FINAL REPORT ON AN EXPLOSION IN THE PANHANDLE MINE OF THE BICKNELL COAL COMPANY AT BICKNELL, KNOX COUNTY, INDIANA ON MAY 22, 1941

see pg 7

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DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

CONTENTS

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By W. H. Tomlinson.

INTRODUCTION

Between 9:30 p.m. and 10:30 p.m. Thursday, May 22, 1941, an explosion occurred in the Panhandle mine of the Bicknell Coal Company at Bicknell, Indiana, resulting in the loss of 14 lives. Seventeen men escaped unhurt and unassisted.

The explosion was limited in extent and violence, and is believed to have been due to the ignition of an accumulation of gas either by an electric arc from the controller of an unapproved coal cutting machine or by smoking. It is not believed that coal dust entered into the explosion to an appreciable extent.

The gas accumulation responsible for the explosion was caused by interrupted ventilation due to ventilation doors having been left open for unnecessarily long periods of time, and indicates extreme laxness on the part of the officials in charge.

Of the 14 men killed only three were burned and, in the opinion of the coroner, they were not burned severely enough to cause death. The death of all 14 men was apparently due to asphyxiation and not to burns or violence.

No water was being used at the face to allay dust and the mine was only partially rock-dusted. No rock-dust had been applied for several months prior to the explosion.

Word of the explosion was received by the Bureau of Mines about 11:00 p.m. Messrs. C. A. Herbert, A. U. Miller, W. H. Tomlinson, and P. P. Senio, arrived at the mine about 11:45 p.m. with the Bureau of Mines' equipment. Mr. W. O. West, who was away from headquarters when the call was received, arrived at the mine about 30 minutes later.

By the time the Bureau of Mines representatives arrived at the mine the very efficient and well-trained mine rescue team from the Bicknell Rescue Station, in charge of Mr. Jack Ogilvie, together with volunteers from nearby mines, were already in the mine restoring ventilation. The Bureau of Mines' participation in the recovery work was limited to underground assistance by Messrs. W. H. Tomlinson and P. P. Senio, and the assembling of a reserve team with equipment to be ready in case of need.

Recovery operations were completed and the last body removed about 8:30 a.m. May 23, approximately 10 hours after the explosion occurred. In view of the limited extent of this explosion, had there been adequate ventilation, recovery operations would have been completed in a much shorter time.

GENERAL INFORMATION

Location

The Panhandle mine is situated on a branch line of the Pennsylvania Railroad, approximately 3 miles southwest of the town of Bicknell, Knox County, Indiana.

Company Officials

The mine is owned and operated by the Bicknell Coal Company, a cooperative organization to which all employees and officials belong, each individual owning 10 shares of stock. The employees at this mine do not belong to any miners' organization.

The supervising officials are as follows:

F. I. Pearce	Mine Superintendent	Bicknell, Ind.
John Milligan	Mine Foreman	Bicknell, Ind.
Wm. Easton, Jr.	Assistant Mine Foreman	Bicknell, Ind.
Charles Wright	Night Boss	(Deceased)
Walter Pollock	Fire Boss	Bicknell, Ind.

The Board of Directors consist of:

F. I. Pearce	President
Guy Hoover	Vice President, and cutting machine operator
E. J. Stivers	Secretary Treasurer, and bookkeeper
Benny Green	Cager
Raymond Smith	Cutting machine operator
John Milligan	Mine Foreman
John Silvers	Loader
Wm. Easton, Jr.	Assistant Mine Foreman

Employees and Production

Two shifts are worked. The day shift starts at 7:00 a.m. and quits at 2:00 p.m. The night shift begins at 4:00 p.m. and ends at 11:00 p.m. A total of 184 men were employed on the two shifts at the time of the explosion. Of these, 16 were employed on the surface and 137 underground on the day shift and the remainder on the second shift.

Approximately 1100 tons of coal per day are produced on the two shifts.

Mine Openings

The mine is opened by two shafts approximately 330 feet in depth. The hoisting shaft is divided into two compartments, both of which are used for hoisting. The return air escapes to the surface through this shaft.

The second opening is divided into three compartments; one is used as the intake airway, one is fitted with a stairway, and one is unused except for the power lines to the No. 5 bed that are taken underground through this compartment. This shaft was arranged as above described, with the original idea of installing hoisting equipment at this opening for men and material, but due to unfavorable natural conditions encountered after reaching the coal the plan was abandoned.

Coal Bed, Roof, and Floor

At the present time two beds of coal are worked in the Panhandle mine. The shafts were sunk in 1934 to the Indiana No. 5 bed and the workings extended in this bed to the boundary lines on two sides of the property.

Due to the reduced height of the coal and the presence of impurities, other parts of the mine were abandoned to such an extent that working places were not available to take care of all the employees.

Since it became apparent that the reduction of the number of working places in the No. 5 bed made it impossible to give work to all employees, operations were begun recently in the No. 6 bed to remedy this situation.

The No. 6 bed lies about 100 feet above the No. 5 bed. Operations in the former have not yet progressed beyond the exploratory stage, the development being carried on from the present hoisting shaft. An opening is being driven to connect the two shafts; however, at this writing the connection has not yet been made.

