-split regulating doors in both the Patterson and the Young electric conversion substations, and no gas could be detected.

A second check was made in the 30 mains face area in which the ventilation had been reestablished subsequent to the explosion with the air from faces of Nos. 11 through 5 entries now returning along the south side of 30 mains.

An air measurement in entry No. 11 and just outby the face crosscut disclosed that 21,000 cubic feet of air a minute was moving

across the faces of Nos. 11 through 5 entries, and gas could be detected issuing from the right corner of the face. The regulator in the return from No. 5 entry was adjusted until only 4,200 cubic feet of air a minute was passing the same measuring point in entry No. 11, and within 15 minutes 1.42 percent of methane was detected at the face (table 1, sample No. L-9020). At the end of 1 hour 5.92 percent methane was present 50 feet from the face of No. 11 entry (table 1, sample No. 0-6365), and gas could be detected with a flame safety lamp 215 feet outby along No. 11 entry as well as on a fall about 900 feet outby in No. 10 entry. Thus in 1 hour gas had accumulated along No. 11 entry and backed up 215 feet from the face against a moving air current of 4,200 cubic feet a minute. This accumulation occurred in 1 hour and it is believed that with virtually no air movement, as was the case for about 44 hours prior to the explosion, the return airways outby the face of 30 mains filled with gas to a point outby C face west, or the extent of the explosion.

For further verification that considerable gas is liberated from the immediate face area of 30 mains, an air sample collected 30 minutes after the aforementioned test and when all accumulated gas had cleared from the test area showed 0.41 percent methane in 20,000 cubic feet of air passing the regulator (table 1, sample No. N-7454).

The investigation also revealed two possible sources for this gas to reach the 30 mains haulageway near C face west. First, a top-hinged inspection door in a stopping between Nos. 6 and 7 entries may have been partly open as a result of a heavy roof fall near the door, pushing the door partly open (figure 3); or with the airflow being reversed as it was prior to the explosion, the door may have been opened by the ventilating pressure differential. Secondly, a block or blocks had been removed from the next outby stopping to ventilate a former compressor station, and testimony indicated that these had not been replaced, thus affording an escapeway for the gas from the return airways onto 30 mains haulage road between the two angle chutes connecting it with C face west.

The mine is classed gassy by the State and is a gassy mine under the provisions of the Federal Coal Mine Safety Act (Public Law 552). The mine as a whole liberated considerable gas, as indicated by the following analyses of air samples collected during the last Federal inspection:

Fan	Volume of air, c.f.m.	Percent methane	Cubic feet of methane in 24 hours
Piper	328,000	0.21	991,872
Hoover	221,000	0.40	1,272,960
			2,264,832

Figure 3. - Hinged inspection door in stopping between No. 6 and 7 entries showing heavy roof fall near the door.

When the mine was in normal operation, onshift and preshift examinations for gas and other hazards were made in all active workings, and weekly gas tests and air measurements were made in return airways of producing areas. The results of the gas tests and air measurements were recorded. Numerous gas wells penetrate the property, but coal pillars of sufficient size to prevent gas from the wells from entering the mine were left around the wells.

Dust

At the time of the last Federal inspection the mine surfaces in general were dry and the mine was rock-dusted in accordance with the provisions of the Federal Coal Mine Safety Act. Water was used in all working places to allay coal dust produced during mining operations, and the working places were kept free of dangerous accumulations of loose coal and coal dust. The incombustible content of the 8 mine dust samples collected during the January 1957 Federal inspection ranged from 81 to 95 percent.

Rock dust was applied by hand daily in the working places, and generalized rock-dusting was done with machines on weekends and days the mine was idle. According to company records, 3,049,600 pounds of rock dust was applied and 769,453 tons of coal was produced during 1956. This amounts to about 3.96 pounds of rock dust used per ton of coal produced.

Of the 109 mine dust samples collected after the explosion, 57, or 52 percent of the total, contained less than 65 percent incombustible matter (see table 2). Most of these samples were collected in the area affected by the explosion and are not indicative of the mine dust conditions prior to the explosion. Of the 52 samples that contained more than 65 percent incombustible material, 5 samples, with incombustible contents of 71.2 to 91.1 percent, were collected along haulageways; 12 samples, with incombustible contents of 65.7 to 89 percent, were collected along intake airways connected to haulageways by open crosscuts; and the other 35 samples, having incombustible contents of 66.3 to 99.5 percent, were collected along return aircourses. The locations where dust samples were collected and the results of the analyses of each are shown in Appendix B.

Transportation

Permissible-type shuttle cars were used to convey coal to mine-car loading stations. Where conventional-type loading machines were used, coal was discharged directly into 8-ton-capacity steel mine cars pulled by 8-ton explosion-tested combination trolley-pole and cable-reel locomotives. The coal was hauled by 10- and 15-ton tandem trolley locomotives to a rotary dump on the Marianna No. 1 shaft bottom

and hoisted in skips to the surface preparation plant. Tracks and haulage equipment were kept in reasonably good condition. Clearance space and shelter holes along haulageways were well maintained, and shelter holes or more than 6 feet of clearance was provided at switch throws. Most of the workmen were lowered into and hoisted from the mine to the surface by an automatic elevator installed in the 581-foot-deep Moore shaft. A double-cage manually controlled hoist was used in Marianna No. 2 shaft for this same purpose and to transport supplies. Persons were transported to and from working places underground in covered steel-constructed man-trip cars. Utility trucks ("jeeps") were used whenever transportation was required for a limited number of persons. Permissible-type battery locomotives were also used as a means of transporting inspection personnel, mainly during idle periods when the direct-current transmission system was deenergized. Twenty-six locomotives, 2 mine-inspection cars, and a Joy WK-83 track-mounted air compressor were found parked in various sections of the explosion area.

Electricity

Electric power, 110, 220, 440, and 2,300 volts alternating current, was used on the surface. Underground electric equipment was operated by 275-volt direct-current power, except for a pump and a battery-charging unit located near the Marianna No. 1 shaft bottom which were operated by 2,300-volt alternating current and a fresh-water pump near the Moore shaft bottom which was supplied with 440-volt alternating current. Direct current was supplied by 4 surface and 4 underground electric-conversion units installed in fire-resistant structures. Alternating current for underground conversion units, pumps, and the battery-charging unit was transmitted by armored cable through boreholes from surface transformer stations. Feeder and trolley wires were installed on insulators and sectionalized with cutout switches. Several automatic-reclosing circuit breakers were installed in the direct-current transmission system. A line diagram (Appendix E) of the underground direct-current distribution system shows the locations of conversion units, automatic-reclosing circuit breakers, and pumps, and the locations of cutout switches in the Moore shaft vicinity.

Underground electric face equipment was permissible and explosion-tested types consisting of Lee-Norse CM42-X continuous mining machines, Jeffrey L-600 and Joy 7-BU and 11-BU loading machines, Jeffrey 29-U and 70-URB mining machines, Joy 10-SC shuttle cars, Lee-Norse RJ5-3K utility trucks, and Jeffrey 8-ton cable-reel locomotives. The permissible-type electric face equipment was maintained in permissible condition at the completion of the last Federal inspection. Trailing cables installed on mobile equipment were fire-resistant and were protected

against excessive overload and short circuits by power-tap fuses, in addition to circuit breakers. At the time of the January 1957 Federal inspection, operators of electric equipment made suitable tests for methane before moving electric equipment into the face region and at frequent intervals thereafter.

Illumination and Smoking

Permissible electric cap lamps were used for portable illumination underground, and fixed electric lights were installed at underground shops and along haulageways at frequent intervals. Smoking was not permitted underground, and employees were searched each shift for smokers' articles.

Mine Rescue

Two regularly trained mine rescue teams, equipped with 2-hour self-contained oxygen breathing apparatus and Chemox 3/4-hour oxygen-generating breathing apparatus, were maintained at the mine. Fully equipped and regularly trained mine rescue teams were also available at the company's nearby Ellsworth No. 51 mine and Somerset Mine No. 60. Tools, gas-detecting devices, and other equipment required for efficient performance of mine rescue operations were provided at each mine.

Portable fire extinguishers were provided on mobile equipment and kept at underground repair shops, permanent pump stations, battery-charging stations, and other advantageous locations in the mine. Filtered water was piped into the mine from a 3,000,000-gallon reservoir on the surface. Six-inch waterlines with fire-hose connections at 1,000-foot intervals were provided along the main haulageways, and smaller-size pipes were used to deliver water to each working section. The water pressure was controlled with water-pressure-regulating valves, and the average static test pressure throughout the mine was 160 pounds per square inch. Sufficient fire hose, adapters, fittings, and wrenches were kept readily available at strategic locations. Sufficient escapeways were provided from each working section to the surface. Self-rescuers were not carried by, or readily available to, underground employees. The check-in and check-out system in effect provided a means of positive identification upon the person of each individual in the mine, and a record of the men in the mine was kept on the surface.

STORY OF EXPLOSION AND RECOVERY OPERATIONS

Activities of Bureau of Mines Personnel

On the day of the explosion, Federal Inspectors R. J. Kirk and R. I. Krek arrived at the Moore shaft about 8:30 a.m. to start a routine inspection. When it was learned that an explosion had occurred, they proceeded immediately to Marianna shaft portal, where oxygen-apparatus crews were preparing to enter the mine. While Krek advised the Pittsburgh office of the Bureau of the explosion by telephone, Federal Inspector Kirk went underground to assist in rescue operations. Additional Bureau representatives arrived at the mine at the following times:

Frank Heffers	10:00 a.m.
G. W. Chastain	10:45 a.m.
H. R. Burdelsky	12:15 p.m.
F. E. Griffith	12:30 p.m.
F. D. Baker	3:00 p.m.
G. L. Lynch	3:30 p.m.
W. L. Lyons	3:30 p.m.
James Westfield	7:00 p.m.
M. J. Satterfield	8:00 p.m.
M. A. Yuhase	10:00 p.m.
E. R. Maize	11:55 p.m.
R. H. Oitto, Jr.	11:55 p.m.

Messrs. R. W. Stahl, W. Dan Walker, Jr., R. T. Davis, J. W. Holcomb, A. C. Jones, and C. L. Brown arrived later to assist in the recovery operations, investigation of the explosion, and to attend hearings conducted by the Pennsylvania Department of Mines and Mineral Industries.

After being briefed regarding known conditions and procedure to be followed, G. L. Lynch entered the mine via Moore shaft at 6:05 p.m. and assisted with the exploration work, rescue of 1 live victim, recovery of 5 bodies, and locating and extinguishing fires.

After being briefed, M. A. Yuhase entered the mine via Moore shaft at about 10:30 p.m. and assisted with the recovery of the last 2 bodies and helped locate and extinguish fires.

Lynch and Yuhase returned to the surface at 4:40 a.m. and 5:57 a.m., respectively.

Starting on Tuesday morning, September 24, Bureau personnel worked in groups on 6-hour shifts until all exploration work and the locating and extinguishing of mine fires had been completed.

