DEPARTMENT OF COMMERCE
BUREAU OF MINES

FINAL REPORT OF EXPLOSION, KEYSTONE NO. 2 MINE, KEYSTONE COAL AND COKE CO., KEYSTONE, McDOWELL COUNTY, WEST VIRGINIA, APRIL 2, 1926.

By

S. P. Howell, Explosives Engineer, and
Jesse Hedyard, Foreman Miner Car 7.

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INTRODUCTION.

A gas and dust explosion occurred in the Keystone No. 2 mine of the Keystone Coal and Coke Company, Keystone, McDowell County, West Virginia, about 10:30 a.m. Monday, April 2, 1928 during the day shift. There were 120 men in the mine at the time of the explosion and an additional 100 men in the adjacent connected Keystone mine No. 1. There were 8 fatalities and none injured. The names of the men killed are given in the appendix. All others escaped.

The probable cause of the explosion was the ignition by a carbide lamp of a body of gas, said gas having been forced down off the gob, against the air current by a major fall or cave of rock. The explosion was localized yet it was propagated to some extent by coal dust. No rock dusting had been done in the mine. It was stated that all working places and all entries outby these places, if used for haulage or traveling, were watered weekly.

The writers arrived at Keystone on April 9th to investigate the explosion. They attended the coroner's inquest; were

underground three days and procured gas, dust and explosives samples.

LOCATION.

Keystone No. 2 mine is 1 1/2 miles northeast of Keystone, McDowell County, W. Va., in the Pocahontas Coal Field, North Fork Township, Elkhorn Mining District. The tipple is about 1 1/2 miles from the mine haulage opening at Keystone on the Norfolk and Western Railway.

The main office of the Keystone Coal and Coke Company was in the Union Trust Building, Cincinnati, Ohio, with T. E. Houston, president, N. H. Franklin, general manager and purchasing agent, John N. Lewis, mining engineer.

It was currently reported that the mine had been acquired the day of the explosion by the Koppers Coal Company of Pittsburgh, Pa.

EMPLOYEES.

Normally Keystone mine No. 2 employed 150 men of whom 120 worked underground.

The daily production averaged about 1,000 tons.

OPENINGS.

This mine had four surface openings, all air intakes, three being drift and one a 280 foot shaft opening. The return air passed through certain entries of mine No. 1 to the exhaust fan, which was also the exhaust fan for mine No. 2.

COAL BED.

The Pocahontas No. 3 coal bed is being mined. It is a low-volatile, friable bituminous coal. The bed averages 5 feet thick and is level. There is a bone parting in the middle of the seam averaging 3 inches thick. In the explosion section a 14 inch "rider" of coal occurs 9 to 18 feet above the bed. This "rider" joins the coal bed a short distance inby the haulage opening so here at the outcrop the coal averages 6 feet, 2 inches thick.

The immediate roof is draw slate which usually requires considerable timbering in entries and rooms. Above the coal "rider" is some 20 feet of blue slate or sandstone.

The immediate bottom is slate which "stands up" well.

MINING METHOD.

Coal is mined by the room and pillar method. About 25 per cent of the coal is mined on the advance. The four main entries in the vicinity of the explosion are driven in pairs on 60 foot centers with a 75-foot pillar between pairs of entries. These four main entries are protected by barrier pillars of about 225 feet. Rooms 18 feet wide on 60 foot centers are driven 275 to 300 feet deep from cross entries 14 feet wide on 60 foot centers. The cross entries extend some 800 feet from the barrier entry - designated D entry - to the butt off along the property line.

A very large percentage - say 70 per cent - of the coal is won on the retreat. The breakline is 45° off both the rooms

and entries. Rooms are driven from entry to entry and both rooms and cross entries are finished just prior to their need for use as haulageways.

The pillars are worked by the "pocket and wing" system, the 14 foot wide "pockets" are worked toward the gob and are parallel to either the rooms or cross entries. The 6-foot "wings" are worked toward the gob from the "pocket" side.

Advanced mining is with machines. On the retreat the "pockets" are undercut, but the "wings" are either undercut by hand or slabbed.

It was stated 98 per cent of the coal is extracted and that no coal has been lost by squeezes.

No coal is loaded with mechanical loaders or conveyors.

Considerable timber is required. In the 14-foot wide entries and pockets, two rows of posts spaced 8 feet are used. Two or three rows of posts are used in the rooms.

VENTILATION AND GASES.

The mine was ventilated by a Capell reversible exhaust fan and by four splits. The fan was 18 by 8 feet direct connected to a 550 volt D.C. 160 horsepower Westinghouse motor of 142 r.p.m. The section in which the explosion occurred was ventilated by the right "pinnacle" split. This air entered at the "pinnacle" intake, passed through one or another of the main entries for some 4500 feet to a booster fan located in a crosscut between 3 main and 4 main entries. This fan was 6 by 3 feet and was belt driven by an

open type 25 horsepower Westinghouse motor operating on 550 volts direct current. It was operated continuously. At the outlet of this fan the air was split into a right and left "pinnacle" split. The right split moved along 4th mains to a cross over, from here to D entry and ventilated working faces of D entry, 37 cross entry to 35 cross entry, passed down both of the 34 cross entries to the butt-off, to the face of the butt-off entries, along the butt-off back entry to the gob line, along the gob line to 29 cross entry to 3 mains. A door just outby 34 cross entry and minor splits just inby the butt-off and gob line permitted some air to ventilate the D entry haulageway and the working places off 32 and 31 cross entries.

