

Report on the Mine Explosion in

Eccles No. 5 Mine

Crab Orchard Improvement Company

Eccles, West Virginia

March 8, 1926

by

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Coal Mining Engineer

Location.

No. 5 and No. 6 Mines are situated in Raleigh County, West Virginia, about 1/2 mile south of Harper Station on the Virginian Railway. A switch from these mines also connects with the Piney Creek branch of the Chesapeake and Ohio Railroad.

Operators.

The Crab Orchard Improvement Company owns and operates these two mines and is closely associated with the Stonega Coke and Coal Company at Big Stone Gap, Virginia. The late Colonel D. B. Wente was formerly president of both companies. The present officials are:

President, Otis Houser, 1787 Land Title Bldg., Philadelphia, Pa.

Operating Vice President, R. E. Taggart, Big Stone Gap, Virginia.

Chief Mining Engr., J. D. Rogers, Big Stone Gap, Virginia.

General Supt., J. P. Horne, No. 6, West Virginia.

Mine Superintendent, C. A. Sine, No. 5, West Virginia.

Mr. W. C. Shunk, General Manager of the Stonega Coke and Coal Co. is indirectly interested in the management of the Crab Orchard Improvement Company.

Coal bed mined.

The property which the Crab Orchard Improvement Company is mining at No. 6 contains two beds of coal, which at this time are of commercial importance and are known in this field as the Beckley and Sewell beds.

The former of these two beds lies at an elevation of about 1579 above sea level at the hoisting shaft. This shaft lies in the narrow valley of Miller's Camp Branch and is approximately 535 feet

deep. The valley runs in a northerly and southerly direction, the hills on the east and west rising rapidly to about 200 feet above the valley. The Beckley bed is being mined by Mables No. 5 Mine and was measured in two places by the writer. Following are the sections:

A		B	
Taken on right rib of main west manway 60 ft. inbye shaft.		Taken on left rib of manway at No. 4 right entry.	
Bottom	Slate	Bottom	Slate
Coal	25 in.	Coal	18 in.
Bone coal	7 in.	Bone	1 in.
Coal	27-1/2 in.	Coal	27 in.
Gray band	4 in.	Gray band	4 in.
Coal	<u>19-1/2 in.</u>	Coal	<u>18 in.</u>
TOTAL	81 in.	TOTAL	68 in.
Roof	Slate	Roof	Slate

The above sections represent clearly the irregularity of the bed. The analyses of the above samples are given on the attached analysis sheets.

The sheet bearing the laboratory No. 20454 contains the analysis of the coal cut from the section marked "A" above and laboratory No. 20455 contains the analysis from Section "B".

From these analyses it will be seen that this is a very low volatile coal. The roof is shaly sandstone or sometimes slate. In many places in the mine the roof is very bad and frequent falls occur. The floor is of a hard slate.

The Sewall bed of coal, which is mined at Mables No. 6 Mine, lies about 250 feet above the Beckley coal. On account of the temporary changes in ventilation occasioned by the explosion, No. 6 shaft had been sealed so that the writer could not readily enter No. 6 Mine.

The Sewell bed will probably average 4 feet 8 inches thick.

Surface plant.

The tippie of No. 5 mine is built of wood and equipped with shaker screens, picking tables and loading boom, and loads an average of 1200 to 1500 tons of coal per day. This is shipped over the Virginian or Chesapeake and Ohio Railroad to tidewater or to the St. Louis and other western markets.

Just east of the tippie is a large stone building the west end of which contains the hoisting engine and drums. This is a 24 inch by 48 inch steam driven Vulcan hoist equipped with hand and steam brakes. There are no overwind or other safety devices, except that possibly the cages are fitted with dogs to prevent them from dropping down the shaft.

In the rear of the building is the power house proper containing engines and generators. As practically all the power used is purchased from the Virginia Power Company, this machinery was idle at the time of the investigation, with the exception of a rotary converter which converts the current from 2300 volts A.C. to 550 volts D.C. the voltage used in the mine. In the extreme east end of the building is the charging station for the lamp batteries.

About 20 feet south of the hoisting shaft and connected to it by an underground airway, an 18 ft. by 6 ft. Jeffrey fan, directly connected to a 235 h.p. Midgway engine which ventilates No. 5 mine. About 75 to 100 feet east of No. 5 shaft and about 40 feet north of the main power building is the fan ventilating No. 6 mine, a motor driven, belt connected 6 ft. by 14 ft. Capell fan. There

is no auxiliary power to run this fan in case the electric power temporarily fails.

A first aid room and fireboss office are provided near the east end of the power house.

About three-quarters of a mile south of No. 5 shaft is the shaft to No. 3 mine at which a fan, acting as a blowing fan, assists the fan at No. 5 in ventilating the No. 3 Mine. Number 3 mine is not in operation, the coal from that part of the field being hauled to No. 5 shaft.

A thousand feet or more north of No. 5 is the main shaft of No. 6 mine, which is also sunk to the Beckley seam. This shaft acts as a down cast to both No. 5 and No. 6 Mines.

While the surface equipment and some of the surface itself is owned in fee by the Crab Orchard Improvement Company, most of the coal is under lease by them.

The mines were formerly owned and operated by the New River Collieries Company which is understood to have been controlled by the Guggenheim Interests of New York.

Originally there were six mines, Nos. 1, 2, 3, 4, 5, and 6. The odd numbered mines being in the Beckley bed and the even in the Sewell bed. All have ceased operating except Nos. 5 and 6.

UNDERGROUND EQUIPMENT.

Drainage.

The mine is not considered to be a wet one, two main centrifugal 500 gallon pumps and nine 8-1/2 inch by 6 inch Deming gathering pumps

taking care of all the water; in fact, only one of the larger pumps runs steadily. Probably 500,000 gallons of water per day would cover the total average amount of water raised from the mine.

Owing to the rather rolling contour of the floor, the water is mostly found in shallow pools and just about covers the rails in the haulageways. The pumps are all electrically driven and the gathering pumps are mounted on carriages.

Cutting machines.

All the coal is cut during the night shift by four Jeffrey cutting machines; one Jeffrey 29B; one Jeffrey 35B3; and two Jeffrey 33A machines; No. 35B3 being a permissible machine. Some of these machines are center cutting machines, the cut usually being made about 30 inches above the floor.

Explosives and shooting methods.

All coal is shot by electric detonators and battery, a permissible, Red No.L.F. being the explosive generally used. The shot firers carry the detonators, load and tamp the charge and fire the shot. Clay is universally used and is tamped with a wooden tamping bar.

The battery used for detonating the charge is an ordinary Edison cap lamp battery and not only furnishes the current for the explosive, but at the same time furnishes it for the cap lamp.

Haulage.

Cage hoists are used and the cars are pushed on by hand, the loaded car pushing off the empty. The main haulage units consist of two Jeffrey 15-ton trolleys, one Westinghouse 15-ton trolley and one General Electric 15-ton trolley locomotive, while 16 Westinghouse

6-ton Bar Steel gathering locomotives with electrically driven reels and 2 Goodman 5-ton locomotives with mechanically driven reels bring the coal to the main central parting.

The track and main haulage-ways are laid with 48 pound rails on standard wooden ties.

Mining Conditions.

The present owners, the Crab Orchard Improvement Company are changing the system of mining somewhat from that used by the old company. In general, the room and pillar system was used but in rather an irregular manner. At present more of the mine is being placed on the panel system, new sets of main entries are being driven on the four entry system and some pillars are being drawn.

There is a large amount of old workings, some of which have fallen in and in some of which part of the coal may be recovered at a later date.

Fig. No. 1 is a map of the workings in the lower bed showing the ventilating system and some of the details of the explosion. It was originally planned to have Mines 1, 3 and 5 develop the Beckley coal and Mines 2, 4 and 6 the Sewell coal. At present the operations are all confined to Mines 5 and 6. The coal is cut about 30 inches from the floor. The lower bench is shot first and then the upper bench.

Rooms are driven from 20 to 25 feet wide and room pillars from 50 to 60 feet. Entries are from 12 to 14 feet wide.

Ventilation.

The ventilation system of the mine before the explosion is shown by the arrows in Fig. No. 1. No. 5 shaft is divided by a 10-inch

reinforced concrete curtain wall into an airway and a hoisting compartment. A fan is connected to the airway and when running normally as an exhaust, the hoisting compartment acts as a downcast.

No. 6 Mine's main shaft has been sunk to the Beckley coal and it was divided by a curtain wall as far down as No. 6 landing into an air compartment and a hoisting compartment. At the level of the Sewell bed false bottoms had been fitted into the shaft in the hoisting compartment which acts as a check to the downcasting air and deflects the current into No. 6 Mine. The air compartment extended down to the Beckley coal and it also acts as an intake to No. 6 Mine. At No. 3 Mine an electrically driven Jeffries 8 ft. x 16 ft. fan, acting as a blowing fan, ventilates the old No. 3 Mine, and a section of the old workings of No. 6 Mine, this latter part of the ventilation exhausting through No. 6 fan. In all between 150,000 and 190,000 cubic feet of air per minute is the normal measurement of the return at the upcast of No. 6 shaft.

Nearly all the stoppings on the main aircurves are either concrete or brick and in less important places of wood.

Masonry over-casts have been built in a number of places.

Lighting.

The bottom of the shaft is lighted with electric lights and the miners are supplied with Mison Cap Lamps approved by the United States Bureau of Mines.

The firebosses use flame safety lamps for testing for gas and at night the machine men are provided with flame safety lamps to test for gas while making their cuts.

Gas Inspection.

Four firebosses enter the mine and make their inspection previous to the day shift commencing work. Through the day casual inspections are made by the mine foreman or his assistant. No regular inspection of the working places are made by a certified mine foreman or fireboss immediately preceding the night shift coming on duty.

Previous Explosion.

On April 28, 1914, an explosion occurred in this same mine which killed 172 men in No. 5 and none escaped. In No. 6 Mine 8 men were killed by afterdamp and 66 escaped, one of whom later died from injuries incurred while getting on the cage.

The explosion in No. 5 was most violent around the shaft bottom, Main East, Main West and Main South entries, and Fig. No. 2 shows the general area of violence of the 1914 explosion.

The evidence found in the investigation of that disaster admits no doubt but that the explosion was propagated by the coal dust on the ribs and floor of the mine and points very strongly to a blown-out shot.

The theory of the explosion being caused by an electric arc, due to the grounding of a power carrying wire by heavy falls, igniting the dust clouds resulting from the fall seems to be disproven. A series of tests to determine the liability of Hoopes dust being ignited by an electric arc was made, which consisted of 56 trials involving 1763 separate flashes. These flashes were made with currents ranging from 10 amperes at 600 volts to 65 amperes at 750 volts. Not a single propagation of flame was obtained in this dust cloud.

In the report on these tests by the electrical section of the Bureau of Mines occurs the following statement. "Such very large areas were obtained in some of these trials that it seems inconceivable that the Moolas dust would not have ignited and propagated if it was possible to accomplish this by electrical means. Every effort was made to obtain ignition, but there seemed a total absence of propagation.

IGNITION AND PROPAGATION TESTS.

Ignition and propagation tests were also made on the Beckley coal at Moolas in the Bureau's Experimental Mine.

The following is taken from the Report of the Explosion made at that time by engineers of the Bureau:

"Two classes of tests were made called ignition and propagation tests. In the ignition tests, a mixture of coal and shale is distributed from the cannon outby in two parallel entries for a distance of 350 feet from the origin. The explosion is started by a blown-out shot from the cannon of a charge of four pounds of FFF black powder stemmed with three pounds of clay. In the propagation tests, the explosion is started in a 50-foot zone of Pittsburgh coal dust; it has been found in practice, that an explosion started in a zone of this length would give an effect which would be equivalent to the ignition of a body of explosive gas. Outby these ignition zones, a mixture of the dust and shale is distributed for 300 feet; the explosion is originated as in the ignition tests by a blown-out shot of black powder

from the cannon at the face of the entry.

The results of the ignition tests in brief are as follows:

With no gas present in the air current, mixtures of coal and shale, containing 30 per cent or less shale, will explode, but those containing 40 per cent or more would not.

With 1 per cent of gas in the air current, mixtures containing 40 per cent or less shale will explode.

With 2 per cent of gas in the air current, mixtures containing 60 per cent or less shale will explode but those containing 70 per cent or more would not.

In the propagation tests, it was found that an explosion originated in a coal dust zone will propagate through mixtures containing 40 per cent or less shale, but not through those containing 50 per cent or more shale; if one per cent of gas was present in the air current, an explosion would propagate through a zone having a mixture containing 50 per cent or less of shale, but it is thought would not propagate through a mixture containing 60 per cent or more of shale."