Mining Conditions Immediately Prior to Explosion

The weather was fair on September 21, 22, and 23, 1957. Records of barometric pressures and temperature readings taken by the U. S. Weather Bureau at the Greater Pittsburgh Airport on September 21, 22, and 23, are as follows:

Saturday, September 21, 1957

Time	Barometric pressure	Temperature	Time	Barometric pressure	Temperature
7:00 a.m.	29.97	71	4:00 p.m.	29.95	83
8:00 a.m.	29.97	71	5:00 p.m.	29.95	83
9:00 a.m.	29.98	72	6:00 p.m.	29.95	82
10:00 a.m.	29.98	74	7:00 p.m.	29.96	82
11:00 a.m.	29.98	77	8:00 p.m.	29.96	81
12:00 noon	29.99	77	9:00 p.m.	29.96	78
1:00 p.m.	29.97	80	10:00 p.m.	29.97	77
2:00 p.m.	29.95	82	11:00 p.m.	29.97	76
3:00 p.m.	29.94	83	12:00 p.m.	29.96	75

Sunday, September 22, 1957

Time	Barometric pressure	Temperature	Time	Barometric pressure	Temperature
1:00 a.m.	29.96	74	1:00 p.m.	29.91	78
2:00 a.m.	29.95	74	2:00 p.m.	29.90	79
3:00 a.m.	29.95	73	3:00 p.m.	29.87	80
4:00 a.m.	29.95	72	4:00 p.m.	29.83	71
5:00 a.m.	29.95	72	5:00 p.m.	29.84	71
6:00 a.m.	29.96	72	6:00 p.m.	29.87	73
7:00 a.m.	29.96	71	7:00 p.m.	29.87	72
8:00 a.m.	29.97	73	8:00 p.m.	29.91	64
9:00 a.m.	29.97	74	9:00 p.m.	29.94	62
10:00 a.m.	29.97	74	10:00 p.m.	29.99	60
11:00 a.m.	29.96	75	11:00 p.m.	29.99	60
12:00 noon	29.93	76	12:00 p.m.	29.97	60

Monday, September 23, 1957

Time	Barometric pressure	Temperature
1:00 a.m.	30.00	59
2:00 a.m.	30.00	59
3:00 a.m.	30.01	58
4:00 a.m.	30.00	58
5:00 a.m.	30.00	58
6:00 a.m.	30.00	57
7:00 a.m.	30.01	56
8:00 a.m.	30.03	56

On Saturday morning, September 21, at the completion of the shift, all workmen left the mine about 8:00 a.m., and the electric power was disconnected from the direct-current transmission system. Between 11:30 and 11:45 a.m., John M. Roule, outside foreman, noticed that the visual warning signal indicated that the Piper fan, one of two fans used to ventilate the mine, was not operating, and a few minutes later he was informed that someone had telephoned his home and reported that the fan was making a strange noise. He immediately proceeded to the Piper fan and learned that the impeller blades had sheared from the hub, so he stopped the fan and notified the superintendent. After determining that the fan could not be repaired in less than 4 days, it was decided to have 4 officials make a ventilation survey in the mine on Sunday morning, September 22, to determine the behavior of the ventilating currents with only the Hoover fan in operation.

At 7:30 a.m., Sunday, Edmond Hardesty, George Zimmerman, Albert Williams, and Viard Moore, assistant mine foremen, entered the mine at Moore shaft. They traveled in pairs on battery locomotives. Moore and Hardesty rode along 30 mains toward Marianna No. 2 shaft, stopping frequently to take and record air measurements. They noticed a musty odor like that of return air along the 30 mains haulage road between the angle chutes connecting it with C face west, but they did not state that they examined for explosive gas at this location. They found that the airflow between B and C faces west had reversed and was flowing from B face west toward C face west. Examination at Patterson substation outby B face west and Young substation near Piper shaft revealed that return air, which was free from explosive gas, was coming out on 30 mains haulage road through small doors in the rear of the stations. It was observed that air was flowing down Piper shaft, which was normally upcast, and moving into the mine through four entries connected to the bottom of the shaft, but not in sufficient quantity to be measured with an anemometer.

Zimmerman and Williams traveled through C face west to 46 mains, where they measured the air along the haulage roads. The volume of air entering 44 butt B face north was not sufficient to afford a measurement, so, in accordance with instructions issued by the assistant superintendent, a regulator in 46 butt B face north was opened to permit 18,000 cubic feet of air a minute to be delivered to 44 butt section. Making such major changes in the mine ventilating system with electric power circuits energized is a dangerous practice. Air movement in 47 butt C face west and the left side of 46 mains was not sufficient to measure. The four officials returned to the surface about noon the same day and reported their findings to the assistant superintendent, but did not record their findings in a book.

About midnight on Sunday, a general assistant mine foreman, 9 assistant mine foremen, a fire boss, and a pumper entered the mine at Moore shaft. The assistant mine foremen were assigned to examine designated sections of the mine and measure the intake and return air

currents in each split. The fire boss was assigned to examine all places where pumps were to be operated, and the pumper was assigned to operate pumps along the haulage roads and near the bottom of Marianna Nos. 1 and 2 shafts. Eight of the assistant foremen had been instructed to travel in pairs and use trolley locomotives for transportation. George Iddings, general assistant mine foreman, and George Harmuth, assistant mine foreman, rode on a battery locomotive to 46 mains, where they started a rectifier at Weaver shaft bottom. After checking to see that the automatic circuit breakers at A face west 46 mains and B face north 46 mains were open, they noticed that a light inby in 46 mains haulageway was dim, so they traveled to near C face west 46 mains to check the automatic tie breaker at this location. They found that the breaker was not functioning properly, so they manually closed the breaker. They then traveled through 46 mains and A face west to 30 mains, where they took air measurements along the haulage road. Examinations were made for explosive gas where return air was entering through the small doors in the rear of Patterson and Young substations, but methane was not detected. After the tests were completed the doors were closed. While they were recovering the broken propeller blades at Piper shaft bottom, Pumper Joe Smith arrived on a "jeep," and the battery locomotive was switched in a chute to permit Smith to travel toward Marianna No. 2 shaft. When Smith had passed, the 2 officials proceeded toward Marianna No. 2 shaft bottom, where they left the propeller blades and returned toward 46 mains to continue their examination. They found that air movement along 30 mains between B face east and A face west was insufficient to measure with an anemometer. Air measurements were taken at the Hoover shaft, and then Iddings and Harmuth proceeded to C face west and 46 mains junction, where they met 4 other officials.

Assistant Mine Foremen William Nelson and Michael Knizner rode to 46 mains C face west junction and parked their trolley locomotive on 46 mains inby C face west switch. They then measured the volumes of air in C face west entries off 46 mains and in 46 mains faces. After completing their assigned work they met some of the other officials at the C face west junction with 46 mains. While the officials were at this junction, Smith arrived and stated that he wanted to travel along C face west haulage road toward Moore shaft. Shortly after Smith left, two other assistant mine foremen arrived, and then all proceeded to Moore shaft where they met James Wright and Phillip Kornet. Iddings collected the reports from the assistant mine foremen and returned to the mine foreman's office on the surface about 7:00 a.m.

Superintendent T. J. Jones entered the mine between 4:30 and 5:30 a.m. at Marianna No. 2 shaft and walked to No. 1 shaft bottom to inspect water accumulation in the sump. When he arrived at the sump he met the fire boss, Stanley Collins, who had been operating the sump pump

which was driven by alternating current that entered the mine through a nearby borehole. After talking with Collins, Jones telephoned the surface engineer and requested him to energize the direct-current circuit at the shaft bottom for lighting purposes. When the lights were on at No. 1 shaft bottom, the superintendent left Collins and returned to the surface.

Story of Explosion

About midnight, Sunday, September 22, 9 assistant mine foremen, 1 general assistant mine foreman, 1 fire boss, and 1 pumper entered the mine. After the general assistant mine foreman and the 9 assistant mine foremen had completed their assigned duties, they returned to the Moore shaft bottom. The general assistant mine foreman had gone to the surface via Moore shaft, the assistant mine foremen were at or in the vicinity of the shaft bottom awaiting quitting time, and the fire boss and pumper were in 30 mains haulageway near C face west when the explosion occurred at 7:15 a.m.

Five of the assistant mine foremen were seated in man-trip cars near the shaft, three were near the new shop, and one was walking toward the elevator when the explosion occurred. See Appendix D, sketches 1, 2, and 3. Nelson, who was in the fourth car, stated that they were engulfed in a strong rush of air and dust. He shouted "Explosion" and got down on the floor of the man-trip car. After the heat of the explosion subsided he got out of the car and found Knizner lying unconscious in a shelter hole. Knizner was revived and helped to the shaft bottom, where Sprowls and Krupzig were waiting. Nelson returned to the man trip and helped Majesky to the shaft. Demko's body was found lying in the shaft chute walkway. See Appendix D, sketch 1.

Communications were established about 10 minutes after the explosion with some of the survivors by shouting up and down the Moore shaft. Nelson, one of the survivors, stated that he was "O.K." but that 4 others with him were painfully burned, and he requested that first-aid materials be lowered to the bottom of the 581-foot-deep Moore shaft so that he could dress their burn injuries. Blankets, first-aid materials, and a two-conductor cable-connected telephone were lowered to the men. Subsequent telephone conversations with one of the survivors revealed that 5 men were still alive and that another had apparently succumbed to injuries and burns. Nelson also stated in telephone conversations with persons on the surface that several fires were burning near the shaft bottom and asked that fire extinguishers be lowered to aid in controlling them. Nelson, who was the least injured, treated the others and also extinguished several fires near the shaft bottom with fire extinguishers from the man-trip locomotives and water carried from the shaft sump, and later with fire extinguishers lowered from the surface.

Recovery Operations

After being notified of the explosion, State Mine Inspector A. J. Nairn proceeded to the Marianna No. 2 shaft, where he met with company officials. Nairn instructed the officials to use all available means to effect rescue of the men at the shaft bottom, while he and several foremen would attempt to reach them from the Marianna portal.

At 8:40 a.m., Nairn, Albert Salvador, assistant superintendent, and 4 assistant mine foremen entered the mine through Marianna No. 2 shaft and proceeded toward the Moore shaft. On 30 mains haulage road about 500 feet outby C face west haulage switch the exploratory party encountered carbon monoxide in the air and had to retreat. Several attempts were made to travel parallel entries along 30 mains, but carbon monoxide was again encountered. While this exploratory work was in progress, Federal Inspector R. J. Kirk entered the mine at Marianna No. 2 shaft with 2 officials and 2 mine rescue teams. At 11:30 a.m. both parties met on 30 mains outby B face west, and arrangements were made for the second group to travel to C face west off 46 mains while the first group would enter the left return aircourse on 30 mains outby B face west. When the exploratory party attempting to reach Moore shaft through 46 mains and C face west arrived at the C face west intersection, carbon monoxide was detected in the air coming from Moore shaft. Attempts were made to enter the return aircourses on C face west, but carbon monoxide was detected in the entries. When efforts to reach the entrapped men failed underground, both exploratory groups, except one 5-man rescue team, returned to the Marianna shaft bottom and to the surface at about 3:30 p.m. The rescue team that remained underground entered the return aircourses near B face west on 30 mains, where it was believed that persons were heard crossing an overcast in this vicinity; however, this report was later disproved.

While the underground exploratory work was being carried on, a temporary emergency hoisting arrangement was being installed on the surface at Moore shaft portal. A company-owned gasoline motor-driven truck with an A-frame boom and a pole-hoisting winch was moved near the shaft opening. Six hundred feet of 3/8-inch wire rope was attached to the winch hoisting drum. See figures 1 and 2. A 55-gallon steel oil drum was connected to the rope and, with a company shaft superintendent in it, was lowered into the shaft at about 1:30 p.m. The shaft superintendent assisted with the loading of the injured men and accompanied them to the surface in subsequent hoists.

The first injured man was hoisted to the surface at 2:09 p.m., and at 4:30 p.m. all injured men who had been at the shaft bottom had reached the surface. Fire-fighting personnel were lowered in most of the descending trips of the oil drum. Rescue operations continued until

4:10 a.m. the following day, at which time all victims had been brought out of the mine. After the shaft superintendent, the first two rescue men to enter the mine were John Dudko and Alexander Dudko, mine laborers. These men rendered meritorious service in the assistance they were able to give the severely burned men.

