FINAL REPORT
GAS AND BLACK POWDER EXPLOSION
OLD FORGE COLLIERY, THE PITTSTON COMPANY
AVOCA, PENNSYLVANIA
September 29, 1930.

By

M. J. Ankeny

Assistant Mine Safety Engineer

DEPARTMENT OF COMMERCE

BUREAU OF MINES

INDEX

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INTRODUCTION

On the morning of September 29, at about 7:05 a.m., a local gas explosion occurred in three chambers of the first right rock tunnel section of the Old Forge Colliery, (otherwise known as the Central Shaft), located at Avoca, Luzerne County, Pennsylvania. As a result of the gas ignition, at least two kegs, or portions of kegs, of black blasting powder were exploded.

Three men were killed instantly by violence, and another died from injuries two days later in the hospital; three others were seriously injured as a result of this explosion. No other persons were in the chambers involved at the time of the ignition.

The United States Bureau of Mines was informed of the explosion of September 29 through the Press. The writer was detailed to investigate the explosion and determine, if possible, the contributing causes, and to make recommendations looking to the prevention of similar occurrences.

The writer arrived at Avoca on October 1 and started the investigation on October 2, which required two days to complete.

GENERAL INFORMATION

Ownership and Management:

The colliery is owned and operated by the Pittston Company, with general offices at Dunmore, Pennsylvania. About six hundred employees work underground, producing about a thousand tons of enthracite per day. The officials of the company are as follows:

G. M. Gillette, general manager, The Pittston Company, Box 553, Scranton, Pennsylvania.

J. C. Cook, colliery superintendent, Old Forge Colliery, Avoca, Pennsylvania.

Andrew Wilson, safety engineer, 134 Searle Street, Pittston, Pennsylvania.

Methods of Mining:

The Red Ash vein of anthracite, which appears in three splits with partings of varying degrees of thickness between, is mined at the Old Forge Colliery. These splits are known as the Nigger (top split), the Five Foot (middle split), and the Bottom Red Ash (lower split). Many rock faults are present in the vein, and overlaps of the veins are prevalent throughout the locality. The breast and piller advancing and retreating system of mining is employed. Trolley locomotives, operating on 250 volts D.C., are used for main haulage, and cable reel and trolley locomotives for gathering.

Gas and Ventilation:

The colliery is rated as non-gassy by the Pennsylvania State Department of Mines. The writer was unable to obtain a

very definite description of the ventilating system of the mine, except that it has numerous openings to the surface and in some instances air is conducted from one vein to another through small local shafts and through rock tunnels. The ventilation and the coursing of the air through the local area affected by the explosion is, however, definitely known and will be discussed later in this report.

Fire bosses are not employed, but one person served as a part time fire boss and made pre-shift examinations of working places. All places are not examined daily before the shift enters the mine as the territory is much too large for one man to cover.

Lighting:

Open carbide lights are used by the underground employees for illumination. There are a number of Davy, Clanny, and Wolf key-locked flame safety lamps at the mine. These lamps are used by the officials in testing for gas.

Explosives:

Black blasting powder and squibs are generally used for blasting coal. Monobel 9ALF, fired electrically with number 6 electric detonators, and ten shot non-permissible blasting units, are used for blasting wet holes and rock. Holes may be drilled as deep as 6-1/2 feet into the solid and are tamped with coal slack. Black powder is issued to the men on the surface in twenty-five pound metal cans, and Monobel in twenty-five pound boxes. Squibs and detonators are stored with, or near, explosives, and the amount of explosive

stored in any one place is not very well regulated. Apparently, the discipline in regard to handling and storage of explosive underground is very lax.

Mine-Rescue Organization:

There is no mine-rescue organization at this colliery, however, the company maintains a well equipped mine-rescue station at the Ewen Colliery, at Pittston, Pennsylvania, which is reasonably close to the Central Colliery. The company has a number of well-trained apparatus crews at their gaseous mines in the district. Incidentally, a number of them have taken the U. S. Bureau of Mines Course, "Advanced Training in Mine-Rescue and Recovery Operations."

Supervision:

A mine foreman is employed at the colliery, also an assistant foreman who makes daily visits to the working places of the affected area. A part time fire boss is also employed who makes pre-shift examinations of working places. Because of the large number of working places, he can only visit each place but infrequently. According to his own statements, he had not visited the places involved in this explosion for a month. A general safety engineer and a ventilation inspector are employed by the company, who divide their time among all the mines of the company.

Mine Conditions Immediately Prior to the Disaster:

The last day the mine had worked previous to the explosion was Thursday, September 25, or about 88 hours had elapsed from the time the men left their working places until they returned Monday

morning, the day of the disaster. According to the statement of the assistant mine foreman, he had visited the places on Saturday, September 27, and he did not find any gas on this visit. The fire boss stated that he had examined places in this mine for ten years off and on and never found any gas in this section of the mine, and that the only place he ever did find gas was in the lower Red Ash vein. It was generally believed by every one that the section involved had always been free from gas.

One other condition which may have some bearing on the case, and which will be discussed further in the following pages, is the fact that on Sunday, the day previous to the explosion, a large fall occurred about a thousand feet ahead of the chambers in which the explosion took place. It is said that this fall or cave broke the rock strata from the bottom Red Ash vein to the surface.