The height of the coal of the No. 5 bed ranges from 4 to 7 feet. The bed is interspersed with laminations of pyrite, bone coal, and shale. The bed is divided near the roof by a parting of "draw slate" (clayey shale), a foot or more thick in some places.

The immediate roof is a fairly strong shale interspersed with numerous "boulders" or secretions typical of the strata lying immediately above the No. 5 coal bed in many parts of this State. The existence of the boulders in the strata adjacent to the coal is not universal for in some parts of the mine they are conspicuous by their absence. Further, as typical of the stratum contiguous to the No. 5 coal bed in Indiana, the roof is considered best in parts of the mine where the boulders appear.

The immediate floor is a fairly hard and smooth fire clay. This stratum weathers quickly and constant heaving occurs in workings open for an extended period.

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

Method of Mining

Development is by the room-and-pillar, panel method. Usually two openings only, are made in a panel; this is done in order that the panel can be easily and quickly sealed as soon as extraction therein is discontinued.

With the exception of the workings immediately surrounding the shaft bottoms all entries are driven in pairs. The map included in the Appendix to this report shows three parallel entries in what is called the main south, (the section in which the explosion occurred), however, the third opening, or left entry (see map), is being driven for the purpose of providing an additional working place, only.

Reference is made here to the manner of marking the entries and different parts of the mine, such as: main south, main northwest, main east, etc. The designation of the entries as shown on the map do not necessarily correspond to the points of the compass since, for instance, the direction of what is called the main east entries is not due east, and the same is true of what is called the main northwest entries. At least two panel entries extending in different directions are called main south. The designations used in this report refer to those marked on the map. The main south entries when mentioned herein refer to what is called first, second, and third south, the section in which the explosion occurred. The center entry, or second south entry, is sometimes referred to as the main south.

Entries are being driven on 26-foot centers and 14 feet wide, leaving a pillar only 12 feet in width. Barrier pillars 50 and 100 feet in width are left adjacent to all secondary and main haulage roads.

Rooms are turned from both entries on 59-foot centers, and are driven 24 feet in width. The depth of the rooms varies according to the conditions encountered. In two instances the rooms were extended to depths of 500 and 600 feet, respectively. This unusual depth was occasioned by the fact that additional coal was purchased from adjacent owners after the original development had reached the boundary lines, and rather than drive additional entries the rooms were driven to extreme lengths into the newly acquired reserves.

Generally, the rooms from one panel entry are not holed through to those driven from adjacent panel entries and small pillars are left for better control of the ventilation and to aid in sealing abandoned workings. The direction and

depth of both entries and rooms are governed, in many cases, by the undulations of the coal. In many cases the courses of entries and rooms have been changed due to rapid rises or dips of the bed. These conditions make uniform extraction rather difficult and add considerably to the cost of extraction and to the hazards of haulage operations.

The entire production comes from advancing work. No pillars are extracted, and provision is not made for the removal of barrier or other pillars.

The coal is cut to a depth of about 6 feet at the bottom of the bed, with shortwall mining machines. Cutting is done on both shifts. The cuttings left by the machines are not loaded out before shots are fired.

Electrically-operated "post" drills are used. Holes are drilled on both shifts. Three holes are drilled in the entries and a like number, or more as needed, depending upon the conditions, in the rooms. The center hole in the entries is placed low in the bed as a snubbing hole. Occasionally, it is necessary to place a short hole in the rooms to "square up" the place before it can be cut.

Coal is loaded by hand into mine cars. Due to a scarcity of working places, two men are assigned to each place. Development entries and the rooms in at least one panel entry, are worked two shifts.

The natural roof conditions in this mine are fairly good, necessitating no great amount of timbering on the entries, especially in parts of the mine where the "boulders" occur. A few posts, and still fewer crossbars are placed along the entries where "slips" or faults are exposed in the roof.

Systematic timbering is not followed in the rooms. Posts are generally placed at the will and according to the judgment of the miner as there are no timbering rules in force at this mine. The tracks are carried up the center of the rooms and from one to three rows of posts are set on each side of the track, depending on the width of the place and the pleasure of the miner. Many of the rooms were found inadequately timbered. In many places the posts were too far back from the face. In one room in the main northwest section the last row of permanent posts was 15 feet away from the face. In another room, at least 16 feet back from the face and on one side of the track in a room in this same section they were 24 feet away from the face. Regardless of the condition of the roof in any mine these distances are much too great. Temporary or "safety" posts are not used.

Ventilation and Gases

The mine is ventilated by means of a 6-foot diameter Jeffrey Aerodyne type fan driven by a 35 horsepower 2300-volt alternating current motor connected to the fan by means of a multiple-belt-drive. The fan is located at the second

opening approximately 150 feet from the hoisting shaft. It is offset from the opening about 10 feet, but explosion doors are not provided.

The fan is operated blowing and moving, at the time of the investigation, approximately 60,500 cubic feet of air per minute as measured about 40 feet inby the foot of the shaft. This quantity of air, however, was not going into the mine at the time of the explosion because the boards of the partition separating the downcast from the stairway compartment in this shaft, were buckled and broken, permitting an excessive loss of air before it left the shaft.