The exhaust fan had a capacity of 120,000 cubic feet per minute (118,020 cubic feet on April 12, 1928). On March 27, 1928 the right "pinnacle" split was delivering 18,000 and the left "pinnacle" split 16,500 cubic feet per minute.

After the explosion a re-arrangement of stoppings and doors directed more of the air which passed through the booster fan into the section previously ventilated by the right "pinnacle" split. On April 11, 1928 this split carried 20,400 cubic feet per minute. The return from the gob section carried 14,700 cubic feet of air as measured on April 10, 1928 on 29 cross entry 50 feet inby 4 main. This represents a loss of about 28 per cent of the air entering the split and indicates the need for tighter stoppings, and double doors along D entry. The main return carried 0.23 per

cent methane or a total of 390,870 cubic feet of methane per 24 hours.

The split carried the following percentages and quantities of methane at the indicated locations:

Location	Methane Percentage.	Methane, cubic feet per 24 hours.
At outlet of booster fan	0.07	20,560
In butt-off at gob line	.15	22,940
In 29 crosscut entry	.23	48,690

The mine was rated as gassy. It generated explosive gas and two fire bosses were employed.

The analyses of the four samples of mine air are given in Table 1. The gas analyses reports are given in the appendix.

HAULAGE.

The track gauge is 44 inches. The rails are 60 pounds on main line haulage and 25 or 30 pounds on entries and other haulage. The clearance averages 18 inches. The three ton cars are of the end gate type, steel with wooden bottoms.

Main line haulage was on intake air using 550 volts, direct current. For gathering, haulage was by five Westinghouse and one Jeffrey trolley locomotives of the non-permissible open type and by three Ironton non-permissible storage battery locomotives. Mules were also used for gathering purposes. The three electric locomotives used for main line haulage were of 110 horsepower Westinghouse open type.

TABLE NO. 1

ANALYSIS OF MINE AIR, KEYSTONE NO. 2 MINE, APRIL 1928.

Date 1928	Sample No.	Lab. No.	Analysis, percentage by volume CO_2	O_2	CO	N_2	CH_4	Wet bulb °F	Dry bulb °F	Relative Humidity	Cubic Ft. air per minute.	Cubic Ft. CH_4 per 24 hours.	Remarks
4/12	108	48224	0.19	20.62	-	78.96	0.23	57	58	94	118,020	390,870	In main return from mine 1 and 2, 75 feet inby exhaust fan
4/10	110	48225	0.19	20.55	-	79.03	0.23	59	60	94	14,700	48,690	In 29 cross entry 50 feet inby 4 main return from explosion section
4/11	117	48226	0.05	20.87	-	79.01	0.07				20,400	20,560	In 4 main 100 feet from booster fan exhaust. Intake to explosion section
4/10	115	48227	0.11	20.83	-	78.91	0.15	58	59.5	91	10,625	22,940	In butt-off at 31 cross entry. Origin of explosion

LIGHTING.

There were no fixed lights. "Motors" carried oil torches or arc lamps. Open flame carbide lamps were in general use. Foremen, fire bosses and the safety inspector carried non-permissible flame safety lamps for inspection purposes.

MACHINERY UNDERGROUND.

Beside the non-permissible electrical locomotives mentioned under Haulage, there wereused two Jeffrey arc-wall undercutting machines, permissible type; three Westinghouse non-permissible electric pumps; and a 6-foot booster fan belted to a 25 horsepower Westinghouse non-permissible motor.

The current used for all these motors was 550 volts direct current.

The power lines entered the mine through the 280 foot shaft to D entry and 27 cross entry. Main haulage was on intake air. Some of the cable reel gathering motors operated on return air from the section involved in this explosion.

The trolley lines were not guarded at crossovers.

EXPLOSIVES.

(a) Use.

The permissible explosives Black Diamond No. 15 and Monobel No. 9 L.F. each in 1 1/4 by 8 inch cartridges and 3 F black blasting powder were used in mining the coal. The permissibles were fired with 6-foot iron wire No. 6 electric detonators; the black blasting powder was fired with squibs. Miners fire

shots at any time during the shift.

40 per cent ammonia dynamite - 1 1/4 by 8 inches - is used by the rock gang for both inside and outside work and is fired with No. 6 detonators and Crescent brand fuse.

The legs of the electric detonators are not electrically short-circuited.

The black blasting powder is used in pillar work. For instance the miners working in a "pocket" off Room 3 off 31 cross entry was using black blasting powder.

The permissible explosives are used by miners in 1 1/2 inch diameter by 5 1/2 feet deep holes in faces which are undercut 6 feet. Three holes are used in 18-feet wide rooms and two or three holes in 14 feet wide entries. The holes bottom two to three inches below the slate and an average of two cartridges (0.59 to 0.70 pounds) per hole was used.