THE EXPLOSION

The explosion occurred in the faces of three chambers off the rock tunnel section in the Nigger vein, low shaft. Figure 1 in the appendix shows the location of these chambers with respect to other working places, and also the coursing of the air. It will be observed that these chambers had been driven up a distance of about six hundred feet and stopped where a rock fault was encountered. These chambers raise with the coal at about 7° from the horizontal. The height of the coal is about 3 feet 1 inch, and about 4.4 feet of bottom rock had been taken up. The chambers were

driven about twenty-five to thirty feet wide, leaving twenty-five foot pillars.

Figure 2 shows this same section on a larger scale, and for convenience, the chambers involved have been labeled, "inby chamber," "middle chamber," and "outby chamber".

According to substantial evidence contained in the testimony of survivors and others working nearby, the explosion occurred about 7:05 a.m., or less than ten minutes after the men entered the working places in the morning.

Outby Chamber:

A miner and two laborers were working in this chamber at the time of the explosion. The two laborers were killed, and their bodies were found at points 4 and 5 indicated on Figure 2. According to the statements of the miner who survived the explosion, with severe injuries and superficial burns, he and his laborers entered their working places, sat down at the miner's box (located at 11) and ate a lunch. The miner then went to the working place, (12), and started to scrape out two holes preparatory to charging. He called to the laborers to bring their shovels to shovel back some coal. He then went to the box to get the charges of black powder which he had already made up. When he reached the box he saw fire coming out of a near by cross-cut on the left. He called a warning to his laborers who were outby from this point, and at that instant the powder keg near by exploded. The miner could not remember what happened after that. The writer is inclined to believe the testimony given by this miner. It is not believed that

the gas ignition took place in this chamber, and it is definitely known that two kegs, or portions of kegs, of black powder exploded in this place, as the remainder of these kegs was found at (6). The forces traveled outward and to the left in this chamber, except at the cross-cut near where the powder exploded, they traveled to the right.

Middle Chamber:

A miner and laborer were working in the middle chamber and were probably the first to enter their working place this morning. The laborer was killed instantly by violence, and his body was found at (3). The miner was fatally injured and made his way to the heading. He died two days later in the hospital without making any statement in regard to the explosion. Upon examination of pack wall stoppings and other evidence, it is clearly indicated that the force of the explosion traveled downward and to the right and left in this chamber. It is believed by the writer that an accumulation of explosive gas was ignited by one of these men by means of an open light in this middle chamber.

Inby Chamber:

A miner and laborer were working in the inby chamber at the time of the explosion. Both of these men survived the explosion with severe injuries and superficial burns. According to the statements of the miner, he entered his working place and went up to the face and sounded the roof when the man in the middle chamber shouted through the break-through and asked him how the air was. He replied

that he had good air and then took up his auger and started to drill a hole, when the explosion occurred. He stated that he did not see any fire at the time of the explosion. He was at (9) when the explosion occurred and made his way to (17) by the time he was found by the rescuers.

The laborer in this chamber stated that he was shoveling coal off the road near the place where the miner was boring the hole when the explosion occurred. He remembers hearing the miner in the middle chamber ask about the air. He said he did not see any fire at the time of the explosion, and all other statements agree perfectly with those of the miner. He was found severely injured at (4).

There was no indication of extreme violence or heat in the inby chamber, and it is doubtful that flame actually entered this chamber.

THE RESCUE WORK

The only other person in the affected area at the time of the explosion was the tracklayer who was on his way up into the section where he was going to work that day. He felt the pressure wave of the explosion and proceeded up into the outby chamber where he encountered one of the bodies. As soon as he realized what had happened, he returned to the work bench at the entrance to the section. He met the motorman, brakeman, and a laborer at this point and told them that men were hurt and to get a stretcher. The concussion was felt at the underground hoist house, and the hoist run-

ner, rope rider, and others proceeded into the explosion area, accompanied by the mine foreman. The bodies and injured men were promptly removed from the scene of the explosion without the aid of protection or detection devices. Open lights were used by most of the men doing the rescue work. About two hours after the explosion, apparatus crews arrived, accompanied by the safety engineer for the company. A complete examination of the area was made by the apparatus crews under oxygen before the area was reventilated. About .3 per cent carbon monoxide was indicated in the air about half way up into the chambers, and over two per cent at the faces of the chambers. (This with the iodine pentoxid CO detector.)

CAUSES OF THE DISASTER

Gas and Ventilation:

Figure 1 in the appendix shows the course of the air before the explosion and after the ventilation had been restored following the explosion as indicated by the arrows. At the time the writer made his inspection the ventilation had been restored and the air was following its normal course. On Friday, October 3, the writer, accompanied by the safety engineer of the company, collected air samples at the intake to the affected area, at the faces of the three chambers involved, and in the return from the affected area. The exact locations of the samples taken are shown in Figure 1 of the appendix. Table No. 1 gives the results of the analysis of these samples.

Table No. 1

Results of analysis of air samples taken in the
Explosion Area of the Central Colliery, October 3, 1930.