A series of tests was made at a later date and the detailed results may be found on page 309 of Bulletin 167.¹

The following table is compiled from these tests and is given here because the results of the tests conducted have a direct bearing upon the explosion of March 8, 1926.

¹ Coal dust explosion tests in the Experimental Mine, 1915-1918, inclusive, by George S. Rice, L. M. Jones, W. L. Eby, and H. P. Greenwald. U. S. Bureau of Mines Bulletin 167, p. 309.

Ignition Tests.

Test No.	Ratio coal dust to shale dust in mixture	Rate of loading lbs. per ft.	Per cent of gas used	Remarks
201	80:20	2.80	0.0	Ignition obtained.
202	70:30	2.86	0.0	" "
203	60:40	3.33	0.0	Ignition not obtained.
204	60:40	3.33	0.87	Ignition not obtained.
205	60:40	3.33	1.00	Ignition obtained.
206	50:50	4.00	2.38	Ignition obtained.
207	40:60	5.00	2.25	Ignition obtained.
208	30:70	5.00	2.10	Ignition not obtained.

Propagation Tests.

206	60:40	3.33	0.0	Propagation obtained.
206	50:50	4.00	0.0	Propagation not obtained.
207	50:50	4.00	1.15	Propagation obtained.

The following recommendations were made in the Bureau of Mines report, some of which have been adopted and put into operation, others are about to be adopted.

1. The exclusive use of safety lamps.
2. The use of dust tight cars.
3. The removal of fine coal and dust from all parts of the mine.
4. The application of stone dust along the principal entries from which rooms are turned, and on all haulage entries.
5. The adoption of the panel system of mining and ventilation.
6. Where connections must be made between the mines, or between large sections of the same mine, dust barriers should be installed.

as shown on sketch in the appendix to this report.

Story of the 1926 Explosion.

The following is a story of the explosion as given to the writer by J. D. Rogers, Chief Engineer of the Company, Mr. Robert Lilly, Inspector of the Department of Mines, West Virginia, and Mr. W. H. Forbes of Bureau of Mines Rescue Car No. 7.

About 6:50 p.m., March 8, 1926, H. S. Mullins, General Mine Foreman of No. 6 mine was standing in the mine foreman's office of No. 6 mine when he saw an explosion in No. 5 shaft and almost immediately smoke and wood came up No. 6 shaft. As far as Mr. Mullins could tell, the two explosions occurred simultaneously.

He immediately went to the fan which ventilated No. 6 Mine and found it uninjured, and running normally. This fan down-casted at No. 6 main shaft and upcasted at the fan shaft. He then returned to the main shaft of No. 6 Mine and cleared the cages for man-trips, as the day shifts had not all come out of the mine; in addition four machine-men, two electricians and one pumper of the night shift had already gone down, so in all there were thirty men in the mine. One machine crew was in C-1 entry, the other machine crew was in A-1, a pumper in the scale house, and the electricians in the motor pit. One main line motorman and brakeman were at the passing siding on Third Left Entry, one main line motorman and brakeman were at C off the main east, one main line motorman and brakeman were at the shaft bottom. A section foreman, two trackmen and one helper were on First Right off First Right off the North.

Thirteen men were at the shaft bottom waiting to be hoisted.

After ascertaining that the No. 6 cages were in a condition to hoist men from the mine, Mullins tried to get in touch with the shaft bottom but without success, but did manage to reach G. J. Jarvis, a main line motorman on the main siding at Third Left. He instructed him to open the Main East door which would short circuit the air from the east section of the mine and prevent smoke and fumes from penetrating the section of the mine where the men were working. Jarvis left the telephone, not knowing of the explosion, and started towards the door about 400 feet distant. Although he met smoke and fumes and could only with difficulty make the door he managed to get it open finally. It was a plucky thing to do and as it probably saved the lives of the thirty men, or at least twenty-nine as one was killed later, he deserves the highest praise.

In the meantime some one had stopped No. 6 fan and at the same time Mr. Mullins had started down the shaft. For this reason he had only been lowered about 150 feet before he was compelled to give the signal to be pulled up. As soon, however, as the fan was started up he was able without difficulty to descend and found twelve out of thirteen of the men who were at the shaft bottom. One of them had been affected probably by CO, but had recovered when Mullins landed at the shaft bottom. Some of the others were unconscious and were put on the cage by Mr. Mullins, Rob Robertson and Joe Pindur who had gone down the shaft with Mullins. One man, Arthur Wilkes, colored, was found lying on his face in the middle of the track; apparently he had just left the motor

pit and started towards the shaft bottom. There is some doubt as to whether he had been overcome with gas or died from some other cause. It is stated that the men felt the shock of the explosion before the power went off and the theory has been advanced that Wilkes in his excitement came in contact with the trolley wire and was electrocuted. It is well known that he was not exposed to the explosion gases as much as were some of the others.

Mr. Mullins telephoned Jarvis to hunt up the men who were working in C-1 entry and vicinity and hold them at the telephone for further instructions. This he did, with the exception of the machine crew in C-1 entry, and later brought them all to the shaft bottom, followed shortly by the mining machine crew and all reached the outside in safety. Soon after the explosion the Department of Mines of the State of West Virginia was notified and Robert Lilly of Mount Hope, State Mine Inspector for the Macon District, arrived about nine o'clock and took charge of the rescue and recovery work. About half an hour later the State Rescue Station's team arrived followed closely by the New River Company's team and the Statesburg and Glen White crews of the S. E. White Coal Company and a crew of the McKell Coal and Coke Company; R. M. Lambie, Chief of the West Virginia Department of Mines, arrived about the same time.

In the meantime without any special orders the station agent of the Virginian Railway had wired the railroad headquarters to have the line cleared for the U. S. Bureau of Mines Rescue Car No. 7, then training at Thorpe, West Virginia. This was done with such efficiency that

the railroad men at Thorpe knew of the explosion as soon as the Rescue Car's crew. Leaving Thorpe March 8 at 8:50 p.m., the car with Walter London, Foreman Miner, and E. H. Graff, First Aid Miner, arrived at Koslos at 1:30 a.m. March 9; W. H. Forbes, Asst. Engineer from Huntington, West Virginia, came on March 10.

With the arrival of the State's force, an examination was made of the surface equipment; the explosion doors of the fan of No. 5 Mine were found to be blown off, 1 cage was at the ground landing, the other wedged about 60 feet from the bottom of the shaft. The cage at the ground landing was in such shape that it could be put in service with but little delay and then four hoists were made to determine whether or not the shafts were clear.

About 7 a.m. on Tuesday morning, March 9, Messrs. Lambie, Lilly, Posey (outside construction foreman) and Stanley were lowered down the shaft to find out its exact condition. It was found that the curtain wall was badly damaged and later when a repair crew was sent down they found the air chamber (normally a return) was filled with debris for about 20 feet from the bottom and the curtain wall had been blown completely out for about 60 feet beginning at a distance of about 20 feet from the shaft bottom. The lower 20 feet was intact. Work in the shaft was stopped and it was decided to reverse the ventilation. No. 6 shaft was sealed and No. 5 shaft was made the main intake, the return air passing through the affected area up No. 6 shaft to the Sewell seam and thence to the air shaft and No. 6 fan. The balance of the return of No. 5 going to No. 3 fan.

After this had been done, Messrs. Lambie and Lilly with canaries and "All Service" masks, carrying flame safety lamps, explored around the shaft bottom and motor pit where they located 7 bodies and 2 legs of another. They then returned to the surface and made up another crew with which they returned and advanced as far as the pump room where they found the pumpman sitting on his bench, evidently overcome with CO, or else a deficiency of oxygen, as he was not burned. They then went to the main west entry and explored as far as the first breakthrough inby the third left. At this point the canary bird showed no signs of distress and as the damage from this point inby seemed to be less than between there and the shaft it seemed to be evident that if any men were left alive they would be found beyond third left. The party then returned to the surface and reported the conditions which they had found and the conclusions at which they had arrived concerning the possibility of finding the men alive. Following this report all efforts were concentrated on getting into the main west entries inby third left and crews began erecting canvas stoppings on the main west. While engaged in this work the bodies of three men, apparently overcome with carbon monoxide, were found. Two of these, Clyde Muncie and T. J. Click, were found on the main west heading just where it turns at an angle to the left inby fourth left entry, and one, E. C. Blair, on the main southwest heading off the main west. Evidence was found that this last body had been dragged to the place where it was found. That this conclusion was correct will be shown later in this report.

The recovery work was then carried on to second Right Entry off the Southwest Mains. The rescue parties were assured that they were on the right track by a sign on the telephone at first Right, which read "You will find us in 2nd Right". Further on another sign read "Come to 3rd Right". This latter sign nearly cost the life of Lambie, Maxwell and Thewliss because when the fresh air had been brought to 2nd Right and the Southwest Mains, these three men fearing that there might be men in 3rd. Right went on ahead of the main crew and into 3rd Right. They soon found that they were wrong and retraced their steps. Because of the fact that the ventilation had not been brought up as far as these three men had gone, they began to feel the effects of carbon monoxide and Lambie went down at 2nd Right and the Main. London, Foreman Miner of Car 7, immediately began artificial respiration and after working over him for some time succeeded in restoring him to consciousness, but with the loss of a couple of teeth broken while forcing open his set jaws.

Maxwell stumbled to First Right and the Main Southwest when he too went down and was also brought back to consciousness by artificial respiration under the direction of London. The third of the crew, Thewliss, walked out alone, although pretty sick.

Meantime the fresh air had been carried up 2nd Right to about the fourth breakthrough where the barricade was found. The ten men who had barricaded themselves, came out over the top at the barricade and were in better condition than the rescue crew itself. The time of this rescue was about 9:50 p.m., March 9th.

After these men were taken care of, the next step was to try and penetrate 3rd Right off the Main West. Stoppings were built as far as the intersection of B 2 and the Main Northwest Headings. This was all done in the fresh air. The party retraced their steps and found the body of a pumper, George Marlin, on 2nd Left off Main West Heading. There were no signs of violence on the body so he had, no doubt, been overcome with carbon monoxide or a deficiency of oxygen. The recovery crews then made their way into 1st Left off the Main West to Room 15, where they found the bodies of two track layers, H. O. Stanley and Richard Keesee; the bodies were close to each other, one man lying on his back, the other on his face. They had the appearance of having been standing facing each other when they were knocked down by the concussion and never had moved. The trolley motor and car, which these men had with them were not damaged; the trolley was still on the wire and the men's dinner buckets had not even been moved. Outbye, was a pool of water, two feet deep. These were recovered about 5:30 a.m. on Wednesday, March 10th. This completed the work of this shift.

The next shift explored the territory around the diagonal entries between No. 3 Right and the Main Northwest entries but found no signs of any men. B2 Entry and the four Main Northwest Headings were sealed in order to expedite the recovery of bodies supposed to be in 2nd Left off "A" Entry, especially as there were evidences of smoke on the return of the Main North West.

It was only with difficulty that the ventilation in this part of the mine could be restored and it was not until Thursday morning that the place was cleared sufficiently to get into the face of the entry.

About 4 p.m. in the afternoon, a crew wearing oxygen breathing apparatus made the last hundred feet or more and recovered the badly burned bodies of William Dickey and W. M. Cyrus, a machine man and helper in the part of the Main Northwest Entry being driven from End Left off A1. No violence was shown on either of these bodies. This practically completed the recovery of those killed in the explosion.

Friday morning smoke was discovered at the intersection of 1st East and 1st West and the Main North Entries. Messrs. Forbes, Lilly, Sine (Mine Superintendent) and the mine foreman of No. 6 Mine, after testing with a CO detector and canary bird found CO present and retraced their steps along 1st West, Third Right and the Main West to No. 6 shaft which was then upcasting and found strong evidences of a fire somewhere in the mine. Smoke, fumes and steam were plainly discernible so they backed up to No. 5 shaft and then went in No. 1 Left off the Main East Entry, which is a part of the old workings, not having been active since 1914. Here were more evidences of a fire, coal and wood smoke in heavy volumes coming down the entry. A test with a flame safety gave a 1/2 inch cap and small traces of carbon monoxide were found by a CO detector.

The writer understood from one or two sources that the mine superintendent refused to believe the existence of fire and was with difficulty convinced of the fact. The above mentioned party returned and organized another crew to continue the exploration.