A "walkie talkie" type of communication system proved very valuable during lowering and hoisting with the temporary emergency hoisting equipment, especially during the first few trips down and up the shaft. The elevator cables and chains were suspended in the shaft and obstructed descent and ascent of the oil drum. With the "walkie talkie" a person riding in the oil drum could communicate with the hoist operator and tell him how the oil drum should be lowered or hoisted, thus enabling the man in the drum to guide it past the obstructions. After a path for lowering and hoisting the oil drum had been established, men on the surface assisted in guiding the oil drum by keeping the hoist rope close to the shaft wall, and the "walkie talkie" was used as a means of communication between the surface and the shaft bottom.

At 6:05 p.m., State Mine Inspector A. J. Nairn and Federal Inspector G. L. Lynch were lowered into the mine, followed by State Mine Inspector C. B. Lozaw, Assistant Superintendent Albert Salvador, and other mine officials, including two mine rescue men with gas masks. When Nairn and Lynch reached the shaft bottom, Inspector Lynch made a short exploratory trip to search for victims while Nairn directed the raising and lowering of the improvised bucket by "walkie talkie" as other inspectors were lowered to the bottom. Lynch searched the man-trip cars that were parked near the shaft but was unable to find any of the missing men. He then returned to the shaft bottom. When Assistant Superintendent Salvador and an assistant mine foreman arrived at the bottom of the shaft, State Inspector Lozaw remained at the shaft telephone while the rescue party proceeded along the main haulage road toward the new shop. When the exploratory group arrived at the new underground repair shop, a survivor was found seated in a man-trip car which was parked at the new shop sidetrack. While the seriously injured man (who subsequently died) was being treated, the body of a victim was found nearby. Inspectors Nairn and Lynch continued searching the shop area while the injured man and the dead man's body were being transported to the Moore shaft bottom. A short time later another body was located near the new repair shop.

The exploratory operations were continued beyond C face west haulage road junction, where the body of the pumper was found lying on 3C mains haulageway, a short distance outby the junction. The pumper apparently had been operating a "jeep" utility truck, which was located about 112 feet outby his body. The body of the fire boss was found in the cab of a battery locomotive a short distance outby the "jeep." The

battery locomotive was, with the exception of the cab, completely covered with fallen roof rock and timbers. See Appendix D and sketch 7. After these bodies were located, State and Federal inspectors assisted in transporting them to the Moore shaft bottom.

About 25 fires were left in the wake of the explosion. The locations of these fires and damage and other items of interest are shown in Appendix D and sketches 4, 5, and 6. Water carried from the shaft sump and fire extinguishers sent from the surface were used to extinguish some of these fires. To extinguish a few of the fires it was necessary to turn over and cool the hot material with rock dust and water. The initial exploratory and rescue work was concluded at about 4:30 a.m.; the fires appeared to be under control. The last of the exploratory group were hoisted to the surface about 6:00 a.m. September 24.

In subsequent exploration and inspection by State, Federal, and Company personnel, other fires were found and several of those thought to have been extinguished had rekindled. Water from a fresh-water line was used to supplement the other fire-extinguishing methods in combating these fires.

On Tuesday, September 24, at about 1:00 p.m. a company-owned shaft-sinking hoist and bucket were installed to supplant the equipment set up during the emergency. The rope used on this hoist was 3/4-inch nonspinning type. This hoisting equipment was used for lowering and hoisting men and supplies during the remainder of the recovery operations.

It is noteworthy that the explosion caused relatively few roof falls in roof-bolted areas, whereas exploration was hampered considerably by extensive falls of roof in areas where conventional timbering was used.

INVESTIGATION OF CAUSE OF EXPLOSION

Investigation Committee

The underground investigation of the cause of the explosion was conducted on September 26, 1957. Members of the official investigation committee were:

Pennsylvania Department of Mines and Mineral Industries (Investigating Commission):

A. J. Nairn	District Inspector
J. M. Black	District Inspector
L. D. Kimmel	District Inspector
J. V. McKenna	District Inspector
C. B. Lozaw	District Inspector

United Mine Workers of America:

Joseph Yablonski	Member of International Executive Board
Michael Budzanowski	Member of District 5 Executive Board

Bituminous Coal Operators' Association:

George C. Trevorrow	Safety Director

Bethlehem Mines Corporation:

K. W. Bartlett	Division Superintendent
A. J. Salvador	Assistant Superintendent, Marianna No. 58 mine
Michael Barshick	Mine Foreman, Marianna No. 58 mine

United States Bureau of Mines:

F. E. Griffith	Supervising Coal Mine Fire Control Engineer
G. W. Chastain	Federal Coal-Mine Inspector
R. J. Kirk	Federal Coal-Mine Inspector
R. Ward Stahl	Mining Health and Safety Engineer
C. L. Brown	Mining Engineer (Electrical)
Frank Heffers	Federal Coal-Mine Inspector
T. J. McDonald	Federal Coal-Mine Inspector

On September 28, 1957, 4 of the victims were interrogated in the Washington, Pennsylvania, Hospital, and a hearing was conducted at the mine office on September 30, 1957, by A. J. Nairn, State Mine Inspector, who was appointed Chairman of the Commission by the Secretary of the Pennsylvania Department of Mines and Mineral Industries, to inquire into the conditions and practices existing in the mine immediately

prior to the explosion. In this hearing questions asked by United Mine Workers of America and Bureau of Mines representatives were given in written form to the chairman, who then presented the questions to the witnesses.

On October 17, 1957, Lewis Evans, Deputy Secretary, Pennsylvania Department of Mines and Mineral Industries, reopened the hearing. Victims in the hospital were again interrogated, and hearings were conducted in the mine office on October 17 and 18, 1957. During these hearings a representative of the United Mine Workers of America and a representative of the Bureau of Mines were permitted to direct questions to the witnesses.

Several mine officials were interrogated during these hearings, and some of the information obtained from their testimony is included in this report.

Methane as a Factor in the Explosion

The mine is classed gassy by the Pennsylvania Department of Mines and Mineral Industries and by the Bureau of Mines, and methane has been detected in the mine on numerous occasions. An explosion resulting in 154 fatalities occurred in this mine in 1908. During the last Federal inspection, completed January 16, 1957, the mine was liberating methane at a calculated rate of 2,264,832 cubic feet in 24 hours.

Mining officials stated that during development the 30 mains entries liberated methane freely. It was necessary to keep an appreciable volume of air sweeping the working faces to keep them clear of methane, and any interruption of face ventilation resulted in gas accumulating at the faces and elsewhere in this area, as shown by tests conducted in this part of the mine on October 15 and recorded elsewhere in this report.

Flame

Evidence of heat and flame was clearly indicated by ashes, soot, particles of coke, and charred papers, brattice cloth, and wood within the area indicated as the flame area on the maps included as Appendixes C and D. This area was approximately 800 by 3,700 feet at the maximum limits.

During recovery and exploratory operations, about 25 fires were extinguished; in addition to these, there was evidence that numerous other fires were started but ceased burning for unknown reasons. The locations of some of the fires that were extinguished during recovery operations are shown in Appendix D.

One hundred and nine dust samples were collected during the investigation of the explosion. Of these, 33 contained small to large

quantities of coke. See table 2. The presence of coke in the dust samples and observations made within the explosion area indicated the extent of the area covered by flame.

It is significant and should be noted that the flame did not extend more than 800 feet outby the suspected point of origin, and extended about 2,900 feet inby this point to Moore shaft and to the face of 30 mains entries.

Forces

The forces of the explosion extended in all of the 30 mains entries for a distance of 4,400 feet and into C face entries for a distance of 900 feet. Minor forces extended into 32 west entries. Therefore, these entries are included within the force area, even though the forces in these areas were not violent. For the direction of forces, see Appendix D. The forces destroyed about 45 masonry stoppings in 30 mains entries and damaged an overcast in C face west entries. Several other masonry stoppings not being utilized for ventilation immediately prior to the explosion were also destroyed. Undoubtedly, further destruction within the mine was averted by the forces being relieved to the surface through the Moore shaft.

The shaft had been completed and a modern automatic elevator had been installed about 4 months prior to the explosion. The elevator was destroyed, as was a portion of the structure above the shaft. See figure 1. The elevator was so controlled that it automatically returned to the surface when not in use to prevent moisture from damaging the controls. When the explosion occurred, the elevator was at the top of the shaft, and forces developed by the explosion projected it into the headframe above the shaft collar.

Evidence of Activities

The location of the battery locomotive and electric-powered trolley-pole "jeep" indicates that this equipment was being operated immediately prior to the explosion by the fire boss and pumper, respectively. After the explosion the battery locomotive was found with the controller in the "On" position on the third point and the direction of travel control in position for travel toward Moore shaft. Although most of the activities of these two men during the first part of their shift could not be ascertained, it is believed that they had been in 30 mains outby C face west and were en route to Moore shaft when the explosion occurred. It is also believed that the fire boss opened the trolley-wire cutout switch near the outby C face west angle chute immediately prior to the explosion.

Evidence and testimony indicate that the other men in the mine when the explosion occurred had completed their assigned work, were near the Moore shaft bottom, and were not operating electrical equipment.

The survivors of this explosion owe their lives to the fact that they were in man-trip cars, which shielded them from much of the heat and forces of the explosion, and, according to testimony of one of the survivors, to the fact that after the explosion pressure was relieved the ventilation rapidly reestablished itself at and in the vicinity of the Moore shaft bottom and carried away from them the deleterious aftergases. This rapid inward movement was induced by the cooling and contraction of hot gases and by the exhausting Hoover fan which remained in operation during the explosion and continued to operate at near-normal efficiency. The rapid clearing of the aftergases was a very important factor because self-rescuers were not available to the victims.

Probable Point of Origin

There is unanimity of opinion of all parties investigating the explosion, namely, the State, United Mine Workers of America, Company, and Federal investigators, that it originated in 30 mains haulageway between the angle chutes connecting this haulage road with C face west haulageway. See Appendix C.

Factors Preventing Spread of Explosion

The major factor in preventing the spread of the explosion was rock dust. This is attested to by analytical results of dust samples collected during the investigation. Of 109 samples collected, the analytical results of which are shown in table 2, 52 show a sufficiency of incombustible matter. All of the samples collected at points of flame extension show an adequacy of rock dust. The samples that contained less than 65 percent incombustible matter were collected in the area where the explosion was most violent and do not indicate the conditions relative to adequacy of rock-dusting prior to the explosion.

It is believed by the Bureau investigators that the relief of the explosion pressure through the Moore shaft definitely limited destruction.

Summary of Evidence

Conditions observed in the mine during recovery operations and the investigation following the disaster, with information obtained from reports of Federal inspections of the mine, company officials, workmen, and mine records, provided evidence as to the cause and origin of the explosion. This evidence is summarized as follows:

1. One of the two fans used to ventilate the mine was stopped between 11:30 and 11:45 a.m., September 21, because its impeller blades were broken.

2. Examinations made by mine officials on September 22 and 23 revealed that the air currents in the mine flowed in decidedly reduced volumes at some points, ceased to flow in certain areas, and reversed direction of flow in some other places. The airflow in Nos. 7 and 8 entry returns in 30 mains was from B face west toward C face west and from the returns to the 30 mains haulageway where openings were in stoppings.

3. Two of the assistant mine foremen making a ventilation survey on September 22 detected a musty odor along 30 mains haulageway in the area between the C face west angle chutes off 30 mains.

4. Methane was liberated freely in Nos. 7, 8, 9, 10, and 11 entries in 30 mains.

5. An opening made in a concrete-block stopping for the purpose of ventilating a compressor station, which was abandoned prior to the explosion, had not been closed. A man door which was in a stopping in the next inby crosscut may have been held open by fallen rock. Gas may have passed from the return to the haulageway at either or both of these points.

