R E P O R T

on

DOLOMITE NO.3 MINE EXPLOSION

WOODWARD IRON COMPANY

NOVEMBER 22, 1922.

by

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and

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U.S. Bureau of Mines.

Birmingham, Alabama.
February 14, 1923.

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EXPLOSION NO.3 DOLOMITE MINE

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INTRODUCTION

General Statement:

An explosion occurred about 2:40 p.m. November 22, 1922 in No. 3 Dolomite Mine, Woodward Iron Company which resulted in the death of 90 men and in injuring slightly or seriously over 70 others. It is believed that afterdamp alone caused about 30 per cent of the deaths while the other fatalities were due to a combination of burns and afterdamp. Fully 60 per cent of those injured were treated by attending doctors for gas (afterdamp); the remaining injured were treated for a combination of burns and afterdamp. According to statement of Dr. F.V. Meriwether, surgeon, U. S. Bureau of Mines, who with a number of other doctors, assisted Dr. E. P. Lacey, chief surgeon of the company, oxygen was administered to eleven of the more serious cases of afterdamp; probably at least 6 lives were saved by use of oxygen from resuscitators owned by the U. S. Bureau of Mines.

This explosion was probably caused by ignition of coal dust by electric arc from an armored cable. The coal dust was thrown into the mine atmosphere (slope and yard) by the wrecking of a runaway trip of three empty cars at the foot of the 850 foot rock slope; and the armored cable (3300 volts) that extended down the slope close to the right rib was struck presumably by a flying piece of steel from the wreckage at a point approximately 100 feet from the bottom of the slope with resultant short circuiting and the arcing of the cable undoubtedly supplied the flame which ignited the dust cloud.

Four hundred and seventy-five men were checked into No. 3 and No. 2 mines thru No. 3 slope on the morning of the explosion. In addition to this number of men 397 were checked into No. 1 mine, making a total of 872 in both mines. Mines 1,2, and 3, are connected but the ventilation of No. 1 mine is separate from mines 2 and 3; in reality No. 2 mine is a part of No. 3 mine. No. 3 slope is driven thru rock on a pitch of 30 degrees and extends 850 feet in length to the main gathering, parting or yard in No. 3 mine. This slope was driven to eliminate the long expensive haulage of old No. 2 mine. The explosion was localized and was confined principally to No. 3 slope and yard and to the main entries for a few hundred feet from the yard or slope parting by the apparently efficient method of sprinkling employed. Men who worked in remote sections of No. 3 and No. 2 mines escaped un-

injured with a few possible exceptions; and all who worked in No. I mine escaped uninjured.

The explosion originated on the main intaking air current of No. 3 slope. Mines Nos. 2 and 3 (constituting really one operation) are ventilated by two separate and distinct fans, housed in fire-proof buildings, one of which serves as an emergency spare and both located on the surface comparatively close to each other. The Capell fan, electrically driven, was in full operation when the explosion occurred and was immediately thrown out of commission due to short-circuiting of the cable in No. 3 slope. The other fan, Sirocco make, can be driven by either gasoline or electric motor; and within fifteen minutes after the explosion, the Sirocco fan was in full operation pulling fresh air thru most of the affected and unaffected parts of mines Nos. 2 and 3. Due to this precautionary measure of duplicate fan installation and to the fact that the explosion was arrested by the efficient method of sprinkling employed, a large number of lives were saved and the mining company is to be highly commended for its pregressiveness and foresight in having provided and maintained these up-to-date safety features.

ACKNOWLEDGEMENTS

The officials of the Woodward Iron Company gave most cordial aid and cooperation during the progress of this investigation. Not only were the investigators allowed to go anywhere at any time and as

frequently as desired but the company furnished maps and other data as well as assistants thoroughly familiar with the mine and its working conditions. For these and many other courtesies, the writers wish to extend heartiest thanks and commend strongly the spirit of the company in its desire to keep abreast of the times in attempting to ascertain the true cause of the explosion and means for preventing a recurrence.

Ownership and Operator:

Dolomite No. 3 mine is owned and operated by the Woodward Iron Company with central offices at Woodward, Alabama. The officials of the Company are:

Mr. Frank Crockard, President,

Mr. A. J. Boynton, Vice President and General Manager.

Mr. W. M. Lacey, General Superintendent of mines,

Mr. John Thomas, Division Coal Mine Superintendent.

Geology:

Dolomite No. 3 mine is located in the Warrior coal field which is a part of the Great Appalachian coal measures. The mine is opened in the Pratt seam which is the principal producing coal bed of the region and belongs to the Carboniferous Age, Pottsville group.

It lies practically horizontal and averages 60 inches in thickness although in some sections, the bed thins to 40 inches. The roof and floor are sandy shale. The principal impurities in the bed are a 2 inch to 3 inch band of "bone" about 6 inches from the roof and a shale parting 6 inches to 10 inches thick about a foot from the floor. The coal bed in this mine was sampled by J.J. Forbes, June 8, 1921. The Following Tables 1 and 2 show the sections of the bed as measured, together with the analyses of the coal.

TABLE I

Sections of Coal Bed, Dolomite No. 3 Mine, measured by J.J. Forbes, 6/8/21

Can No. / Lab. No.	6724 / 80183	23623 / 80184	6293 / 80185	05581 / 80186	05967 / 80187
	Ft-In	Ft-In	Ft-In	Ft-In	Ft-In
Roof:Sandrock	-	-	-	-	0 2
Coal	0 6	0 6½	0 7	0 2¾	0 5
Sulphur Band	-	-	-	0 5/16	-
Coal	-	-	-	0 4½	-
x Bone	0 2	0 2¼	0 3	0 1¾	0 2
Coal (a)	3 0	3 0	3 7	3 5	3 1
x Rock (middleman)	0 10½	0 5½	0 11	0 11	0 9½
Coal	0 10	0 2¼	1 0	1 1½	1 1½
x Rock	-	0 2¼	-	-	-
Coal	-	0 9	-	-	-

(x) Excluded from sample

(a) 3 small bands sulphur about 1/16" thick each.

TABLE 2

ANalyses of Coal Samples Taken from Dolomite No.3 Mine.
June 8, 1921.

Lab.No. Can No.	Sym-bol	Moist-ure	Velatile matter	Fixed Carbon	Ash	S.	B.T.U.	Location
80183	a	3.56	27.27	63.26	5.91	1.80	14089	Face 4th Rt.
6724	b	.45	28.15	65.30	6.10	1.86	14543	off 49 W Entry.
80184	a	2.49	27.91	63.62	5.98	1.66	14207	Face room 8 off
23623	b	.53	28.47	64.90	6.10	1.69	14492	1st left 50 E
80185	a.	2.44	27.71	63.87	5.98	1.87	14275	Face 49 W Entry.
6293	b	.53	28.25	65.10	6.10	1.91	14551	
80186	a	3.82	28.25	60.77	7.16	1.50	13842	4th left off
05581	b	.53	29.22	62.85	7.40	1.55	14316	50th East
80187	a	2.28	28.86	60.82	8.04	1.70	13972	Face 7th left
05967	b	.38	29.42	62.00	8.20	1.73	14244	off 50th East.
80188	a	2.95	28.13	62.40	6.52	1.71	14080	Composite anal-
	b	.52	28.83	63.97	6.68	1.75	14432	yses of above samples.

a - Coal "As received".

b = Coal "Air dried".

Coal Analyses:

It will be noted by referring to Table No. 2 which gives the analyses of coal on "As received" and "Air dried" basis that the moisture content of samples "As received" basis, ranged from 2.28% to 3.82% and also the moisture in the composite analyses from sample Nos. 6724, 23623, 6293, 05581, 05967, gives the moisture content of the samples as 2.95%. By referring to Table 5 which gives the analyses and sizing tests of a number of road samples which were taken at representative places along

haulage ways, it will be noted that the moisture content in road samples ranged from 4.7% to 11.6%. The average moisture content of all road samples collected, 8.5% therefore, comparing the average moisture content in the road samples which was 8.5% to the moisture content in the composite analyses of face samples, namely 2.95%, it is apparent that the road samples absorbed in excess of moisture in face samples 5.5%.

Production and Employment:

The average production of No.3 mine approximates 2,000 tons daily. About 475 men are normally employed underground, 350 of whom are "diggers". About 15 to 20 men are employed on the surface. According to the State Mine Inspector's report for the year 1920, 282,056 tons were produced in 157 working days as against 497,437 tons in 1921 with employment of 485 men in 310 working days.

Mining Methods:

Dolomite No. 3 Slope is a part of No. 2 mine and was driven as an intake aircourse and to eliminate the long expensive haulage of No. 2. It is approximately 4 miles from the mouth of No. 2 mine to No. 3 slope. No. 3 slope is sunk on a pitch of 30° (degrees) thru rock and intersects the coal seam at 850'. In line with the slope, which is double-tracked throughout, is the yard or parting which has two empty and two loaded tracks and extends 500' in length. The rock slope is about 6 feet high and 20 feet wide. This slope, and No. 2 opening, serve as the

intakes with No. 3 slope carrying about 70,000 cu. ft. of air per minute, of a total return of 130,000 cu. ft. per minute. In addition the slope acts as the haulage road from the "yard" or parting, to the tipple.

All coal is hauled in tight gate cars by electric locomotives to the yard where it is weighed and then hoisted to the surface usually in five car trips. The mine is developed by the ordinary room and pillar system. Main entries are usually driven triple, the center entry being called the heading, while the two side entries are designated left and right aircourses. Cross entries are driven double and are spaced at intervals of 300' off main entries, the distance between main entries is about 2200 feet. Entries are driven 16' wide and "gobbed" with dirt partings to about 10'. Rooms are driven 30' wide to a length of 250'. Coal is undercut with mining machines to an average depth of 6' excepting in pillar work where is is pick mined; blasting is done with permissible explosives.

Lighting:

Open carbide lamps are used exclusively by underground employees. Safety lamps being used only by firebosses and section foreman for examination work. Electric lights are provided only in the yard and not along haulage ways.

Haulage:

Coal is transported in tight-gate wood cars by electric locomotives to the yard, thence to surface in five car trips to tipple and dumped by means of a double 5 car rotary dump. Empty cars weigh about 2200 pounds and are loaded with 3600 pounds of coal. The track gage is 40 inches with 60 pound steel used on slope and yard, 40 pound on mains, 30 pound on cross entries, and 16 pounds in rooms. Cars are handled by the miner from the entry to the face of the room.