The air currents are split at the foot of the downcast shaft; a very small quantity of air sweeps the seals of two abandoned sections near the shaft. The amount of air going to these seals is regulated by a small door in a wooden stopping near the foot of the shaft. Usually, this door is kept closed and the air that leaks through is all that is required to keep the outby sides of the seals free from accumulations of gas. This current of air is returned immediately from the seals to the main hoisting shaft.

A major split occurs in the intake air currents about 200 feet from the foot of the downcast; part of the air travels through the 2 east entry (see map) to a small abandoned section at the extreme end of the workings, then is returned through 5 and 6 south, main east panel entries, in which several rooms were being worked on the day shift at the time of the explosion. This air is then returned through the haulage entry (1 east) to the hoisting shaft, passing under the overcast near the entrance to this entry. Since the explosion the entire 1 and 2 main east section has been abandoned and preparations are being made at this writing to seal these workings near their entrances.

The larger quantity of air from this major split is used in ventilating the remainder of the mine. By referring to the map it will be noted that the fresh air is first coursed through worked-out unsealed workings before reaching the active workings in the main northwest section. It will be noted further, that one panel through which the fresh air is taken is on a squeeze. Before reaching the live workings at the face of the main northwest entries a small sub-split is made, the smaller quantity of air going to the "A" and "B" entries. From the main northwest section the air is taken into the main south, the section in which the explosion occurred. The air travels up the 3 south entry through 1 and 2 west, 3 and 4 west, around the faces of 1, 2, and 3 south, and is returned to the hoisting shaft by way of the main haulage road.

The air currents are guided and controlled by stoppings and doors of wood. In at least two places brattice cloth was used in the construction of a regulator and at one place, (in the explosion region), it was used as a curtain in place of a door. It was reported that the bratticeman was getting ready to erect a door to replace this curtain at the time the explosion occurred.

All doors are of the two-way type; in other words, they will swing in either direction. In addition, the doors are hung by only one hinge, a rocker arm taking the place of the lower hinge. This type of construction makes it very easy to knock the door off its lower hinge (rocker arm), in which position it would very likely not close of its own accord.

Some of the doors are poorly constructed and leak badly along the top and bottom sill. In fact, several were not equipped with a bottom sill. The door is a very poor device for controlling the ventilation even if when constructed it is erected so as to swing in either direction, because any appreciable ventilating pressure will keep such a door partly open, thus short-circuiting the air to at least some extent. The reason for erecting two-way doors is, that locomotives and trips can pass through rapidly without having to stop the trips to open and close the doors where trappers are not employed. The use of this type of door is, in itself, a definite indication that the mine is poorly ventilated.

The Mining Laws of Indiana do not classify coal mines as gassy or nongassy, therefore, the Panhandle mine is not classed as gassy, although it is recognized as such by the Indiana Bureau of Mines and Mining. It is well-known that this mine, in common with others working the same bed in this field, liberates considerable gas. Open lights were replaced with permissible electric lamps at this mine sometime ago to attempt to overcome the hazards because of the amount of gas produced.

Only one fire boss is employed. He enters the mine about 11:45 p.m. to 12:00 midnight and returns to the surface just before the day shift enters at 7:00 o'clock the next morning. If gas is reported the fire boss returns to the mine and with the assistance of the bratticeman, removes it.

The extent of the workings before the explosion was too great to be thoroughly covered by one fire boss and due to the fact that he entered the mine about 7 hours before time for the day shift to enter, his examination (no matter how thorough) meant little as to the safety of the places by the time the day shift entered the mine.

The night boss also acted as fire boss on the night shift. He entered the mine at least 2 hours ahead of the night shift and was supposed to examine the workings before the shift entered. No method was used to "check up" on the work of the night boss to insure that he examined all places properly before the men entered. The fire boss is the only official required to leave his mark at the face of places examined or to report the result of his examinations in a book provided for the purpose.

Judging from the report of the fire boss, both as to the manner and frequency of the reporting of gas, it is believed that little importance or attention has been given to its occurrence in this mine. For instance, the report shows: "little

gas", "very little gas", or, "a dangerous condition". When asked at the inquest what he considered a dangerous condition the fire boss replied, "from three to six inches of gas", evidently referring to the distance from the roof where he could first detect gas with his safety lamp, without considering the size of the place, the quantity of gas present, or other important factors which under special conditions might be of vital importance.

Any place wherein explosive gas is present in quantities sufficient to be detected by a flame safety lamp should be considered as being dangerous. Further, when gas is found in the same place frequently as on successive days, especially when reported day after day in the same place as a "dangerous condition", in view of the foregoing definition of what constitutes (in the opinion of the fire-boss), a "dangerous condition", it appears that little importance was attached to the accumulation of gas in this mine. Since accumulations of gas were reported in the same place on successive days it is reasonable to assume that essentially no effort had been made to remove the gas immediately upon its discovery, and little, if any, provision made to prevent the recurrence of the accumulation.

The recordings on the following pages were taken from the fire boss' report book and show the frequency of the discovery of gas in this mine for several months previous to the explosion.