6. Most of the feeder and trolley circuits along the main haulageways were energized between 12:30 a.m. and 2:30 a.m., September 23, and power remained on the circuits until after the explosion occurred.

7. A battery locomotive and trolley-pole "jeep" were being operated in the area between the angle chutes that connect C face west to 30 mains haulageway; no other electric equipment was in operation in the explosion area.

8. A trolley-wire cutout switch was found in the open position about 20 feet outby the point where the battery locomotive was found.

9. The trolley wire was kinked near the location where the body of the pumper who was operating the "jeep" was found.

10. The body of the man who was operating the "jeep" was found lying between the rails of 30 mains haulage track with his head toward Moore shaft.

11. The stopping in which a hole had been made to provide ventilation for a compressor station was blown toward the return airways by forces of the explosion, while all other stoppings that were blown out of crosscuts between Nos. 6 and 7 and Nos. 8 and 9 entries in 30 mains were blown in the opposite direction, toward the haulageway. Stoppings in Nos. 7, 8, 9, and 10 entries in the vicinity of the new repair shop were blown toward the faces.

12. Records indicated that examinations of 30 mains faces and the north return airways therefrom had not been made for some time prior to the Piper fan breakdown and subsequent explosion.

13. Gas was ignited and the resulting explosion was propagated by gas and some coal dust that was rendered explosive by the presence of gas.

14. About 25 fires were left in the wake of the explosion.

15. Of the 109 dust samples collected after the disaster, 33 contained coke in amounts varying from small in several to very large in a few.

16. In general, the incombustible contents of dust samples collected outside the area influenced by the explosion were well above the minimum required by the Federal Coal Mine Safety Act.

Cause of Explosion

The Federal investigators believe that the explosion was caused by the ignition of gas liberated in Nos. 9, 10, and 11 entries in and near the 30 mains face area. Accumulations of this gas moved slowly, owing to disrupted ventilation, outby through the Nos. 7 and 8 entries, 30 mains return. Because of changed differential in the air pressure, this gas passed through the opening or openings in the stopping or stoppings near the abandoned compressor station into the No. 6 entry, which was normally an intake, and then through an open crosscut into 30 mains haulage entry between the angle chutes connecting it with C face west.

The gas was ignited by an arc or spark from an energized trolley wire and the collector shoe of an electric trolley-pole "jeep" when a momentary opening occurred in the circuit, or by an arc or spark created when the fire boss opened the trolley-wire cutout switch in 30 mains haulageway near the outby C face west angle chute. When that part of the accumulated gas which extended to the 30 mains haulageway was ignited, the flame traveled to the parallel intake entry and then to the back entry returns on the north side of 30 mains haulageway, where it was propagated by gas and some mine dust (mixed coal and rock dust that was rendered explosive by the presence of gas) to the faces of these and adjoining entries.

RECOMMENDATIONS

The following recommendations are made to prevent similar disasters:

1. When a major change occurs in the ventilation system of a gassy mine, such as a major breakdown of a main fan, all electric power should be disconnected immediately from the entire mine, and all men should be removed promptly from the mine. In this instance, men were not in the mine when the Piper fan failed.

2. When underground power circuits have been deenergized because of interruption of the mine ventilation system, the circuits should not be reenergized until adequate ventilation has been restored and all affected areas have been thoroughly examined by competent personnel and reported safe. Suitable records of the examinations should be entered in the mine record book.

3. Adequate precautions should be taken in mines ventilated with multiple fans to preclude the possibility of return air entering active working areas or travelways in the event of failure of one or more of the fans.

4. Major changes in the mine ventilating system should be made only when all underground electric power circuits are deenergized, and only those persons assigned to make such changes should be allowed in the mine.

5. Return aircourses and the stoppings separating them from the intake aircourses should be examined at least once each week, and a written record of the findings should be kept at the mine.

6. Suitable examinations for gas and other hazards should be made at least once each week in all idle portions of the mine, and in abandoned areas insofar as the conditions will permit, and a written record of these inspections kept at the mine.

7. Openings in stoppings used for ventilation purposes should be promptly sealed when they are no longer essential for this purpose.

8. Self-rescuers should be readily available to all underground personnel and the employees should be instructed in their use, limitations, and maintenance.

ACKNOWLEDGMENT

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Respectfully submitted,

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TABLE 1. - Analyses of air samples collected after explosion

Bottle No.	Location in mine	Percent in volume				Cubic feet air per minute	Cubic feet methane in 24 hours
		Carbon dioxide	Oxygen	Methane	Nitrogen		
L-9012	Face No. 11 entry 30 mains	0.13	20.58	1.08	78.21		
L-9020	Face of No. 5 entry 30 mains (regulator closed)	0.15	20.44	1.42	77.99		
N-7451	Face of No. 11 entry 30 mains (regulator closed 1/2 hour)	0.05	20.79	0.19	78.97		
N-7454	Return air, outby regulator, return from 30 mains faces, left outby side	0.03	20.77	0.41	78.79	20,000	118,080
0-1071	Top of fall, 1st outby fall No. 10 entry 30 mains (regulator closed)	0.21	19.80	5.21	74.78		
0-1072	Face, 2d outby left crosscut No. 11 entry 30 mains	0.12	20.69	0.54	78.65		
0-6365	50 feet from face No. 11 entry 30 mains	0.25	19.56	5.92	74.27	7,560	644,475
0-6352	Face No. 11 entry 30 mains	0.11	20.66	1.20	78.03		
J-5555	Main return, 1 face, of A faces 30 mains	0.13	20.57	0.11	79.19	15,000	23,760
J-5563	Main return, return from 30 right B face north 1 face A face west	0.09	20.75	0.21	78.95	42,000	127,008

TABLE 1. - Analyses of air samples collected after explosion (Con.)

Bottle No.	Location in mine	Percent in volume				Cubic feet air per minute	Cubic feet methane in 24 hours
		Carbon dioxide	Oxygen	Methane	Nitrogen		
L-9010	Main return, outby right side 30 mains 180 feet from Piper shaft	0.10	20.68	0.10	79.12	112,800	162,432
J-9026	Main return, left side of B face north	0.05	20.77	0.31	78.87	21,000	93,744
0-6325	Main return, return from right side A face west toward Shidler shaft	0.26	20.32	0.06	79.36	6,800	5,875
0-6334	Main return, between 5 and 6 entry, 15 feet outby south mains overcast along 30 mains	0.11	20.72	0.17	79.00	22,400	54,835

TABLE 2. - Analyses of mine dust samples collected after explosion

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
A-1	Band	Sixth crosscut outby face of No. 3 entry, 30 mains	61.6	Trace
A-2	Band	Sixth crosscut outby face of No. 2 entry, 30 mains	80.5	None
A-3	Band	Fourth crosscut outby face of No. 1 entry, 30 mains	62.9	None
A-4	Band	Fifth crosscut outby face of No. 5 entry, 32 butt	81.0	None
A-5	Band	Fifth crosscut outby face of No. 4 entry, 32 butt	70.6	None
A-6	Band	Fifth crosscut outby face of No. 3 entry, 32 butt	61.0	None
A-7	Band	Fourth crosscut outby face of No. 2 entry, 32 butt	95.4	None
A-8	Band	Fourth crosscut outby faces of Nos. 1 and 2 entry, 32 butt	91.0	None
A-9	Band	Fifth crosscut outby face of No. 1 entry, 32 butt	95.2	None
A-10	Band	Crosscut between Nos. 3 and 4 entry 1,280 feet outby 30 main faces	44.7	None
A-11	Band	1,260 feet outby face of No. 2 entry, 30 mains	51.1	None
A-12	Band	1,080 feet outby face of No. 1 entry, 30 mains	72.4	None
A-13	Band	1,100 feet outby face of No. 1 entry, 32 butt	83.7	None
A-14	Band	1,660 feet outby face of No. 1 entry, 32 butt	83.4	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
A-15	Band	2,140 feet outby face of No. 1 entry, 32 butt	94.8	None
A-16	Band	2,140 feet outby face of No. 2 entry, 32 butt	74.6	None
A-17	Band	1,120 feet outby face of No. 2 entry, 32 butt	89.1	None
A-18	Band	1,280 feet outby face of No. 2 entry, 32 butt	70.1	None
A-19	Band	1,140 feet outby face of No. 3 entry, 32 butt	87.1	None
A-20	Band	2,140 feet outby face of No. 3 entry, 32 butt	63.7	None
A-21	Band	2,300 feet outby face of No. 4 entry, 32 butt	50.8	None
A-22	Band	2,300 feet outby face of No. 5 entry, 32 butt	53.9	None
A-23	Band	1,920 feet outby face of No. 4 entry, 32 butt	69.8	None
A-24	Band	1,140 feet outby face of No. 4 entry, 32 butt	69.2	None
A-25	Band	1,200 feet outby face of No. 5 entry, 32 butt	51.5	None
A-26	Band	1,960 feet outby face of No. 5 entry, 32 butt	81.8	None
A-27	Band	1,940 feet outby face of No. 1 entry, 30 mains	77.7	None
A-28	Band	2,700 feet outby face of No. 5 entry, 32 butt	64.3	None
A-29	Band	2,700 feet outby face of No. 1 entry, 30 mains	57.3	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test: Amount of coked particles present
A-30	Band	2,880 feet outby face of No. 2 entry, 30 mains	49.7	None
A-31	Band	2,880 feet outby face of No. 3 entry, 30 mains	40.1	None
A-32	Band	2,200 feet outby face of No. 3 entry, 32 butt	48.5	None
A-33	Band	2,300 feet outby face of No. 3 entry, 32 butt	68.1	None
A-34	Band	800 feet inby overcast No. 5 entry C face west	63.9	None
A-35	Band	1,440 feet inby overcast No. 5 entry C face west	59.0	None
A-36	Band	No. 1 entry 31 butt, 1,600 feet outby No. 1 entry C face west	82.3	None
A-37	Band	No. 2 entry 31 butt, 1,600 feet outby No. 1 entry C face west	77.8	None
A-38	Band	No. 3 entry 31 butt, 1,600 feet outby No. 1 entry C face west	79.1	None
A-39	Band	No. 4 entry 31 butt, 1,600 feet outby No. 1 entry C face west	70.6	None
A-40	Band	No. 5 entry 31 butt, 1,600 feet outby No. 1 entry C face west	81.9	None
A-41	Band	No. 1 entry 30 mains, 1,600 feet outby No. 1 entry C face west	66.9	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
A-42	Band	No. 2 entry 30 mains, 1,620 feet outby No. 1 entry C face west	64.6	None
A-43	Band	No. 3 entry 30 mains, 1,630 feet outby No. 1 entry C face west	41.0	None
1	Band	300 feet outby face of No. 10 entry, 30 mains (back entry, return airway)	41.5	Small
2	Band	320 feet outby face of No. 9 entry, 30 mains (back entry, return airway)	37.9	Small
3	Band	320 feet outby face of No. 8 entry, 30 mains (intake airway, open parallel)	66.9	Small
4	Band	320 feet outby face of No. 7 entry, 30 mains (intake airway, open parallel)	42.3	Small
5	Band	260 feet outby face of No. 6 entry, 30 mains (intake airway, open parallel)	39.9	Trace
6	Band	220 feet outby face of No. 5 entry, 30 mains (intake airway, open parallel)	54.6	Small
7	Band	880 feet outby face of No. 10 entry, 30 mains (back entry, return airway)	55.9	Small
8	Band	880 feet outby face of No. 9 entry, 30 mains (back entry, return airway)	41.7	Small