Explosives:

Permissible explosives are used for breaking down coal and for brushing. About 350 pounds of explosives are used daily to gain a production of 2,000 tons. Drill holes are usually 1½ inches in diameter and are charged with one to two sticks of explosive and tamped with clay. Clay tamping is hauled into the mine by the company and is centrally placed to live workings. Explosives are detonated by No. 6 cap and fuse and shooting is usually done at noon and at quitting time under the supervision of section foremen. "Bug dust" is loaded out before blasting. Explosives are kept by miners in locked boxes.

The company maintains a safety inspector who makes periodic visits of inspection to all mines of the company and personally interviews each man and instructs him in safe practices. At the time of the explosion the inspector was in the adjacent No. 1 Mine.

Dust and Sprinkling System:

The principal sources of dust as observed during the course of this investigation are: (1) Undercutting of coal; (2) Drilling holes preparatory to blasting; (3) Blasting coal; (4) Loading of coal and (5) Transportation of coal. Dustiness is controlled to a considerable extent by the apparently efficient method of sprinkling employed. All working places and main haulage entries are sprinkled about once every three or four days, there being 9 men employed practically full time on sprinkling.

Sprinkling lines traverse main and side entries, four inch (4") and two inch (2") pipe lines being employed for this purpose with taps usually placed at one-hundred foot (100') intervals. Common garden hose in fifty foot (50') sections is used for sprinkling rooms and entries. Prior to the explosion the yard or parting was sprinkled frequently; according to statement of Lige Eger, sprinkler, at the Coroner's Inquest proceedings, the yard was well sprinkled the night before the explosion, however little or no provision was made to keep walls or floor of the slope washed and little or no sprinkling was done on the slope. Also pillar workings and abandoned sections were not wetted. It is probable however, that this explosion was arrested by the method of sprinkling employed; and that a large number of lives were saved due to this fact. On the other hand it is felt that improvement

could be made and the efficiency of the system increased by wetting the dust at the working faces during the operations of undercutting, loading and blasting of coal; also pillar workings should be sprinkled regularly and abandoned sections should be sealed or be kept in a moist condition. As before mentioned, a corps of nine (9) men are engaged in sprinkling and it takes about 3 to 4 days to sprinkle the mine.

In addition to ordinary methods of sprinkling by hose, in manner similar to sprinkling of a surface lawn, sprays are used at the East and West end of the yard to sprinkle loads and empties. Prior to the explosion, according to statement of a sprinkler, the only means used to sprinkle the slope was a line of four atomizers situated near the mouth of the slope. The system of sprays used on the yard assisted greatly in reducing the dust that would have been thrown into suspension along the yard; but the dust thrown into the atmosphere due to the velocity of the air in the No. 3 slope and to the excessive leakage and spilling of coal dust on the slope thru cracks on the cars and to excessive loading of cars was not adequately cared for nor was sufficient provision made to prevent excessive dustiness of the No. 3 slope and yard caused by drying effect of large quantities of moving dry intake air.

The meteorological records of Birmingham on the day of the explosion shows that the highest temperature attained was 57 degrees F. lowest 34 degrees and mean temperature 46 degrees F, with no precipitation and with an absolute humidity 3.2 gallons per 100,000 cu. ft. of air or 2.2 gallons per 70,000 cu. ft. of air per minute. The records for

November 20 and 21 show the mean temperature to be 47 degrees F and 44 degrees F, with no precipitation and absolute humidity of 4.2 and 3.6 gallons per 100,000 cu. ft. of air respectively or 3 and 2.5 gallons per 70,000 cu. ft. of air per minute respectively. Taking the average temperature of the return air from No. 2 fan at 68 degrees saturation or absolute humidity, 13 gallons per 100,000 cu. ft. or about 9½ gallons for 70,000 cu. ft. per minute, indicates that on the day of the explosion and for two days previous about 7 gallons of water were being extracted from the mine every minute by the 70,000 cu. ft. of intake air. The atomizers near the portal of the slope had little or no effect in wetting the dust along the ribs, roof or floor of the slope, 850 feet in length; and the consequent cloud of dust that resulted from the run away trip was undoubtedly in a dry condition, and was probably of a very finely divided nature.

During the course of this investigation temperature observations were taken at frequent intervals for several days at the portal of No. 3 slope and in the yard.

The following Table 3 gives the results of these observations:

TABLE 3

Humidity Observations Taken Outside and Bottom of Slope or Yard

Date	Hour	Place	Wet	Dry	Humidity	Gal.per 70,000 cu. ft. per Minute.	Remarks.
12/8/22	10:35 a.m.	Outside portal	67½	72	79%	8.0	Partly cloudy
12/8/22	10:50 a.m.	Yard	66	66	100%	8.3	Ribs, roof, wet.
12/8/22	1:30 p.m.	Yard	65½	66	97½%	8.1	"
12/8/22	3:30 p.m.	Yard	65½	65¾	98½%	8.2	"
12/8/22	3:45 p.m.	Outside	66	75	62%	7.0	Clear - sunshiny.
12/11/22	10:40 a.m.	Outside	49	50	93%	4.8	Cold and cloudy.
12/11/22	11:00 a.m.	Yard	56	57	94%		Moist in spots
12/11/22	4:30 p.m.	Yard	54½	57	86%	6.0	Ribs and roof dry.
12/11/22	4:45 p.m.	Outside	49½	51½	87%	4.8	Clear and Cloudy.
12/12/22	10:00 a.m.	Outside	51½	52	97%	5.1	Drizzling rain.
12/12/22	10:15 a.m.	Yard	55	56	94%	4.9	Moist in spots.
12/12/22	3:45 p.m.	Yard	50	53	81%	4.6	Ribs - Roof dry.
12/12/22	3:50 p.m.	Outside	43½	47½	72½%	3.2	Clear.
12/13/22	8:30 a.m.	Outside	34	39	60%	2.1	Clear.
12/13/22	8:40 a.m.	Yard	41½	43	88%	3.4	Ribs and roof dry.
12/13/22	12:30 p.m.	Yard	46	48	86%	3.9	Ribs and roof dry.
12/13/22	2:45 p.m.	Yard	50	53	81%	4.6	Ribs and roof dry.
12/13/22	3:15 p.m.	Outside	49	57	55%	3.5	Clear.

It will be noted by a study of the foregoing observations with 70,000 cu. ft. of air intaking thru No. 3 slope that there was only one day (December 8) that the ribs and roof of the yard were in a moist condition: and for the balance of the observations the ribs of the yard were generally dry. In addition to the moisture in the air for those particular days, moisture was injected into the current by 5 rows of atomizers, 4 atomizers per row, placed about 150' to 200' intervals along the slope.

The dry condition of the slope and yard can be overcome to a limited extent by the humidification of the intaking air but it is feared that since the air would have a comparatively short travel(850') and using steam either exhaust or live that the yard would be fogged and rendered dangerous to the workman on the yard. If the intaking air were preheated and then steam or fine atomized water injected into the air, the cost of the system would be prohibitive and impractical. It is probable that the danger from the dry condition of the slope and yard can be overcome by the application of rock dust applied to ribs, roof and along floor. In case of runaway cars on the slope a cloud of rock dust would mix with the resultant cloud of coal dust, thereby making a mixture that probably would be non-ignitible.

Psychrometric Observations -Dolomite No.3 Mine.

Table 4

No.	Date	Bar.	Wet	Dry	Hum.	Location	Remarks
1	12/8/22	29.60	66½	67½	95%	50th East 30' inby 2nd cross	Dirt compact & wet- would not go thru scoop -no rib or roof dirt. Border of explosi onzone
2	12/8/22	29.60	69½	70	98%	50th between 4th & 5th cross.	Dirt compact & wet, would not go thru scoop - no rib or roof dust -without explosion zone.
3	12/8/22	29.58	70½	71	98%	Roadway 8th cross off 47th East -500 ft. inby.	Roadway wet- no rib or roof dust, without explosion zone.
4	12/8/22	29.56	69	70	95%	47th East Roadway at 4th cross	Roadway wet- no rib or roof dust.sprinkler spraying outby Without explosion zone.
5	12/8/22	none taken				4th cross off 50 East at Room 5.	Road dirt compact & when squeezed in hand stays intact no rib &roof dust-without explosion zone.
6	12/11/22	29.88	59	60½	91%	49th West heading bet-4th& 5th crosses.	Roadway moist & compact-ribs clean -but dry,without explosion zone.
7	12/11/22	-	67½	68½	95%	6th cross heading bet-rooms 1 and 2.	Roadway moist -ribs and roof dry, but clean -without explosion zone.
8	12/11/22	-	66	67	95%	5th cross aircourse off 49 west	Roadway moist, ribs and roof cleaned.
9	12/12/22	-	69	69½	97	50th East at 5th cross	Roadway moist- ribs & roof clean.
10	12/13/22	-	69	70	95	28th East bet-4 and 5 crosses.	Roadway moist-ribs and roof clean.
11	12/12/22	-	68½	69	97	44th west 200' from face.	Roadway moist -ribs & roof clean. - Return air.
12	12/12/22	-	68	Bore hole temperature		Face 44th west.	Bore hole temperature of coal
13	12/12/22	-	67	68	95	44th West bet-5 and 6 cross.	Roadways wet-sprinkler spraying 200' inby-without explosion zone. ribs and roof -clean.
14	12/12/22	-	68	69	95	44th West bet-11th & 12th c.	Roadway moist without explosion -ribs & roof clean.
15	12/13/22	-	70½	71½	95	150' outby 42 nd, west c.c.	Roadway moist-without explosion zone. Ribs and roof clean.
Average			67	68	95		

Table 4 gives the psychrometric observations at representative places throughout the underground workings exclusive of yard and slope. Generally speaking the roadways were found to be in a wet to moist condition wi with ribs and roof clean. It was not possible to collect a sample of rib or roof dust although the ribs and roof were generally dry, the dust on these surfaces were too small to collect samples of them. The average temperature of the mine air is 68 degrees F. with a humidity of 95%. It is interesting to note that the average dry bulb temperature is the same as the coal temperature. A drill hole (2' deep) temperature was taken at the face of the 44th west heading and found to be 68 degrees F.

Ventilation:

For details as to method of ventilating workings of mines 2 and 3, refer to maps which are a part of this report.

At the time of the explosion, the mine was ventilated by the exhaust system. Slopes 2 and 3 acting as the intakes and the air shaft, the upcast. It will be noted that No. 3 workings, as well as No. 2 workings are ventilated by a practically continuous current. The full intake of No. 3 slope is split at the face of 49 West heading; the split going to the right sweeps the right side of the 49th West workings, all of the 50th East and 47th East and thence thru the old workings to upcast fan. The split going to the left of 49th West sweeps the region between 42nd West and 49th West. No. 2 intake is split at 34th West off old No.2 slope, the left split going to No. 1 mine workings and old workings inby

while the right split sweeps 41st West region and the live workings of 42nd West.