Mention should be made of the danger involved in these explorations because explosive gas was being generated all over the mine and nobody knew what minute it might come in contact with the fire and cause a second explosion. Finally a small fire was found in Room 9 on the First

Left off the Main Mast. A bucket brigade was organized and put it out. This was only the beginning, however, as fires were found in Nos. 12 and 13 rooms on the same entry. Chemical extinguishers were obtained, but were insufficient and 2 hand pumps were installed at an available water hole and with these, on Saturday night, the fire was extinguished. Then a 2 inch pipe line was laid from the shaft bottom and a continuous stream of water was pumped into this area. At the low points in this section wooden dams were built so that the entire bottom was submerged. From that time the temperature dropped until after a week it was down to 66° Fahrenheit.

Experiences of Two Men Saved by Barricading.

Story of James Keith

At the time of the explosion James Keith and his son, Green Keith, and a pumper were working in 5 Right off the Southwest Mains when there was a gust of air that stirred up the dust near the place where they were working. Keith thought that a pocket of gas had been ignited because there was no report. The air on the entry seemed to be standing still, but from where he was standing, in the haulageway between 5 Right and the aircourse just outbye 12 room, it was clear and the reflection of his light on the dust near No. 12 room made it appear white. He continued his work of laying track in the place where the dirt cloud was and also in 11 and 12 rooms which were driving towards No. 6 Right. He was engaged upon this work for about an hour and then came back to 4 Right through an entry which had been driven parallel to and just west of the four Southwest Mains. Here he met L. G. Blair, R. L. Bailey, and

six other men among them T. J. Davis, one of the night foremen. There were two other men with them when they started, but who had been lost. From the location of the bodies it is thought that these two men were Clyde Munsie and T. J. Glick. This party, headed by Davis, were looking for Edgar McKenzie to lead them to the connection with old No. 3 mine. No. 3 mine is directly south of No. 5 mine and originally was separated from it by a solid barrier of coal about 100 feet thick. Part of this pillar had been mined and there had also been several places driven through in order to allow the air from No. 3 fan to assist in ventilating No. 5 mine. Messrs. Keith and Davis disagreed on their chances of reaching No. 3, Keith maintaining that this would be impossible. That he was probably right can be seen by a study of the mine map in Fig. 1. In the first place, from the fact that they were looking for McKenzie to lead them, it is evident that no one knew the way. Then even if any one had been able to lead, they would have had to travel down the main southwest headings to the main west headings, and out these main west entries at least as far as No. 4 left and possibly No. 3 left. Then up one of these left entries towards the connection to No. 3 mine.

That the effects of the explosion penetrated this area is shown by the bodies of Munsie and Glick found on the main west headings and of Stanley and Keesee on 1st left off the main west.

Keith finally prevailed and took them to No. 6 left off the main west where they found a trap door blown 6 feet inby. They then went back to 2nd right where there was a stopping across the entry and a door. On the way there Davis wrote on a board at the telephone at

1st right and the main southwest "You will find us in 2nd right" and at the intersection of the main and the haulageway to 2nd right Keith drew an arrow indicating that rescue parties should go to 2nd right. For some reason Davis wrote "Come to 3rd right" and it was this direction that caused Lambie, Maxwell and Thewliss to go ahead of the others when recovery operations had been brought to 2nd right and so nearly cost them their lives.

Keith and the others then argued for some time as to the proper place to build a barricade so that it would be in the safest place. Some evidently wanted to go nearer to the face, but Keith argued that the air near the face was "too hot" and if they should want better air, their retreat would be cut off. Finally the rear barricade was built about 270 feet in by the stepping across 2nd right. These barricades were only temporary but were made heavier and stronger later by piling up logs, rock and dirt against the canvas. It was Keith's idea to build this so no one could tear it down easily.

When asked how he had obtained the knowledge which enabled him to barricade the men, Keith said he could not read, but that he had heard people talk about barricading and also about the picture (probably the Bureau of Mines film, "When a Man's a Miner") which showed barriers being constructed. He said he had to keep cool and not lose his head because he thought of his wife and how she would feel at the loss of the son which he had with him.

They stayed inside the barricade from about 11 p.m. Monday until about 9 p.m. Tuesday, most of the time trying to keep warm. The

temperature on the outside was near zero on the day of the explosion.

Story of Grever Wilson.

Another survivor whose life was saved by the barricade was Grever Wilson who, at the time of the explosion, was on 2nd right off the main southwest headings. The first thing he noticed was that the ventilating current had stopped, while he was putting a fly across an entry to turn the air up into a room, although he remembered hearing a sound as of a pillar fall.

He went over to 2nd right and found it filled with white dust and he then knew what had happened.

He rushed to the door at the mouth of 2nd right where he thought he would find some of the other men and found Davis, Fridley, Nicks, Blair and Bailey. They discussed the situation and tried to decide upon the best thing to do. Wilson suggested that two of them go hunt Clyde Muncie, James Keith and his son, while the rest hunted a suitable place for a barricade. No one wanted to do this and some one said Muncie and Glick had gone out. All of them then went to 4th right and Blair and Bailey went to hunt Keith and found him coming down the same entry. When they had all gotten together, Keith maintained that there was but one thing to do, to hunt a place for a barricade, while Davis wanted to try to get out through No. 3 mine; both Keith and Blair said it couldn't be done. There seemed to be eight men against barricading and three for. Finally some of them realized that they were losing precious time by arguing the question and finally they got lost wandering around. After some time they found themselves on the main west

entry. From there they went up the main west air course to 6, Left where they found the afterdamp. They knew it was useless to go on, so they retraced their steps to 1st right off of the southwest mains. Some of the men even then wanted to try and dash through the afterdamp but were persuaded not to. When they reached the door at first right Wilson stated they saw the afterdamp wasn't traveling fast so went on into 2nd right. They tried to find out how the air was traveling in this entry because they thought surely it would be reversed. Davis, by that time had become convinced that their hope was in barricading themselves and he together with Blair and Keith decided 2nd right was the best place to build their barricade. No materials such as canvas, etc. were at hand. The nearest place where canvas could be obtained was 10 room on 2nd right. Wilson went to the door at 3rd right for nails. He also got an ax and pick in No. 9 room on 2nd right and they hung a temporary canvas over the door across 2nd right, and then another canvas about 270 feet in by. They decided not to do anything more because they thought it was a small, local explosion and in any event they knew the rescue car would soon be there. This was about 10:30 p.m. of the night of the explosion. They did nothing more for a while because they felt that the canvas brattice would be all right. Finally, Davis, Blair and Wilson decided to go out and see how near the afterdamp was getting and first found it about 225 feet out by the barricade. Then they went down the main southwest entries as far as 1st right trap door. Davis stopped at the telephone and said "Boys, don't go any farther, you have gone far enough". Blair wanted to go on down to 4 left off the main west and so

Wilson said "We will go a piece" and so he and Blair started, Wilson leading Blair three or four feet, while Davis stayed by the telephone. After they had gone 75 or 100 feet they began to feel the effects of the afterdamp and Wilson fell as if "he had stepped on an electric wire" as he expressed it. He got up, made three or four steps but kept growing weaker all the time. Blair also tried to walk, but fell down several times until he finally gave up. Wilson tried to crawl but was so weak he could make but little progress. He did manage, however, to pull himself along by holding to the rail of the haulage track, and finally worked himself over to where Blair had collapsed, lying across the left hand rail with one hand over his nose. Getting hold of Blair's hand, by pulling himself along by means of the rail, Wilson managed to drag Blair a few feet at a time until he reached the door at 1st right. He called to Davis to come and help him and then lost consciousness. When he came to he found himself just below the switch at 2nd right entry; how he got there or what Davis did, Wilson does not know. He tried to get up but felt too weak, so he crawled a little further and seemed to revive somewhat. By crawling and running on all fours, a short distance at a time, gradually getting stronger, he fell through the brattice.

In connection with the death of Blair there are some rather confusing reports. According to Wilson, he called to Davis to help him and the next thing he knew was that he was near 2nd right entry, and by crawling and running he fell through the canvas barricade about a minute before Davis. He says that he "did not know what Davis did".

Others of those who were rescued said that when Wilson, just

before losing consciousness, asked Davis to help save Blair. Davis refused to go, and then said he was affected by the afterdamp and couldn't. It was strongly suspected that he was not so badly affected as he stated. And it was also strongly rumored that Davis allowed these men, Wilson and Blair, to go ahead of him on purpose. Personally the writer is loath to believe this to be the case, but from the fact that he told them that they "had gone far enough" would rather think that Blair and Wilson little knew the real danger or at least did not realize it, and perhaps out of curiosity or the headlessness of youth wanted to go on, while Davis was more conservative. As to refusing to help Wilson with Blair, there is this to say, Wilson went down near 1st right and knew nothing more until he found himself near 2nd right. It seems unlikely that he could go that distance and not know it and it is possible that Davis dragged him that far. At the time of the investigation Davis had left the vicinity and gone to some part of Virginia. It would seem that the worst that can be said of him is that he lacked the qualities of leadership necessary at that time and to be expected from one who was one of the foremen.

After Davis and Wilson had returned to the barricade, with Blair who had gone out, well and strong, with Davis and Wilson only a comparatively short time before, lying dead at 1st right, the seriousness of the situation seemed to impress all of them and Davis said to Keith "Jim, all get together and pray". Some of the men did and some did not. Davis then suggested that they make the barricades more permanent so they filled the space between the canvas and door frame with slack, slate and track dirt. The labybarricade was built of logs laid somewhat like cribbing, intervening space being filled with rock, dirt and slack. Fig. 5 is an illustration of the general plan of these barriers. Fig. 4 shows the probable wanderings of the men before barricading.

Lessons to be Learned from the Story of the Barricade.

From the experiences of these two men and from the information gained concerning their efforts to escape, there may be learned some valuable lessons which should be impressed upon men working in the mines so that they may avoid some of the mistakes made at this explosion.

It will be noted in Keith's story that a party headed by Keith were seeking McKensie to lead them through No. 3 mine to safety.

In Wilson's narrative it will also be noted that even in a portion of No. 5 mine with which they were familiar, they wandered around evidently lost. These two incidents bring out very strongly the futility of a body of men who are unfamiliar with the traveling ways of a mine trying to find their way to safety. In a mine explosion no one knows what entries may be blocked by falls; overcasts and timbers may be destroyed, and it is very easy to get lost. Again, the ventilating current may be gone or at least changed and no one knows where the afterdamp may be found. In this very case, had Davis and the others had their way and tried to get to No. 3 mine, they would have surely run into carbon monoxide.

It would seem to be wise to impress upon those who are liable to be caught as these men were caught, that, unless they are sure, beyond any question of doubt, of the freedom of the atmosphere from afterdamp and unless they know absolutely where they want to go and how to get there, they should lose no time before building a barricade. These men stopped and argued, wandered around and lost precious time. As it was, they did not get their barricade built a moment too soon. In such an

emergency it should be impressed on all miners that time is one of the most precious things which they have and every minute should be utilized in barricading.

A valuable aid to the rescue crews were the directions written in the different places directing them where to find the barricade.

The one fatal mistake made after the barricade had been built and the eleven men safely inside was the exploring trip of Davis, Wilson and Blair. If this had not been done, Blair's life would have been saved. There is an interesting psychological study connected with this trip and shows what the workings of the minds of some men might be under similar circumstances. These men knew they were in danger, knew that they couldn't do any good by going outside and yet there seemed to be that indefinable curiosity to see the danger approach. It seems to be the same "urge" which causes a person to touch a painted building when the sign "Fresh Paint" is displayed, or the impulse to jump which comes to some people when they are on top of a high building.

To the writer this seems a real and important problem to solve; the impulse, once a miner is comparatively safe, to go out of his barricade to see what is happening.

Another point noted in the stories of these two men is the fact that it was necessary to travel some distance to find material with which to build the barricade. This brings up the question as to the desirability of having on each entry materials stored which might eventually be needed for building barricades. The best solution would

be to have chambers especially built for this purpose and to have them scattered through the different working sections. They should be so constructed that they could be easily entered and closed by tightly fitting doors. In the absence of such refuge chambers, rooms should be set apart in which barricade material would be easily accessible.

Evidence Obtained by Bureau of Mines.

On March 19 and several subsequent days the writer assisted by Mr. W. H. Forbes and Mr. W. P. Yant of the Bureau of Mines, Mr. J. D. Rogers, Chief Engineer of the Company, and Mr. Robert Lilly of the West Virginia Department of Mines, made an investigation of the explosion at No. 5 mine. Owing to the fact that ventilation had not been entirely restored and also to the fact that parts of the mine had not been explored, it was impossible to go over all of the mine. Those parts were visited in which the explosion seemed to have originated and where was the most apparent damage. Also the part of the mine where the men were barricaded.