Clay was used for stemming.

Current for firing was from Willard dry cell batteries with recessed terminals.

Field samples of Black Diamond No. 15 and of Monobel EXPLOSIVES No. 9 L.F. were procured from the company magazine near Keystone, W. Va.; were submitted to a limited number of the safety tests which these brands passed when submitted by the manufacturers to determine their permissibility and each passed within the tolerances all the tests made upon them.

C. Kendrick, a miner who used black blasting powder testified that sometimes after a shot the gas lights if he does not "fan" shot or brush out the gas.

(b) Surface storage.

1. The distributing magazine was located about 550 feet down Burke Hollow from the mine entrance and was between 160 and 250 feet from three inhabited dwellings, one a boarding house. It had 18 inch walls of sandstone and a 6-inch reinforced concrete roof. It contained-

1550 pounds of black blasting powder,
100 pounds of pellet powder,
400 pounds of 40 per cent ammonia dynamite,
450 pounds of Black Diamond No. 15 (permissible),
250 pounds of Monobel No. 9, L.F. (permissible),
1950 No. 6 electric detonators,
1650 No. 6 detonators,
2000 feet of fuse,
A few small fibre or wood high explosive carrying boxes,
A few metal jacks or boxes for explosives and
one 18-inch steel hand crowbar.

The magazine was clean and good housekeeping prevailed. Miners and other employees are permitted to take boxes and empty powder kegs home.

Explosives are delivered weekly from the storage magazine.

2. The storage magazine was located about one mile down Burke Hollow from the mine entrance and was situated from dwelling houses as follows:

150 feet from one house

250 feet from six houses

500 feet from fourteen houses. It was similar in construction to the distributing magazine. It contained:

1250 pounds of 40 per cent ammonia dynamite,

1650 pounds Monobel No. 9 L.F. (permissible),

9000 pounds 3 F black blasting powder and

1500 No. 6 electric detonators.

The black blasting powder was purchased in carload lots about twice a year; the permissible explosive was purchased in two ton lots about every two months; the electric detonators were purchased in lots of 10,000 about every two months.

The magazine was clean and good housekeeping prevailed.

DRAINAGE.

The mine is naturally dry except in dip workings, such as "swags". Three electrically driven pumps were in use.

DUST.

But very slight quantities of coal dust were found on ribs, roof or timbers. It was therefore not feasible to procure such samples. Much fine dust was found on the floor in certain places such as in 33 and 34 cross entries and especially on the butt-off (sample 197). Much coarser coal and coal dust was found along the haulageways (A-49, 151, F-766 and H-979).

Cross entries 30, 31, 32, 35, 36, 37 and 38 and their working places, D entry, 37 and 32 side tracks and the main entries were generally intermittently watered and were found to be generally moist to wet with occasional pools of water. The most recent watering in these sections was on March 29, 1926. The plan was to water any given place an average of once a week with hose and spray nozzle from a 2-inch water line under a head of about 280 feet. The water tank was located near the collar of the shaft, the 2-inch line passing down the shaft.

The four samples of road dusts averaged 22.3 per cent ash varying from 11.4 to 26.4 per cent. The fine dust collected from the flat slate falls in the butt-off (sample 197) contained 9.1 per cent moisture and 21.9 per cent ash. 53.7 per cent of this 20 mesh dust passed through 200 mesh.

The record of the road, settled dust, and coke samples taken is given in Table 2 and by detailed sheets in the appendix.

To prevent the propagation of an explosion the dust of this mine should contain not less than 50 per cent of incombustible rock-dust.

ROCK-DUST.

The mine had not been rock-dusted. It is now planned to rock-dust the mine, two high pressure rock-dusting machines having been ordered.

SALIENT CONDITIONS IMMEDIATELY PRIOR TO EXPLOSION.

The mine had been idle for the three days March 30, 31 and April 1, and as no watering was done on these days the mine

TABLE NO. 2

RECORD OF ROAD AND SETTLED DUST, AND COKE SAMPLES,
KEYSTONE NO. 2 MINE, APRIL 1928.

Sample No.	Lab. No.	Kind of sample Location where taken Remarks	Proximate analysis, as received					V / V+FC	Fineness %			
			Moisture	Volatile Matter	Fixed Carbon	Ash	Ash + H_2O		Thru 20 mesh	100 % through 20 mesh. What % through 48	100	200
A-49	A-41676	Road dust. 145 feet in room 2 off 32 cross entry. Coke particles present, large amount but less than sample 197	4.0	14.4	55.2	26.4	30.4	0.207	57.8	47.4	23.0	11.9
H-806	A-41681	Coke. From rib 156 feet in room 3 off 32 cross entry	.8	9.2	71.8	18.2	19.0	-	-	-	-	-
151	A-41677	Road dust. 3rd main just outby 32 side track. No coke particles present	1.6	14.7	58.7	25.0	26.6	.201	67.9	53.7	26.5	17.1
197	A-41678	Floor of aircourse, settled out of ventilating current. From butt-off at head of 32 cross entry off 20 sq. ft. of flat slate on floor. Top brown in color. 16 grams per sq. ft. collected. Coke particles present, large amount	9.1	10.0	59.0	21.9	31.0	.145	93.1	89.4	73.8	53.7
F-766	A-41679	Road dust on 32 cross entry at room 2. Coke particles present, small amount	3.7	16.8	68.1	11.4	15.1	.198	63.5	52.6	27.9	17.3
H-979	A-41680	Road dust. 30 feet from 4 main between 4 main and D entries on 31 cross entry aircourse, used as haulageway. No coke particles present.	2.7	14.0	56.9	26.4	29.1	.197	77.4	59.4	33.9	20.0

was undoubtedly dryer than usual. The mine was working on April 8, the day of the explosion.