The devices used in deflecting air are gob stoppings, doors and line brattices.

The present method of ventilating the live workings of mines 2 and 3 is practically by a continuous current system and in the event of derangement of ventilation, dangerous accumulations of gas would undoubtedly result. It is felt that a much safer method would be to ventilate all live workings of No.3 and No.2 mines by a complete split system of ventilation and that gob stoppings be faced with a mixture of clay and cement to eliminate as far as possible leakage of air.

Roadways and Road Dust Samples:

During the course of this investigation samples of road dust were collected both within and outside of the explosion area, and at other representative places along haulage entries throughout the mine. The analyses together with sizing tests of all these samples are shown in Table 5. It was observed that leakage coal from cars was greatest at partings, in the yard and along the floor of the slope. Tight-gate cars are used for hauling coal and since the coal from this bed(Pratt seam) is soft and slacks readily, the cars, therefore, should always be kept in good repair to prevent leakage of fine coal onto roadways. Due to the friable nature of the coal, cars are not "racked" but in many instances are overloaded, hence considerable fine coal falls from the sides of cars during

transit. Boards are not placed on ends of cars hence spilled coal along the 30 degree slope is excessive, amounting to about 32 cars or over 50 tons per week. With the present car that stands 38" above the rail and due to the fact that the coal bed thins in places to forty inches(40") the placing of end and side boards on cars to prevent falling of coal from the cars on slope and haulage entries is not practical. However, as previously noted it is felt that the spilling of coal during transit could be reduced to a minimum if cars were not excessively loaded. Track cleaners are employed to clean roadways and are paid on a tonnage basis. The roadways during the course of this investigation were found in a wet to moist condition. This fact is borne out by reference to Table 4 which gives the humidity of the mine air taken at representative places in the mine, together with the corresponding side notes at locations where road samples were taken. All road samples were taken by standard Bureau of Mines method during period when the mine was operating normally and consisted in laying off a zone of 50 lineal feet of entry from which 3 to 5 grooves of road dirt were collected by means of road scoop having 10-mesh screen. The oversize from the scoop being rejected while the undersize was coned and quartered and worked down to about four pound samples.

The Bureau experiments in relation to the explosibility of coal dust have demonstrated that the principal factors that determine the explosibility of coal dust are: fineness, ratio of the volatile matter to fixed carbon and the per cent of incombustible present. Coal dust

that is too large to go thru a 20-mesh sieve is considered not explosive and coal dust that will go thru a 20-mesh sieve is likely to be explosive and its relative sensitiveness as to explosibility is increased by increase of the percentage of coal finer than 20-mesh; that is to say, coal dust all passing thru 20-mesh is the more explosive in proportion to the percentage of 100 or 200 mesh dust present. Pittsburgh coal dust that passes 20-mesh and has as much as 30% of 100 mesh dust produces a strong explosion, but when all passes 100 mesh and has 30% of 200 mesh the explosion is violent and the violence increased as the precentage of 200 mesh is increased.

The ratio of the volatile matter to the total combustible (fixed carbon plus volatile matter) is an index of the ease of the explosibility of the dust, the higher the volatile matter the more easily is the dust ignited.

The road samples from this mine have an average ratio of volatile matter to fixed carbon of .321 and since the total incombustibles (moisture plus ash) does not average more than 38.1% the samples all fall within the zone of explosibility when compared with Pittsburgh coal dust that has a ratio of .40. Also it is noted that of all the samples collected 67.3% of the total weight was rejected and non-explosive being larger than 20-mesh; also that 32.6% passed thru a 20 mesh sieve and is considered explosive and of this weight (408.8 grams average weight) 18.2% passed thru 100 mesh and 8.2% thru 200 mesh sieve.

This explosion died away approximately at points where these samples were taken and it would appear even though the laboratory results show the samples to be explosive that the fine dust in the road samples contained the most water and were deeper seated which undoubtedly was due to the fact that the extremely fine dust was washed down from the ribs, roof, and ledges, onto roadways and naturally had a tendency to be below the immediate surface of compact roadways and the flame and first on-rush of air and gas undoubtedly were unable to come in contact with any considerable amount of fine dust which naturally would be necessary for ignition and propagation. Also since the explosion had its origin on the intake air near the mouth of the slope, the explosion had an opportunity to vent the pressure towards the mouth of the slope and the concussion inby was not sufficiently great to bring this fine road dust into suspension.

In order to render this dust non-explosive in the event of its being brought into suspension, there should be added either sufficient rock dust to bring the total inert material up to 80% when there is as much as 2% gas present or sufficient water should be added to bring the moisture up to 15% or 20%.

Referring to Table 5, dust sample No. 6, laboratory No. 88363 as being fairly representative of normal dust conditions, it would be necessary to add about 45% shale dust or about 10% moisture to render it non-explosive. A full discussion concerning the various factors which enter into explosibility of coal dust is contained in U. S. Bureau of Mines Bulletin No. 167.

TABLE No. 5

ROAD DUST ANALYSES DOLOMITE NO. 3 MINE.

****

No.	Date	Lab. No.	Location	Wet Bulb	Dry Bulb	Rel. Hum.	Dry Equiv. Sample (grams)
1	12/8/22	88362	30th East 30' Inby 2nd cross	66.5	87.5	95	1461.0
2	"	88357	30th between 4th & 5th cross	69.5	70	98	1374.0
3	"	88358	Roadway 8th Cross cut 47 East 300' inby	70.5	74	98	1280.0
4	"	88361	47th E. Roadway at 4th cross	69	70.5	95	1420.0
5	"	88359	4th Cross cut 30th E. Room 5	None taken			1389.0
6	12/11/22	88363	49th W. Heading Between 4th & 5th crosses.	59	60.5	91	1379.0
7	"	88355	5th cross head-ing, Between Rooms 1 and 2	67.5	68.5	95	1286.0
13	12/12/22	88356	44th W. Between 5th & 6th crosses	57	58	95	1423.0
14	"	88360	44th W. Between 11th & 12th cr's	58	59	95	1397.0
		88013	50 E. M. Heading 450' from end of yard.				1038.0
		88014	49 W. heading 360' from end of yard.				1006.0
	m	88015	Slope heading 200' from yard				1115.0
		88016	49 W. 200' from yard.				837.0
			AVERAGE	64.6	68.1	95.3	1238.6

NOTE: Copies of the complete analyses of all the foregoing road samples of Table No. 4; in order to obtain humidity observations wher

* The percentages thru 48, 100 and 200 Mesh screens are cumulati hence not analyzed.. All samples were taken from slurp of 50

** Ratio of Volatile Material (V.M.) to Volatile Material (V.M.) F

Gas and Air Samples:

The map of the mine which is a part of this report shows the directiom of air currents and the place at which air samples were taken in the mine. The table is arranged according to order of sampling so the gas emitted in any particular section can be readily calculated. For example, referring to Table 6, Lab. No. 17720, taken in the 49 West left aircourse and between the 6th and 7th right crosses. This particular sample shows .04% gas and is the return from the 49th West right aircourse, partial return from face of 49th West heading and workings in the 6th and 7th right cross entries off 49th West. It will be noted from samples 17721 and 17722 which is the return from the left side of 49th West, including old workings between the 1st and 4th right crosses shows a CH_4 content of .60% and .58% respectively. These samples are conspicuous since the disturbance was greatest in this particular region and it would seem apparent that old workings be more systematically ventilated and protected by erection of rock dust barriers or preferably be sealed. Samples 17724 and 17725 which is the full return from the mine shows .12% and .11% respectively with 132,000 cubic feet of air returning. The gas emitted per minute from the workings of mines 2 and 3 approximates 160 cubic feet or 3840 cu. ft. per hour. This mine gives off sufficient quantities of gas that in the evant of an interruption of ventilation a dangerous accumulation of gas would result and this was the case in the recent explosion in Dolomite No. 1 mine resulting in loss of five lives.

Location and Analyses of Air Samples Taken from Dolomite No. 3 Mine.

Table 6

Date 1922	Lab.No.	Location	Q	CO_2	O_2	CH_4	N.	Remarks
12-11	17720	49 West left A.C. bet- 5th & 6th left crosses.	6762	.05	20.84	.04	79.07	Return from 49th West heading and 6th & 7th crosses.
12-11	17719	5th cross A.C. off 49 West.	3920	.09	20.66	.19	79.06	Return from 6th, 7th 8th, C. and face of entry (49th West).
12-11	17717	1st cross off 49th West.	4692	.13	20.55	.20	79.12	Return from right side of 49th West.
12-11	17723	50 East at 5th cross	7050	.16	20.46	.14	79.24	Return from 49th West right side & 50 East
	(check) 17718		7050	.15	20.46	.14	79.25	
12-13	17727	28th East betw- 4th & 5th Crosses.	48000	.19	20.56	.11	79.14	5th cross -Return 49 West Right side, 44, 45
	(check) 17726		48000	.17	20.42	.11	79.30	47, 50 E. slope Headig
12-12	17721	Left Aircourse 44th West.	6072	.12	20.44	.60	78.84	Return from left side 49th W. left old work
	(check) 17722		6072	.14	20.44	.58	78.84	outby 4th C. and Rt side 44th West.
12-13	17728	150' outby 42 West overcast.	45780	.19	20.57	.15	79.09	Return from 41, 42, 44 and left side 49 West
12-13	17725	25' from fan in fan drift.	132,300	.20	20.44	.12	79.24	Return from mine.
	(check) 17724			.21	20.40	.11	79.28	

Story of the Explosion

The explosion occurred about 2:40 p.m. November 22, 1922, and the alarm was sent out immediately. The Bureau office at Birmingham received the report about 2:50 p.m. Mr. D. Harrington, supervising mining engineer of Denver, Colorado, confirmed the news and he with Dr. F. V. Meriwether proceeded with the Bureau's rescue truck to Dolomite No. 3 Mine, arriving at 3:50 p.m. Before the arrival of the rescue truck there had been a considerable accumulation of people near the mine and the region around the mine opening had been roped off. There also had been a number of people who had gone into the mine.

Mr. Harrington conferred with General Manager A. J. Boynton and placed at the Company's disposal the Bureau's truck and equipment. Mr. Boynton advised that over 450 men were (actual number of men checked and about 325 additional men in the adjacent connected No. 1 mine) into the Mine No. 3, 475/) in the mine before the explosion and at that time (about 4 p.m.) about 50 men had already reached the surface, hence it looked very serious as the explosion had sent flame out the 850 foot slope of 30 degrees and the flame had ignited and partially burned down the wooden part of the tipple superstructure about 250 feet from the mouth of the slope; the lower portion of the tipple being of concrete construction was intact. Shortly after 4:00 p.m. Pittsburgh and Washington were notified of the explosion and a request was made for dispatching a Bureau rescue car to the scene. Before 5:00 p.m. men more or less burned from the explosion began to come out of the mine and were being treated by

doctors at the supply house near the mine. Dr. Meriwether (Bureau of Mines surgeon) offered his services to Dr. Lacey, chief surgeon of the Company and aided in systematizing the work and secured the Bureau's two oxygen inhalators and used them to good advantage upon gassed men at least eleven (11) of whom were given oxygen and probably at least six (6) lives were saved by the administration of oxygen. In all over twenty-five (25) men were treated by the doctors for burns and gas and at least thirty-five (35) more for gas.