Sample No.	Bottle No.	Location	Per cent N_2	Per cent O_2	Per cent CO_2	Per cent CH_4	Quantity Air cu.ft. per min.	Quantity CH_4 cu.ft. per min.
1	577	Intake at Chamber No. 3 - 1st Right of Rock Tunnel Section	79.13	20.59	.28	.00	-	-
2	580	Face of No. 3 (inby) chamber	79.03	20.30	.43	.24	-	-
3	578	Face of No. 2 (middle) chamber	78.96	20.36	.43	.23	-	-
4	579	Face of buggie place off No. 1 (outby) chamber	78.96	20.28	.45	.31	-	-
5	581	Return from 1st right of Rock Tunnel section	79.13	20.49	.32	.06	11,000	6.6

Note: 6.6 cubic feet of methane per minute being liberated in the area.
396.0 cubic feet of methane per hour being liberated in the area.
9504.0 cubic feet of methane per 24 hours being liberated in the area.

It will be observed from this table that the sample taken in the intake of No. 3 chamber, which is the intake for the section involved, did not show a trace of methane. Samples taken in the moving air current near the faces of the three chambers involved showed a methane content of 0.24, 0.23, and 0.31 per cent. The sample taken in the return from the involved section contained 0.06 per cent methane in 11,000 cubic feet of air per minute. The results of these analyses prove conclusively that methane is being liberated at the faces of the three chambers and that there is about 6.6 cubic feet of methane per minute being liberated from somewhere within the explosion area, which would amount to 396 cubic feet per hour. This quantity, diluted down to the minimum explosive point for methane which is 5 per cent, would produce 7,920 cubic feet of explosive gas per hour, or 190,080 cubic feet of gas at an explosive mixture per 24 hours.

From the above, the writer has come to the conclusion that the exact cause of the explosion is as follows:

The ignition of an unexpected accumulation of explosive gas by means of an open light in a mine that was generally supposed to be non-gassy, and in which no precautions were taken against the possibility of sudden emissions of explosive gas.

The exact cause of the sudden appearance of explosive gas in the three chambers is not definitely known. It is quite possible that the door between the middle chamber and inby chamber may have been previously left open. This would have short-circuited the air and allowed for the accumulation of gas. The miners from the inby

chamber who passed through this door on the morning of the explosion, when interviewed at the hospital, stated that they did not remember whether the door was opened or closed when they passed that point.

Another possible cause of the sudden appearance of explosive gas is the explanation that a heavy fall occurred in another section of the mine about a thousand feet ahead of the faces of the three chambers. It is thought that the disturbance caused by this fall may have shaken the rock strata about the fault at the faces of the three chambers and loosened up crevices which may have released methane into the chambers.

Over a period of years, in which the Bureau of Mines has investigated many explosions, the fact has been repeatedly demonstrated that all coal mines are potentially gassy and that any coal mine, regardless of its classification, is liable at any time to encounter explosive gas. The details of this explosion bring forcibly to attention the Bureau of Mines Safety Decision No. 1, relating to miners' lamps in coal mines.

> "Decision 1, relating to miners' lamps in coal mines. The Bureau of Mines recommends:
> 1. In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps; and also
> 2. In places where fire damp or black damp is liable to be encountered, a permissible, magnetically-locked flame safety lamp for gas detection, or equivalent permissible device, be supplied to at least one experienced employee in each such place; and
> 3. Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and
> 4. All coal mines, whether classed as non-gassy or gassy in any part, be supplied with magnetically-locked, per-

missible, flame safety lamps, properly maintained, and in sufficient number for all inspection purposes."

Inspections:

The chambers in which the explosion occurred were not subjected to daily pre-shift examination by a competent fire boss; the only supervisory inspections made were upon the daily visits of the section foreman and frequent visits of the mine foreman. Had these chambers been examined for gas by a fire boss before the shift entered the mine, the presence of explosive gas would probably have been discovered and the place cleared out before the men would have been permitted to enter their working places. Pre-shift examinations of working places , and all places where men are required to travel, should be made, not only for explosive gas and conditions of ventilation, but for dangerous roof conditions as well. The writer was informed that the management had decided to employ four regular fire bosses at this colliery to take care of these examinations. This may be regarded as one measure toward the elimination of similar explosions, and the management is to be commended for the action taken.

In this connection, it might be well to cite Bureau of Mines Safety Decision No. 6, relating to sealing all parts of a coal mine which can not be kept well ventilated and inspected.

> "Decision No. 6, relating to sealing all parts of a coal mine which can not be kept well ventilated or inspected:
> In the interest of safety, the Bureau of Mines, Department of Commerce, recommends that in coal mines, all entries, rooms, panels, or sections that can not be kept well ventilated throughout, or can not be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, be sealed by strong, fireproof stoppings."

Explosives:

While the use of explosive in this colliery was probably not a factor in the cause of the ignition, it is known that two kegs of black blasting powder, or portions thereof, actually did explode, presumably having been ignited by the burning gas. Incidentally, it was observed that considerable black powder, Monobel 9ALF, squibs and detonators were scattered about the working places without regard to the quantity allowed in any one working place, or the proper method of storing small quantities of explosive underground.