Date 1941	Place		Gas
1--3	1 W. M. N. W.	Room 4	Little gas.
	2 E. 8 S.	" 5	Dangerous condition.
1--4	2 E. 8 S.	" 5	Very little gas.
	1 W. M. N.	" 3	Very little gas.
	"A" Entry M. N.	" 2	Very little gas.
	"A" Entry M. N.	" 4	Very little gas.
	4 E. 5 N.	" 13	Very little gas.
1--5	8 S. E. 2 E.	" 9	Little gas.
	1 W. M. N.	" 2	Little gas.
1--8	"A" Entry M. N.	" 5	Little gas.
	2 E. 8 S.	" 9	Little gas.
1--9	"A" Entry M. N.		Little gas.
	"B" Entry M. N.		Little gas.
	"A" Entry M. N.	" 4	Little gas.
	1 W. M. N.	" 4	Little gas.
	2 E. 8 S.	" 5	Little gas.

Date	Place			Gas
1941				
1-10	2 E. 8 S.	Room	8-9	Little gas.
	1 W. M. N.	"	4	Little gas.
	"A" Entry	"	4	Little gas.
1-11	1 W. M. N.	"	3	Little gas.
	2 E. 8 S.	"	4	Little gas.
	2 E. 8 S.	"	5	Dangerous condition.
1-12	1 W. M. N.	"	4	Little gas.
	2 E. 8 S.	"	8	Little gas.
	2 E. 8 S.	"	9	Little gas.
	2 E. 8 S.	"	10	Dangerous condition.
	2 E. 8 S.	"	5	Dangerous condition.
2--6	M. N.			Little gas.
3-14	3 N. E.	"	18	Dangerous condition.
3-16	M. N. Entry			Little gas.
	4 M. N. Entry			Little gas.
	"A" Stub	"	12	Little gas.
3-19	M. N. Entry			Gas.
4--7	3 and 4 N. 6 N.			Dangerous condition.
4--8	4 E. 5 N. E.	"	6	Little gas.
4--9	4 E. 5 N. E.	"	6	Dangerous condition.
	3 E. 5 E. N.			Dangerous condition.
	M. N. Entry			Little gas.
4-16	4 E. 5 N. E. N.	"	5	Dangerous condition.
4-22	3 and 4 E. N. E. N.			Dangerous condition.
4-23	3 and 4 E. 5 N. E. N.			Dangerous condition.
4-24	3 and 4 E. 5 N. E. N.			Dangerous condition.
	2 E. 8 S. E.	"	1	Little gas.
	M. N. Entry			Little gas.
4-25	3 and 4 E. 5 N. E.			Dangerous condition.

Date 1941	Place	Gas	Time Gas Was Removed
4-26	3 and 4 E. 5 N. E.	Dangerous condition.	
4-27	3 and 4 E. 5 N. E.	Dangerous condition.	
4-28	3 and 4 E. 5 N. E.	Dangerous condition.	
4-29	3 and 4 E. 5 N. E.	Dangerous condition.	
4-30	3 and 4 E. 5 N. E.	Dangerous condition.	
5--5	2 S. N. Entry	Little gas.	
5--7	M. S. Entry	Gas.	
	2 S. Entry	Gas.	
5--9	3 S. N. Entry	Little gas.	
5-10	3 S. N. Entry	Little gas.	
5-12	5 S. Entry	Little gas.	
	2 N. Entry	Dangerous entry.	
5-13	2 N. Entry	Dangerous condition.	
	3 S. Entry	Little gas.	7:30 a.m.
5-14	2 N. Entry	Dangerous condition.	8:00 a.m.
5-15	2 S. Entry	Dangerous condition.	
	2 E. N.	Little gas.	8:00 a.m.
	1 E. N.	Little gas.	8:00 a.m.
5-16	1 E. N.	Little gas.	8:00 a.m.
	2 E. N.	Little gas.	8:00 a.m.
	1 E. Entry	Little gas.	
5-17	M. S. Entry	Dangerous condition.	9:00 a.m.
	1 E. N. Entry	Little gas.	10.00 a.m.
	2 E. N. Entry	Little gas.	10:00 a.m.
5-18	3 E. N. Entry	Little gas.	10:00 a.m.
	2 E. N. Entry	Little gas.	10:00 a.m.
	M. S. Entry	Little gas.	10:00 a.m.

Date	Place	Gas	Time Gas Was Removed
1941			
5-21	3 S. Entry	Little Gas	10:00 a.m.
5-22	3 S. Entry	Dangerous condition.	9:00 a.m.
	2 S. Entry	Little gas.	9:00 a.m.

A number of air samples were collected on June 3 and 4, 1941, approximately two weeks after the explosion.

Inasmuch as extensive repairs have been made since the explosion, to the partition in the airshaft and to doors and stoppings in the explosion region, the quality and quantities of air shown in the following Table are not representative of the conditions existing prior to the explosion. In fact, the conditions herein shown are much more favorable since, very likely, the ventilation doors were kept closed during the time the samples were taken, which was not at all likely to be the case previous to the explosion. Moreover, considerably more air was probably traveling through the mine after the partition in the airshaft had been repaired than was being handled previous to the explosion.

The results of the analyses of air samples collected are shown in Table 1.