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
9	Band	880 feet outby face of No. 8 entry, 30 mains (intake airway, open parallel)	87.2	Small
10	Band	880 feet outby face of No. 7 entry, 30 mains (intake airway, open parallel)	81.9	Large
11	Band	920 feet outby face of No. 6 entry, 30 mains (intake airway, open parallel)	47.5	Small
12	Band	840 feet outby face of No. 5 entry, 30 mains (intake airway, open parallel)	65.7	Trace
13	Band	620 feet outby face of No. 4 entry, 30 mains (intake airway, open parallel)	71.9	Small
14	Band	1,430 feet outby face of No. 10 entry, 30 mains (return airway, explosion area)	34.9	Small
15	Band	1,430 feet outby face of No. 9 entry, 30 mains (return airway, explosion area)	34.8	Small
16	Band	1,430 feet outby face of No. 8 entry, 30 mains (intake airway, explosion area)	51.9	Small
17	Band	1,430 feet outby face of No. 7 entry, 30 mains (intake airway, explosion area)	52.6	Very large
18	Band	1,460 feet outby face of No. 6 entry, 30 mains (intake airway, explosion area)	62.3	Trace

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
19	Band	1,480 feet outby face of No. 5 entry, 30 mains (haulage road, open parallel, explosion area)	76.0	Trace
20	Band	1,240 feet outby face of No. 4 entry, 30 mains (return airway, explosion area)	48.0	Small
21	Band	2,420 feet outby face of No. 8 entry, 30 mains (return airway, explosion area)	41.5	Small
22	Band	2,420 feet outby face of No. 7 entry, 30 mains (return airway, explosion area)	42.4	Trace
23	Band	2,360 feet outby face of No. 6 entry, 30 mains (intake airway, explosion area)	53.9	Trace
24	Band	2,280 feet outby face of No. 5 entry, 30 mains (haulage road, open parallel, explosion area)	57.6	Small
25	Band	2,040 feet outby face of No. 4 entry, 30 mains (intake airway, explosion area)	75.8	None
26	Band	3,100 feet outby face of No. 8 entry, 30 mains (return airway, explosion area)	55.5	Small
27	Band	3,020 feet outby face of No. 7 entry, 30 mains (return airway, explosion area)	34.6	Small
28	Band	3,000 feet outby face of No. 6 entry, 30 mains (intake airway, explosion area)	57.7	Small

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
29	Band	2,920 feet outby face of No. 5 entry, 30 mains (haulage road, open parallel, explosion area)	51.9	Trace
30	Band	2,740 feet outby face of No. 4 entry, 30 mains (intake airway, explosion area)	61.3	None
31	Band	2,800 feet outby face of No. 3 entry, 30 mains (intake airway, explosion area)	46.7	None
32	Band	40 feet inby first overcast No. 3 entry C face west (intake airway, explosion area)	73.4	None
33	Band	10 feet inby C face west overcast No. 1 entry, 30 mains (haulageway, explosion area)	71.2	None
34	Band	3,840 feet outby face of No. 8 entry, 30 mains (return airway, explosion area)	48.2	Very large
35	Band	3,642 feet outby face of No. 7 entry, 30 mains (return airway, explosion area)	47.6	Small
36	Band	3,180 feet outby Moore shaft No. 6 entry, 30 mains (intake airway, explosion area)	58.9	Trace
37	Band	3,800 feet outby face of No. 5 entry, 30 mains (haulage road, explosion area)	81.4	None
38	Band	2,660 feet outby face of No. 2 entry, 30 mains (intake airway, explosion area)	38.5	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
39	Band	2,500 feet outby face of No. 1 entry, 30 mains (haulage road, explosion area)	91.1	Trace
40	Band	4,640 feet outby face of No. 3 entry, 30 mains (return airway, explosion area)	83.3	None
41	Band	4,740 feet outby face of No. 2 entry, 30 mains (return airway, explosion area)	55.2	None
42	Band	40 feet inby No. 6 entry B face west along No. 5 entry, 31 butt (return airway, explosion area)	69.4	None
43	Band	980 feet outby first overcast C face west along No. 1 entry, 30 mains (return airway, explosion area)	63.9	None
44	Band	1,090 feet inby B face west along No. 5 entry, 31 butt (return airway, explosion area)	99.5	None
45	Band	1,020 feet inby B face west along No. 4 entry, 31 butt (return airway, explosion area)	84.0	None
46	Band	1,020 feet inby B face west along No. 3 entry, 31 butt (return airway, explosion area)	78.5	None
47	Band	1,030 feet inby B face west along No. 2 entry, 31 butt (return airway, explosion area)	66.3	None
48	Band	5,640 feet outby face No. 5 entry, 30 mains (intake airway, open parallel)	89.8	None
49	Band	5,300 feet outby face No. 6 entry from Moore shaft, 30 mains, (haulage road, open parallel)	62.1	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
50	Band	5,800 feet outby face No. 4 entry, 30 mains (haulage road, open parallel)	57.0	None
51	Band	5,425 feet outby face No. 3 entry, 30 mains (return airway)	58.9	None
52	Band	5,500 feet outby face No. 2 entry, 30 mains (return airway)	50.6	None
53	Band	460 feet first overcast B face west along No. 1 entry, 30 mains (return airway)	73.2	None
54	Band	5,040 feet outby face No. 8 entry, 30 mains (return airway)	57.4	None
55	Band	4,360 feet outby face No. 7 entry, 30 mains (return airway)	93.6	None
56	Band	4,920 feet outby face No. 6 entry, 30 mains (return airway)	52.9	None
57	Band	4,260 feet outby face No. 5 entry, 30 mains (intake airway)	77.3	None
58	Band	4,680 feet outby face No. 4 entry, 30 mains (intake airway)	64.6	None
59	Band	90 feet outby face No. 1 entry 33 butt along No. 1 entry C face west (return airway)	60.4	None

TABLE 2. - Analyses of mine dust samples collected after explosion (Con.)

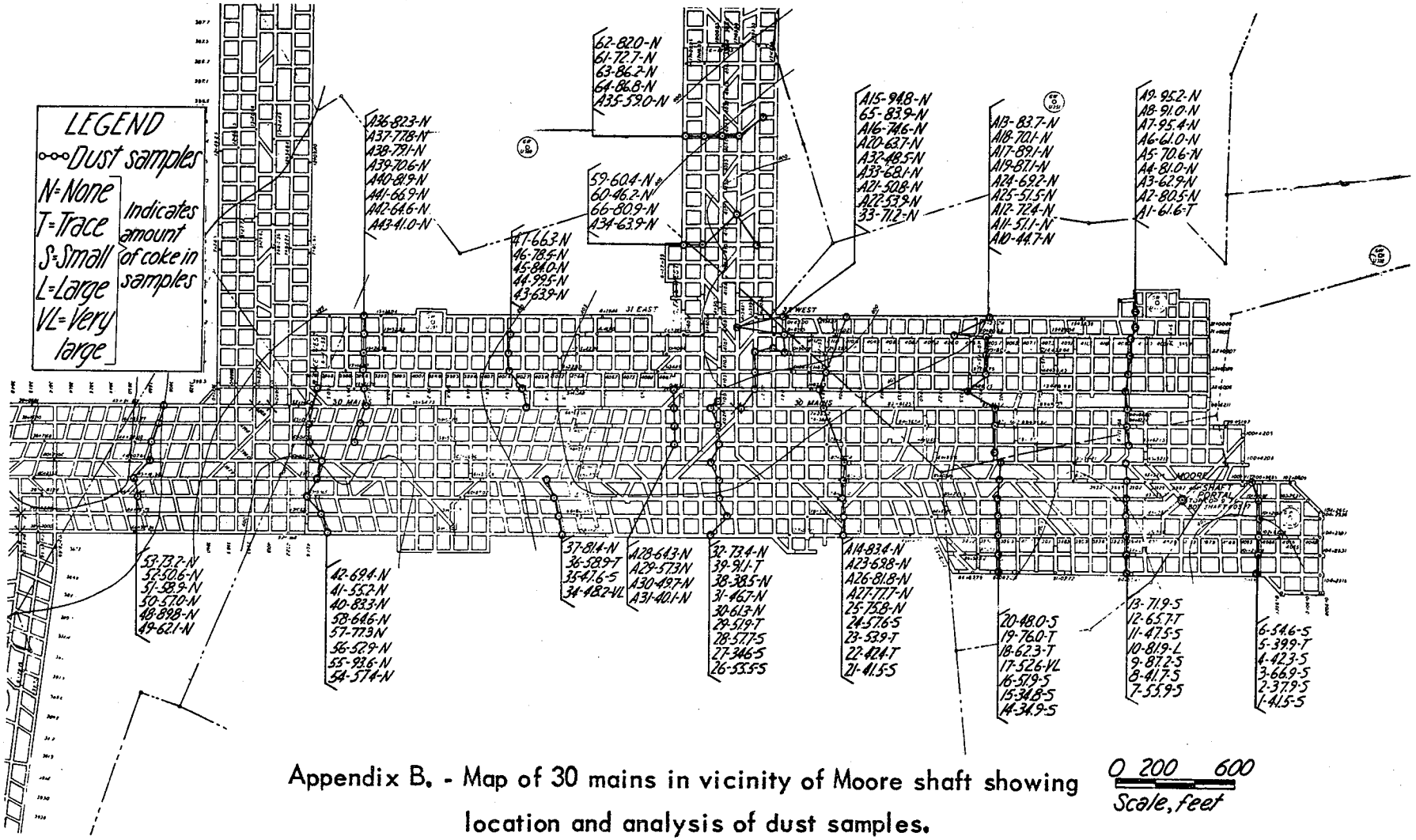
Sample No.	Sample of dust from	Location in mine	As-received percent incombustible	Alcohol coke test Amount of coked particles present
60	Band	180 feet outby face No. 1 entry 33 butt along No. 2 entry C face west (return airway)	46.2	None
61	Band	1,320 feet inby C face overcasts along No. 2 entry C face west (return airway)	72.7	None
62	Band	1,320 feet inby C face overcasts along No. 1 entry C face west (return airway)	82.0	None
63	Band	1,320 feet inby C face overcasts along No. 3 entry C face west (haulage road, open parallel)	86.2	None
64	Band	1,320 feet inby C face overcasts along No. 4 entry C face west (intake airway)	86.8	None
65	Band	400 feet inby C face west overcasts along No. 4 entry C face west (intake aircourse)	83.9	None
66	Band	960 feet inby C face west overcasts along No. 4 entry C face west (intake aircourse)	80.9	None