Upon descending the shaft the first evidence of violence was seen in the concrete curtain wall which had 60 feet blown entirely out beginning about 20 feet from the bottom, the lower 20 feet being intact. At the shaft bottom which is approximately 20 feet wide the roof is supported by a series of 10 inch I-beams spaced about three feet center to center. These beams showed evidence of great force; the beam next to the shaft was buckled, into a complete arc, and also having a distinct vertical deflection. Another beam had buckled at least 10 inches outward. Several more were distorted to a more or less degree. From the

direction of the curve the force must have been down the main west heading towards the shaft.

A car was wedged in the bottom of the shaft about 6 feet from the bottom.

The two concrete overcasts over the main west and main right aircourse were completely destroyed. The stoppings on the main east, at least as far as 3rd left, were all out. Beyond this point the mine had not been explored, but there was little indication of any increased violence.

All the stoppings on the main north and on No. 1 west were destroyed.

Going up 3rd right all the stoppings were gone and there were evidences of force and violence all through the entry. Continuous roof falls six feet or more high almost blocked the entry. There was one room running from 2nd right which in one corner had a machine cut into 3rd right aircourse. Previous to the explosion the coal had not been shot down. After the explosion this curtain of coal had been blown out.

On A aircourse at approximately the 12th breakthrough from the mouth of the entry was found the first evidences of coke. This was on the outby side of a post and seemed to have been dust slightly coked while in place. All through this section of the mine were many roof falls and evidences of violence. At the mouth of A₁ and A₂ off 1st west, the overcasts had been completely destroyed.

On 2nd left at the intersection of A₁ aircourse there had occurred a roof fall 5 or 6 feet high and 15 or 20 feet long. The trolley

wire, which also furnished the power for the cutting machine, had been carried down in the fall. This fall gave evidences of having been continuously dropping as part of the roof was still bright and shining, while other parts were duller and partially covered with dust. There was no perceptible amount of dust on the top of the fall. It was stated that almost simultaneously with the explosion the circuit breaker went out.

There were no indications of heat on the trolley wire which might have come from a grounded live wire, but the ends of the wire, provided the wire had been broken, would have been so far under the fall, that any such signs of arcing would have been covered up.

Just in the mouth of 2nd left a few feet inby the fall was a good sized pool of water, at least 2 inches deep and one or two other pools were in breakthroughs between 2nd left and its aircourse.

At the 1st breakthrough between the two above mentioned entries were the only signs of force in either the left headings or the short piece of entry driving towards the main northwest headings. At this point the track had a sharp deflection toward the left rib as if some one had taken a track lining bar and forced it out of line. A heavy fall had occurred at the same place burying the end of the machine cable, although the "nips" were found near the fall. Practically all of the posts and cross timbers in this vicinity were standing unharmed, and a pile of timbers which apparently had been lying along the rib of 2nd left were just slightly disturbed. Although but little violence was in evidence, yet there were signs of intense heat. On the inby side of some of the

posts the dust had been subjected to a very high temperature. A piece of roof which projected lower than the remainder had layers of coked dust on both the outby and inby edges. The appearance of this dust, when subjected to great heat, is rather peculiar. It is very difficult to coke and instead of masses of coke such as may be found after an explosion in a mine in the Pittsburgh bed, it has more of the appearance of having been partially baked forming a cake which is easily disintegrated when handled. Sometimes small globules of coke may be found on the roof and timbers.

About 300 feet inby on 2nd left, an entry had been turned to the left to meet the main northwest headings. It had advanced approximately 50 feet rising about 2 feet in this distance. No levels are given on the map, but from the intersection of 2nd left and A₁ aircourse to the point where this heading was turned there is a raise of 10 feet or over 3 per cent. And apparently the heading which had been turned was rising at about the same rate.

At the face of this short piece of entry was a turret cutting machine said to have been of the Jeffrey-Drennan type, one of the earliest of the turret machines made. It had been equipped with a controller which apparently had once been part of the equipment of a Goodman haulage motor and was so placed that it was only a few inches below the roof. When found the controller handle was closed but the reverse lever was open. The machine had the appearance of having just been run to the face and stopped, as the cutter bar was only about 10 inches from the face of the coal, and about 2 feet above the floor. It

is possible that the operator of the machine throw in the reverse to stop it quickly. If so the danger of arcing would be increased.

A magnetically locked safety lamp was found so securely hooked to the wire mesh protecting the rear headlight that only with difficulty could it be removed.

There were evidences of intense heat around the face of this entry, but little, if any, signs of violence. Small coke bubbles were formed on the roof and flakes of coked dust on the machine. These flakes were apparently formed by the action of the high temperature upon the coal dust which would ordinarily be found on a coal cutting machine.

It was in this entry just outby the machine that the bodies of the two machine-men, William Dickey and W. W. Cyrus, were found, badly burned, but they did not show such signs of violence as did some of the bodies found near the bottom of the shaft.

Pieces of canvas brattice cloth were found by the exploration party during the work of restoring ventilation, indicating that the air from the last breakthrough on 2nd left had been conducted to the place where the machine was ready to cut, by a line canvas brattice.

An attempt was made to go down A-1 haulageway but the methane and air snapped and crackled so violently in a flame safety lamp that it was not considered safe and the idea of returning through this entry was given up. Fig. 5 shows some of the details of evidence in A-1 and 2nd left off A-1.

On 1st west haulageway several heavy falls were encountered, some of them covered with unburned, or partly burned, coal dust 2 or 3

inches deep. The dust had the appearance of having been deposited by the slowing up of a moving current of air which decreased its dust carrying power. Some of these deposits were in wave-like forms, but there was nothing to indicate which direction the air current had been moving.

The overcast on the main north and 1st west entries was blown out. The territory around A_2 and A_3 , off 1st west had not been explored while B_2 , B_3 , B_4 were in similar condition. Consequently the condition of the stoppings in these headings could not be learned, but there is strong probability to believe that they were blown out.

There was but little violence on the main west headings inby 3rd right, nor in the sections on the left side of the main west entries. One door at 6 left off the main west was blown inby and this was the only sign of force visible. As has been stated the bodies of H. C. Stanley and Richard Keese were found, one lying face downward and the other on his back, as if they had been suddenly knocked down while facing each other. Their dinner buckets, standing near, were not harmed, the trolley of the motor was still on the wire and just outby was a low place with water 2 inches deep. The stoppings on the main west haulage between 3 and 4 left were undisturbed.

Unburned coal dust was piled against the rib of main west and 4 left showing that the dust carrying current had slowed down here and deposited some of the dust.

A sample of road dust was taken near this point, the mouth of 4 left, and the analysis is given in the attached analysis sheet of sample A-20457. Sample No. A-20456 was taken on the roadway of the main

west just in by 5 left, and the analysis is given on the attached sheet.

It was in this general area that the men who were in the barricade wandered around before finally going to 2nd right.

Miscellaneous Information Obtained by Bureau of Mines Representatives. -

It was stated by officials of the company that the regular fire boss' inspection had been made of the entry in which the mining machine was found at 5:30 a.m., March 8, and reported clear. As the fire boss' record book had been taken into custody by the State Department of Mines this information was not verified, nor was the statement that A₁ section had been reported clear of gas for months back.

In consequence of this assertion and because of the possibility of the explosion originating in the A₁ section, some tests were made by Mr. Yant to obtain information about the rapidity with which an explosive mixture of gas and air would be formed should the ventilating current be stopped. There was a canvas line brattice in the entry off 2nd left off A₁, where the machine was found, and by opening this a short circuit of air could easily be made.

A sample of air was taken at the face of the entry before the ventilating current was shut off and by analysis contained 0.50 per cent of methane. The following table shows the rate of methane accumulations:

Sample No.	Time	Location of Sample	CH ₄ (Per cent)	O ₂ (Per cent)
1	10:20 a.m.	Face of coal	0.50	20.1
2	10:21 a.m.	Over mining machine 12 ft. from face	0.40	20.8
3	10:45 a.m.	Over mining machine, 15 ft. from face, 6 inches from roof	5.9	18.8
5	11:06 a.m.	"	13.3	15.6
6	11:20 a.m.	"	16.5	16.5

It is to be especially noted that Nos. 2, 3, 5 and 6 samples were taken almost identically in the same place.

In addition to the above, two samples, No. 4 at 10:45 a.m. and No. 7 at 11:25 a.m. were taken over the cutter bar of the machine, about 4 feet from the face and 18 inches from the roof. Sample No. 4 contained 4.2 per cent methane and 19.4 per cent of O_2 .

Sample No. 7 contained 7.4 per cent methane and 19.2 of O_2 . In connection with this sample it is to be noted that the air in the entry was thoroughly stirred by swinging a piece of canvas around. Therefore, the 7.4 per cent of methane is representative of the atmosphere from the roof to the floor.

At 10:45 a.m. or about half an hour after the ventilation was cut off, an explosive mixture was detected 22 feet from the face or about 8 feet from the rear end of the cutting machine. At 11:25 a.m. or in an hour of interrupted ventilation an explosive mixture was found 40 feet from the face. Fig. 6 is a curve showing the rate of accumulation of methane per unit of time.

There are, to the best knowledge of the writer, no systematic inspections of the working places in the mine by certified fire bosses or assistant mine foremen during the day shift and after the fire bosses have made their rounds in the morning. There are four regular fire bosses who make their rounds before the day shift goes in, but none on duty in the daytime.

There may be casual inspections by the mine foremen or his assistants, but none of these whose sole and only duty is to guard against gas accumulations through defective ventilation, roof falls or other

means.

According to the West Virginia law, an electric machine may not be brought beyond the last breakthrough unless the machine-man makes an examination for explosive gas. It seems evident that the company placed their dependence for safety from gas accumulations upon the machine-man. In the case of Dickey it is said that he had been severely burned about four years ago by running his machine into a place before he had examined it. One man expressed his opinion that if everything was running smoothly and Dickey was not in a hurry he would probably test for gas; if he had been delayed and was anxious to get his place out he would not test for gas.

Inasmuch as the signs of violence pointed to the propagation of the explosion by the dust on the entries and rooms, two samples of road dust which were typical of conditions through the mine were taken and subjected to tests to determine their explosibility. Two face samples of coal were also taken and analysed, and the analyses sheets are attached hereto.

In order that the coal and road dust samples may be more readily compared, the analyses are shown in the following tables:

Lab.No.	Moisture	Volatile matter	Fixed carbon	Ash	Volatile ratio
A-20454	2.0	18.5	75.8	5.7	.196
A-20455	2.2	18.9	75.3	5.6	.200
A-20456	5.4	15.5	60.4	20.9	
A-20457	2.6	15.8	60.3	22.1	

These dusts were also tested in the dust explosion gallery and the following table gives the amount of inert dust which must be present in the coal dust and road dust to make the mixture inert:

Lab. No.	I	Material
A-20454	56	Coal
A-20455	56	Coal
A-20456	45	Road dust
A-20457	45	Road dust.

The I value in the table is the percentage of inert material which should be present in the samples in order to prevent propagation of an explosion. These percentages are in confirmation of the results of tests conducted in the experimental mine and given on page 12 of this report.

In a 50:50 mixture of coal dust and rock dust no propagation was obtained in the absence of gas but with 1.15 per cent gas present this mixture gave propagation, and this is the condition which is most likely to be met in this mine, and to be on the safe side, the mine dust should be treated with rock dust so the mixture will show at least 60 per cent inert material.

In selecting a sample of road dust particular care was taken to avoid picking a place where the normal amount of dust might have been increased by that deposited by the explosion.

Sample No. A-20456 weighed 9 lbs. and was taken over an area of 6 x 12 feet, or 9/72 of a lb. of dust per sq. ft. If the entry was 12 feet wide, this would amount to 1-1/2 lbs. of dust per linear foot of entry. The screen tests of these two samples are as follows:

	No. A-20456	A-20457
Through 20 mesh	100%	100%
" 48 "	48.6	45.1
" 100 "	29.3	17.2
" 200 "	15.4	7.5

In the case of sample A-20456 there was over 1/4th of the sample fine enough to pass through 100 mesh or nearly 1/2 lb. per linear foot of entry. Owing to the roof falls, the dust which had settled on the floor of the mine in those sections north of the main west and on the main west themselves, representative dust samples could not be obtained.

In a previous paragraph the statement was made that the battery used for shot firing purposes also furnished the current for the cap lamp.