The use of black blasting powder in coal mines presents a hazard which must be recognized. It is much more likely to ignite explosive gas than any type of permissible-branded explosive and is much more likely to cause premature shots and misfires. Black blasting powder is also more easily ignited, therefore, harder to handle and store safely. Mine Safety Decision No. 2 deals with the kinds of explosive recommended for use in coal mines, and is quoted herewith:

> "Decision No. 2, relating to the kind of explosive to use in coal mining.
> In the interest of safety, the Bureau of Mines recommends that for blasting in coal mines, permissible explosives, fired electrically, be exclusively used, and that as an aid to blasting, all coal which is feasible to cut should be cut or sheared."

RECOMMENDATIONS

1. Pre-shift examinations for explosive gas should be made in all working places and all places adjacent to working places and all abandoned areas unless they are effectively sealed.

2. Permissible flame safety lamps, or their permissible equivalent, only, should be used for making such examinations.

3. Portable lamps for illumination should be permissible, portable, electric mine lamps.

4. Permissible-branded explosive only should be employed for blasting, and it should be used in a permissible manner.

5. Not more explosive than is needed for one shift should be stored in any working place at any time.

6. The provisions of Mine Safety Decision No. 12, relating to the methods of firing shots in coal mines, should be adopted and enforced. (See appendix.)

7. In mines where explosive gas is liberated, or where explosive gas is liable to be liberated, haulage and hoisting should be kept in intake air as far as is possible.

8. The provision of Mine Safety Decision No. 13, relating to electrical equipment in coal mines which may become gassy, should be carefully considered. (See appendix.) All replacements of electrical equipment should be of a permissible type.

ACKNOWLEDGMENT

The courteous assistance of Mr. G. M. Gillette, general manager, and Mr. Andrew Wilson, safety engineer, who placed full information at the disposal of the writer is gratefully acknowledged.

Respectfully submitted,

M. J. Ankeny

M. J. ANKENY
Assistant Mine Safety Engineer

Approved:

A P P E N D I X

The foregoing ten decisions were issued as Circular 6091, in December, 1928. Since that time Mine Safety Decision No. 11 was approved by the Director and issued in Circular 6139, May, 1929.

Decision No. 11 relating to haulage and hoisting in coal mines with reference to the ventilation

In the interest of safety, the Bureau of Mines, Department of Commerce, recommends that in coal mines, haulage and (or) hoisting be kept in intake air as far as possible.

As in the case of previous mine-safety decisions, the subject matter covered by this decision has frequently come to the attention of the Bureau of Mines through the reports of its mining engineers on explosion disasters and in accident-hazard investigations.

Although expressed in a few words, this decision is a matter of the greatest importance in the safe operation of mines, especially with the increasing use of electricity in mines. It has been frequently pointed out that since the very general use of permissible miners' lamps and permissible explosives in coal mines, the chief cause of explosions during the last few years has been electrical, and a number of these have been caused on haulage entries.

APPENDIX

Following the issuance of the decisions included in Information Circulars 6091 and 6139, the Mine Safety Board made the two recommendations, 12 and 13, which are under consideration for approval as decisions by Director Scott Turner.

Decision No. 12 relating to methods of firing shots in coal mines.

The Bureau of Mines, Department of Commerce, extending Mine Safety Decision No. 2, recommends that for blasting either coal or rock in coal mines, permissible* explosives or equivalent permissible device be used exclusively, and in addition recommends that in blasting**

1. Each charge shall be in a hole properly drilled and stemmed with incombustible material.

2. Each shot shall be fired separately by a permissible single-shot blasting unit, using an electric detonator or igniting equivalent of a kind specified by the bureau for the particular permissible explosive or permissible blasting device.

3. Before and following each shot in gassy and slightly gassy coal mines, examination for gas shall be made with a permissible flame safety lamp or permissible equivalent*** and

4. If more than 1½ per cent of inflammable gas is found, in the quantity and by the method specified in Mine Safety Decision No. 9,**** the place shall be considered to be in a hazardous condition and before another shot is fired the gas shall be reduced by ventilation below the percentage and quantity specified in Decision No. 9.

5. Each shot employing explosives shall be prepared and fired by or under the immediate supervision of a man having a state certificate as a mine examiner, fire boss, or foreman, and whenever conditions permit all other men than those authorized to prepare and fire shots shall be out of the mine when shot firing with explosives is being done.

* Anything that has successfully passed scheduled tests and is officially approved by the United States Bureau of Mines is termed "permissible."

** Exception: This would not apply where shot firing is done electrically from the surface when all the men are out of the mine.

*** Mine Safety Decision No. 2 relative to permissible flame safety lamps or equivalent.

**** Decision No. 9, Paragraph 5: "If the air of any unsealed place when sampled or tested in any part of that place not nearer than 4 feet from the face and 10 inches from the roof shall be found to contain:

"(a) More than 1½ per cent of inflammable gas, the place shall be considered in a hazardous condition and require improved ventilation and

"(b) If more than 2½ per cent of inflammable gas, the place shall be considered dangerous, and only men who have been officially designated to improve the ventilation and are properly protected shall remain in or enter said place."