Appendix A

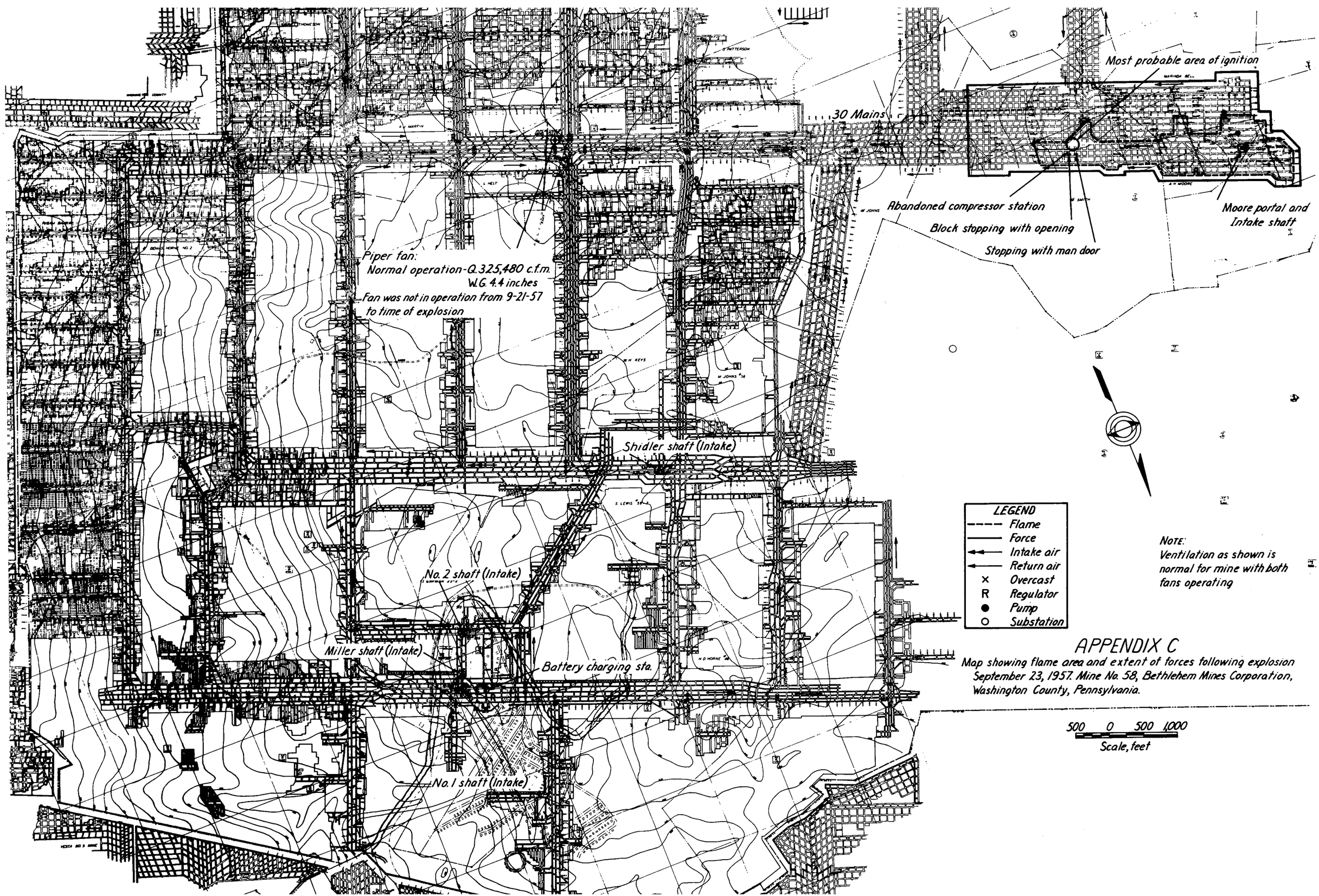
Victims of Explosion, Marianna No. 58 mine
Bethlehem Mines Corporation
September 23, 1957

Name	Age	Occupation	Years experience in this occupation	Years experience in coal mines	Marital status	Dependents
Stanley Collins	56	Fire Boss	23	33	Married	Wife
Joe Smith	58	Pumper	27	37	Married	Wife
George Demko	56	Assistant Foreman	10	29	Widower	None
Phillip P. Kornet	43	Assistant Foreman	9	27	Married	Wife and 3 children under 18
George A. Harmuth	44	Assistant Foreman	6	8 1/	Married	Wife and 3 children under 18
James L. Wright	57	Assistant Foreman	6	29	Married	Wife

1/ Record of mine experience other than that at Marianna No. 58 mine not available.

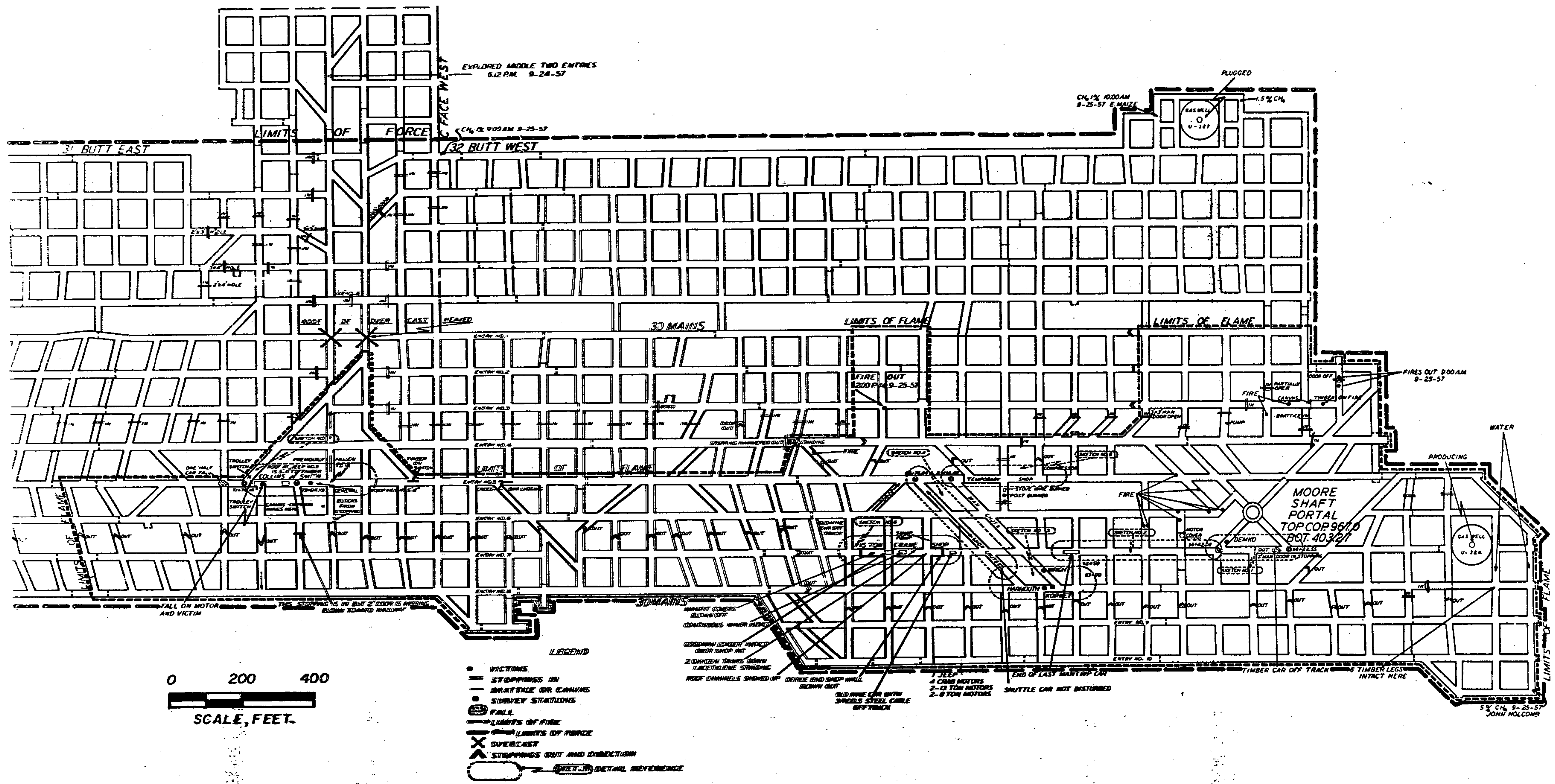


Appendix B. - Map of 30 mains in vicinity of Moore shaft showing location and analysis of dust samples.