One of these batteries was examined and revealed the fact that its "permissibility" had been practically destroyed. The method of adapting this cap lamp battery to a shot firing battery is shown in Fig. 7. Two holes are shown, which were drilled through the metal casing opposite to the battery terminals. Around the holes on the inside of the casing were riveted two pieces of insulating material. When the shot firer was ready to fire his shot, he inserted the ends of the lead in the holes until they came in contact with the terminals and completed the circuit, thus causing the detonation of the explosive. These batteries, although changed from their original design, are still carrying the Bureau's "permissible" stamp.

The writer understands that these batteries are sometimes issued to others than to shot-firers.

These batteries were originally so constructed that one cell is grounded against the metal case and consequently if one wire of a circuit is against a terminal and the other is brought in contact with the outside of the case, the circuit will be completed and will receive the voltage of one cell or one-half that of the battery. The fibre insulating material around the drilled holes does not prevent this but simply is to prevent a short circuit by both wires being in contact with the terminals and the battery casing at the same time.

In addition to the evidence gathered in connection with the explosion there were some matters which pertain directly to the safety

of the men which it would not appear to be out of place to mention in this report.

In looking over the hoisting engine there were no indications of any safety devices, which would act in case anything should happen to the hoisting engineer either through accident, sickness, or if he should become careless and neglect to shut off his power when the cage neared the top landing. There were no overwinds or automatic brakes. The ground landing at the shaft is protected only by a manually operated gate, no automatic gate having been installed.

The chart for the pressure gage at No. 6 fan is placed in a position which almost invites an accident. This fan is a belt driven one and both units are close to the side of the building.

The pressure gage is fastened to the side of the building about midway between the motor and the fan. The most natural thing for a man to do in order to reach the gage is to step between the two lines of the rapidly moving belt; over the bottom and under the top line. Otherwise he would have to walk to the end of the building, under the fan shaft and back to the gage.

If, in going between these lines of belt, a loose piece of clothing should be caught, he would be instantly killed.

There were one or two incidents that came to the writer's attention that appeared to indicate that, notwithstanding the fact that the explosions in this mine had killed about 200 men, the mine officials did not realize the danger which is always present in this mine and the quickness with which the explosive forces will act in case a single act of carelessness gives them a chance.

The following is illustrative of the point in question. During the investigation being made by the Bureau of Mines representatives a party which included the State of West Virginia's mine inspector in charge of recovery work, were returning to the shaft bottom from 2nd Right off to the South West Main when they met a negro laborer wandering around as if he was lost. When asked what he was doing, he said he had been sent by the "boss" with a sledge to some one working on an overcast. Across the Main West just inbye 3rd Right a danger-board had been placed and this negro had gone over the danger-board without even knowing what it was or that it was there. It later developed he was one of a gang working on the shaft bottom and was given explicit directions to go back a couple of breakthroughs or so to an overcast, but had failed to remember the directions and came on wandering up the entry over the danger-board.

The foreman should have realized that the average negro laborer is not a safe man to send around a mine as disorganized as was Eccles. If the danger-board had no significance to him at that time, it never would have. It is such lapses of vigilance that often cause disastrous explosions.

Another incident still further emphasizes the apparent ignorance of the dangerous conditions which exist. One evening the power went off and consequently the motor running the fans stopped, leaving the mine with no fresh air.

The writer was reliably informed that when the suggestion was made to get all the men out of the mine, one of the mine officials said that it was not necessary, natural ventilation would be sufficient.

The mining law of West Virginia plainly states in Section 29 -

"The ventilation of all mines in case of accident to a ventilating fan or its machinery whereby the ventilation of the mine would be seriously interrupted, the mine foreman shall order the men to withdraw immediately from the mine, and he shall not allow them to return to their work until the ventilation has been restored and the mine has been thoroughly examined by him, or by an assistant mine foreman, a fire-boss and reported safe."

In this case the power must have been off nearly two hours, at least long enough so that "the ventilation of the mine was seriously interrupted."

To the best of the writer's knowledge there is no well equipped first aid room underground and the one on the surface is, to say the least, not an ideal first aid room.

Summary of Evidence:

1. An explosion occurred in this mine on April 28, 1914, which killed every man in No. 5 Mine, 173 in all, and 9 men in No. 6 Mine, or a total of 181 men, due either to a blown out shot or the ignition of a dust cloud by an arc caused by a fallen power wire, probably the former.

2. In 56 trials involving 1763 separate flashes, with a current ranging from 10 amperes at 600 volts to 85 amperes at 750 volts, not a single propagation of flame through a dust cloud was obtained.

3. In tests for ignition by a blown out shot consisting of 4 pounds of FFF black powder, stemmed with 3 pounds of clay discharged from a cannon into a 50 foot zone of Pittsburgh coal dust, it was found that with no gas

present a mixture of 30 per cent or less of shale dust and 70 per cent or more of Beekley dust would explode, but a mixture of 40 per cent shale dust and 60 per cent of Beekley dust would not explode.

When 1 per cent of explosive gas was present in the air current, a mixture of 40 per cent or less of shale and 60 per cent or more of Beekley dust would explode.

With 2 per cent of explosive gas present in the air current a mixture of 60 per cent or less of shale and 30 per cent or more of Beekley dust would explode. In the propagation tests it was found that an explosion would propagate through mixtures of 40 per cent or less of shale but not through a 50 per cent mixture; if 1 per cent of gas were present in the air current, an explosion would propagate through a mixture of 50 per cent or less of shale but probably not through 60 per cent or more of shale. These tests were made at the time of the 1914 explosion.

4. Tremendous violence was manifested in the shaft and around the shaft bottom and extended up the main West entries as far as 3rd Right. Inbye that point, beyond the blowing out of a wooden door, there were no signs of an explosion. On the south side of the mine, survivors say they felt nothing more than a rush of air. The area of force seemed to be confined to the space east of 3rd Right off the main West and A1 headings and North of the Main West headings. How far east of the shafts the damage extended was not determined because of the unexplored territory. Evidences of violence and the presence of a large amount of explosive gas were very pronounced along 3rd Right and A1 headings and No. 1 West.

5. The greatest evidence of intense heat, accompanied with but

little force, was found in 2nd Left of A1 and the short piece of entry turned south from No. 2 left. Here were found about the only coked particles of dust in the mines.

6. The bodies of two men, badly burned, but not mutilated were found here, while some of the bodies at the shaft bottom were badly mangled.

7. Posts in 2nd Left breakthroughs and in 2nd Left were still standing but had been subjected to intense heat. Some of the cross timbers in 2nd Left were also in place.

8. A cutting machine with a controller evidently taken from a haulage motor of a different make, had evidently just been run to the face of the heading. It was found with the controller closed but the reverse lever open. A safety lamp was hooked to the wire netting over the rear headlight so securely that it was dislodged with difficulty. The machine was an old type turret machine, the controller being only a foot or so from the roof. The machine was covered with coked dust.

9. On A1 entry just at the intersection of 2nd Left, a heavy fall had buried the power wire for a distance of 12 or 15 feet. The circuit breaker in the power house went out practically simultaneously with the explosion. Evidence was apparent that the roof over this fall had been dropping from time to time since the explosion.

10. Both Second Left and the heading in which the machine was located go to the raise quite rapidly.

11. An examination of the attached analyses sheets of mine air samples shows that the mine was generating gas very freely, especially in the 2nd Left area. In one entry the methane percentage was so high that it was not considered safe to travel it carrying a flame safety lamp.

12. The fire-boss' report is said to have shown the mine to have been clear of gas for some months. No regular examinations are made by fire-bosses immediately preceding the time the night shift goes on, nor during the day shift after the fire-bosses, who made the morning inspection have gone off duty.

13. The entire safety of the mine depended upon the ability and inclination of the machine man to examine his place for explosive gas before he ran his machine into it.

14. The machine man, who was killed in the 2nd Left section had been burned several years previous because he failed to examine his place with a safety lamp.

15. Permissible cap lamp batteries had been tampered with by altering them so that they could be used for shot firing purposes. This change now permits a premature circuit to be made with one wire touching the battery terminal and the other the outside of the battery casing.

16. No. 6 Mine felt no effects of the explosion other than after-damp. All the men escaped but one and it is a question whether he was overcome with afterdamp or died from some other cause.

CONCLUSIONS

There are three types of explosions which may occur in a coal mine; a gas explosion, a dust explosion and a combination of the two. The general characteristics of the three are as follows:-

1.- A gas explosion is more or less locally confined, especially in a mine which is in daily operation, and where only a comparatively small section could be filled with explosive gas. The wooden stoppings in other parts of the mine might be blown out due to the sudden increase in pressure,

but signs of extreme violence are confined to the locality in which the explosion occurred.

2.- The second type can only be initiated by some agency which raises and ignites a dust cloud simultaneously. One of the most common forms of an explosion of this kind is that of an imperfectly tamped charge of black powder blowing out and igniting the dust cloud raised by the concussion. Another form is where a dust cloud is ignited by an electric arc; a trip may break in two and part of it may run down a slope, jump the track and pull down the timbers carrying the power wires. These may short circuit and ignite the dust cloud raised by the run-a-way trip. In fact, an actual explosion killing about 90 men is supposed to have been caused by this very thing.

Many dust explosions show manifestations of immense violence, in fact it can be said almost without exception that when an explosion exhibits signs of tremendous force over wide area, the contributing cause is the fine dust swept from the floor and sides of the entries and rooms in the mine.

3.- The third type is the ignition of a body of gas which in turn raises and ignites a dust cloud and the explosion is propagated by a series of dust clouds which are raised and ignited by the original wave. The presence of an appreciable amount of gas in the ventilating current increases its violence.

In addition to the greater and more widely spread violence of a dust or dust and gas explosion over a pure gas explosion, the path of the first mentioned types is often traceable by the coked dust on the timbers, posts and ribs and roof. The formation of coke is, of course, dependent

upon the chemical quality of the coal and its coking properties. This is particularly true at Eacles because the coal contains few, if any, characteristics of a coking coal.

However, from the evidences of force shown in the shaft and the northern and northwestern sections of the mine, there is no doubt that the explosion was at least propagated by dust.

In an explosion of this kind it is mostly true that the immediate area of its origin will show less signs of violence than any other part of its path, and at the same time will indicate the presence of very high temperatures.

It is natural, at first, to connect the cause of such a condition to the human element, and therefore in endeavoring to seek the cause of an explosion one would consequently seek it in the vicinity of one of the working places.

In the Eacles explosion, as there were no signs of violence south of the Main West Entries it is perfectly obvious that the explosion must have started in some part of the mine north of these entries. Following out the idea that it would probably be started by some action of one of the men at work, it will be noted that at the time of the explosion the only persons known to be in the section north of the Main West Entries were the two men in the short entry off of 2nd Left on A1 entry.

At this point, the evidence shows there was little force, but the coked dust indicates high temperatures which probably lasted for some

time. The tests made to determine the rapidity with which an explosive mixture of gas and air could accumulate, with interrupted ventilation, indicates that methane was being generated very rapidly and would reach the

danger point in a comparatively short period of time.

Furthermore, a mining machine was standing in the area with the power off but with the reverse lever open and with its cutter bar only a few inches from the coal. The bar was parallel to the central axis of the machine, showing that the machine was not in a position to make a sumping cut but had apparently just come into the heading under its own power.

Still further evidence may be found in the grounding of the trolley wire by a fall in A1 entry opposite Snd Left.

It is also known that about 4 years ago the machine man Dickey had been severely burned by an ignition of gas in a place in which he was cutting, because he had not made an examination for explosive gas; and in this case his safety lamp was found so securely fastened to the machine that it could only be removed with difficulty. This chain of evidence pointing to the area around Snd Left Entry off A1 as being the origin of the explosion is difficult to combat.

The lack of signs of force in the part of the mine south of the Main West Headings or inbye Snd Right, the only other part of the mine where men were at work, (those at the shaft bottom not being considered) precludes the idea of an explosion starting in that section. Neither is the theory of the explosion starting at the shaft bottom tenable, because of the terrific force which was developed at that point.

This leaves the north side of the mine the only other place where men were at work. With such direct evidence as has been given it would be almost unreasonable to endeavor to assign a cause which would

not be connected with the human element or the work connected thereto; that is to say, to attribute the cause to a fall or crossed wires or spontaneous combustion in some part of the mine in which no person had been for many hours, seems to be going out of one's way to seek an explanation of the origin.

Therefore, the writer is compelled to believe that the explosion originated in the vicinity of the 2nd Left Entry off A1 Entry.