The main fan and the booster fan were both operating.

The fire boss had found no gas in the mine the morning of the explosion and had it so noted in the fire bosses book. He testified that he had tested on the gob near the origin of the explosion that morning.

A gas feeder was under observation on D entry between 33 and 34 cross entries the morning of the explosion, the safety inspector, Fred Platzer, being here at the time of the explosion. Mine Foreman Dillon had tested at this gas feeder about 10 minutes before the explosion but could not find any gas. The writers tested here for gas and could not detect any with a flame safety lamp.

PREVIOUS EXPLOSIONS.

No explosions had occurred previously in Keystone No. 2 mine.

In the adjacent Keystone No. 1 mine it was stated that about 1906 a foreman carrying a torch walked into gas in an old entry the resulting explosion causing, say 7 fatalities. Additional information regarding this explosion was not available.

PROPERTY DAMAGE.

The principal property damage was the blowing out of some 76 board stoppings, 7 doors and general roof falls. The property damage was estimated at $10,000. Operations were to be

resumed in this section as soon as safety lamps were installed say about April 23, 1928.

DETAILS OF INVESTIGATION (See map in Appendix).

There was practically no evidence of force near the assigned origin of the explosion; the bodies or clothing of the five men (No. 1 to 5) showed no evidence of force; cars and locomotive were not moved; carbide lamps were on the locomotive; a loose block at the base of a post was not overturned. The destruction of some 83 board stoppings and doors showed that the force radiated from the butt-off (Room 1) and 33 and 34 cross entries with the greatest violence down 33 cross entry where Poole (No. 7) died of traumatic injuries. Mine Foreman Dillon, at the mouth of 5th left was blown, or fell, down by the rush of air and dust. The experience of Assistant Mine Foreman White, also at this location, was similar.

The six men (No. 1 to 5, 7) were badly burned; there was considerable coke found on the ribs in rooms 1, 2, 3, 4 and 5 off 32 cross entry, on top of the cars in the pockets between rooms 1 and 2 and in the butt-off between 31 and 32 cross entries. In the crosscut and the two "pockets" between rooms 1 and 2 adjacent to 31 cross entry the timbers were charred.

There was no evidence that explosives had burned or exploded, or that electric arcs were formed.

The principal zone of coal dust combustion appeared to be localized within 300 feet of the butt-off and 31 cross

entry with an extension down room 1 (the butt-off) and possibly down 33 and 34 cross entries.

The following are suggested by the writers as the probable causes of the limitation of the propagation of the explosion:-

(a) The very small amount of fine dust on ribs, roof and timbers in 30, 31 and 32 cross entries and their rooms due to washing it down.

(b) The expansion into nearby rooms and their entries.

(c) The relatively low ratio of volatile to total combustible in the road dust as shown by samples A-49 and B-766, namely, 0.202.

(d) The high ash content of the road dust as shown by these samples, namely, 18.9 per cent.

(e) The pools of water, such as the one in 33 cross entry.

(f) The very low ratio of volatile to total combustible, and the high ash and moisture content of the very fine dust which settled from the air current in the butt-off and represented by sample 197. These values are respectively: ratio 0.145, ash 21.9 per cent, moisture 9.1 per cent, 93.1 per cent of the sample passed through 20 mesh and of that portion 53.7 per cent was through 200 mesh.

(g) It is also possible that the gas explosion was not as violent as it might have been.

The maximum moisture content of the road-dust samples was 4.0 per cent (sample A-49); the average moisture was 3.0 per cent. The average moisture content of coals from Pocahontas No. 3 bed in McDowell County, W. Va. is given as 2.4 per cent in the coal catalogue.

STATE INSPECTORS' CONCLUSIONS.

The state inspectors and the operating mine officials concluded that the explosion originated in or near the butt-off at 31 cross entry and was probably caused by methane being forced onto an open light, said methane being released and moved from the gob by a fall of rock.

The state inspectors recommended permissible electric cap lamps for general illumination; permissible flame safety lamps for testing; permissible explosives; rock-dusting and more air in the section.

SUMMARY OF EVIDENCE.

The general burns of the bodies No. 1 to 5; the lack of force at the assigned origin; the force outby this locus; the absence of gas from the feeder on D entry; the proximity of the assigned origin to the gob line and the evidence of greatest coke production and therefore greatest heat near the butt-off and 31 cross entry all point to this location as the probable origin of the explosion.

The fact that E. M. Hall, miner, with a carbide lamp was nearest the gob line indicates that it was his light which

ignited the gas.