This decision, as stated in its opening words, supplements Mine Safety Decision No. 2 (p. 4) which primarily recommended the use of permissible explosives. Since the time of issuing that decision, a blasting device has been tested by the Bureau of Mines and determined to be suitable for use in gassy and dusty mines and has been termed a "permissible blasting device." This instrument consists of a reusable steel cylindrical shell which is charged with highly compressed or liquefied carbon dioxide and contains a heating element to be ignited by an electric squib within the container. A firing circuit can be established only after inserting a bayonet-locked firing plug in the end of the container. Only a permissible single-shot blasting unit should be used for firing.

Permissible explosives are "permissible" only when used in the manner prescribed in the "Schedule of tests." This tentative decision specifies that permissibility requires the shot hole to be properly located with reference to the "burden" of the blast and that the explosive charge be stemmed with incombustible material. The charge is to be fired by electrical detonator, using a permissible single-shot blasting unit, one shot at a time, except in firing electrically from the surface when all men are out of the mine, as is the practice in the mines of Utah and in certain other districts.

When the schedule of permissibility tests or requirements for blasting devices was under consideration, the question arose as to whether it was essential that the stemming be of incombustible material. The Mine Safety Board recommended that the use of incombustible material for stemming is necessary, for the reason that in the blasting device approved by the bureau there is included a "heating element" which may, under certain conditions, produce sufficient external heat to ignite dust or gas by flame. Moreover, the sudden release of carbon dioxide under high pressure, which causes adiabatic compression of the air and methane (if any) confined in the hole adjacent to the shell, may under special conditions cause the temperature of the mixture to rise to the ignition point of methane - hence, the need of incombustible stemming.

As concerns that part of the decision in paragraphs (3) and (4), the need of testing for inflammable gas before firing a shot and between shots has been abundantly demonstrated by the explosions which have been the result of not doing so.

The rapid firing of a series of shots in coal mines by shot firers who have not charged the shots, who proceed from place to place firing the groups of shots, and who do not make any inspections is a great hazard. Where several shots are fired in one place gas may be liberated and (or) coal-dust stirred up into the air by the first shots and a subsequent shot may ignite the dust and (or) gas, as has frequently happened.

Furthermore, if the shots in a working place are "depending shots," it is impossible to foresee how much or how little coal is thrown out by the first blast, leaving too light a burden for the second blast or so heavy a burden that it may cause a blown-out shot. No permissible explosive or blasting device so far tested and given permissibility is absolutely free from some flame, and if there is inflammable gas in explosive proportions in an amount in excess of that given in clause (4), or if there is a dense heavy cloud of coal-dust present, ignition may occur which may lead to a disastrous explosion. Although this combination of circumstances is perhaps rare, it has occurred and may occur again if every precaution is not taken.

Paragraph (5) recommends that the men who fire the shots shall be certified men and that they shall know what each hole contains before firing it, either charging it themselves or having it charged under their immediate supervision. It also recommends as an additional precaution that where the organization of the mine and other conditions permit, the shot firing shall be done when all other men than those authorized are out of the mine.

Tentative Decision No. 13 relating to electrical equipment in coal mines which may become gassy

The Bureau of Mines, Department of Commerce, recommends that when electricity is used in coal mines rated as gassy,* or wherever in any mine the atmosphere may become gassy:

1. Electrical equipment shall be permissible,**

2. Nonpermissible electrical equipment*** shall be used only in pure intake air,****

3. Electrical power shall be cut off whenever the air in the workings is in a dangerous condition,***** due to inflammable gas.

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* Decision No. 3 classifies coal mines on the basis of the specific amounts of methane found in the mine atmosphere. See also, Decision No. 9.

** Anything that has successfully passed scheduled tests and is officially approved by the U. S. Bureau of Mines is termed "permissible."

*** Including trolley wires, trailing cable connections other than through permissible junction boxes, and power lines (except armored rubber-covered cables which meet the specifications of the National Electrical Code.)

**** Decision No. 8 defines "pure intake air."

***** Decision No. 9 defines the proportion or amount of gas in a mine working which shall be considered dangerous.

The alarmingly frequent explosions, due to electrical ignition, which have occurred in coal mines, especially in recent years, make it highly important that electrical equipment should be "permissible" when used in any parts of a mine where gas is likely to be encountered. The bureau in its Mine Safety Decision No. 3 (p. 4) states that in its opinion "all coal mines are potentially gassy," but for purposes of administration in respect to the prevention of explosions and fires, it recommends their classification as nongassy, slightly gassy, and gassy.

Decision No. 9 (p. 10) states that if more than 1½ per cent of inflammable gas is found in the air of a place, it is in a hazardous condition, and if more than 2½ per cent is found, no men should remain in the place except those charged with the duty of improving the ventilation and who are properly protected, as by wearing oxygen breathing apparatus and using gas detectors of precision.

If the gas inflow into a coal mine from the surrounding strata was constant and the workings and other conditions uniform, provisions for ventilation could be made that would practically insure against ever having a hazardous gas condition in that mine, except by breakdown of ventilating equipment. But none of the factors are constant; the gas inflow changes as the mine faces advance, new fissures carrying gas are encountered, large roof-falls occur which tap gas "feeders" or throw down gas collected in caved ground, and the mine workings are constantly changing in shape and conditions, all of which in turn affect the ventilating arrangements.