There were practically no cases of broken bones among the injured and very few if any among the killed, death being due to burns and gas. By 10:00 p.m. practically all the live persons including the seventy (70) or more injured or gassed had been removed from the mine and by 3:00 a.m. November 23, 1922, almost all the bodies had been removed. One body was recovered on November 23 and another on November 24, still another on the 25th; and by November 24 the mine was being cleared preparatory to resuming work.

The rescue and recovery operations were carried on ~~systematically and~~ expeditiously under the direct supervision of General Manager Boynton. A number of the rescuers who ventured too far into the affected zones suffered from the effects of afterdamp. Since the explosion originated on the intaking air current in No. 3 slope and was confined to a comparatively small territory, there was very little difficulty encountered in restoring the air currents to their former

courses, hence there was practically no need for self contained rescue apparatus in the recovery of the victims. Rescue apparatus were only used for short exploration trips into the 4th and 5th crosses off 44th West entry. Men who worked in the live working parts of the mine, report in almost every instance that there was a slight concussion on the air and felt that something unusual had happened. In most cases the men used very good judgement and almost invariably remained in their working places for an hour or more before attempting to make their way to the "yard". One colored miner, John Lacey, who was employed as a "digger" at the face of the 8th cross, 47th East entry, stated that he felt sure something unusual had occurred but never surmised that an explosion had occurred near the "yard". He, as leader held six other colored miners at the face of the 8th cross, 47th East, until 4:00 p.m. Then the men made their way to the yard without accident. John Lacey further stated that his party traveled thru some "bad air" (afterdamp) but there was not enough to effect them. In all 30 men who worked in the cross entries of the 47th East escaped without injury. Again, all men who worked side entries off the 50th East escaped uninjured. Most of these men worked an hour or more before they learned what had happened. All the men with a few exceptions who worked off the 49th West escaped unharmed about an hour or so after the explosion. About fifty (50) men from the workings off the 49th West barricaded themselves in the first cross. The following statement of George

Ann Barth

Anthony, section foreman, 49th West, describing the method of procedure and the actual work in constructing brattices in the 1st cross off the 49th West only emphasizes that extremely good judgment was used by most of the men who worked in remote sections.

Statement of Geo. Anthony, section foreman,
on 49th West 1-2-3- and 4 Crosses.

"I was in the 49th West 4th cross heading when the explosion happened, it made me deaf for a moment. I felt the air rushing thru the crosscut next to me. I asked the men who were working in the face of heading if they had set off gas in the aircourse; they said,'No'. I said, 'Come on out of there, don't stay in that smoke.' Then I went out ahead of them and when I got to the trap door, I met Sam Travis, Albert Shoemaker, A.D. Jones and a number of others, they were coming out of the aircourse at the 4th cross door. They asked me the way to the 3rd cross. I told them we could go through No. 4 room, so we went that way to the aircourse of the 3rd cross to the heading. We tried to get out to main line there but could not get out. We went thru No. 11 room to the 2nd cross and met the bad air there, - then thru No. 15 room to the 1st cross and tried to get to the slope but could not stand the air. We went back up the 1st cross ahead of the smoke and Mr. Travis and I decided we had better build a brattice to keep the smoke off of us, so we went to work and made 2 walls of rock across the entry leaving a space of about 50 feet between them. There were about 8 white men and 40 or more negroes in our bunch. After completing those 2 walls the smoke was coming thru them, so we went up to the switch hole and put up another one just above the switch and took canvas down out of the switch hole and took it in with us. While some were working on the last wall, I told Sam and Albert to go with me down the aircourse to see if we could go farther back that way than we could go down the heading, if so, we could take out a brattice and maybe we could pass the smoke, but we could not get back that way, so we went back and finished the brattice and stayed there until one man who was outside the wall in the aircourse went out the aircourse, and met the rescue men, not wearing apparatus, coming in, and he came back and told us to come on that the way was clear. We went out through the first cross aircourse thru No. 15 room to 2nd cross and out to the slope that way. There were at least 50 of us." (See map for location of brattices).

Barricades were erected each with two walls of dry rock with about two feet between walls and the intervening space was filled with dirt in order to make tight stoppings. According to statement of survivors which included the statement of George Anthony, the first barricade had been erected in this manner but it was not possible to obtain sufficient dirt to fill the intervening space between the walls. Consequently, the smoke and a certain amount of afterdamp seeped thru the first barricade built thereby making it necessary for the men to retreat farther towards the face of the 1st cross. The final barricade was built towards the face of the 1st cross and the intervening space between walls was filled with coal dirt and other material and made fairly air tight.

The 44th West region was affected more than any other part of the mine with the exception of the yard and slope. About fourteen (14) men died from afterdamp in this section, and all but two of the deaths occurred within a few hundred feet from the yard. Two men died from the effect of afterdamp in the side entries off the 44th West; one of these was found near the face of the 4th cross, and the other at the face of the 5th cross. Eight other men were rescued by rescue parties near the fact of the 5th cross off the 44th West who were seriously affected by afterdamp. Several of the rescuers who were not equipped with rescue apparatus suffered from the effects of afterdamp. All the remaining men who worked in this section escaped either by way of the yard or through old No. 2 slope.

INVESTIGATION

A joint investigation of the Dolomite No. 3 disaster was made November 24, 1922, by Company, State officials and D. Harrington, representing the U. S. Bureau of Mines. This investigation was made to collect evidence leading up to the cause of the explosion. J. J. Forbes, U.S. Bureau of Mines, Birmingham, Alabama, during the first half of December made several underground trips into Dolomite No. 3 mine for the purpose of collecting road and air samples and supplementing Mr. Harrington's observations. The observations of the Bureau of Mines investigators together with a description of the tipple slope and yard layout are herewith given.

Dolomite No. 3 mine is in reality a part of No. 2 mine, the No. 3 slope having been sunk on a pitch of 30 degrees and extending 850 feet from the surface through rock to the coal bed, and from the point of intersection with the seam and on line with the slope is a four car track (two empty and two loaded) "yard" or parting. The rock slope is about six (6) feet high and about twenty (20') feet wide with two tracks and the slope acts as the air intake with 70,000 to 75,000 cubic feet of air per minute going down. In addition, the slope acts as the haulage road to the tipple, there being two tracks in the slope. On the east side of the slope along the floor close to rib there was a 3300 volt spiral wound armored protected cable.

The yard, in addition to having the two sets of loaded and two sets of empty tracks, had scales, weigh-house, locomotive pit, office

for officials, etc., In the ordinary operation of the yard there were twelve (12) to twenty (20) employees which included couplers, weighmen, sandmen, sprayers, etc., On the afternoon of the explosion thirty (30) additional employees had gathered on the yard due to cessation of dumping operations on the tipple including seven (7) locomotive crews (three per crew), master mechanic, machinist, electrical workers, transportation foreman, sprinkler, assistant mine foreman, etc.,

The sub-station (see map for exact location) located in the right aircourse of old No. 2 slope and to the east of the yard was pretty well fire-proofed but had a wooden picket fence to protect men from coming in contact with switchboard.

There were really two mines Nos. 1 and 2, connected in numerous places and the ventilation of No. 1 mine was entirely separate from No.2. No. 2 mine has as its main intake the No. 3 slope (known as No. 3 mine) but in addition it secured additional air from old No. 2 opening (slope). The No. 2 fan pulled about 130,000 cu. ft. of air per minute, 70,000 to 75,000 of which came as intake through No. 3 slope, the remainder coming through No. 2 slope as intake. (See map for ventilation of No. 2 and No. 3 mines.) At the time of the explosion the Capell fan, electrically driven, was in operation. This fan is in a fire-proofed house and about 75 to 100 feet from the Capell fan house is another fire-proof house for the Sirocco fan which can be driven by either gasoline or electricity from the same shaft by simply manipulating jaw clutches. The "blowing"

of the cable in No. 3 slope threw all electrical motors out of commission but within fifteen (15) minutes after the explosion, the gasoline motor was in full operation, driving the Sirocco fan.

Between 2:15 p.m. and the time of the explosion, the tail car of a three car trip became jammed in the guide rails of the west dump (rotary dump) on the tipple. A chain block was first used by the tipple crew to pull back the trip but without success. In the effort to release the car that was jammed, two of the cars (front two) were disconnected and pulled forward for a short distance - the hoisting cable being disconnected, the cars run forward with considerable mementum and dislodged the jammed car and broke a 60 pound rail that had been placed across riding ring of dump, about two feet above tipple track rail and about 10 to 15 feet below the jammed car. The rail was placed in the position to prevent the trip from going into the slope in case the jammed car became loosened suddenly. This rail it is believed broke due to crystallization. Upon breaking of the above mentioned 60 pound rail, the cars started back into the slope running on the west track; near the foot of the slope, they crossed over to the east side, (still on the rails) and were wrecked at the foot of the slope and against some loaded cars on the east side of the yard; two of the three cars were on the loaded track at the foot of the slope and the third car jumped to the empty track and was deposited at least 50 feet farther on into the yard against the west rib. According to statement of W. M. Johnson, electrical superintendent for the Company, made at the

Coroner's Inquest, he with Mr. Sneddon found a flattened place in the 3300 volt electrical cable about 100 feet from the foot of the slope and this flattened place caused two of the three copper wire strands to "cross" with resultant short-circuit. Johnson also stated that he found a broken car wheel about fifteen feet (15') below the flattened place in the cable. This cable consisted of three strands, six wires to the strand, of No. 4 copper wire. Each strand was covered with varnished cambric and separated by jute. The jute was protected by a covering of 1/8 inch lead, over the lead was a heavy covering of jute string and over this winding of string were two flat steel tape spirals about 3/4 inch wide and 1/32 inch thick wrapped so one steel tape covered spaces left by the other. The cable was guaranteed for 5000 volt working pressure and was called a submarine cable and said to be suitable for submarine use.