No direct evidence that there had been a fall near the gob line at the butt-off was found or submitted, but the fact that the fire boss, John Severn, tested here on the gob at 5:00 a.m. April 2 and found no gas makes it necessary to presume that there was a fall in order to force gas off the gob against the air current onto the butt-off. The finding of coke on the ribs of rooms 1 to 5 off 32 cross entry; the presence of coke particles in sample H-766, 350 feet from assigned origin; the general burns on body of Wayne Poole, No. 7, about 1500 feet from the origin; the greater force down the entries which were not watered - 33 and 34 cross entries and the butt-off - in preference to following down the haulage and traveling way - 32 cross entry, indicates that there was propagation due to coal dust.

PROBABLE CAUSE.

The probable cause was the ignition by a carbide lamp of a body of gas, said gas having been forced down off the gob by a fall of rock.

RECOMMENDATIONS.

A. The following recommendations, which represent the bureau's idea of maximum safety, are made to prevent a recurrence of such disasters.

1. That the portable lamps for illumination be permissible electric mine lamps. While the writers were at the mine the company ordered permissible electric cap lamps and the

mine is now operated on a closed light basis.

2. That for gas detection permissible, magnetically-locked flame safety lamps, or equivalent permissible device, be provided and used for the purpose, by the mine foreman, assistant mine foremen, entry bosses, fire bosses, shot-firers, machine men and safety inspectors and that each such employee be examined by a competent official of the mine to assure the man's ability to detect gas. These lamps should be examined by a competent official before being taken into the mine and they should also be tested in a cabinet containing explosive gas before being issued for underground use.

3. That for blasting, permissible explosives, fired electrically, be exclusively used; and that as an aid to blasting, all coal which is feasible to cut, should be cut or sheared.

4. That the mine be rock-dusted, in every part, whether in damp or dry condition. The company has already ordered two M.S.A. high pressure rock-dusting machines. In initiating rock-dusting immediate protection should be afforded by starting rock-dusting at working faces and applying the rock-dust from the face toward the mine opening.

5. That rock-dust barriers be used to sectionalize the mine as additional defense, but these should not be regarded as a substitute for generalized rock-dusting.

6. That permissible "explosion proof" electrical equipment, mining machines, gathering motors, stationary motors and their accessories and blasting units replace the present non-permissible equipment. As a temporary expedient, no open type locomotives or trolley wires should be permitted within 500 feet of the face of the working places, and then only on the intake air.

7. That smoking and smoker's supplies, such as smoking tobacco in any form, pipes, matches, and lighters, be prohibited underground.

8. That water be used on cutter bars of machines, in drenching the coal just after shooting, in drenching the coal just after loading and in washing down the coal on cars in trips at key locations such as at the entrance of partings or sidings.

9. That neither auxiliary nor booster fans should be used underground as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

B. To increase further the safety of the men and the mine the following recommendations are submitted:

10. That no black blasting powder, whether in granular or pellet form, or dynamite be taken underground for any purpose.

11. That bull-dozing (mud-capping, adobe, etc.) and crevice shots be prohibited. Rocks and boulders should be

broken by sledging or by permissible explosives properly confined in holes.

12. That high quality rubber covered blasting cable be used.

13. That the wires (legs) of electric detonators should be electrically short circuited and this maintained until necessary to connect to the blasting cable. This is a precaution against premature electrical firing of the electric detonators.

14. That permissible blasting units only be used.

15. That explosives and electric detonators be taken into and stored in the mine in separate small fibre or wood boxes in quantities not exceeding one day's estimated supply.

16. That these containers be stored in niches, or recesses, in the rib at least 50 feet from the working face and separated by at least 10 feet.

17. That wooden tamping bars only be used.

18. That all shots be fired by shot-firers, preferably when all other employees are out of the mine.

19. That, when feasible, all underground equipment operated by electricity should be on pure intake air.

20. That ventilation should be improved by cleaning air courses and erecting tight stoppings and doors.

21. That more substantial stoppings of incombustible material such as brick or concrete should be used than the present wood-pulp composition coated wooden stoppings. These should be air-tight.

22. That at least two rescue crews, trained in the use of self-contained mine-rescue breathing apparatus and the All Service gas masks, should be available, in case of emergency. Such crews should be selected from among the underground officials and superintendents.

23. That at least two sets (12) mine-rescue breathing apparatus and five All Service gas masks should be maintained and kept on hand for emergency use.

24. That to insure that these safety measures are carried out adequate supervision should be provided.

To illustrate:-

(a) Effective rock-dusting requires systematic and regular sampling to insure its adequacy.

(b) The exclusive use of permissible explosives and permissible equipment presupposes that no black blasting powder, dynamite or non-permissible equipment be taken into the mine.

(c) Frequent and regular inspection of permissible mining equipment is necessary to insure its continued permissibility.

(d) The exclusion of smoker's supplies from the mine requires occasional and unannounced searching of the men as they enter the mine.

25. That new magazines for explosives should be constructed of lean cement-mortar for in addition to other favorable features no missiles will be thrown in the event of an explosion within it. The Bureau of Mines will furnish a blue print of this type of magazine upon request.