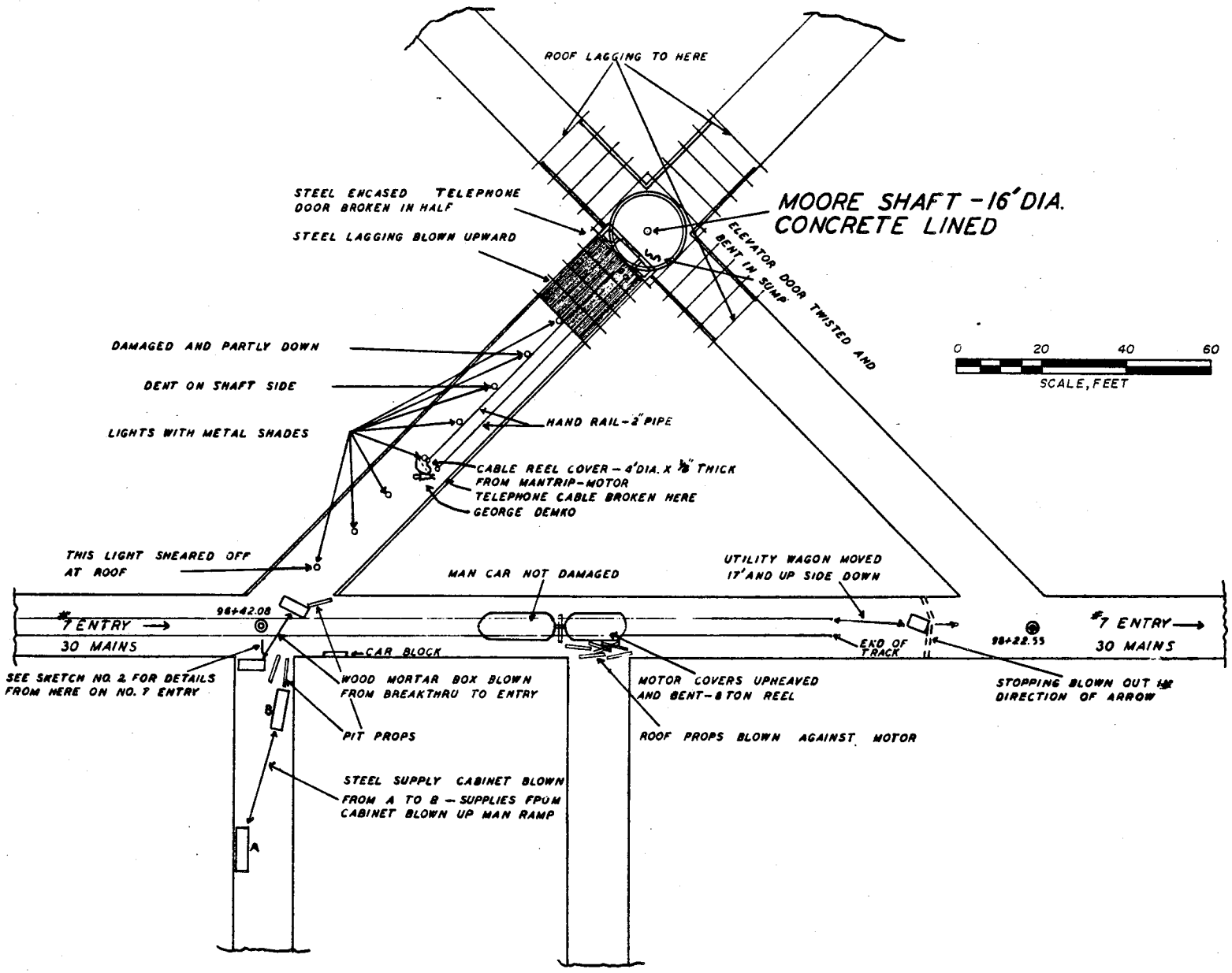


APPENDIX C

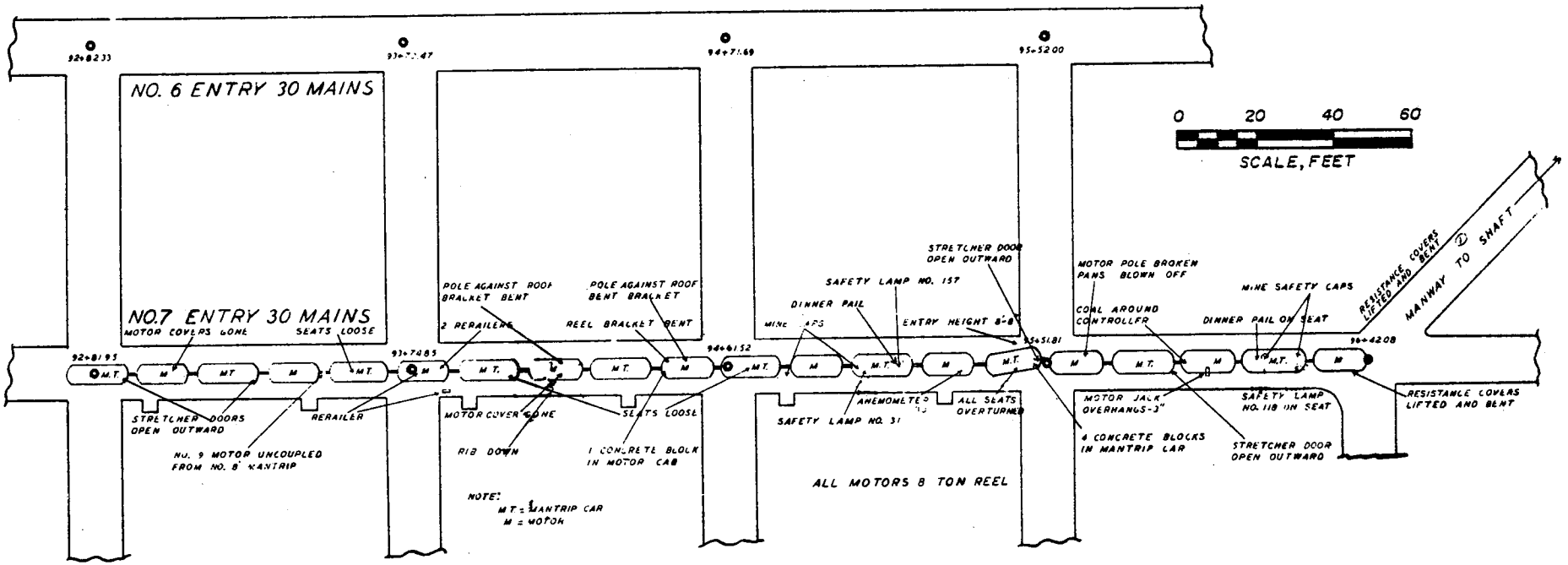
Map showing flame area and extent of forces following explosion September 23, 1957. Mine No. 58, Bethlehem Mines Corporation, Washington County, Pennsylvania.



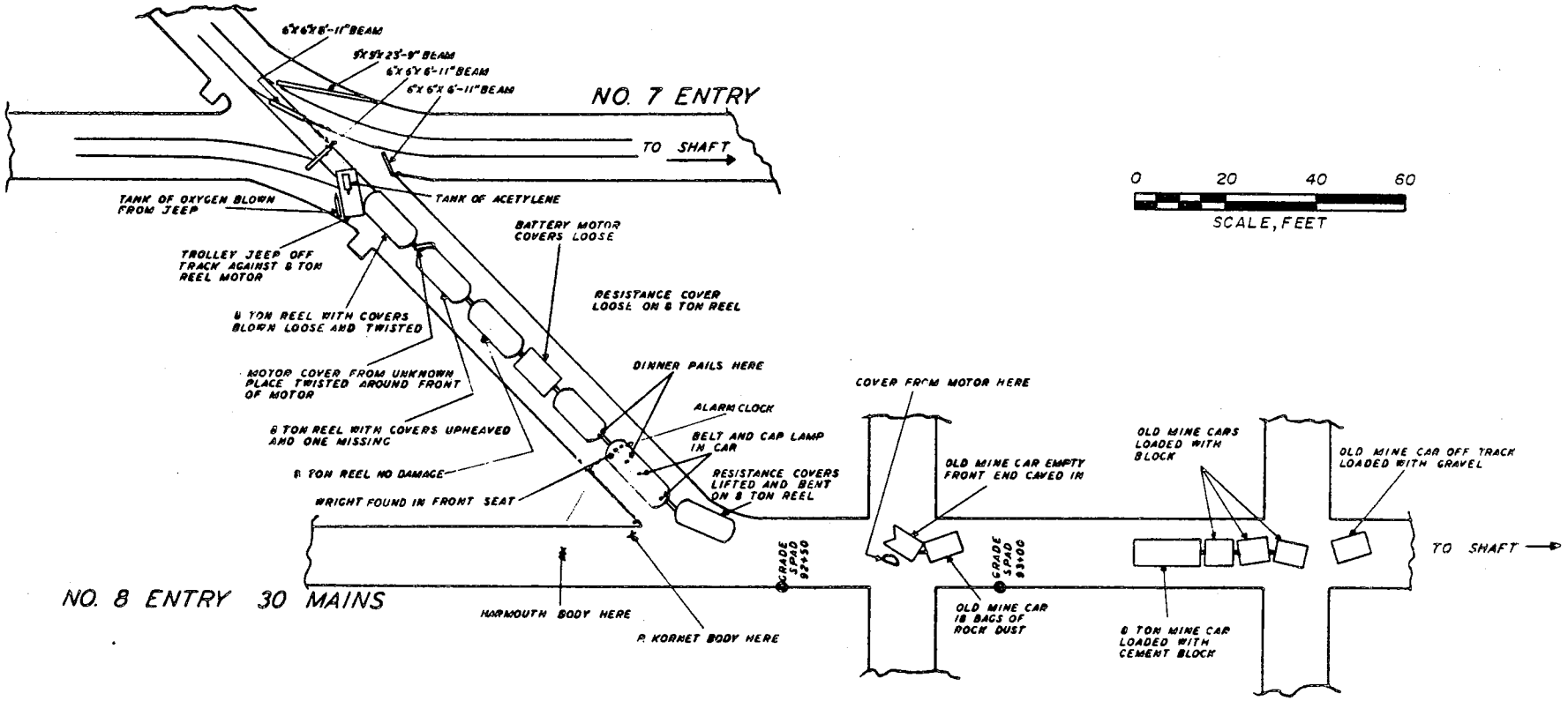
Appendix D. - Map showing explosion area, direction of forces, and location of detail sketches within explosion area.



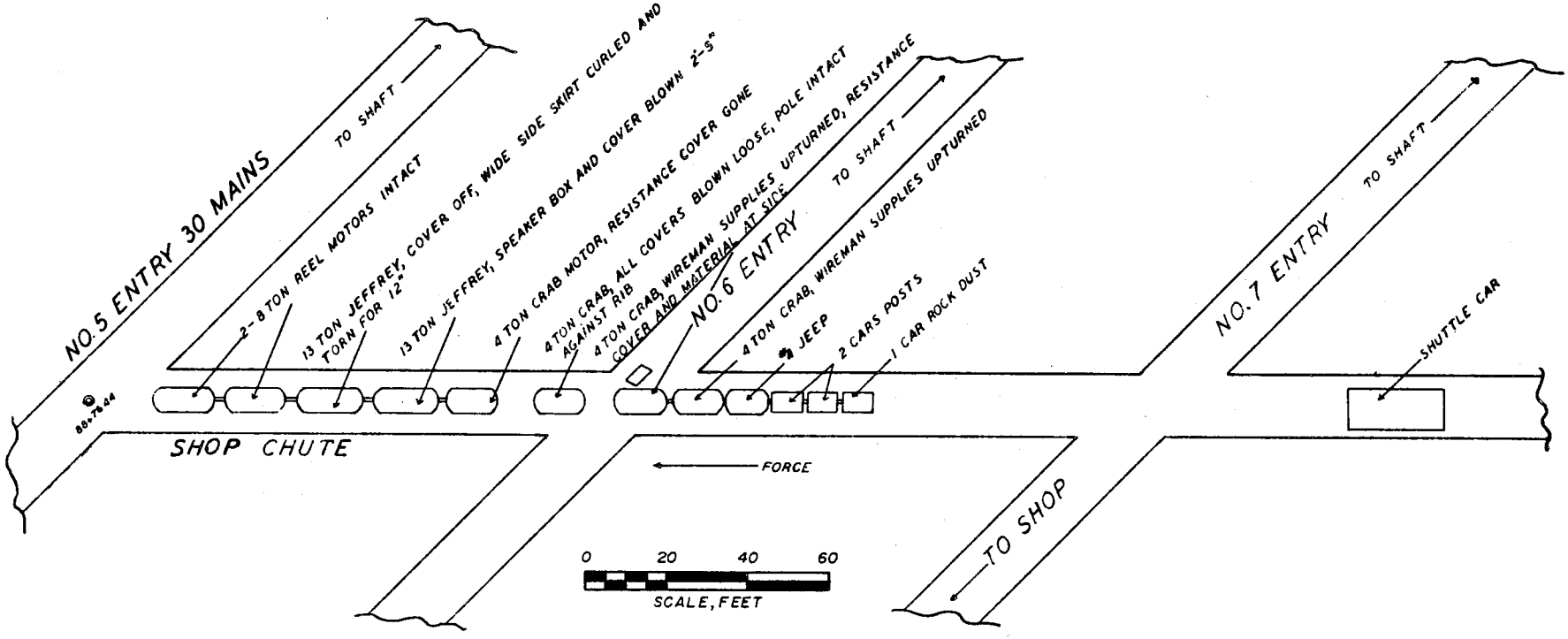
Sketch No. 1. - Detail drawing of shaft bottom.



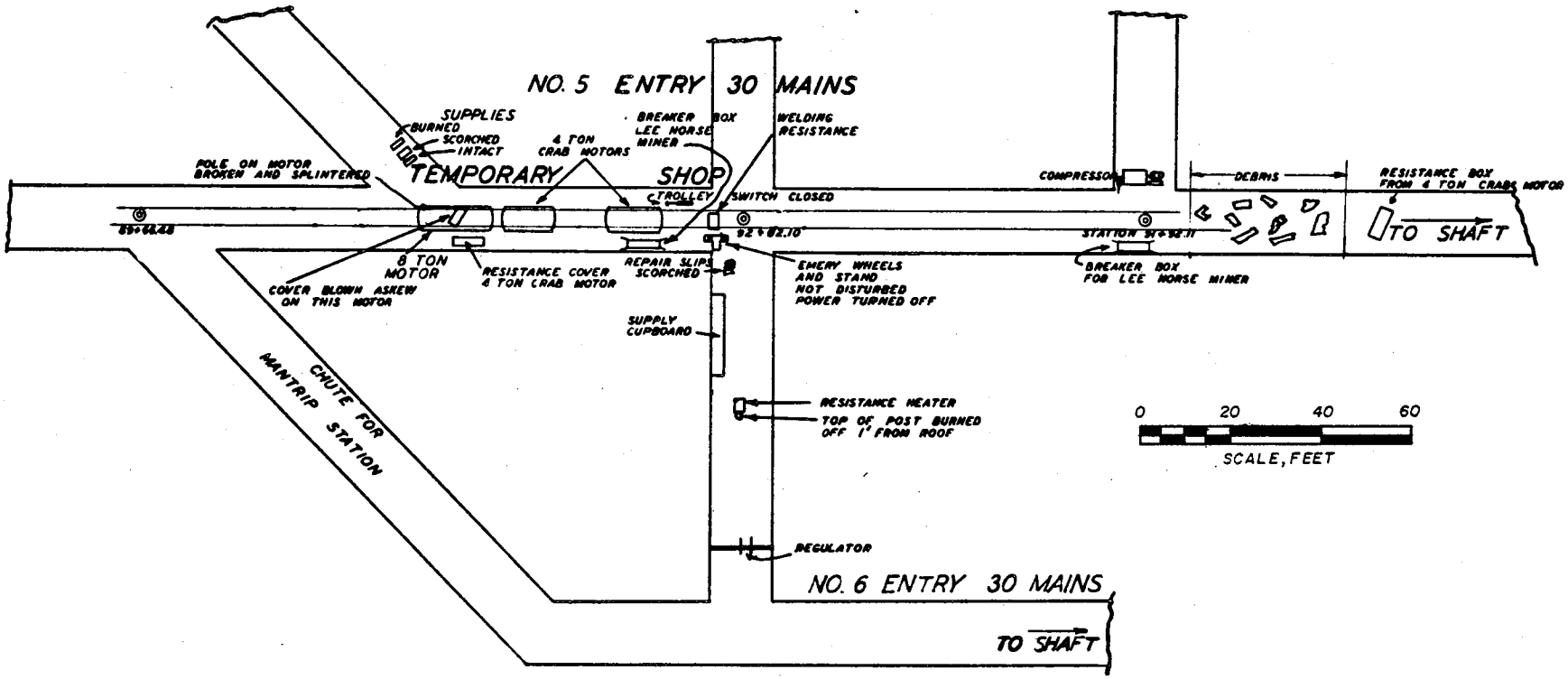
Sketch No. 2. - Detail drawing of man trip in No. 7 entry near shaft bottom.