The Bureau's investigators had an opportunity to examine this cable in the mine as well as during the inquest proceedings and afterwards, and they observed the flattened place in the cable and the point at which the cable "blew" or arced. It is said, that whenever a trip broke loose from the tipple and wrecked in the yard, it almost invariably threw into the air a cloud of dust, so dense that at times it was difficult to see any considerable distance on the yard for some minutes. Undoubtedly this runaway trip brought about the usual dense cloud of dust and the attendant short-circuiting of the cable with the resultant arc ignited the coal dust that was thrown into suspension from the wreck. The explosion was propagated to a marked degree by the dry dust on the roof, ribs and

floor of the slope and sent flame with some force from the mouth of the slope igniting the timber part of the tipple structure and tressle work and a tree about 50 feet from the mouth of the slope. It is reported by survivors who were on the tipple that there was considerable flame and the smoke was so dense on the tipple that it was not possible to see for several minutes. F. E. Dean, tipple foreman stated at the Coroner's Inquest, that almost immediately after the trip was wrecked in the slope, particles of coal started to fly, followed almost simultaneously by flame. The explosion also went inby filling the "yard" with flame and killing practically every one in the yard either by burns or by gas or by both and setting fire to the electrical insulation on some of the locomotives that were standing in the yard and to timbers on the far end of the yard. (See map showing yard layout and details of evidence of explosion). The flame then started into the haulage entries and other openings radiating from the yard but was stopped within a few hundred feet presumably because of encountering lack of dust for propagation. This fortunate lack of dust was due undoubtedly to the efficient method of sprinkling of workings and to the fixed sprays at the end of the yard.

At the far end of the yard on the east and west tracks, fixed sprays are used to water incoming loads and outgoing empty cars. These sprays are operated by a lever by a switch thrower. The region around these sprays was thoroughly wet even several days after the explosion. In addition to spraying of cars, nine (9) men are constantly engaged in sprinkling entries and rooms and the entire working parts of mine is kept

well

live men badly burned were found in a place where coke was plentifully splattered along the roof. A few stoppings and a door were blown inby but all evidence of heat disappeared in less than two hundred feet (200') from the inby end of the yard. A grab sample of road dust, Can No. 05796, was taken at this point in a region where heat and to a less extent, force died away. (The analyses, sizing and interpretation of road samples are given in Table 5). Similarly evidence of heat disappeared in the 50th East heading about six hundred feet (600') from inby end of yard, the forces however being sufficiently strong to wreck an automatic door ((American Mine Door Co.). An engineering corps of four men who were in the 50th East heading opposite 2nd cross entry were thrown to the floor and received slight injuries. These men state that they were facing the explosion wave and observed no flame, but that there was considerable heat. The door between 50th East heading and aircourse at 2nd cross showed slight evidence of being moved in the direction of the aircourse. A grab sample of road dust, Can No. 3056 (Lab. No. 88013) was taken on the 50th East heading approximately four hundred fifty feet (450') from the inby end of the yard where the flame apparently disappeared. (See Table 5).

The motor pit and machine shop near inby end of the yard were practically unaffected by flame or violence but it is reported that at least one man was killed by gases.

In the 49th West heading flame disappeared within three hundred feet (300') of the west end of the yard. A grab sample of road dust was taken in Can No. 37 (Lab. 88014) in a region three hundred seventy five (375') from the

yard. It was observed that gob stoppings between the heading and the right aircourse were partially destroyed and blown in the direction of the right air course at practically all intersections to the 3rd cross heading. A door between the heading and right aircourse opposite 1st cross was wrecked and blown inby. Violence and flame appeared in the worked out region which included the 1st, 2nd, and 3rd, cross entries between the 49th and 44th west headings and was probably due to dust, as little or no sprinkling was done or other means of wetting dust available prior to the explosion. An automatic door situated in the first left cross heading was blown towards the 44th west heading. There was considerable evidence of flame, coking, and violence in this heading which serves only as a haulage entry for the 44th west workings. A grab sample of road dust was taken in Can No. 812 (Lab. 88016) in the 1st cross off 49th west and opposite room No. 1. On the day of the investigation November 24, 1922, a fire was found on a post in room No. 1 which had fallen and become partly covered with coal. Also on this same date the body of a negro miner was found a short distance from place of getting grab samples in Can No. 812.

On the 44th West heading there was little or no evidence of coking with the possible exception of the region between the 1st cross and the old No. 2 slope. There was also evidence of considerable force in this heading towards the 1st cross, probably due to dust since this part of the 44th West is not used as a haulage way and is considered more or less abandoned, and not kept sprinkled.

In most of the haulage entries, the trolley lines were still in place and while a few doors were blown out and brattices forced, the violence was not very great at any place except possibly at the motor-generator room (sub-station) where the flame had an abandoned drift in which to gather dust and the flame in this room was intense, charring the paper on the face of ammeters, volt meters, etc., on the switch board; painted wooden pickets on fence around this switch board were badly charred at the top about 3 to 4 feet from the floor but not affected near the floor. The force hit the glass faces of the electrical instruments on the switch board and sent the glass in against the paper dials. An extreme evidence of force was shown in the piercing of a piece of 1/16 inch sheet steel by a piece of wood, the wood being about 1½ by 1½ inches by 3 imches. The hole in the sheet steel being 2 inches by 2 inches and the piece of wood still in the hole on 11/24/22. Two men were killed here, both being badly burned.

Most of those on the yard or main parting were probably killed immediately but had the men in the interior of the mine remained at their working places probably few, if any, would have been killed. In a number of instances, men rushed out of their working places upon hearing the blast or feeling the concussion and upon reaching main aircourses soon met the gases which were being borne by the ventilating current towards the fan, the prompt starting of the gasoline engine after failure of the electrical fan, keeping air currents going nearly normally. When the gases were encountered some of the miners retreated and later on came out safe in fresh air after the currents cleared the gas. Some were rendered unconscious

by inhalation of the very poisonous gases immediately following the explosion and (especially on the east side of the mine) the fresh air quickly replacing the poisonous gases allowed rescuers, without apparatus, to pull the unconscious men out of adjacent gas pocketed places and to leave them in fresh air to recover. It is said, no "diggers" from the east side of the mine died. On the west side, the men, upon leaving working places also met gases soon after the explosion but it seems probable that the extensive open abandoned workings between 49th and 44th West and slope allowed a reservoir of poisonous gases to continue to flow into the west side workings and to prevent fresh air from aiding in resuscitating those overcome by the first rush of gas. Hence, those overcome by the first flow of poisonous gases did not recover and many were found dead in the region of or adjacent to the above mentioned abandoned workings. Moreover, there was more destruction of brattice on the west than on the east side and ventilation was more definitely interrupted, hence some of the workers on the west side died from the gases, though probably very few from burns or violence. Moreover, rescuers report that long after fresh air was found elsewhere, there continued to come from the above mentioned abandoned workings hot gases indicating a fire or fires in those places and that this probably was true is substantiated by the fact that on November 24, 1922, or two days after the explosion a small fire was found in one of these workings.

The map with details of evidence, shows where the dead were found; 29 bodies on the west side of the yard, 30 bodies on the east side of the yard and two along old No. 2 slope and between 47th and 50th East. One body

was found in 43rd West off old No. 2 slope, three in the crosscut leading from the yard to old No. 2 slope, four on 49th West heading between the yard and 1st cross off 49th West, three in 1st cross off 49th West, two in the sub-station, ten on the 44th West heading in proximity to 44th West parting; and finally two bodies were recovered near the faces of 4th and 5th cross entries off 44th West. The total bodies recovered from the mine was 86, and 4 who were seriously burned or affected with afterdamp died in hospitals making a grand total of 90 dead.

One of the odd features of the rescue and recovery work was the fact that open lights were used almost continually and oxygen apparatus scarcely at all, though at least 3 - five men teams, from the Tennessee Coal Iron and Railroad Company wearing Gibbs apparatus, went underground and remained about two hours aiding in helping gassed men to safety, though breathing of oxygen was not necessary with the exception of short exploration trips into 4th and 5th crosses off 44th West. When the first rescuers went into the mine after the explosion they used closed lights but soon live men were encountered coming from various directions and using their ordinary open lights hence closed lights were abandoned. Observers on the outside not knowing exact conditions underground were aghast at the free use of open lights and were distinctly afraid that a second explosion would occur.

Some of the Tennessee Coal Iron & Railroad Company's rescuers used gas masks underground to a slight extent and say they were very handy and efficient. However, it must be borne in mind that practically all of the rescue and recovery work was done without the use of any kind of apparatus

as there was essentially no interruption of ventilation, hence apparently successful use of gas masks in this case is by no means a legitimate argument for general use of them after explosions or fires, as men without apparatus worked practically side by side with the wearers of the gas masks.

CONCLUSIONS

(1) It is the investigators' belief that this explosion was caused by ignition of coal dust by the arc from short-circuiting of the electric cable that extended along the right rib of the slope and that this cable was struck by a flying piece of steel (probably car wheel) from the runaway cars on the slope and flattened to such an extent that at least two strands of the three (3) strand wire cable were forced together, thereby causing the short-circuit with consequent arcing. It is further believed that the dry condition of the slope which includes ribs, roof and floor furnished the fuel for ignition; and that this dust was thrown into suspension by the fast moving trip on its way to the bottom of slope.

(2) It is interesting to note that there were other possible sources of ignition of the dust such as the use of open lights by men working in yard and the possible short-circuiting of electric wires in yard caused by wreckage of trip, either source of flame being capable of causing ignition of the dust cloud but the evidence available indicates that the short-circuited cable was the source of ignition of the dust.

(3) It is apparent that this explosion was stopped from propagating throughout the mine workings by the efficient method of sprinkling employed along the haulage ways that radiated from the yard. There was

however, considerable propagation due to dry dust on ribs, roof and floor in the abandoned region between 49th and 44th West and inby from 1st cross. Also the dry condition of the crosscut from east side of the yard to No. 2 slope afforded opportunity for propagation towards the sub-station and out-by No. 2 slope to 44th West. The 44th West entries between No. 2 slope and 1st cross off 49th West were apparently in dry condition and helped considerably the propagation. It is firmly believed that a large number of lives were saved by the efficient method of sprinkling and a very disastrous explosion prevented which would undoubtedly have found its way into the entire workings of No. 2 and No. 3 mines and possibly into No. 1 mine had the naturally dry dust of the mine workings not been kept well moistened.

(4) It is felt that a large number of lives were saved by the commendable arrangement of ventilation fans. This mine is equipped with two fire-proof fan houses; one fan being electrically driven, while the other fan can be driven from one shaft either by electricity or by gasoline engine. Approximately 15 minutes after the explosion occurred, cutting off the electric current, the gasoline engine was placed into commission and a full current of fresh air was sweeping most of the affected and unaffected parts of No. 3 and No. 2 workings, within a comparatively short time after the explosion. This unique arrangement together with promptness in the issuance of necessary instructions cleared the workings of poisonous gases within a short time and permitted workers and rescue parties to travel in fresh air, and also allowed many overcome by first rush of gas to be resuscitated or to be removed to safety.