It will be observed from Table 1 that considerable quantities of explosive gas are being liberated in this mine. All of the samples contained some gas and four of the total of seven contained 0.40 percent or over. It will be further noted that 245,700 cubic feet of pure methane is being liberated in this mine in 24 hours. This amount of gas, if mixed with air to about the maximum explosive point, would make approximately 2,457,000 cubic feet of maximum explosive mixture in 24 hours, or enough of the mixture to fill an entry sixty square feet in area for a distance of about 1700 feet, in an hour if the ventilation were interrupted for this period of time.

Testimony given at the inquest indicated that at least one door, and probably three doors, controlling the ventilation to the section in which the explosion occurred, had been left open for over an hour on the night of the explosion.

TABLE 1. - Analysis of mine air samples collected in Panhandle mine, June 3 and 4, 1941

Laboratory No.	Location in mine		Percent			
			Carbon dioxide	Oxygen	Methane	Nitrogen
67314	On empty track at shaft bottom.	Main returns from main south and main northwest section.	0.15	20.39	0.40	79.06
67313	On loaded track at shaft bottom.		0.15	20.34	0.40	79.11
67315	Outby junction of M. S. with M. N. W.	Ditto.	0.17	20.39	0.41	79.03
67316	At main east overcast.	Main return from main east section.	0.13	20.44	0.10	79.33
67312	Return from main	south seals.	0.07	20.87	0.26	78.80
67317	On main northwest outby split to "A" and "B" entries.	Return from old workings and intake to main northwest section.	0.12	20.33	0.23	79.32
67318	At 2nd crosscut junction of M. S. with M. N. W.	Return from main northwest section and intake to main south entries.	0.24	20.14	0.41	79.21

See note on page 13.

TABLE 1. - Analysis of mine air samples collected in Panhandle mine, June 3 and 4, 1941 (cont'd.)

Laboratory No.	Location in mine		Quantity of air, cu. ft. per min.	Methane cu. ft. in 24 hours
67314	On empty track at shaft bottom.	Main returns from main south and main northwest section.	5,400	31,100
67313	On loaded track at shaft bottom.		26,400	152,060
67315	Outby junction of M. S. with M. N. W.	Ditto.	2,000	11,800
67316	At main east overcast.	Main return from main east section.	26,400	38,010
67312	Return from main south seals.		3,400	12,730
		TOTALS	63,600	245,700
67317	On main northwest outby split to "A" and "B" entries.	Return from old workings and intake to main northwest section.	6,300	20,860
67318	At 2nd crosscut junction of M. S. with M. N. W.	Return from main northwest section and intake to main south entries.	14,250	84,130

Note: Samples were collected by W. H. Tomlinson and P. P. Senio, U. S. Bureau of Mines, Vincennes, Ind., June 3, 4, 1941, and analyzed at the Gas Laboratory, U. S. Bureau of Mines, Pittsburgh, Penna. June 6-12, 1941, by H. H. Schrenk, Chemist.

It will be further observed by reference to the foregoing table that the "intake" air entering the main northwest section (sample No. 67317), contained 0.23 percent of methane. This gas is given off in the old workings through which the ventilation is coursed before reaching the active workings. Also, that this air picks up considerably more gas in the main northwest section and that it contained 0.41 percent methane (sample No. 67318), before entering the main south entries. Since the latter entries produce considerable gas due to "feeders" in the crosscut and the face of 2 south entry there is no doubt that an explosive mixture accumulated quickly in these entries because doors were left open immediately prior to the explosion.

In view of the comparatively large quantities of gas being released in this mine it is apparent that:

(a) The quantity of air entering the mine is entirely inadequate to dilute the gas, carry it off, and render it harmless, and it should, therefore, be increased considerably;

(b) Abandoned workings should be sealed immediately after being worked out and the air currents should not be taken through old workings before being used to ventilate active workings;

(c) Sufficient air should be provided so at least 10,000 cubic feet per minute reaches the last open crosscut in all panel entries;

(d) Each pair of panel entries should be ventilated by a separate split of air;

(e) Stoppings, at least those between main intake and return air currents, should be of masonry or concrete well plastered and tight in all respects;

(f) All doors should be made to close one way only; doors should be hung to close automatically and also to close "with the air";

(g) Where practicable, air locks should be provided by using two doors instead of one, so that at least one door is always kept closed when trips or persons pass through;

(h) Curtains should not be used in place of doors;

(i) Trappers should be employed at all main doors unless automatic-type doors are used;

(j) The present method of reporting the finding of gas should be discontinued When gas is found in any place in quantities sufficient to be detected by a safety lamp the place should be considered to be in a "dangerous condition" and to require improved ventilation;

(k) Accumulations of gas should be removed as soon as practicable after the gas is discovered;

(l) All officials should be required to "leave their mark" as evidence of their presence, at the face of all places visited during the shift;

(m) Examinations by the fire boss should be made within three hours of the appointed time for the shift to enter the mine;

(n) Fire boss examinations should be made prior to and during both the day and night shifts.

Non-permissible key-locked (Baby Wolfe) flame safety lamps were used by the fire boss and night boss for the detection of gas. The mine foreman and section (assistant) foreman also sometimes carry these lamps. The latter two officials usually take their lamps underground unlit and carry them in their pockets or in the "bib" of their overalls, except when actually making a test for gas.