It is therefore the opinion of the Mine Safety Board that the maximum degree of safety from electrical ignition in coal mines would be obtained by using only permissible machinery, permissible appliances, and other permissible equipment, including locomotives

and hoists. The board recognizes, however, the practical difficulties of putting this recommendation into effect, as for example, in nongassy mines and in the intake air of mines rated as gassy. Nevertheless, the Mine Safety Board is emphatically of the opinion that nonpermissible electrical equipment should not be used except where the atmosphere is as free from inflammable gas as is specified for "pure intake air" in Decision No. 8 (p. 9), which calls for not over .05 per cent of inflammable gas in "pure intake air."

Power cables for underground use in coal mines classed as gassy have not as yet been covered by a Bureau of Mines schedule of tests for "permissibility." It is tentatively recommended that only those cables termed "armored cables" of the rubber-covered type constructed in accordance with the specifications of the National Electrical Code be used, and that the "armor shall be electrically continuous throughout and grounded." (Tech Paper 402, p. 5.)[7]

Trailing cables also have not been covered by the Bureau of Mines schedule for permissibility. Until a "permissible list" for trailing cables is established by the bureau, the users of permissible machinery should employ the trailing cables recommended for the specific permissible machinery. (Details of the general character, installation, protection, and inspection are given in Technical Paper 402.) In all places where inflammable gas might be encountered and permissible machinery and armored cable is used, the Mine Safety Board recommends that trailing cables should receive current through permissible junction boxes.

In gassy and slightly gassy mines there are great hazards in having trolley wires or unarmored power lines in headings and working faces beyond any open crosscuts. Such electric wires should not extend into rooms, longwall faces, or pillar workings, or beyond any continuously operated ventilating circuit which is not controlled by effective ventilating doors or stoppings. Curtains and loose gob stoppings or any stoppings or doors which allow air leakage should not be considered effective.

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7 - Safety Rules for Installing and Using Electrical Equipment in Coal Mines. Tech. Paper 402, Bureau of Mines, 1926. 21 pp.

LIST OF DECISIONS

DEPARTMENT OF COMMERCE
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 577 Laboratory No. 52934

Sample of Mine air

Mine Central Colliery Operator Pittston Co.

State Pa. County Luzerne Township

Town (distance and direction from, and railroad) Avoca

Name of coal bed Red Ash Sec. , T. , R.

Location in mine Intake at Chamber No. 5 1st rt. of rock tunnel section

Method of sampling vac. Date sampled 10/3/30 Hour 12:45 pm

Velocity - Area - Quantity -

Barometer: Inside Outside

Corrected to sea level: Inside Outside

Bulbs: Wet 57.5 Dry 58 Humidity %

Collector M. J. Antony Asst. Mine Safety Engr. Mailed - Received 10/4/30

Laboratory No.	52934 577		Ethane (C_2H_6)		
Carbon dioxide (CO_2)	.28		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.59		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)					
Carbon monoxide (CO)			Sulphur dioxide (SO_2)		
Methane (CH_4)	.00				
Nitrogen (N_2)	79.13				
Total	100.00				

Remarks:

Date 10/9/30 (Signed) W. P. Yant, Chemist.

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DEPARTMENT OF COMMERCE
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 578 Laboratory No. 52955

Sample of Mine air

Mine Central Colliery Operator Pittston Co.

State Pa. County Luzerne Township

Town (distance and direction from, and railroad) Avoca

Name of coal bed Red Ash Sec. , T. , R.

Location in mine Face of No. 2 chamber 1st rt. of rock tunnel section

Method of sampling vac. Date sampled 10/3/30 Hour 1:30 pm

Velocity - Area - Quantity -

Barometer: Inside Outside

Corrected to sea level: Inside Outside

Bulbs: Wet 57 Dry 58 Humidity %

Collector M.J.Anbony Mailed - Received 10/4/30
Asst. Mine Safety Engr.

Laboratory No.	52955 578	Ethane (C_2H_6)	
Carbon dioxide (CO_2)	.43	Hydrogen sulphide (H_2S)	
Oxygen (O_2)	20.56	Unsaturated hydrocarbons (C_2H_4, etc.).	
Carbon monoxide (CO)		Sulphur dioxide (SO_2)	
Methane (CH_4)	.25		
Hydrogen (H_2)			
Nitrogen (N_2)	78.96		
Total	100.00		

Remarks:

Date 10/6/30 (Signed) W. P. Yant, Chemist.

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DEPARTMENT OF COMMERCE
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 879 Laboratory No 32934

Sample of Mine air

Mine Central Colliery Operator Pittston Co.

State Pa. County Luzerne Township

Town (distance and direction from, and railroad) Avoca

Name of coal bed Red Ash Sec. , T. , R.