(5) The present method of sprinkling in which haulage entries and rooms are washed clean should be continued, also the method of spraying loads and empties at east and west end of yard should be continued. However, it is felt that improvement can still be made in sprinkling and spraying methods such as; (a) Spraying at working faces during important operation of undercutting and loading coal. This would reduce considerably the dust that would be thrown into suspension by fast moving trips. (b) The use of high-pressure sprays placed at convenient locations on main haulage entries. This arrangement would further help to reduce the dust thrown into suspension. The sprays used for sprinkling loads and empties at the far end of the yard could be materially helped by the use of higher water pressure, thereby giving better penetration. (c) The wetting of pillar workings and the wetting or preferably the sealing of abandoned workings. It is believed that failure to wet abandoned workings in the region between 1st cross off 49th West and 44th West entries or to have had them sealed was probably responsible for most of the loss of life on 44th West heading.

(6) The spilling of coal along haulage ways, partings, yard and particularly on the slope could be materially decreased by eliminating as far as possible the overloading of cars. The spilled coal on the slope which amounts to approximately 50 tons per week, makes it necessary to clean the floor of the slope twice per week.

(7) Since No.3 slope is only 850' in length and on a pitch of 30 degrees and at the bottom of this slope is the yard or parting in direct line with the slope, it is felt that the question of the humidification of No.3

intake either by injection of live and exhaust steam or by preheating air with subsequent injection of steam or sprays of water into the air would not altogether eliminate the dangerous condition in the yard and on slope. On the other hand it is believed that if spilling of coal on slope and yard as well as on main haulageways could be held to a minimum, the matter of rock dusting the slope and yard would be effective and solve the dangerous condition present when a runaway trip throws into the air of the slope and yard heavy clouds of dust. The rock dusting of the slope supplemented by use of rock dust trays along the ribs of the slope and the placement of a rock dust barrier in the roof a short distance from the bottom of/slope would throw into suspension clouds of rock dust with the coal dust and probably render the mixture non-ignitable. In fact, it is felt even with the spilled material along the slope and in the yard under present operating practices that rock dusting would undoubtedly be successful, if the large pieces of coal were forked during cleaning operations instead of being shoveled. This would permit rock dust to mix with the fine coal dust and render it inert and only the fines cleaned from the slope would have excessive ash. It would be necessary, however, to clean this mixture at such times that the inert matter, (moisture plus ash) in the road material fell below 75 per cent. Furthermore, the rock dusting of the main haulage entries to points in the mine where the air temperature approximated the ground temperature, these points being a few hundred feet from the yard, could be handled in the same manner, and the present method

of sprinkling carried forward from these places.

(8) Since the ignition of clouds of coal dust is possible by open carbide lamps and also by the short-circuiting of electric light wires, open lights should not be allowed on the yard and electric lights and electric wires should be guarded from breakage through possible wreckage of trips on slope or on the yard.

(9) It was observed during the course of the investigation that all shooting was done by the use of permissible explosives using fuse and cap after coal had been undercut to an average depth of 5 to 6 feet and that shots were tamped with clay stemming brought into the mine by the company and placed at convenient and accessible places to live workings and that shooting was done usually at noon and quitting time, under the supervision of section foremen, when men were in the mine. It is felt that a safer practice would be to fire all shots by the use of electric detonators and blasting machines preferably when all men except shot firers were out of the mine.

(10) It will be noted by a careful study of the gas content of air samples collected at representative places that sufficient gas is emitted to be dangerous in the event of a derangement of ventilation. This fact was very forcefully demonstrated in the explosion which occurred January 10, 1923, in Dolomite No. 1 mine where five men lost their lives by walking into an accumulation of gas and igniting same by open carbide lamps. From the evidence collected leading up to the cause of this explosion it is apparent that the accumulation of gas was caused by a short

(4) Since dangerous accumulations of explosive gases are likely to occur through deranged ventilation and also since there is danger of an explosion through the possible ignition of coal dust by opencarbide lights, the use, throughout this mine, of closed lights, preferably the permissible cap variety is recommended.

(5) Since dangerous accumulations of explosive gas are likely to occur through disarranged ventilation; it is recommended that the workings of each of No. 2 and 3 mines, as well as No. 1 Dolomite Mine be ventilated by a separate split system of ventilation and that gob stoppings be faced with a mixture of clay and cement for prevention of leaks.

(6) It is recommended that the high tension cable be removed from slope and carried through bore hole to the sub-station. (Shortly after the explosion the Company issued orders for all cables along slopes to be removed and run down bore-holes to sub-stations, but as a precautionary measure as concerns No. 3 slope, the Company has laid the electric cable which ran down the right rib of No. 3 slope in a four inch (4") steel pipe in a trench 18 inches deep in the floor of the slope.)

(7) It is recommended that a derailing device be placed on the approach to tipple preventing as far as possible runaway trips from going down the slope. This device could be operated by attendant employed on the tipple. Also it is recommended that another derailing device be placed in the slope approximately 100 feet from the point where it intersects the yard.

at the outby end of the yard. This would practically make the yard neutral as to air flow and would greatly decrease the difficulty of keeping the coal dust safely moist.

(14) The yard should be sprinkled daily before the shift comes on.

(15) It is recommended that the mining company adopt the system of spraying with hose attached to cutter bar of mining machines, in a manner similar to that being done by certain other mines in the Alabama coal regions.

(16) It is recommended that doctors employed in connection with coal mining communities should be aided in familiarizing themselves with treatment for persons afflicted with poisonous gases which are likely to be met in coal mines, especially at time of explosion.

(17) If rock dusting of the slope and yard and part of the main haulageways is not deemed feasible by the company, the following measures are suggested for consideration.

a. A series of sprays, probably every 25 or 50 feet should be placed on the slope and be operated not only at night but during the working shift. The sprays could be closed when handling men on the slope.

b. Instead of introducing steam for humidifying purposes, it is suggested that water used by above mentioned sprays be heated to about 65 or 70 degrees which is essentially the temperature of underground strata. This could be done by placing a small tank on surface with steam coils in a tank, the water from the tank to be sent by gravity into the mouth of the slope, provision being made for about 100 foot head at the upper most spray near mouth of slope by placing the tank near the tipple. The amount of

water necessary would be but 10,000 to 15,000 gallons per 24 hours. If during the cold months the outside temperature is 40° and it is desired to raise the 70,000 cu. ft. of air entering the mine to 70°, it will be necessary to add 30° temperature to the air, and this will require 43,068 B.T.U. per minute, whereas the heat available from 15,000 gals. of 70° water per 24 hours would contain only one-seventieth part of the required heat units.

c. The yard and the slope should be sprinkled daily before the shift comes on. The tipple and the approach to No. 3 slope should also be sprinkled daily. This would prevent winds from sending the dust from the tipple and along tipple plane into the intake air current.

Explosibility of dust from the Dolomite No. 3 Coal Mine,

Woodward Iron Company, Alabama.

Report on the relative explosibility of dust, compared with pulverized coal dust from the Pittsburgh coal bed.

Pulverized Pittsburgh coal dust has been ground until 98 to 99% passes through 100-mesh screen and 85 to 88% through 200-mesh screen.

When tested in the laboratory steel gallery, the igniting flame is produced by firing 9.66 grams of fffg black powder from the bore of a small steel cannon. The gallery is 10 inches in diameter and 17 feet long.

The following lengths of flame in the laboratory gallery are recorded when using pulverized Pittsburgh coal dust at the rate of 285 grams per 1000 cu. ft. of space:

Length of powder flame alone	11.1 ft.
" " flame with shale dust	8.5 ft.
" " flame coal dust alone	17.5 ft.
" " " " " 50% + shale dust 50%	13.5 ft.
" " " " " 40% + " " 60	12.5 ft.
" " " " " 30% + " " 70	12.1 ft
" " " " " 20% + " " 80	11.7 ft.

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Samples of road dust from the Dolomite No. 3 mine have been tested in the laboratory steel dust gallery to determine their degree of explosibility. For this purpose two groups of samples were tested. In the first group samples 88013, 88016, 88358 and 88361 were combined to form composite No. 89192, and

in the second group samples 88014, 88357 and 88360 were combined to form composite No. 89193.

The average degree of fineness of all the road dust samples collected gave the following:

Through 20-mesh screen	100%
Through 48-mesh "	34.7
Through 100-mesh "	18.2
Through 200-mesh "	8.2

The composite samples used for testing in the laboratory gallery were taken from the part of each sample, all of which part had passed through 48-mesh. In the make-up of the composite test samples, all the dust between 20 and 48-mesh was rejected, amounting to 65.3% of the original samples. These test composite samples had the following cumulative screen sizing:

	Lab. No. 89192	Lot No. 89193
Through 48-mesh	100%	100%
" 100-mesh	65	42.2
" 200-mesh	56.4	33.5

Length of flame in gallery 89192 - 15 to 15½ ft.
" " " " " 89193 - 14, 15 and 16 ft.

The analysis of the composite of all the face samples of coal gave,- Lab. No. 80188:

Moisture	2.95	: The ratio of volatile to total
Volatile matter	28.13	: combustible gave $\frac{V}{V + F.C.} = .31$
Fixed carbon	62.40	:
Ash	6.52	: Moisture + ash = 9.47
	100.00	

The average of all road dust samples gave a value for $\frac{V}{V + F.C.} = .321$ and the moisture plus ash gave 38.0, varying from 27.8 to 51.6%.

Comparing the laboratory tests and the analytical data of these samples with the result of tests with Pittsburgh coal in the Experimental mine, it is found that the coal dust and all the road dusts fall within the "region of explosibility," as shown by the curves on the Bureau's explosibility chart, figure 45, B. of M. Bulletin 167.

Both the laboratory gallery tests on the samples and by comparison with the result of tests in the Experimental mine, indicate that the dry dust in the mine should contain at least 73% incombustible material in the form of shale or rock-dust to prevent the dust from being explosive, assuming that the dust in the mine is dry and has as much as 75% of 20-mesh dust that will pass through a 200-mesh screen.

Tests of the samples of road dust show that the 200-mesh dust does not exceed 11%, consequently the amount of shale dust will be less in proportion as the percentage of fine dust becomes less.

In a series of tests conducted in the Experimental mine on 20-mesh coal dusts having different percentages of dust as fine as 200-mesh, it has been shown that the total incombustible required to prevent an explosion diminishes as the percentage of the extremely fine dust diminishes. However, the quantity of dust per foot of entry is also a governing factor. The quantity of 20-mesh dust collected in the mine averaged about 163 grams per foot of entry, 10 feet wide, and this is a

little under 1/3 pound per lineal foot of entry.