These practices are outmoded and hazardous and should not be continued. First, all flame safety lamps should be of the permissible (magnetically-locked) type; second, the lamps should be properly serviced on the surface by a competent man; third, all lamps should be thoroughly tested in explosive gas on the surface immediately before they are taken underground; fourth, the officials should be required to have their lamps with them at all times in proper condition for testing for gas. They should be prohibited from carrying the lamps in their pockets or in their clothing. If these suggestions are carried out the probability that the lamps will be opened to light them in the presence of gas would be greatly decreased.

No employees, except those above-mentioned, use flame safety lamps. Some states require the use of such lamps by operators of electrically-operated machines and specify that tests with the lamps be made for gas before the machines are taken to the face of a working place. This is an excellent safety precaution if carried out effectively, and the practice should be followed at all mines. Had this been done at this mine, this explosion might not have occurred.

It is strongly recommended that the operators of all cutting machines and drills be provided with flame safety lamps and that they be required to make a test for gas before taking their machine or drill beyond the last open crosscut next to the face. Further, that before being entrusted with a lamp, each and every man should be given a thorough course of instruction until examination proves him to be familiar with the lamp and indicates that he is conversant with the hazards incident to its use. In order to meet this requirement the machinemen would have to be certified fire bosses, according to the interpretation of the Indiana mining law, by the present Chief of the Mine Inspection Department.

No prohibition against smoking in the mine was in force before the explosion, consequently, many of the workmen smoked at will. At a safety meeting held after the explosion, the majority of the workmen voted to prohibit smoking underground.

Permitting persons to smoke in a mine that liberates gas as this one does is a flagrant violation of the principles of common sense and good mining practice. It remains to be seen whether the rule against smoking underground will be obeyed by those casting dissenting votes.

Haulage

Combination cable-reel and trolley type locomotives are used for gathering the coal from the faces to local sidetracks, and a straight trolley type locomotive is used for main line haulage.

None of the locomotives observed were equipped with gongs and the head lights of all are in bad condition. None of the headlights are protected with a lens and only one had a reflector. On at least one locomotive the headlight consisted of a small light bulb with its socket merely attached to the frame of the locomotive. Another was observed in operation without a headlight.

Obviously, these practices are not conducive to safety. All locomotives should be equipped with gongs or alarms and headlights should be kept in good repair. No locomotive should be operated without a headlight.

Mine cars are of composite construction, lift-up endgate type, and have a capacity of approximately 2 tons. The cars are in fair condition. Some of them leak at the endgate, but, as a whole, the cars are in better average condition than those in use at many mines. The cars are fitted with semi-circular bumpers and coupled with a single link and pin.

The track guage is 36 inches. Main line tracks are laid with 40-pound rails on 4- by 5-inch ties placed on about 18-inch centers. In panel entries and rooms 20-pound rails on 3- by 4-inch ties are used.

Essentially, no effort is made to maintain an adequate clearance along haulage roads and shelter holes are not provided. The entries are driven wide enough if they were straight and the tracks were properly laid in line with the sights, to provide sufficient clearance, but this is not done. At many points cars or tripscan be passed only on the trolley wire side; moreover, these wires are hung low. Where there is sufficient width on the side opposite the trolley wire to provide suitable clearance the side of the road is piled high with refuse. It is the usual practice in this mine to store the refuse from the coal along the tracks as the faces are advanced; it remains there until it is convenient to send a company-paid (day) man to load it out. One of the men killed in the explosion

was engaged in loading this "gob". It would be considerably more economical to have this refuse loaded by the miners as the faces advance rather than send a day man with a locomotive to do this work on idle days or on the night shift. The face loaders would do more of the work in a given time for the same pay and the entries would be free from thestumbling hazard and the clearance, where present, would be unobstructed. This practice would also obviate the handling of the refuse by trackmen or others, constituting a waste of time.

The trolley wires are not maintained at a safe distance above the rails in this mine and no guarding of the wires was observed. At one point near the shaft bottom the bare wires were only 54 inches above the rails. At the first crosscut on main south entry outby a new entrance to 3 and 4 west, there was only 50 inches of clearance above the rail. At the entrance to 1 and 2 west, main south, there was less than 48 inches of clearance. At one point in the main northwest section the trolley wire was observed crossing a switch less than 48 inches above the rail and no guards were in place.

Failure to guard trolley or other bare power wires is a dangerous practice, especially where the wires are hung as low above the rails as they are in this mine. All trolley wires over the entire mine where placed less than 6-1/2 feet from the rails, should be adequately and completely guarded.

Haulage and hoisting are on return air. The Bureau of Mines recommends that haulage be performed on intake air.

Lighting

Electric permissible miners' lamps are used by all underground employees and officials. The officials also sometimes carry non-permissible (key-locked) Baby Wolfe flame safety lamps.

The mine is not well lighted. A few fixed incandescent lamps are placed at various points. The lamps are installed in an unworkmanlike manner; the wires are insulated but the positive lead in most cases is wrapped around the stems or studs of the trolley hangers and the negative lead is fastened to the track circuit by means of a track spike or wire nail in a tie holding the bare end of the lead against the rail. Also, the supporting of the lamp is done in slipshod manner; small wooden pegs are driven into holes drilled in the roof and the lamp socket is secured to the peg by a small wire nail.