26. That consideration be given to so locating and barricading the magazine that they will conform to the American Table of Distances.

27. That detonators and electric detonators be not stored with explosives.

28. The exhaust fan should be provided with explosion- doors.

ACKNOWLEDGMENTS.

The assistance and cooperation of the following company officials expedited this investigation and is gratefully acknowledged. They were W. A. Wilson, general superintendent; F. E. Houston, mine superintendent; C. W. Dillard, mine foreman; Robert White, assistant mine foreman.

Respectfully submitted,

S. P. Howell, Explosives Engineer.

Jesse Redyard, Foreman Miner Car 7.

APPENDIX.

The location of the men killed in the mine is given on the map. Their names, occupations and map numbers are given below.

Map No.	Name	Color	Occupation
1	E. M. Hall	white	miner
2	Walter Wade	colored	motorman
3	F. M. Sturtevant	white	miner
4	Joe Preston	colored	brakeman
5	Archie Frasier	colored	brakeman
6	J. W. Cochran	white	miner
7	Wayman Poole	colored	trapper
8	Fred Platzer	white	safety inspector

Form 6—137

U. S. BUREAU OF MINES

E—DESCRIPTION OF MINE

(1) State West Virginia (2) County McDowell (3) Town Keystone (Post office.)

(4) Mine sample of Coal Dust (Material—for coal give classification.) (5) Coal field Pocahontas (6) District Elkhorn

(7) Mine Keystone No. 2 (a. Name.) Drift (b. Kind of opening—if shaft give depth.) (c. Height of opening above sea level.)

1½ N.E. of Keystone (d. Distance and direction from town.) (e. Sec., T., and R., if necessary.) N&W (f. Railroad connections.)

Keystone (g. Shipping point.) No (h. State if wagon mine or prospect and give distance from shipping point.)

(8) Coal bed Pocahontas No. 3 (a. Name.) (b. Geologic system.)

(c. Formation.) 0 (d. Dip, degrees.) 0 (e. Strike, direction.)

(9) Mining system Room and pillar (Long wall, room and pillar, panels, etc.) (10) Undercutting Machine (advance) (Hand or machine.)

(11) Explosives Black blasting powder & permissible (a. Used for coal.) Oxygen (b. Used for roof or floor.)

(12) Operator Keystone Coal & Coke Co., Keystone, W. Va. (Name and address.)

(13) Sales agent (Name and address.)

(14) Output per day 1000 T. net (Average—gross or net tons.) (15) Maximum day's output (During past year.) (16) Last year's output (Gross or net tons.)

(17) Output from advance workings, per cent 25 (At present.) (18) Lifetime of mine 100 (Years—estimated.)

(19) Run-of-mine, per cent Varies (Of output shipped.) (20) Is coal screened? Yes (21) Type of screens Shaker

(22) Type of washer None (23) Per cent of coal washed

(24) Maximum size washed (25) Sizes produced (Washed coal.)

(26) Sizes produced 3/4" up (Coal not washed.) (27) Is coal picked? Yes--both (State whether on car or belt.)

(28) Per cent of coal coked (At mine.) (29) Sizes coked (Screenings, crushed, washed, etc.)

(30) Type and number of ovens (31) Remarks (For any additional information indicate after subject by mark X if additional information is given here.)

(32) Can Nos. A (or H) 49 H 806 151 197 F 766 H 979 (Give Nos. of all samples forwarded.)

(33) Laboratory Nos. A 41676 A 41681 A 41677 A 41678 A 41679 A 41680 (Laboratory to fill in immediately below corresponding can number.)

(34) Mine sampled at 6 (Number) points, by S. K. Howell (Collector.) Pgh. (Office.) on Apr. 10-11-12 (Date.), 1928

Above information copied from Card A by Fischer on April 26, 1928

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Form 261

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. _____ Lab. No. A 41676

Sample of ROAD dust (through 20-mesh screen). Can No. A (H) 49

Operator Keystone Coal & Coke Co. Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #3

Town Keystone

Location in mine 145' in room 2 off 52 cross entry

Method of sampling thru 10 m. sample Gross weight, lbs. _____ Net weight, gms. 367.0

Date of sampling 4-10-28 Date of Lab. sampling 4-27-28 Date of analysis _____

For B. of M. section Mine Acc. Collector S. P. Howell

		Air-dry Loss 3.5	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture		.5	4.0		
	Volatile matter		14.9	14.4	15.0	20.7 [a]
	Fixed carbon		57.2	55.2	57.5	79.3
	Ash		27.4	26.4	27.5	
			100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen			Grams	Per Cent	
	Carbon	On 20 mesh		268.0	42.2	
	Nitrogen	thru 20 mesh		367.0	57.8	
	Oxygen	total wt. of sample		635.0		
	Sulphur		V M	= .207		
	Ash		V M + F C			
Calorific value determined	Calories					
	British thermal units		Coked particles present--relatively large amount. Less than A 41678			

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	47.4
through 100 mesh	23.0
through 200 mesh	11.9

Area from which sample was taken (sq. ft.) _____

Date, May 7, 1928 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

11—9383

Form 261

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No.____ Lab. No. A 41677

Sample of ROAD dust (through 20-mesh screen). Can No. 151

Operator Keystone Coal & Coke Co. Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #3