It is of interest to note that the average of all road dust samples have moisture 8.5 plus ash 29.5, total 38.0, and when compared with the Bureau's chart showing the effect of free moisture on the explosibility of coal dust, this would fall just within the region of explosibility, whereas samples 88362, 88357, 88356 and 88360, all taken outside of the explosion zone of the mine, fall outside of the region of explosibility and all other dust samples fall within the region of explosibility of the Bureau chart. This is probably the best practical exemplification of the application of the Experimental mine test results to a large commercial mine that has been presented.

To be on the safe side of danger from dust explosion hazards in this mine, it will be best to assume that the degree of fineness of the dust passing a 20-mesh screen will have not less than 20% of 200-mesh; so, on this basis, with road or rib dust having 10% free moisture, there should be added sufficient inert material to bring the total of moisture plus ash up to 55%, or in lieu of inert material, the moisture should be kept up to 18%, a requirement that will involve much expense and frequent sampling and analysis to determine the efficiency of the method. If, however, the dry method, rock dust, is used, sufficient material should be added to bring the inert material to not less than 64%.

J. W. Paul

J. W. PAUL,
Chief of Coal Mining
Investigations.

Pittsburgh, Pa.,

April 11, 1923.

A P P E N D I C E S

APPENDIX 1

Humidification System - Sopris No. 2 Mine.

By
J.J. Forbes - May 1919.

Humidity readings collected along the main intake of the Sopris Mine, Colorado Fuel & Iron Company, Sopris, Colorado, at intervals of 100 to 300 feet.

"One hundred feet inby from the portal of the Sopris Mine there are steam radiators 150 feet in length, arranged in two tiers, 9 pipes in each tier, diameter of pipes 1 inch. About 25 feet inby from end of steam radiators exhaust steam from radiators is injected into the air current. The foregoing curve shows the increase in humidity, commencing 100 feet below injection of steam into intake. On the day these readings were collected the barometer on the outside registered 23" Hg, dry bulb 63 degrees, wet bulb 56 degrees. R.H. 64.3. Total quantity of air entering intake was about 53,000 cubic feet. On the same day a reading was taken in the main return from the Sopris Mine, giving a dry bulb of 63 degrees. wet bulb 62½ degrees. H.H. 98½%, velocity 1350, area 42, quantity of air returning 55,700 It is extremely interesting to note that reading taken opposite radiator was 82 degrees dry, 60 degrees wet, R.H. 26%, indicating a decrease in humidity between the outside of 38.3%. At a distance of 3800' down the main slope the air current was saturated at a temperature of 61 degrees. From this point inby the humidities began to drop slightly, as shown by the curve.

The following table shows all the readings, namely, wet and dry and humidities, taken along the main slope at intervals of 100 to 300 feet.

At place along main slope where steam is injected into intake will be considered as 0 station and all other readings will be based from this point.

Appendix 1 (continued)

Dry	wet	Station Outside portal opposite radiators and about 100' from portal. 100' below live steam jets.	R.H. %
63	56		64.3
82	60		26
85	67		42.8
85	70	200	50
83	70	300	55
80	69	400	60
79	69	500	64.6
77	68	600	68.3
76.5	67.5	700	69.3
72	65	800	72
71	65	900	76
70	65	1000	77½
70	65½	1100	80
69	65	1200	81
69	65	1300	81
68	64½	1400	82.5
66	63	1500	85
65½	62½	1600	85
65	62½	1700	87.5
64½	62½	1800	87.5
64	62	1900	89.5
64	62	2000	89.5
63½	62	2100	91.5
63	61½	2400	92.5
62½	61	2700	93
62	61	3000	94.5
61½	61	3300	97.5
61½	61	3600	97.5
61	61	3900	100
61	60½	4200 outside of parting	97.5
62	61	4700 inside parting.	95.0

Note: At the time of the explosion in March 1919, there were 23 one-inch steam pipes, each one inch diameter and 75 feet long at the mouth of the Main slope (intake), and 27 one-inch diameter pipes, each 36 feet long at the mouth of the Manway (intake), the total quantity of intake air being normally about 75,000 cubic feet per minute.

Appendix 1 (continued)

Road, Rib and Roof Dust Samples Analyses, Sopris #2 Mine.

Samples Taken May 13, 14, 1919 by J.J. Forbes,

Analyses by W. A. Selvig, Asst. Chem.

	Material Samples & Place of Sampling.				
	Rib dust 3rd E. entry 300' inby Main Slope	Rib & Roof Main Slope below 3rd E. Entry	Road 3rd E. Entry between Rooms 26 and 27.	Road 3rd E parting on Main Slope	Road 4th W. Entry.
Date sampled	5/14	5/14	5/13	5/13	5/14
Total weight of sample (grams)	505.2	246.3	-	-	127.7
Per cent on 20-mesh	17.6	19.3	-	-	53.3
Per cent thru 20-mesh	82.4	80.7	-	-	46.7
% of 20-mesh material thru 200 mesh	53.0	59.4	18.6	21.7	14.8
Moisture (as received)	6.61	9.03	5.78	3.22	5.03
Volatile matter (as received)	28.51	29.77	19.83	27.31	25.66
Fixed Carbon (as received)	40.90	38.26	29.23	42.24	41.18
Ash (as received)	23.98	22.94	45.16	27.23	28.13
Moisture plus ash	30.59	31.97	50.94	30.45	33.16

Note: For analysis of sample of coal taken at face of 3rd East entryon May 13, 1919, by J.J. Forbes, see page 14 of the Sopris No. 2 mine explosion report, of which the above tabulation is an appendix.

Note: It is noted that all of the above samples of dusts from Sopris No.2 Mine, taken when operating normally, gave ash plus moisture (inert material) much less than the amount of inert material necessary to prevent propagation of an explosion. (For amount of incombustible to prevent propagation of an explosion see Explosion Hazard Report, pages 91 to 99, of 1918, report of Colorado State Mine Inspector. Also see appendix No. 4 for abstracts from that report). For mine air humidity at time of taking the above dust samples see Appendix 1.

APPENDIX 2

HUMIDIFICATION *

The Sopris explosion, in my opinion, has proven that even with the high relative humidity derived from radiators and steam, ranging from 90 to 100 is not sufficient to render coal dust immune from taking part in a local explosion of fire damp. In my opinion all that can be expected from this system at tis best is that the natural moisture in the mine or from pipes, hose or water cars, will be maintained. Nothing can be added to the above conditions except at points where the dew point has been reached, when the air gives off moisture in the form of water. This only occurs at points where two currents of air at different temperatures meet or where the temperature is otherwise reduced; the current at the higher temperature being saturated to a reasonable degree, deposits part of its moisture upon coming in contact with the current of lower temperature. This generally happens near the outlet or return airway.

The U.S. Bureau of Mines, in their experimental work with coal dust, have proven that to be immune from having coal dust take part in an explosion, it must be so wet that it can be made into wet balls. This can only be brought about by direct application of plenty of water, not at stated times but as often as necessary.

I do not want it understood that my motive is ridicule of the radiators and injection of steam. The desire is only to make evident its weak point by lack of sufficient moisture through inability of the atmosphere to carry more. Unfortunately, no one can say to what extent it has minimized disasters in which coal dust is a factor, further than to say that it is ten or eleven years since we had an explosion in which coal dust was a factor in any of the mines in this state where radiators and steam were used.

The following was taken from Bulletin 425 U.S. Geological Survey: (Bureau of Mines No. 20)

"The rapidity with which water throws off vapor up to the point of the saturation of the adjacent space is remarkably demonstrated in mines. Technically, the air has not a capacity for moisture, and does not become saturated with it, the aqueous vapor filling a given space with practically neglibible reduction in the quantity of air in the same space. The moisture may properly be spoken of as partly or completely saturated, but for brevity it is usual to speak of the 'Moisture carried by mine air' or of the 'relative humidity of the air.'

appendix 2.

"Repeated observations of the amount of moisture carried by mine air, as measured in percentages of the amount of saturation for the observed temperature, have shown that the air current, after traveling about the mine, has a relative humidity of 80 to 100 per cent. In mines in this country the 'return' air current near the outlet rarely, except in the dry climate of the Rocky Mountain region, shows less than 90 per cent of saturation, even in a mine that has appeared dry.

"These observations were chiefly made in March and April 1909, when the conditions contrasted much less than they would in winter. It will be observed that the relative humidity of the return air is nowhere less than 90 per cent, except in the New Mexico and Colorado mines, where the relative humidity of the outside is n normally very low. Therefore the effect of air currents of a relative humidity less than 80 to 90 is to drytout the walls of the passageways through which they pass."

If we have by use of radiators and steam approximately succeeded in preventing the quantities of water given in the table just read, from being carried from the mines, we have in my opinion materially minimized the hazard from coal dust.

* By James Dalrymple, Chief Coal Mine Inspector, Colorado. This article appeared, January 15, 1923, in the "Colorado Fuel and Iron Co. Industrial Bulletin"

APPENDIX 3

Humidity Readings Taken Along Dolomite No. 1 Slope (Night 12-20-22)

Exhaust and Live Steam Introduced Close to Portal - Readings taken by J.J. Forbes U. S. Bureau of Mines and M.H. Crutcher, R.O.

Time	Station	Wet	Dry	Humidity	Quantity	Remarks
9:15 PM	Outside	34.5	35	95%		Air foggy.
	50'	80.0	80.0	100%		Dense fog. Supersaturated condition
	100'	83.0	83.0	100%		" "
	150'	78.0	78.0	100%		" "
	200'	75.0	75.0	100%		Dense fog.Slight dripping from roof
	250'	73.0	73.0	100%		" "
	275'	45.0	45.0	100%		Air misty,This reading taken about 15' above manway that intersects slo
10:30 PM	285'	45.0	45.0	100%	22900	Opposite manway to Right. Misty. Section 4.5 by 6.5 Vel 790. 29sq.ft.
	300'	46.0	46.0	100%		Temperature in manway 39.5-40.5 92% misty, can see roof,floor and ribs for 15 to 20 feet.
	350'	46.0	46.0	100%		Misty. Can see 20 to 30 feet.
	400'	46.5	46.5	100%		Misty. Can see 25 to 40 feet.
	450'	48.0	48.0	100%		Misty. Can see 25 to 50 feet.
	500'	49.0	49.0	100%		Misty.
	550'	52.0	52.0	100%		Misty.
	600'	51.5	51.5	100%		Misty.
	650'	52.0	52.0	100%		Misty.
	700'	53.0	53.0	100%	42000	Section 7x24, 168sq.ft. V equals 750 ft. for 3 minutes. Misty.
	750'	52.5	52.5	100%		Roof dry,left rib dry. Floor and Right rib moist. misty.
	850'	52.5	52.5	100%		Roof and ribs fairly dry. Floor moist to wet. misty.
	950'	54.0	54.0	100%		Roof center moist. Floor wet. Roof near left rib & left rib dry. Right rib moist.
	1050'	53.5	53.5	100%		Right rib and floor moist to wet, left rib and roof left of center dry misty, light.
	1150'	54.0	54.0	100%		Roof and ribs fairly dry. Floor wet Light mist-Roller man's hole.
	1250'	54.0	54.0	100%		Roof center moist. Left rib dry. Right rib moist,light mist. Can see considerable distance ahead, about 50 to 75 feet.
	1350'	54.5	54.5	100%		Roof,floor and Rt rib moist. Left rib dry. Very light mist. Can see almost normal.
11:55 PM	1450'	55.0	55.0	100%		Roof center moist and dry near ribs Right rib moist, left rib dry. Floor wet. Very light mist. Can see almost normal.

appendix 3.