Location in mine Face of buggie place off No. 1 chamber - 1st rk. of rock tunnel section

Method of sampling Vac. Date sampled 10/2/30 Hour 1:45 pm

Velocity - Area - Quantity -

Barometer: Inside Outside

Corrected to sea level: Inside Outside

Bulbs: Wet 57 Dry 59 Humidity %

Collector M.J.Anthony Mailed - Received 10/4/30

Laboratory No.	32934 879		Ethane (C_2H_6)		
Carbon dioxide (CO_2)	.45		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.43		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)					
Carbon monoxide (CO)			Sulphur dioxide (SO_2)		
Methane (CH_4)	.51				
Nitrogen (N_2)	78.96				
Total	100.00				

Remarks:

Date 10/9/30 (Signed) H. P. Yant, Chemist.

Form 213 11—8890

GOVERNMENT PRINTING OFFICE

DEPARTMENT OF COMMERCE
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 520 Laboratory No. 52937

Sample of Mine air

Mine Central Colliery Operator Pittston Co.

State Pa. County Luzerne Township

Town (distance and direction from, and railroad) Avoca

Name of coal bed Red Ash Sec. , T. , R.

Location in mine Face of No. 2 chamber, 1st rt. of rock tunnel section

Method of sampling vac. Date sampled 10/3/30 Hour 1:05 pm

Velocity - Area - Quantity -

Barometer: Inside Outside

Corrected to sea level: Inside Outside

Bulbs: Wet 67 Dry 58 Humidity %

Collector M.J.Antony Asst. Mine Safety Engr. Mailed - Received 10/4/30

Laboratory No.	52937		Ethane (C_2H_6)		
Carbon dioxide (CO_2)	520 .45		Hydrogen sulphide (H_2S)		
Oxygen (O_2)	20.50		Unsaturated hydrocarbons (C_2H_4, etc.).		
Hydrogen (H_2)					
Carbon monoxide (CO)			Sulphur dioxide (SO_2)		
Methane (CH_4)	.84				
Nitrogen (N_2)	79.05				
Total	100.00				

Remarks:

Date 10/6/30 (Signed) K. F. Yant, Chemist.

DEPARTMENT OF COMMERCE
BUREAU OF MINES

GAS ANALYSIS REPORT

Bottle No. 561 Laboratory No. 22936

Sample of Mine air from affected area

Mine Central Colliery Operator Pittston Co.

State Pa. County Luzerne Township

Town (distance and direction from, and railroad) Avoca

Name of coal bed Red Ash Sec. , T. , R.

Location in mine 1st right of rock tunnel section

Method of sampling Vac. Date sampled 10/3/30 Hour 12:30 pm

Velocity 200 Area 65 Quantity 11,000

Barometer: Inside Outside

Corrected to sea level: Inside Outside

Bulbs: Wet 66 Dry 58 Humidity %

Collector E.J.Ankeny Mailed - Received 10/4/30
Asst.Mine Safety Engr.

Laboratory No.	22936	Ethane (C_2H_6)	
Carbon dioxide (CO_2)	561 .53	Hydrogen sulphide (H_2S)	
Oxygen (O_2)	20.49	Unsaturated hydrocarbons (C_2H_4, etc.).	
Hydrogen (H_2)			
Carbon monoxide (CO)		Sulphur dioxide (SO_2)	
Methane (CH_4)	.06		
Nitrogen (N_2)	79.12		
Total	100.00		

Remarks:

Date 10/9/30 (Signed) H. P. Yant, Chemist.

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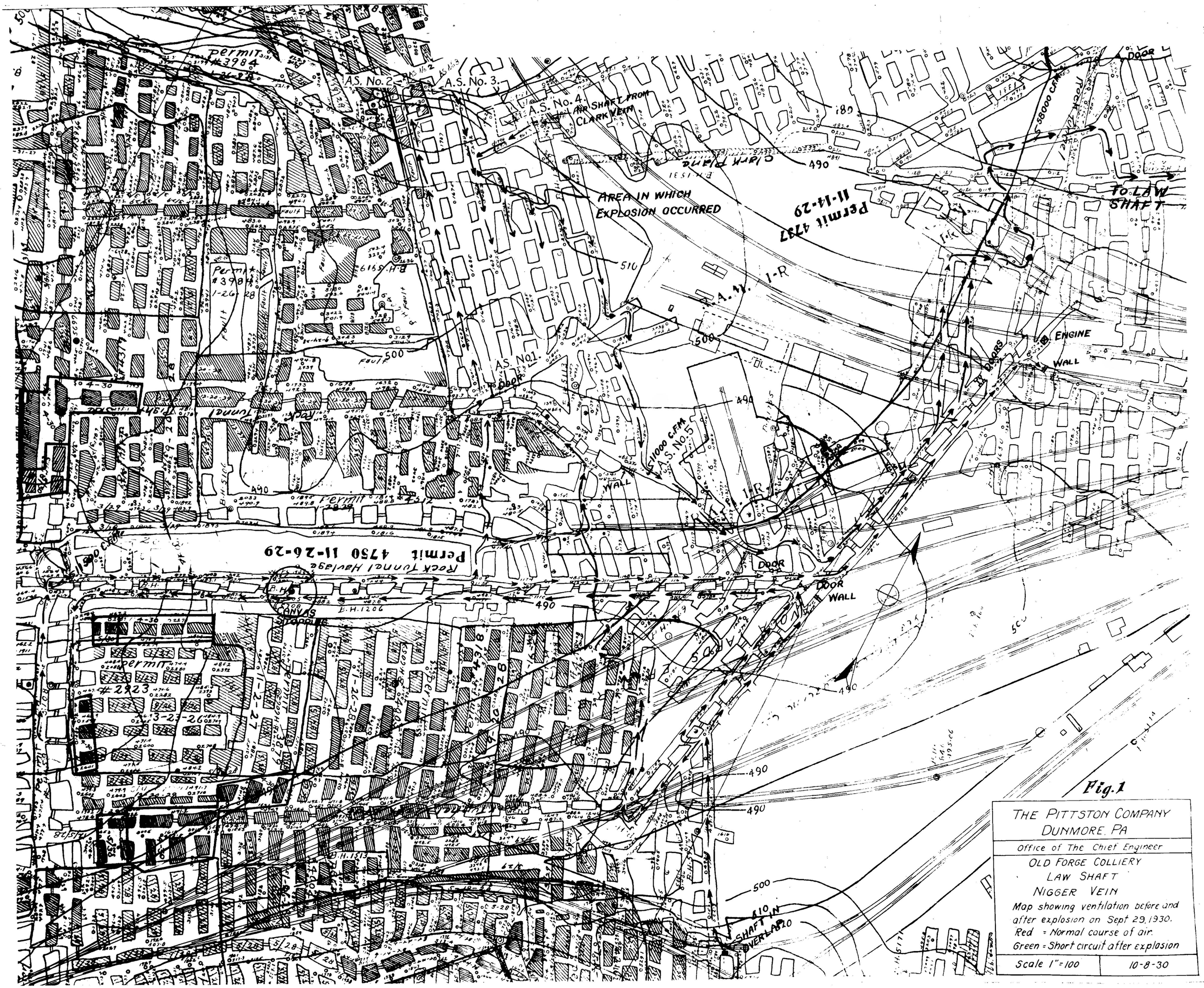