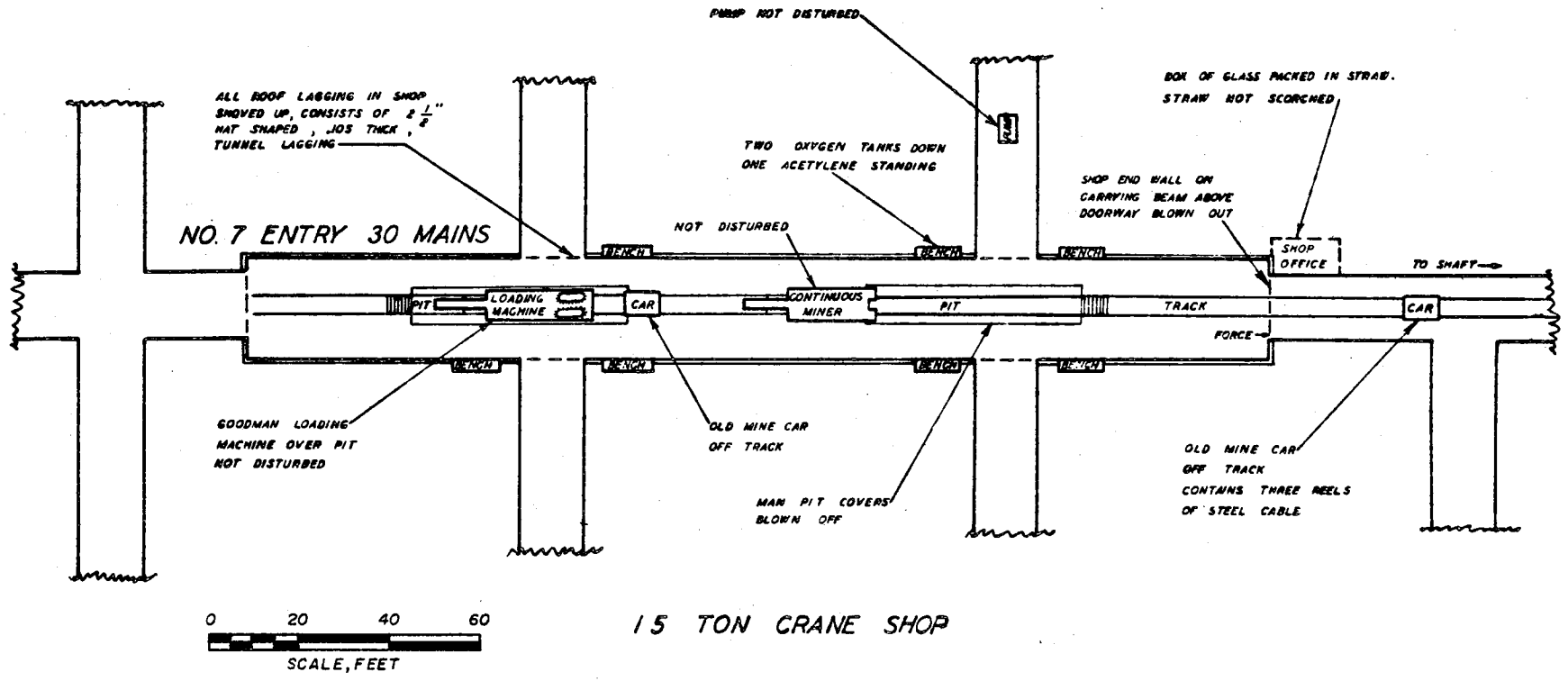
Sketch No. 3. - Detail drawing of man trip in man chute near 15-ton crane shop.



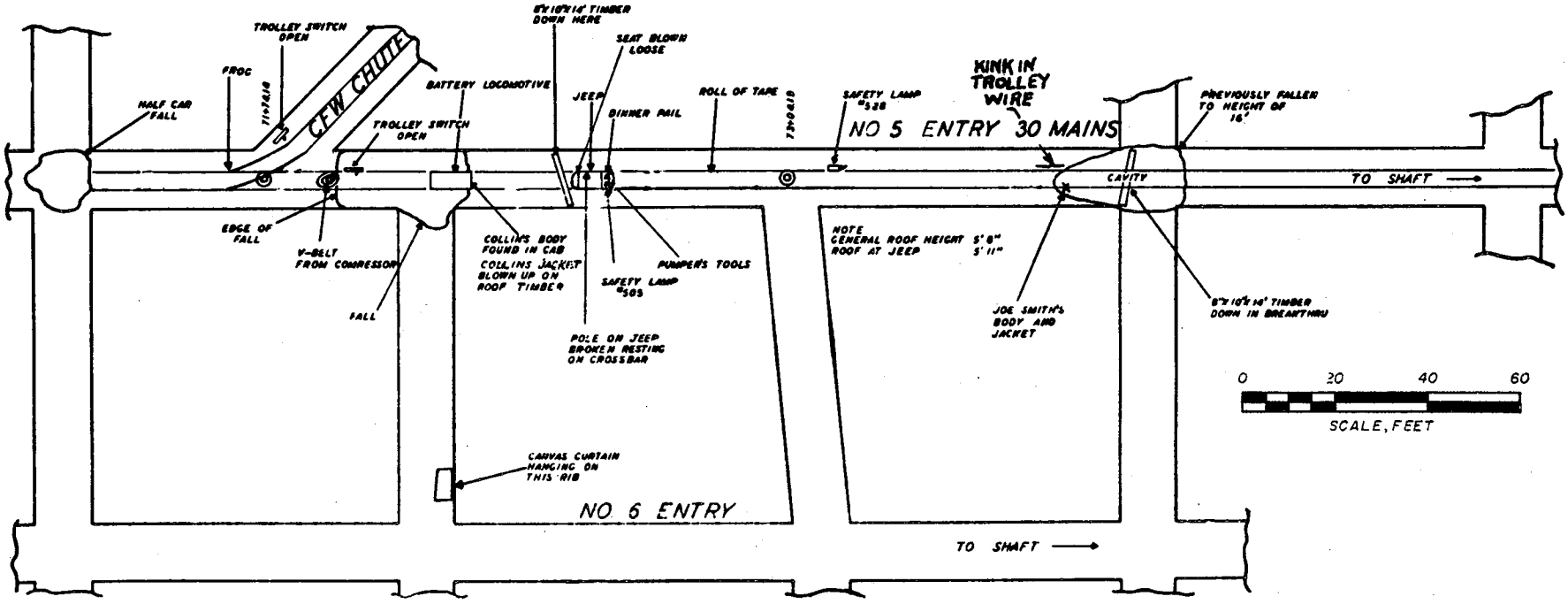
Sketch No. 4. - Detail drawing of shop chute.



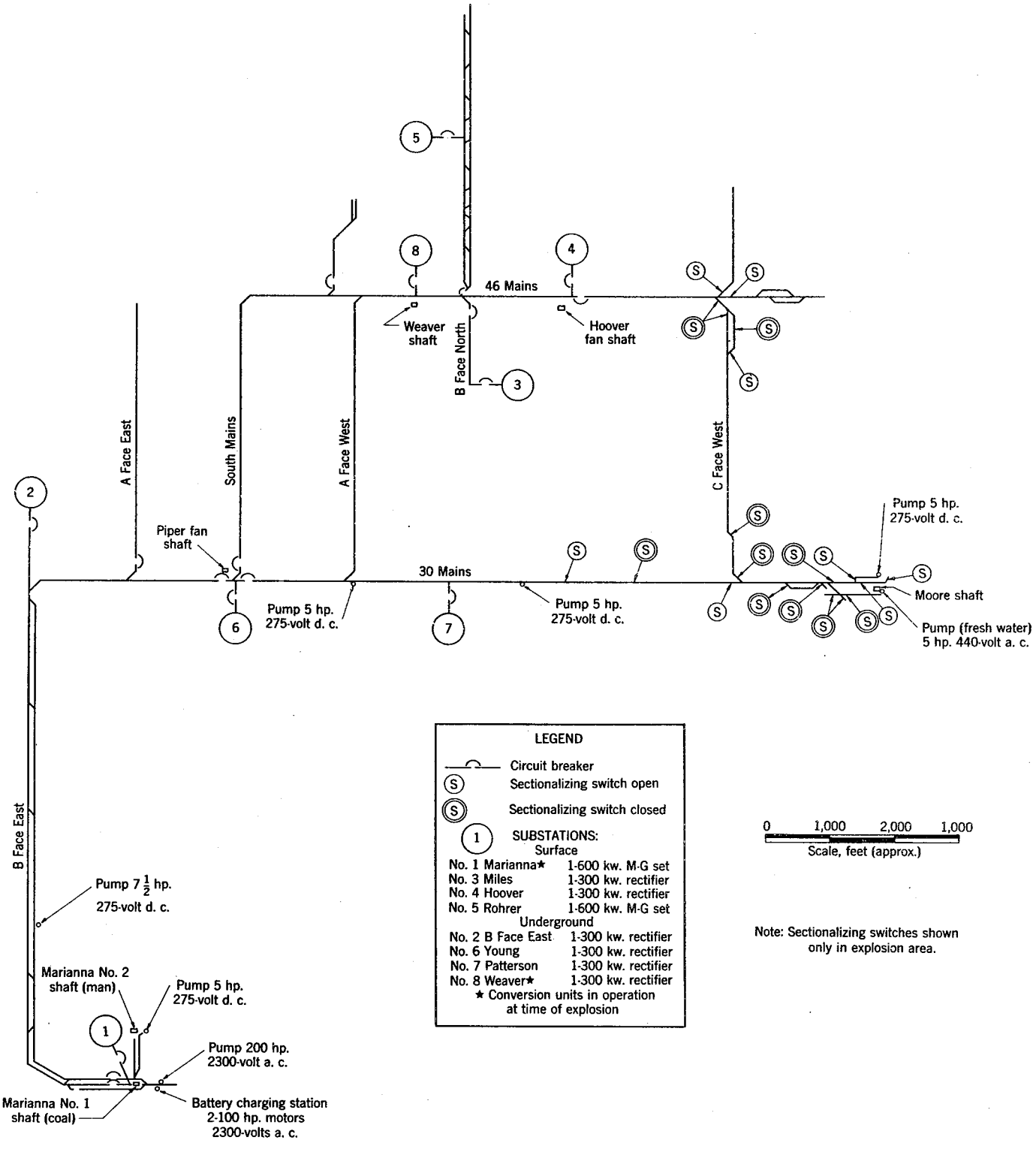
Sketch No. 5. - Detail drawing of temporary shop.



Sketch No. 6. - Detail drawing of 15-ton crane shop.



Sketch No. 7. - Detail drawing of No. 5 entry in ignition area.



Appendix E. - Electrical power distribution plan.