Town Keystone

Location in mine 3rd main just out by 32 side track

Method of sampling thru 10 m. sample Gross weight, lbs.____ Net weight, gms. 731.0

Date of sampling 4-11-28 Date of Lab. sampling 4-27-28 Date of analysis____

For B. of M. section Mine Acc. Collector S. P. Howell

	Air-dry Loss 1.2	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	.4	1.6		
	Volatile matter	14.9	14.7	15.0	20.1 [a]
	Fixed carbon	59.4	58.7	59.6	79.9
	Ash	25.3	25.0	25.4	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen		Grams	Per Cent	
	Carbon (On 20 mesh)		345.0	32.1	
	Nitrogen (thru 20 mesh)		731.0	67.9	
	Oxygen (total wt. of sample)		1076.0		
	Sulphur	V M	= .201		
	Ash	V M + F C			
Calorific value determined	Calories				
	British thermal units	Coked particles present--none			

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	53.7
through 100 mesh	26.5
through 200 mesh	11.1

Area from which sample was taken (sq. ft.)____

Date, May 7, 1928 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

11—9383

Form 261

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. _____ Lab. No. A 41678

Sample of RIB dust (through 20-mesh screen). Can No. 197

Operator Keystone Coal & Coke Co. Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #3

Town Keystone

Location in mine In Butt off at head of 32 cross entry off 20 st. ft. of flat slate on floor. Top was brown in color.

Method of sampling thru 10 m. sample Gross weight, lbs. _____ Net weight, gms. 29f.0

Date of sampling 4-11-28 Date of Lab. sampling 4-27-28 Date of analysis _____

For B. of M. section Mine Acc. Collector S. P. Howell

	Air-dry Loss 8.1	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	1.1	9.1		
	Volatile matter	10.9	10.0	11.0	14.5 (a)
	Fixed carbon	64.2	59.0	65.0	85.5
	Ash	23.8	21.9	24.0	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen On 20 mesh		Grams	Per Cent	
	Carbon		22.0	6.9	
	Nitrogen thru 20 mesh		296.0	93.1	
	Oxygen total wt. of sample		518.0		
	Sulphur	V M	= .145		
	Ash	V M + F C			
Calorific value determined	Calories				
	British thermal units	Coked particles present--large amount.			

	Cumulative per cent.
Screen test, through 20 mesh	100
through 48 mesh	89.4
through 100 mesh	73.8
through 200 mesh	53.7

Area from which sample was taken (sq. ft.) _____

Date, May 7, 1928 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

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Form 261

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. _____ Lab. No. A 41679

Sample of ROAD dust (through 20-mesh screen). Can No. P 766

Operator Keystone Coal & Coke Co. Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #3

Town Keystone

Location in mine On 32 cross entry at room 2

Method of sampling thru 10 m. sample Gross weight, lbs. _____ Net weight, gms. 501.0

Date of sampling 4-11-28 Date of Lab. sampling 4-27-28 Date of analysis _____

For B. of M. section Mine Acc. Collector S. P. Howell

	Air-dry Loss 3.2	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture	.6	3.7		
	Volatile matter	17.4	16.8	17.4	19.8 [a]
	Fixed carbon	70.3	68.1	70.8	80.2
	Ash	11.8	11.4	11.8	
		100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen		Grams	Per Cent	
	Carbon	On 20 mesh	286.0	56.5	
	Nitrogen	thru 20 mesh	501.0	63.5	
	Oxygen	total wt. of sample	789.0		
	Sulphur	V M	= .198		
	Ash	V M + F C			
Calorific value determined	Calories				
	British thermal units	Coked particles present--small amount			

Screen test,		Cumulative per cent.
through 20 mesh		100
through 48 mesh		52.6
through 100 mesh		27.9
through 200 mesh		17.3

Area from which sample was taken (sq. ft.) _____

Date, May 9, 1928 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

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Form 261

DEPARTMENT OF COMMERCE
BUREAU OF MINES

DUST-ANALYSIS REPORT

Test No. _____ Lab. No. A 41680

Sample of ROAD dust (through 20-mesh screen). Can No. H 979

Operator Keystone Coal & Coke Co. Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #3

Town Keystone

Location in mine 50 ft. from 4 main between 4 main & D entry on 51 cross entry, air course used as haulage way which is 51 & 52 cross side tracks

Method of sampling thru 10 m. sample Gross weight, lbs. _____ Net weight, gms. 959.0

Date of sampling 4-13-28 Date of Lab. sampling 4-27-28 Date of analysis _____

For B. of M. section Mine Acc. Collector S. P. Howell

		Air-dry Loss 2.3	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture		.4	2.7		
	Volatile matter		14.3	14.0	14.3	19.7 [a]
	Fixed carbon		58.3	56.9	58.6	80.3
	Ash		27.0	26.4	27.1	
			100.0	100.0	100.0	100.0
Ultimate Analysis	Hydrogen			Grams	Per Cent	
	Carbon	On 20 mesh		251.0	22.6	
	Nitrogen	thru 20 mesh		859.0	77.4	
	Oxygen	total wt. of sample		1110.0		
	Sulphur		V M	= .197		
	Ash		V M + F C			
Calorific value determined	Calories					
	British thermal units		Coked particles present--none			

Screen test,		Cumulative per cent.
through 20 mesh		100
through 48 mesh		52.4
through 100 mesh		33.9
through 200 mesh		20.0

Area from which sample was taken (sq. ft.) _____

Date, May 8, 1928 (Signed) H. M. Cooper, *Chemist.*

[a] This figure is the ratio of volatile combustible to total combustible.