Fig. 1

THE PITTSTON COMPANY DUNMORE, PA	
Office of The Chief Engineer	
OLD FORGE COLLIERY LAW SHAFT NIGGER VEIN Map showing ventilation before and after explosion on Sept 29, 1930. Red = Normal course of air. Green = Short circuit after explosion	
Scale 1" = 100	10-8-30

LEGEND

OUTBY CHAMBER

1 - Mine cap torn to pieces.
2 - Pocket carrying flask.
3 - Top of lamp.
4 - Laborer found - head inby.
Piece of shirt charred.
Top of cap.
5 - Laborer found - head outby - arm broken in half.
Carbide container intact.
Shoe - Dinner can badly shot up.
6 - Glove - tarred box - piece of shirt.
Carbide box shot up - 2 lamps.
2 powder cans badly shot up.
Tool box smashed up.
Smashed tin with squibs.
7 - Piece of overalls unburned.
8 - Dinner can in X cut.
9 - Shoe.
10 - 6 Detonators.
11 - Monobel box broken - Monobel & Exploders scattered.
12 - 2 Holes - Left hand corner - 6-1/2 feet deep.
2 Posts not set - tools undisturbed ready to make shot.
13 - Top Deck of 2 rails - Pick.
14 - Dinner bucket - badly smashed.
15 - Wool jacket - some burned holes - singed on one side.
16 - Top of carbide can - top of powder can.
17 - Water flask.
18 - Carbide can.
19 - Piece of cartridge paper - burned.
20 - Battery in center of track - shooting wire along rib.

MIDDLE CHAMBER

1 - Glove torn to pieces.
Dynamite box blown to pieces.
2 - 2 caps in road.
3 - Blood on ground - head print - belt.
(Miner made way out to heading - laborer found dead)
4 - Bottom of lamp.
5 - Empty carbide can - pocket.
6 - Dinner can - can powder - jacket - water bottle - paper - pick - heel off shoe. Box of Monobel.
7 - Glove and squib.
8 - Part of box of Monobel and keg of powder.
Squibs scattered - gloves & misc. small tools.
9 - Wall blown by force.
X - Last X cut all tools undisturbed.

INBY CHAMBER

1 - Jacket - no burns.
2 - Can powder - nearly full.
3 - Bucket - Gloves - no burns.
4 - Shovel & check - Laborer found here.
5 - 2 shovels on right rail.
6 - Auger bit on left rail.
7 - Carbide can part full of carbide.
8 - Scraper - bent.
9 - Axe & bit in X cut.
10 - Post - marked on inby side.
11 - Spike bar - bent needle - sledge - carbide lamp and batteries.
12 - Drill - pick - hammer - anchor.
13 - 1 prop dislodged by force.
1 broken by gob.
1 loose prop [illegible] and lying across road.
14 - Tool Box - Checks #304 - Lid off empty can.
15 - Top of bucket - coat.
16 - Bucket.
17 - Miner made way to here.
18 - Door broken.

Arrows indicate direction of explosion force as shown on gob.

Fig. 2

THE PITTSTON COMPANY
DUNMORE PA.

Office of The Chief Engineer

OLD FORGE COLLIERY
LAW SHAFT
NIGGER VEIN
MAP
showing conditions as found by