The above methods of the installation of lighting equipment are hazardous. Proper and safe installation demands that the wires be protected by conduit. They should also be protected against being loosened or broken by derailed trips. If the lamps are supported by pegs in the roof the pegs should be of substantial size and the insulated socket (not the wires), secured to the pegs.

Electricity

Both alternating and direct current are used underground - the former for the operation of the cutting machines, drills, and pumps, with the exception of one, and the latter for the trolley circuit. One pump is operated from the trolley circuit.

The alternating current line to the lower bed is taken into the mine through the airshaft opening. This line from the surface to a short distance underground from the shaft bottom is armored. The remainder of the cable is rubber-sheathed. This line carries 2300 volts to the transformers near the faces of the various sections. The output of the transformers is 220 volts. The high tension (2300-volt) lines are supported on hangers in the rib or roof and carried in some cases along the haulage roads, and in other cases they are taken up unused entries to points near the face. When taken up the haulage entries they are usually carried on the opposite side from the trolley wire and feeder (direct current) cable.

Transformer stations are not fire-resistant. The transformers, in banks of three, are placed in a crosscut or in a hole cut into the rib, or other unused place. At one point it was observed that the transformers were placed within about two feet of the rib without any protection against fire. There are no switches in the high tension lines or other means of cutting off the power from these lines outby the transformers, except on the surface. Due to this lack of protection of the lines underground it is very likely that a serious mine fire may occur in case of failure of a transformer. Fuse plugs and open-type switches are installed in the lines on the low tension (220-volt) side of the transformers.

High tension lines, if carried along the haulage road, should preferably be buried in the floor or rib. If not buried, they should be carried up the entries on the same side as the trolley and feeder circuits to keep the traveling ways clear; however, every precaution must be taken to keep the high tension circuits separate from all contact with other circuits. The high tension side of transformers should be adequately protected by circuit breakers or fuses installed at the transformers.

Transformers and all other stationary electrical apparatus should be installed in fireproof stations or enclosures. A practice followed in many mechanically-operated mines today (which appears to be good) is to install transformers in enclosed metal boxes on mine car wheels. This affords protection against fire and also provides a ready means of moving the transformers when necessary. Transformer cases should be grounded. None of those observed in this mine were thus protected.

The alternating current power lines to the No. 6 bed are taken underground at the hoisting shaft. The workings in this bed were not examined during the investigation.

Direct current is generated at a substation situated near the airshaft opening, by a motor-generator set of 300 kw. capacity. Another motor-generator set of 150 kw-hr. capacity has been recently installed and will be used in place of the larger set on the night shift. Arrangements are also made for "cutting in" both sets when the occasion demands it.

The direct current lines are also taken underground through the airshaft opening and connected to the trolley circuit at a point near the hoisting shaft. A feeder cable parallels the trolley line to which it is connected at various intervals; this feeder cable is insulated but at some places the insulation has been cut or worn off. It is carried on hangers at some points, while at others it is attached to posts by nails through copper straps about two inches in width. Feeder cable, like the trolley lines, should be supported by suitable hangers. If the feeder is insulated, bare places occurring in the cable should be taped or otherwise repaired. Employees, knowing that the feeder is, or should be, insulated, are apt to be careless in handling it and may be severely or fatally injured.

Telephone lines are carried along the feeder cable from the repair shop near the shaft bottom to the junction of the main south with the main northwest entries. The lines are wrapped around the cable in some places. At one point the telephone line rests on a bare place about 6 inches long in the cable; the lines are insulated, however, the insulation is poor and could easily break down, causing the lines to become "alive." At another point both the telephone lines and the cable are bare and the exposed points only about 6- to 8-inches apart. About midway between the shop and junction above mentioned, the telephone lines are crossed over the tracks and carried along the high tension alternating current cable, to which they are attached by string and friction tape.

These practices are dangerous and should be prohibited. Telephone lines should be adequately insulated from power wires and should be carried on the opposite side of the entries from these wires. In no case, should the telephone lines be wrapped about or tied to feeder cables or high tension lines.

Flexible welded bonds are used on main line haulage tracks. Both rails are bonded on the main line between the shaft bottom and the junction of the main south with the main north west entries. From this point inby on the north west for several hundred feet only one rail is bonded. No bonds are used in the main south entries and for approximately 1,500 feet outby the face in the main northwest section, the grounded return in these sections being provided by a cable attached to the rails at several points by track spikes. It is reported that the use of the cable as a grounded return is only temporary and that as soon as the permanent tracks are installed in this section the rails will be bonded and the use of the cable discontinued.

The tracks in the main south and especially in the main northwest section, should be adequately bonded to the point of termination of the trolley wires. This will result, not only in a saving of power, but will be more efficient for the haulage equipment and reduce the hazard of fire.