As to the cause of ignition there are two possible explanations. Explosive gas was ignited by a spark either when the cutting machine was traveling up the short piece of entry in which it was found or just as it stopped at the face. Second, a dust cloud or a combination of gas and dust were ignited when the fall on A1 entry at 2nd Left tore down the trolley wire and caused an arc when it grounded.

In the tests made subsequently to the explosion in this mine in 1914, the evidence shows that in 1763 flashes not an ignition was obtained and referring to the report of the electrical section, previously mentioned, it would seem next to impossible to ignite Eccles dust by an electric arc. However, these tests were presumably made without the presence of explosive gas. There might be a possibility that in a mixture of 1 or 2 per cent of methane, an ignition by an electric arc might occur.

On the showing of the above mentioned tests with an electric arc, it is quite reasonable to abandon the theory of the ignition of a dust cloud by an electric arc in the absence of explosive gas. This leaves the possibility of the ignition by the grounded wire of a cloud of dust in the presence of explosive gas. An inspection of Fig. 5 will show that 2nd Left Entry rises from an elevation of 1514.9 at its intersection with A1 Entry to an

elevation of 1588.2 at a point near the entry in which the machine was cutting. This entry was also going to the raise and it can safely be stated that its face was at least 2 feet higher. This would give a difference in elevation of about 15 feet between the fall at the mouth of 2nd Left and the face of the coal near the machine. In order to have a mixture of gas and dust, the gas would have to back up from the face of the 2nd Left Headings and in doing this would nearly fill the entire heading with an explosive mixture, because the ventilating current in A1 and 2nd Left Entries would have to be stopped.

Granting, however, that this accumulation might have occurred, it would have taken several hours, because in the tests made, after an hour had elapsed with interrupted ventilation the explosive mixture was only back 40 feet from the face. With the type of mining machine used, with the contact of the rope and the trolley wire and the usual arcing between the rails and the wheels it would be almost impossible not to have ignited a body of gas before the mining machine ever reached the position in which it was found. Therefore, it is difficult to conceive a mixture of dust and air sufficient to cause a cloud to be ignited by an arc at the mouth of 2nd Left or even half-way up the entry.

This leaves only the theory of an arc igniting a body of gas which in turn raised and ignited a cloud of coal dust. The fact that the machine was at the face of the entry would seem to preclude any ignition of gas by the contact of the rope and trolley wire.

The evidence shows that a line brattice was carrying the ventilation up to the face of this entry and, therefore, it can be taken for granted that this was the weak spot in the ventilating system and any

disarrangement would allow gas to accumulate, or even perhaps without any such disarrangement. Consequently, it is reasonable to assume a pocket of gas had collected near the roof of the entry in which the cutting machine was found, possibly from a defective line brattice. This assumption is strengthened by the fact that the machine man had been burned previously because of neglecting to examine his place for gas, and that his safety lamp was found so securely fastened to the machine, all of which tends to the belief that he did not examine his place for gas.

From the position of the machine, together with the open reverse lever, the probabilities are that when the machine reached the end of the track, the controller was thrown in reverse while the power was on. The controller, which formerly belonged to an entirely different piece of apparatus, undoubtedly arced and , in a position so near the roof, ignited a layer of gas.

Having seen what had happened, the man operating the machine shut off the power and with his helper started to run down the room. By this time the gas flame had reached the explosive mixture which then let go, knocking the man over and raising the dust cloud, by which the explosion was propagated.

The direction of greatest force seemed to extend directly across to the aircourse of 2nd Left, then down this aircourse and through the chute to 2nd Left, as evidenced by a fall and the forcing of the track in 2nd Left against the rib opposite the chute. Then traveled down A1 and aircourse and 3rd Right, spreading through these rooms which had been connected to the other parts of the affected section.

SUMMARY

In the opinion of the writer the direct cause of the explosion was the ignition of a body of gas which had accumulated at or near the face of the short entry being driven towards the Main North West Headings from End Left off A 1, by an arc from the cutting machine found at the face of the entry. Also the machine-men evidently neglected to make an examination for gas before he ran his machine into the heading. The gas explosion raised and ignited the coal dust in the various rooms and entries, thereby propagating the explosion through that part of the mine north and northwest of No. 5 Shaft.

RECOMMENDATIONS.

From the experience of those men who saved their lives by barricading, two recommendations can be made. First: there should be placed at each entry mouth the name of that entry and also at its junction with other entries. The testimony of these men brought out the fact that some of them were looking for McKensie to lead them through to No. 5 Mine and later they all were lost for a while. The writer well remembers the argument between a state mine inspector, the Chief Engineer of the Crab Orchard Company and some of the sub-bosses of the mine as to the entry in which, at the time, they were standing and the writer also remembers how the members of the party had to back-track before they finally oriented themselves. In the Pittsburgh Coal Field, where there are long smooth "slips" in the coal it is customary to paint the designations of the entries and number of the rooms on the rib in white lead. While the nature of the Beckley may not permit this to be done, signs for the more important entries, especially where there is liability for confusion, might be painted and erected. This

not only would aid the rescue crews in case of possible disaster, but would aid those who might be trapped in the mine.

The testimony also states that the men were compelled to travel some distance from the site selected for the barricade to obtain materials with which to build it. The writer would make the following recommendation in regard to this: That permanent places be constructed as refuge chambers and to be placed in sufficient numbers and in such places that they may be easily accessible to the most number of men in the particular section of the mine in which they may be located.

This is being done by several companies in the Pittsburgh district in connection with their rock-dusting and safety program. The following description is taken from the Bureau's Technical Paper 24, "Mine Fires", by George S. Rice, page 26:- "A refuge chamber can be made out of an ordinary mine room or chamber by timbering it securely, walling up the crosscuts and putting in double or triple doors at the mouth. Except when the emergency arises these doors must be left open and a line brattice led into the room from the entry or gangway for ventilation; otherwise a crosscut must be made for this purpose and must be provided with double or triple doors".

The Bureau's Miners Circular No. 25 "Erection of Barricades during Mine Fires or after Explosions", by Paul, et al, page 7, states:- "Experiments have shown that a man in a confined space needs a cubic yard of normal air per hour. At the end of an hour this cubic yard of air will contain about 14 per cent of oxygen and 5 per cent of carbon dioxide; an oil lamp will not burn and an acetylene lamp will almost go out. On the basis of a cubic yard of air an hour an inclosed space 10 feet wide, 10 feet high, and 10 feet long, containing 1,000 cubic feet, or 37 cubic yards of space, will support a miner 37 hours before he begins to suffer through lack of breathable air. This minimum allowance of 1 cubic yard per hour per man, however, does not provide for losses of oxygen through absorption by the coal or timber in the inclosed space, nor for the impairment of the air by methane or carbon dioxide from the coal or rock".

In case these chambers are not built materials for building barricades should be stored in convenient places about the mine. This step has been taken by some of the large progressive companies in Western Pennsylvania and it may be of value to quote the following list of material which has been found by them to be necessary for building a barricade. This material is furnished by the company and placed at easily accessible places.

Assistant Foreman's Office.

- 1 Roll of brattice cloth
- 5 M.S.A. Self rescuers
- 1 - 5 gallon bottle of distilled water
- 1 - Axe
- 1 - Saw
- 5 - Pounds of nails
- 250 - Backup tile, size 5" x 8" x 12"

Material to be placed at convenient points on the Assistant Foreman's Section.

- 250 - Backup tile, 5" x 8" x 12"
- 1 - Pit car of loam
- 16 - yards of brattice cloth
- 1 - pound 20 d. nails

As there have been so many men killed at this mine and had all of the men, or even a large part of them proper knowledge of barricading together with a sufficiency of material, possibly more lives might have been saved. It is most earnestly desired that the Grab Orchard Improvement Company give this recommendation the most serious consideration.

It is also urged most strongly that the officials of the company arrange to impart such information as will teach the men how to care for themselves in an explosion and, what is perhaps more important, to impress upon them the importance of safety measures to prevent such disasters. This can be done systematically and methodically by the establishment of Holmes Safety Association Chapters or by getting in direct touch with J. J. Forbes, Chief of the Safety Extension Service, Pittsburgh, Pa., and also by the liberal distribution of Miner's Circular 25 entitled "Erection of Barricades During Mine Fires and After Explosions" by J. W. Paul, B. O. Pickard and H. W. von Bernovitz of the Bureau of Mines.

In connection with the Holmes Safety Association the general purpose is to establish chapters at each mine which shall advance the safety movement and the conduct of work looking to the prevention of accidents and the improvement of health in the mining industry. It also provides opportunities and facilities for the training of its members in first aid and mine rescue work. It also seeks to promote educational, social and recreational activities among its members, cooperating with Federal, State and local agencies engaged in this work.

This mine is an exceedingly gassy and therefore dangerous mine and no precautions should be omitted for safeguarding the men. In the opinion of the writer the practice of depending on a machine man to examine his place for gas before moving his machine in and letting the safety of the entire mine rest on this man's action is an unsafe practice. The machine man's wages depend entirely upon the tonnage produced, which in turn is proportionate to the number of places which he may cut. It is only human nature for him to take a chance if he can gain a little time here and a little time there which will

accumulate sufficiently to cut an extra place, and thereby earn extra money. If he can gain some of this time by not examining his place, he will surely do so. It is parallel to the loader who is too busy loading coal to post up the roof. Eccles No. 5 is a mine in which it is not safe to take chances; a slip in the ventilation system, a sudden gas blower out or perhaps a fall of roof and a consequent outburst of gas may wreck the entire mine. Therefore, the mine should be divided into sections and placed in charge of a fireboss, whose sole duty during the time the men are working in that section, should be the systematic examination of every working place for explosive gas. The safety of the mine should not depend entirely on the examination of a machine man.

The discipline of the mine, regarding safety, should be as rigid as possible and assistant foremen should be impressed that a danger board is not to be crossed. If necessary, especially prepared danger boards should be used, either metal or wood, painted red and the word "danger" lettered thereon in white. The higher officials should see that the fire bosses who make the regular morning inspection should not be given so large a territory to cover that there will be a temptation to slight some part of the working in order to make his rounds on time. The writer believes that many times an examination of a place is merely perfunctory, time enough not being taken to be able to detect a gas cap, unless the percentage present is almost at the explosive limit. There is on record an explosion in which 75 or 80 lives were lost and the evidence was exceedingly strong that the fireboss had not examined thoroughly all the working places. In fact, an examination of the map showed it would be almost a physical impossibility to have covered the area in the

time required and to have thoroughly examined the working places. It might also be stated that it had been reported that two fire bosses had been employed previously but just before the explosion one had been let out for reasons of economy. So it may be more economical to employ enough fire-bosses to thoroughly cover the mine than to use too few and skip a part of the mine.

If the incident of one of the mine official's intention to let the men stay in the mine when the power was off is true, and this happening at the time immediately following an explosion, and also if the fact that he refused to acknowledge the existence of a fire notwithstanding the unmistakable evidence of fumes and smoke is substantiated, then the operating officials should very carefully consider his qualifications for a position of responsibility in a gassy and dangerous mine.

The recommendations of the former report concerning rock dusting are again emphasized, although it is understood the company were making arrangements for rock dusting previous to the explosion and had a rock dusting machine ordered.

No machines except those bearing the approval plate of the Bureau of Mines should be used in the mine.

Regarding the system of ventilation, there is some question as to the advisability of blowing the air through No. 3 Mine into No. 5 and thence through the upcast. The writer is not familiar nor does he have sufficient data to definitely determine the feasibility of changing the fan at No. 3 Mine from a blowing fan to an exhaust, but would recommend that a thorough study be made by the company as to the advisability of such a change, looking at it from a safety point of view. If the writer correctly understands the ventilation system as outlined to him by the officials of the company, all the

old workings south of No. 5 shaft and part of the old workings of No. 3 mine (now abandoned) are ventilated by an air current from No. 3 shaft sweeping through these workings and upcasting through No. 5 fan. The fan at No. 3 shaft relieving the load on No. 5 fan by acting as a blowing fan. Therefore, any explosive gas which may be generated in these old workings is swept into the live workings. Furthermore, if the pressure is above atmospheric, gas which may be trapped in the overlying or underlying strata will be held back until the air pressure is lowered, possibly by the stopping of No. 5 fan, when it may feed out and possibly create a dangerous situation.

If the fan at No. 5 could run as an exhaust and ventilate all these old workings, using No. 5 shaft as an intake, the gases would then be drawn away from No. 5 Mine and this hazard would ^{be} greatly decreased.