Appendix 3 (continued)

Humidity Readings Taken Along Dolomite No. 1 Slope, (Night 12-20-22)

Time	Station	Wet	Dry	Humidity	Quantity	Remarks
11:55PM	1550'	56.0	56.0	100%		Right rib roof and floor moist, left rib dry. Very light mist. See about normal.
	1650'	56.0	56.0	98.5%		Right rib, floor and roof moist. Left rib dry. Clear.
	1750'	56.5	58.0	98.5%		Roof moist center. Floor right rib moist, Left rib dry & dusty, Clear.
	1900'	57.0	57.5	97.5%		Floor, roof and right rib moist. Left rib dry and dusty. Clear. 7th yard, place where hoist takes care from endless chain. Bar 29.70.
	2000'	58.0	58.0	98.0%		Ribs and roof damp to dry. Floor moist.
	2100'	58.0	59.0	95.0%		Ribs and roof dry. Floor moist. Sprinkling behind.
	2200'	58.0	59.0	95.0%		"
	2300'	58.5	59.5	94.0%		"
	2400'	58.5	59.5	94.0%		"
	2500'	58.8	59.5	95.0%		"
	2600'	59.0	60.0	95.0%		"
	2700'	59.0	60.0	95.0%		"
	2800'	59.5	60.5	95.0%		"
	2900'	59.5	60.5	95.0%		"
1:10 AM	3000'	60.0	61.0	95.0%		"
	3200'	62.5	63.5	95.0%		"
	3400'	62.8	63.5	95.0%		"
	3600'	63.0	64.0	95.0%		"
	3800'	63.2	64.2	95.0%		"
	4000'	64.0	65.0	95.0%		"
	4200'	64.0	65.0	95.0%		"
	4400'	64.5	65.5	95.0%		Roof and ribs dry. Some dust. Floor moist to wet in tunnel.
	4600'	64.5	65.5	95.0%		Roof and ribs dry. Floor moist and compact. Near top of rock cut. Fault
	4800'	64.5	65.5	95.0%		Top of grade, Roof & ribs dry. Floor moist and compact.
1:39 AM	5000'	65.0	66.0	95.0%		Floor moist and compact. Roof and ribs dry. Roof and ribs clean. Bar. 29.76.

Note: Measurement on air taken in slope at top of second heavy pitch about 800 feet, from mouth of slope. Section 15.5 x 5.4 - 84 sq.ft. Vel. for 2 minutes, 964 ft. or 482 per minute. Quantity of air flowing 40,000. Time 2:15 A.M.

Measurement at mouth of slope. (intake) Section 5.3 x 14.7 = 78 sq. ft. Vel. 400 ft. per minute. Quantity 31,200.

APPENDIX 3

Humidity Readings Taken Along Dolomite No. I Slope (Night of 12-22-22)
By J.J. Forbes, U.S. Bureau of Mines and M. H. Crutcher.

Exhaust and live steam introduced close to portal.

Time	Station	Wet	Dry	Humidity	Quantity	Remarks
8:50 PM	Outside	37.5	39.0	88%		Bar. 29.30 Clear, no winds, Steam issuing mouth of slope in large volume
	25'	105.0	105.0	100%		Heavy fog-dripping from roof.
	50'	95.0	95.0	100%		" "
	75'	88.0	88.0	100%		" "
	100'	84.0	84.0	100%		" "
	125'	79.0	79.0	100%		" "
	150'	79.0	79.0	100%		" "
	175'	75.0	75.0	100%		" "
	200'	73.0	73.0	100%		" "
	225'	72.0	72.0	100%		" "
	250'	45.0	45.0	100%	20720	Fairly clear. Upper rib of manway. Reading in manway 41°-42° - 92%. Vel. 740 Section 28 sq. ft.
	300'	49.0	49.0	100%		Roof and left rib dry. Dust dry left rib. Floor and Right rib wet. Mediumfog
9:40 PM	350'	48.0	48.0	100%		Left rib and left part of roof dry. Floor, rest of roof & right rib wet. Collected sample of dust from left rib Can No. 02584. Light fog.
	400'	49.0	49.0	100%		Right and left ribs damp to moist. Roof dry. Floor wet. Can see lights over 50 feet.
	450'	51.0	51.0	100%		Right and left ribs damp to dry. Roof dry, floor wet. light fog.
	500'	52.0	52.0	100%		Right and left ribs damp to dry. Roof dry. Floor wet. light fog.
	550'	52.0	52.0	100%		Ribs damp. Roof dry. Floor wet. lightfog
10:05 PM	650'	52.5	52.5	100%		Right rib moist. Floor wet. Roof dry. Left rib dry. light fog. Can readily see lights 150 ft.
	750'	53.0	53.0	100%		" "
	850'	54.0	54.0	100%		Light vapor. Can see lights 200' or more
	950'	54.0	54.0	100%		" "
	1050'	54.5	54.5			Very light fog. almost clear. Rock part of perimeter dry. Balance, including floor, moist to wet.
	1150'	55.0	55.0	100%		Clear. Right rib moist. Roof dry. Left rib moist.
	1250'	55.0	55.0	100%		Roof dry. Left and right ribs and floor moist. Clear.

Humidity Readings Taken Along Dolomite No. I Slope (Night of 12-22-22)

Time	Station	Wet	Dry	Humidity	Quantity	Remarks
10:05 PM	1350'	55.5	55.5	100%		Roof dry. Left & right ribs & floor moist. Clear.
10:25 PM	1450'	56.0	56.0	100%		Floor moist. Start of 2nd heavypitch
	1550'	56.0	56.5	97%		Part of right rib dry. Roof and left Floor wet. considerable dry dust on right rib and roof.
	1750'	57.5	58.5	94%		Considerable dry dust on roof and left rib within this distance. Bottom of 2nd incline.
	1950'	58.0	59.0	94%	29.73	Roof dry and clean. thruout distance Floor moist. Ribs damp.
11:05 PM	2150'	58.0	59.0	94%		Right and left ribs and roof dry. Floor moist. Ribs and roof in this distance clean.
	2350'	58.5	59.5	94%		Right and left ribs damp to moist. Roof dry and Floor wet.
	2550'	59.0	50.0	94%		" "
	2750'	59.5	60.5	94%		" "
	2950'	63.0	64.0	95%		" "
	3150'	63.0	64.0	95%		" "
11:50 PM	3350'	63.0	64.0	95%		" "
	3550'	63.0	64.0	95%		" "
	3750'	63.0	64.0	95%		" "
	3950'	64.0	65.0	95%		Sample taken from ribs and roof. Cam No. 96029. Ribs and roof dry. Large quantity dust. Floor damp.
	4350'	64.5	65.5	95%		Ribs, roof and floor damp to wet. Natural water dripping.
2:20 AM	4550'	64.5	65.5	95%		125' from top of rock tunnel.(Fault) Ribs and roof dry. Roadway damp and compact.
	4750'	64.5	65.5	95%		Ribs damp, roof dry, floor damp and compact.
2:30 AM	5000'	65.0	66.0	95%		Barometer 29.75. Roof dry. Ribs mois Floor moist and compact.
2:50 AM	In slope 75' below manway		Atmosphere clear		38,350	V. for 2 minutes 650. 1 min. 325 Sec. 178 sq. ft.
3:00 AM					22,960	Reading in manway where slope inter sects V. 820, Sec. 28 sq.ft.
3:15 AM	Outside	34.0	35.0	91.0%	24,600	Reading at manway portal V.820 Area 30 sq. ft.

General Note

Steam issuing from slope portal in large volumes before going into mine and also when surface was reached at 3:15 AM. Seems yo be a short circuiting of air in slope due to large quantity of hot steam entering slope. In other words manway is carrying bulk of air 60 lbs of steam pressure is echausting into slope.

Appendix 3. (continued)

Humidity Readings Taken Along Dolomite No. 1 Slope (Night 12-22-22)

General Notes

The drop in temperature when manway air mixed with slope air, also the decreasing in the fogging. Seems if manway air was either cut off or steam introduced there would be a marked improvement in the humidity, but slope would undoubtedly be fogged a much greater distance down slope.

Note: that there is considerable dry dust found along right rib and roof even thou the air is in a saturated state. Ribs and roof should be washed clean; the system cannot be relied upon as furnishing very much moisture to dust. Further the temperature of the intaking air should be raised a few degrees (3 to 5 deg.) above the temperature of the return air, also meterlogical records of the district should be gone into for minimum temperature. (Probably 30 deg. would be the fair minimum temperature in coal months for district.)

APPENDIX 3

Analyses and Sizing Tests of Rib Dust Samples, Dolomite No. 1 Mine.

The attached report gives the analyses and sizing tests on two samples of rib dust which were collected in conjunction with the humidity readings taken along rib of No. 1 Dolomite slope on the night of December 22, 1922. It will be noted that rib sample 02584, Lab. 88498 was taken approximately 350 feet from No. 1 Dolomite slope and the wet bulb temperature was 48° F, humidity 100%. The air was like a fog, consequently the atmosphere in which this dust sample was taken was in a super-saturated condition; aAgain, Can No. 96029, Lab. No. 88499 was taken along left rib, 4150 feet from portal , dry bulb 65° F, relative humidity, 95%. It will be noted that the moisture content in samples No. 02584 was 8.9% and No. 96029, was 4.7%. Also it will be noted that there is a slight difference in ash content. A sample taken near the portal of slope contains twice as much moisture as sample taken 4150 feet down the slope. According to results of tests run on similar coals in the experimental mine of Bruceton, Penna., all these samples <u>are considered as being capable of propagating coal dust explosions</u> and if sufficient moisture is added to neutralize explosions, there would have to be 21 to 25% respectively, of moisture in the samples.