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DEPARTMENT OF ~~THE INTERIOR~~ COMMERCE

BUREAU OF MINES

Test No. _____ G—COAL-ANALYSIS REPORT Lab. No. A 41681

Sample of Coke after mine explosion Can No. H 806

Operator _____ Mine Keystone #2

State W. Va. County McDowell Bed Pocahontas #5

Town Keystone

Location in mine 150 ft. in room 3 off 32 cross entry

Method of sampling Collected off rib Gross weight, lbs. _____ Net weight, grams _____

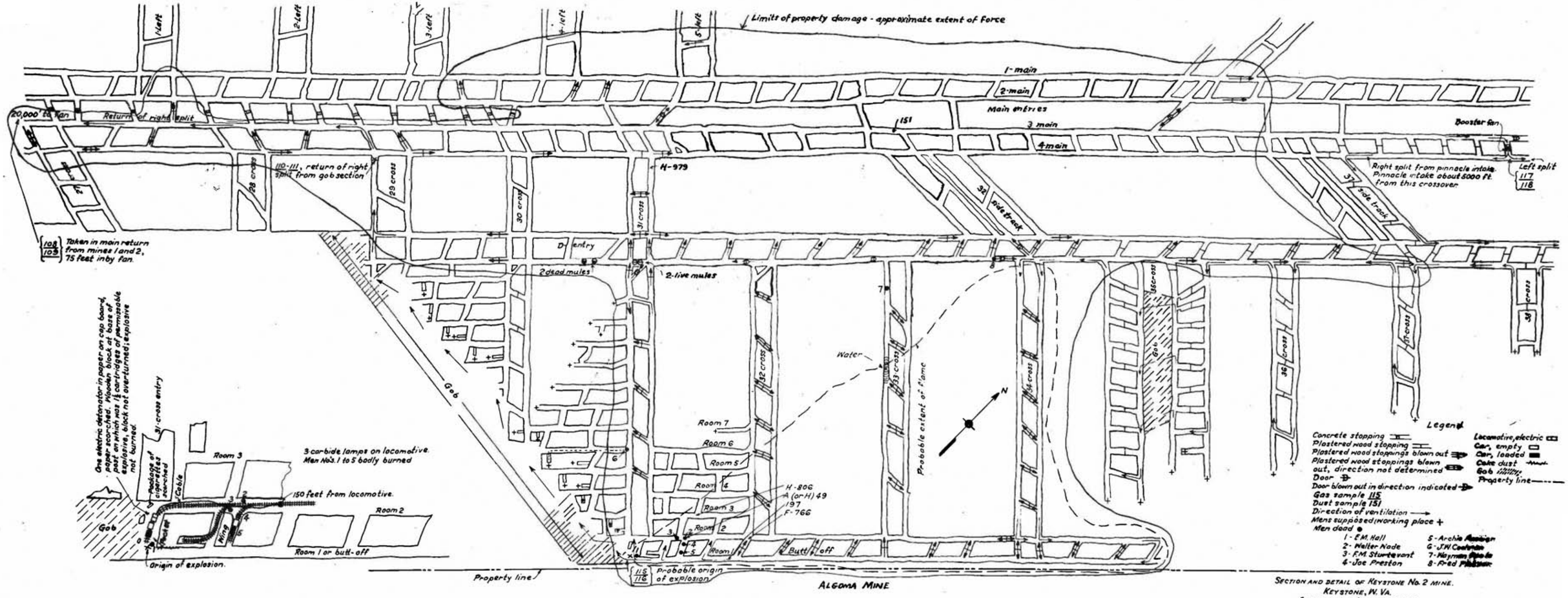
Date of sampling 4-10-28 Date of Lab. sampling _____ Date of analysis _____

B. of M. or U. S. G. S. section Mine Acc. Collector Jesse Redyard

	Air-dry Loss	Coal (Air dried)	Coal (As received)	Coal (Moisture free)	Coal (Moisture and ash free)
Proximate Analysis	Moisture		.8		
	Volatile matter		9.2	9.3	
	Fixed carbon		71.8	72.4	
	Ash		18.2	18.3	
			100.0	100.0	
Ultimate Analysis	Hydrogen				
	Carbon				
	Nitrogen				
	Oxygen				
	Sulphur				
	Ash				
Calorific value	Calories				
	British thermal units				

Softening temperature of ash _____ ° C. _____ ° F.

Date 6—6089 May 5, 1928 (Signed) H. M. Cooper *Chemist.*



SECTION AND DETAIL OF KEYSTONE No. 2 MINE.
KEYSTONE, W. VA.
EXPLOSION OF APRIL 2, 1928.