There is an alternative which seems to be feasible especially from an economic standpoint as well as from a safety one. The writer would suggest that a study be made of a plan for absolutely sealing off as much as possible of the old workings of No. 5 Mine and all of No. 3 Mine. This would release the necessity of running No. 3 fan and do away with the expense for power and maintenance. The objection may be made against having the amount of explosive gas confined so close to the No. 5 Mine. This objection may be overcome by placing well located drill holes from the surface, permitting the accumulated gas to drain out. It is questionable whether the interest on the investment necessary for putting down the holes would amount to more than the cost of the operation of No. 3 fan. Even if these holes are not drilled, the hazard of the gas in the sealed area apparently would be no more than that of the dust and gas which may now exist in these old workings. As the workings advance further away from the shaft and the distances which the air has to

travel become greater and especially as the No. 5 fan is not of the more modern type, it may cost less per ton for ventilation to sink a new air shaft and install a more economical system of ventilation. It might be profitable to make a careful study of the economics of the present ventilation including the amount of power costs, the air resistance, the efficiency and the safety.

When new gathering motors are purchased, the merits of the storage battery type should be investigated, especially those which bear the Bureau's approval plate. There are now twelve of these permissible gathering motors, one main line motor and one power truck on the market.

The practice of altering permissible lamp batteries into non-permissible shot firing batteries is, to say the least, reprehensible. In the first place, the battery as altered presents a menace to safety. It has been stated that one cell in the battery is grounded to the casing and if a lead wire should come in contact with the casing while the other is touching one of the terminals, one-half the voltage of the cell will go to the detonator and possibly cause a premature detonation.

The Bureau has a record of one shot firer who was blown to pieces by a premature explosion and the supposed cause was one leg of a detonator which he was carrying, coming in contact with the battery casing and the other leg striking the head piece, so that a short circuit was formed, firing the detonator which probably set off others in his possession. This company has prohibited shot-firers from carrying electric cap lamps. Another danger comes from the drain on the battery by the bulb and the firing of the shots, so that there is danger of mis-fires.

These shot firing lamps will carry the Bureau's Permissible Plates when, in fact, they are not any longer "permissible". The practice of altering approved equipment tends to break down the very safe-guards which it has taken many years to build up. If coal companies allow approved machines, drills, motors and lamps to be altered so that they are no longer safe then the entire object of "permissible equipment" is defeated.

It is recommended, therefore, that these "shot firing lamps" in Heeles Mine be discontinued and regular approved shot-firing batteries be substituted.

The question of safety devices about the shaft and on the hoisting engine is one worthy of serious consideration. In a paper read before the American Institute of Mining and Metallurgical Engineers and published in 1923 on pages 206 to 215, inclusive, in volume 68 of their Transactions, Rudolph Kudlich, Assistant to the Chief Mechanical Engineer of the Bureau of Mines, states that in the coal mines of Pennsylvania, West Virginia, Ohio and Illinois, from 1904 to 1913, there were 1001 shaft accidents of which 552 were fatal.

The largest number were either killed or hurt by falling down the shaft. Kudlich also states that "Experience has shown that men cannot be relied on to keep the gates closed". The best protection appears to be automatic gates on the shaft landing.

There were 139 accidents which were due to overhoisting. This is the third largest class of shaft accidents and one which can readily be guarded against. An example of the type of accident and its cause due to the carelessness of the engineer may be seen in the following case: The coal was worked on two different levels and all hoisted up one shaft. In this accident 8 men from the upper level got on the cage to be hoisted to the surface. While engaged in hoisting the cage the engineer forgot apparently

that he was hoisting from the higher level and continued the operation of the engine as though he was hoisting from the lower level, with the result that the self-dumping cage was wrecked and five men were pitched down the 600 foot shaft and one man down to the surface landing, all probably instantly killed, and two men badly injured. The evidence showed the engineer had had a similar accident before although no one was killed, and that he had been drinking before he had gone on duty. An engineer does not necessarily have to be intoxicated, because there is evidence to show that engineers have become drowsy during the warm summer days. In Illinois where two and three hoists are made every minute, two engineers are employed, to avoid tiring a man from the constant concentration.

In any event, it might prove more economical to provide safety devices on a hoisting engine than to pay the cost of an accident. It is therefore recommended that steps be taken to provide safety devices for the hoisting engine and the surface landing at Kesles No. 6 Mine.

Mention has been made of the location of the pressure gage chart and the liability of a man going under the belt from the motor to the fan and his clothes catching in the belt. An accident of this kind might be fatal and the writer would recommend that this chart be placed in a location where a man would not be liable to be injured in getting to it.

The first aid facilities either above or below ground did not seem such as should be found around a coal operation the size of Kesles. The surface room did not strike one as especially clean nor antiseptic. For the information of the company a photograph of an outside first aid station and one of an underground one is hereto attached. These ^{are} actual installations at mines of companies in Pennsylvania.

ACKNOWLEDGMENTS.

The writer wishes to acknowledge the very great assistance rendered by Mr. J. D. Rogers, Chief Engineer; Mr. J. P. Horne, General Superintendent of the Crab Orchard Improvement Company; and to Mr. W. C. Shunk, General Manager of the Stonewall Coke and Coal Company, in making this investigation. Every facility for obtaining information was given to him and maps and data placed at his disposal.

Valuable aid was also rendered by Mr. R. M. Lambie, Chief of the West Virginia Department of Mines, and Mr. Robert Lilly, District Inspector. Mr. W. G. Forbes, Assistant Mining Engineer of the Bureau, together with Mr. W. P. Yant, Associate Chemist of the Bureau, also cooperated very effectively in getting air samples and other important information.

Respectfully submitted,



L. D. Tracy,
Coal Mining Engineer.

APPROVED:



J. W. Paul.

U. S. BUREAU OF MINES

E-DESCRIPTION OF MINE

1081

(1) State West Virginia (2) County Raleigh (3) Town Eccles
(Post office.)

(4) Mine sample of Coal (5) Coal field _____ (6) District New River
(Material—for coal give classification.)

(7) Mine Eccles No. 5 Shaft
(a. Name.) (b. Kind of opening—if shaft give depth.) (c. Height of opening above sea level.)

3/4 mi. North of Eccles Sta. On Virginian R.R.
(d. Distance and direction from town.) (e. Sec., T., and R., if necessary.) (f. Railroad connections.)

Eccles
(g. Shipping point.) (h. State if wagon mine or prospect and give distance from shipping point.)

(8) Coal bed Beckley Pottsville
(a. Name.) (b. Geologic system.)

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

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

(11) Explosives Permissible
(a. Used for coal.) (b. Used for roof or floor.)

(12) Operator Crab Orchard Improvement Co.
(Name and address.)

Sales agent General Coal Co., Philadelphia, Pa.
(Name and address.)

(14) Output per day 1500 tons (15) Maximum day's output _____ (16) Last year's output 120-12500
(Average—gross or net tons.) (During past year.) (Gross or net tons.)

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

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

(22) Type of washer _____ (23) Per cent of coal washed _____

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

(26) Sizes produced _____ (27) Is coal picked? _____
(Of coal not washed.) (State whether on car or belt.)

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

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

(32) Can Nos. 234-483-504 B411-D784-F272 H971-33030 2860
(Give Nos. of all samples forwarded.)

(33) Laboratory Nos. A 20454 A 20455 A 20456 A 20457
(Laboratory to fill in immediately below corresponding can number.)

(34) Mine sampled at 2 points, by L. D. Tracy on March 23, 19 21
(Number.) (Collector.) (Office.) (Date.)

Above information copied from Card A by Fischer on March 29, 19 21
6-6372

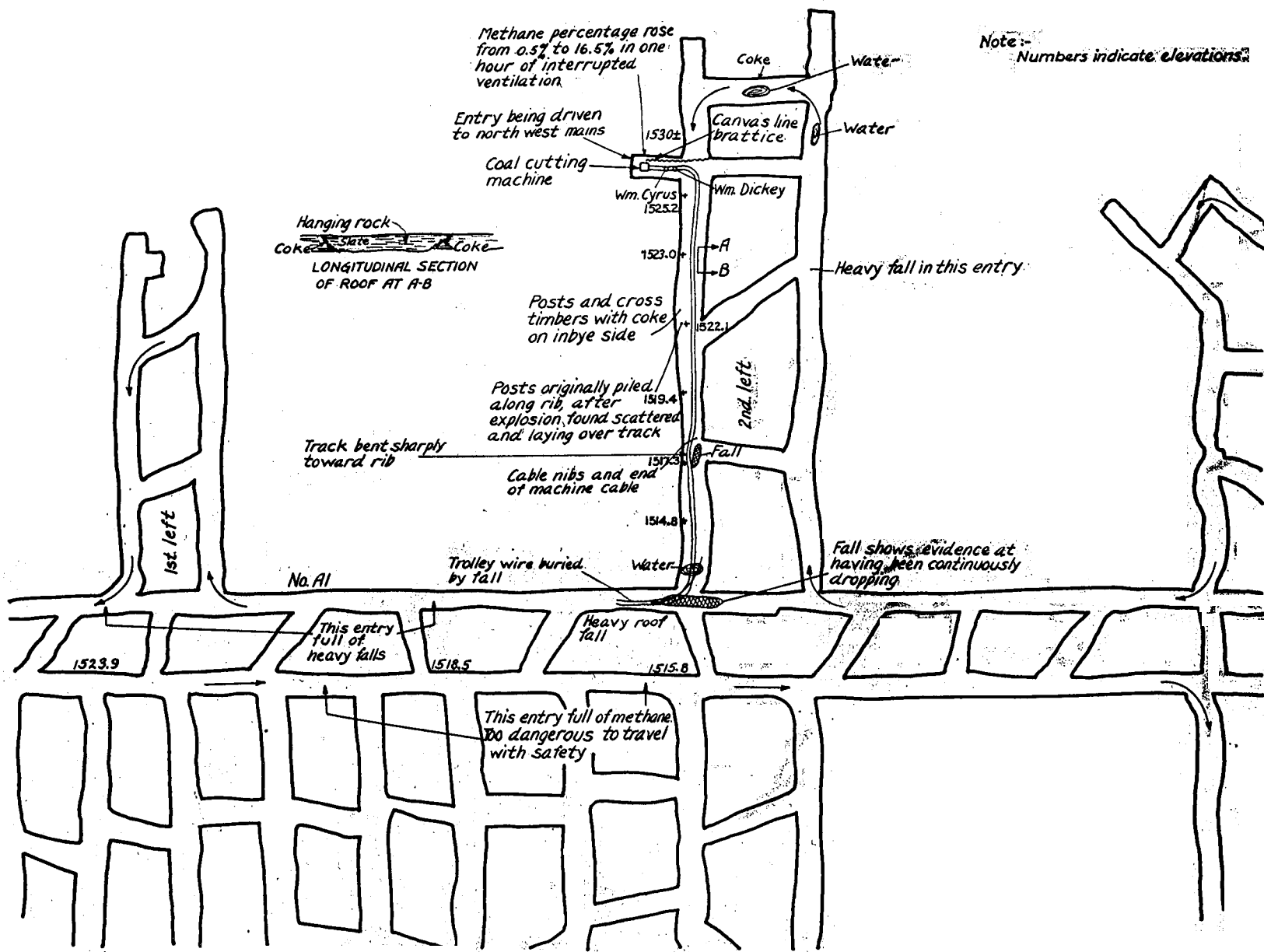


Fig 5

Detail of alleged origin of explosion on 2nd left entry, Eccles No 5 mine, Eccles, W. Va.

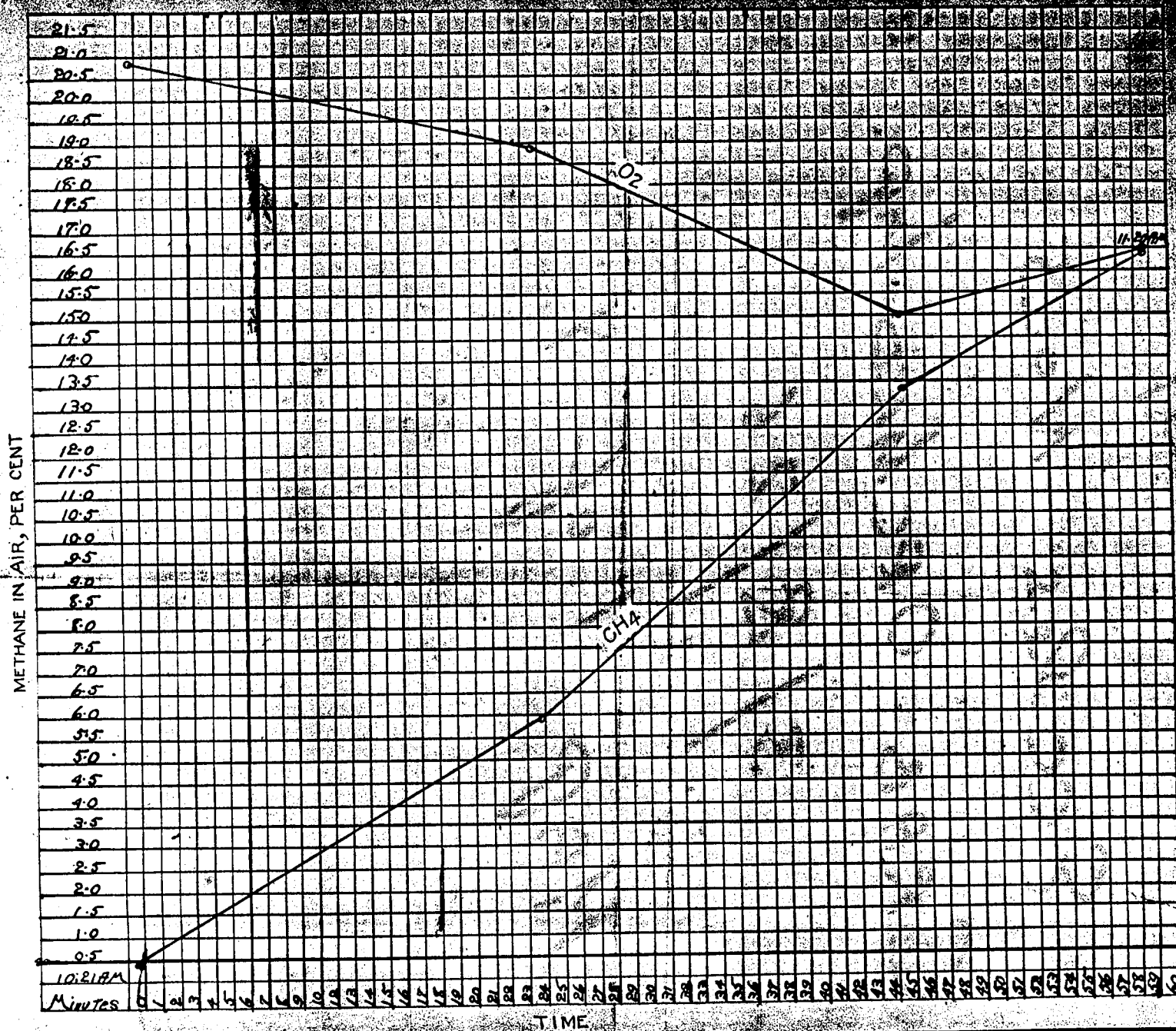
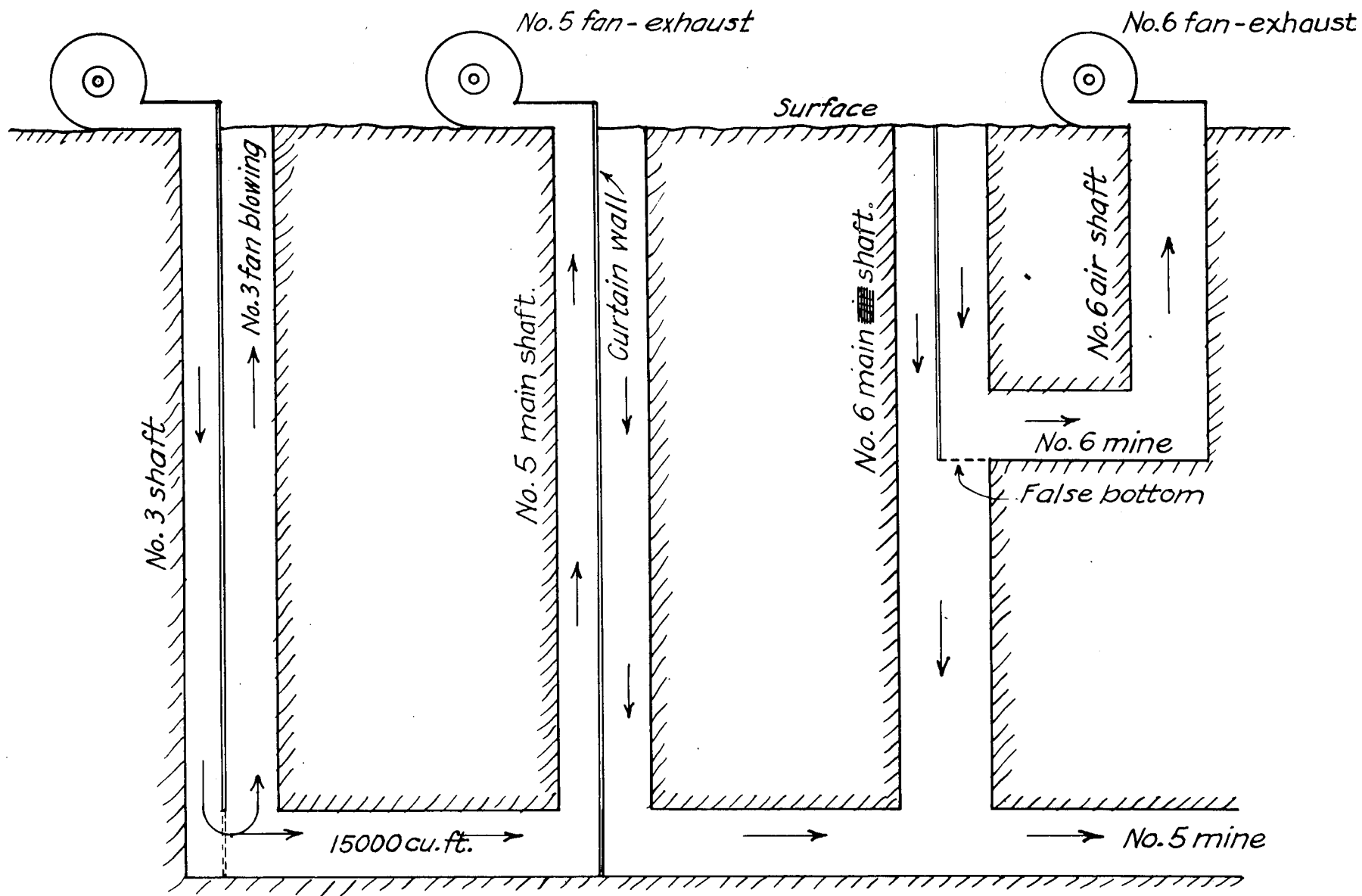


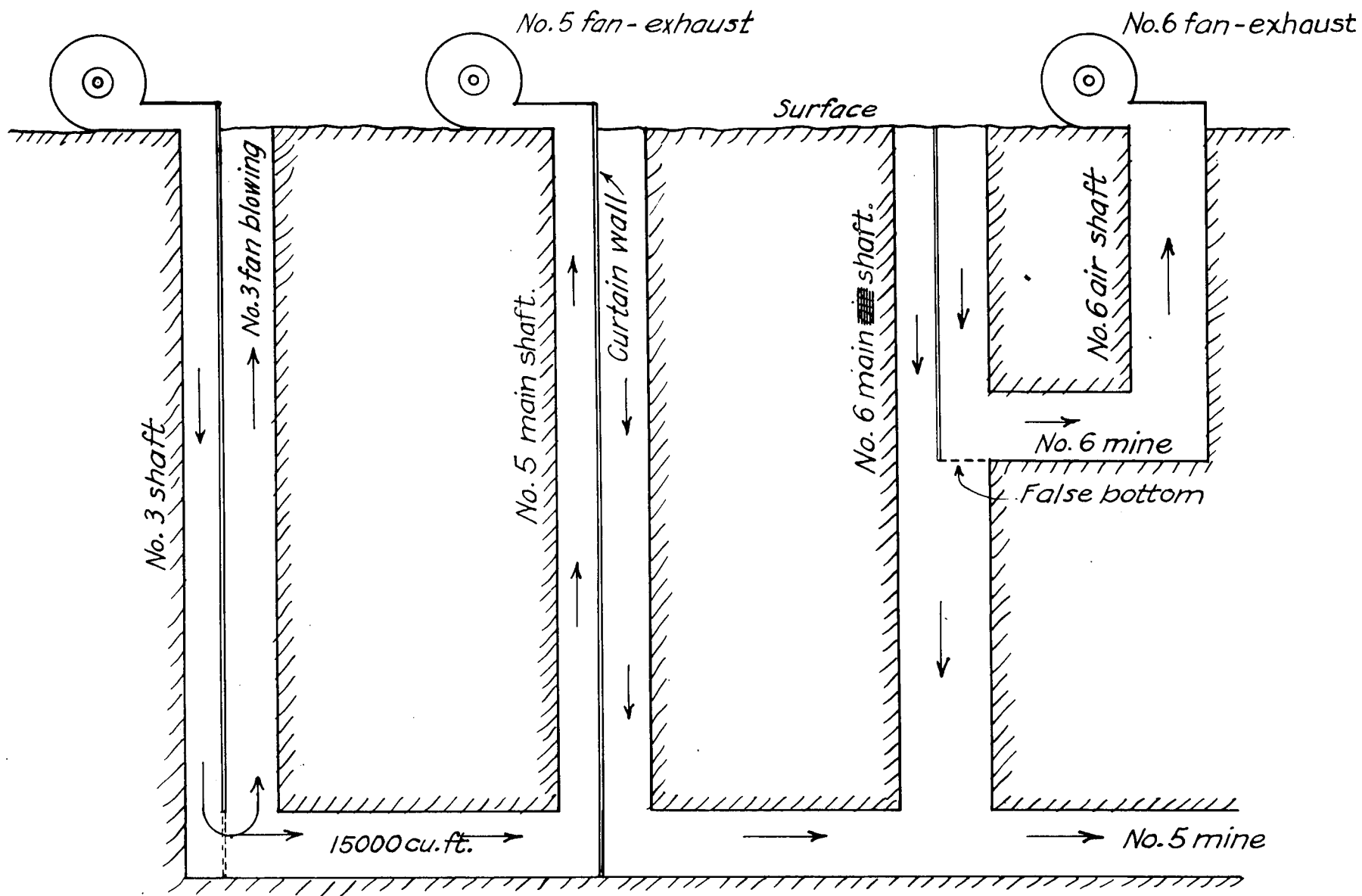
CHART SHOWING RATE OF ACCUMULATION OF METHANE ON AIRCOURSE OF THE MAIN NORTHWEST ENTRY OFF 2ND LEFT OFF A1 AIRCOURSE, CAUSED BY AN INTERRUPTION IN VENTILATING CURRENT.

Fig 8



Flow sheet of air through ventilating shafts for Eccles No. 5 mine

Fig 8



Flow sheet of air through ventilating shafts for Escal No. 5 mine

Report on the Mine Explosion

at the

Ecclus No. 5 Mine

of the

GPAB ORCHARD IMPROVEMENT COMPANY,

Ecclus, West Virginia.

Brief statement.

About 6:55 p.m., Monday, March 8, 1926, an explosion occurred in the Ecclus No. 5 Mine of the Crab Orchard Improvement Company at Ecclus, West Virginia, and extended into No. 6 Mine which was mining a superimposed coal bed. Eighteen men were killed and 10 men were rescued in No. 5 Mine and one man was killed and 39 men escaped in No. 6 Mine. Following are the names of the men who were killed:

<u>No. 5 Mine.</u>		<u>No. 6 Mine.</u>
1. George Keith	10. L. C. Blair	Arthur Wilkes
2. W. B. Mullins	11. George Martin	
3. George Hilton	12. H. C. Stanley	
4. J. H. Russell	13. Richard Keesee	
5. J. H. Hendricks	14. M. E. Holt	
6. Arch Price	15. William Dickey	
7. J. F. Lybrooks	16. W. H. Cyrus	
8. Clyde Muncie	17. Edgar Clay	
9. T. J. Click	18. G. H. Young	

The numbers opposite the above names correspond to the numbers on the accompanying map indicating the location of their respective bodies.

The men who were in No. 5 Mine and were later rescued follow:

Edgar McKennie	H. L. Bailey
H. E. Findley	George Wilson
J. W. Gales	T. J. Davis
G. H. Steets	Green Keith
Limer Nikal	James Keith