The cutting machine trailing cables are in extremely poor condition. The cable on the machine in the entry where the explosion occurred contained at least twenty temporary, makeshift splices in about 250 feet of the cable. The end of the cable attached to the reel is in a very bad condition; it had deteriorated to such an extent that for 15 to 20 feet from the end the outer insulation had broken, exposing the leads, and in more than one instance the insulation covering the leads was cut, exposing the bare wires within possible arcing distance. The hand cable on this machine also contained six poorly made temporary splices. The trailing cable of another machine examined in the main northwest section was in even worse condition; the outer insulation of the first five or six laps on the reel had deteriorated to such an extent, possibly due to heating, that the power lines could be seen through the cracks an inch or so apart throughout this length of cable. The individual conductors were bare in some instances. The cables on several of the gathering locomotives also contained numerous temporary splices.

The use of makeshift splices in trailing cables creates a definite hazard which should be avoided. The splicing of cables should be done by trained men. If temporary splices are made they should be done in a workmanlike manner and the cable used only to the end of the shift. The cable should then be removed to the repair shop, the splices properly made by expert hands, and preferably vulcanized. Workmen should be shown how, and required, to make reasonably safe temporary splices.

Explosives and Blasting

Permissible explosives and electric detonators are used in this mine for blasting both coal and rock. The explosives and detonators are taken underground in their original cases and stored together in crosscuts or other abandoned openings.

Extreme carelessness in the storage and use of explosives was observed. During the investigation two cases of explosives and two boxes of detonators were found on the gob in the 3 south entry outby 1-2 west entries. Many other detonators were found scattered by the explosion along the 3 south entry from this point towards the face and in the entrance to 4 west entry. Many were out of their protective "spool" and some of the wires were unwound and the detonators under rails, timbers, or refuse. In all probability, had these detonators been properly stored in a suitable box or building they would not have been disturbed by the explosion which resulted in comparatively little violence. In the main northwest section a case of explosives was observed resting on a pipe line which in turn was in contact with the grounded return circuit cable mentioned previously in this report under the heading of "electricity". Also, six sticks of deteriorated explosives were found on the refuse along the rib at this storage station.

The drilling crews working on shift, in addition to drilling the holes, also prepare the charges and load and tamp them. Fine coal is used as stemming and the tamping bar is of metal tipped with copper, a "hold-over" device from

the time when black powder was used. Only a small amount of stemming is used, possibly two and not over three "dummies" (paper bags about 16 inches long, in which the stemming material is placed). The shunt or "short" on the ends of the detonator leg wires is removed, evidently by the drillers as soon as the holes are tamped. During the investigation it was observed that three holes had been tamped in the face of 4 west entry (off main south), three in a room neck and two in a crosscut near the face of this entry, and the shunts had been removed. Shots are fired with a non-permissible ten-shot magneto-type device. Regular shot firers are employed to fire shots, presumably after working hours.

Other careless practices were observed considerably more dangerous than the above. Apparently, the drilling crews made a practice of drilling places ahead of the cutting machine, then preparing the primers and leaving them, together with other explosives at the face of places drilled, until the coal is cut. The investigating party found three primers, three extra sticks of explosive, together with several dummies of stemming material at the corner of a crosscut within two cuts of the face of 3 west entry. Further, three primers and three sticks of explosives were found on one side of the entry and a like amount on the other side at the location of the cutting machine where the explosion occurred in the main south entry. These explosives were within 3-1/2 feet of the tracks and the machine and so located that the machinemen could hardly help throwing tools or the machine cable upon the explosives. The face of the entry and a crosscut at the face had been drilled and the explosives left by the drillers until the place could be cut. Such downright ignorant and careless practices invite disaster and cannot be too strongly condemned. It appears that the drillers have absolutely no conception of the hazards involved in using explosives. One would think that they would have taken the most elementary precaution of at least storing the explosives at some distance from the face instead of leaving them at points where they are almost certain to be struck by tools or possibly set off by arcs or sparks from the cable or machine.

The mining laws of Indiana require that explosives be stored underground in a "tight wooden box" xxx "approved by the Department of Inspection" xxx "secured by a suitable lock" xxx and "not be placed at a less distance than seventy-five (75) feet from the working face". The law further requires that "said detonators or dynamite caps shall be placed in a secure container, and shall not be placed nearer than five feet from any powder, dynamite, or other explosive". A further requirement is that fire clay or other noninflammable material be provided at points within 500 feet of the face of each entry in the mine. It is also illegal to fire shots while the workmen are in the mine; however, evidence given at the inquest indicated that shots were being fires on shift.

It is recommended that:

(a) The above requirements of the mining laws be carried out;

(b) That the drilling of holes before places are cut be discontinued;

(c) The shot firer be required to make up the primers immediately preceding the moment of placing the same in the holes;

(d) That the legs of the detonator wires be kept shunted until the moment of firing;

(e) The tamping bar be of wood; and

(f) Permissible devices be used for firing all shots.

The leaving of primers or other explosives scattered about at the working faces by the drillers or others should be cause for immediate dismissal. The same action should be taken against shot firers who leave deteriorated explosives lying about the place of storage. All persons engaged in handling, transporting, and use of explosives, should be properly and thoroughly instructed regarding the hazards involved. Written rules governing the use of explosives should be formulated and enforced. Prompt disciplinary action should be taken against any person for infraction of these rules.

Examinations for gas are not made before and after blasting. Neglect of this kind invites disaster which will surely occur if the practice is continued. It is recommended that such examinations be made and that no shots be fired in any place where gas is detected.

Drainage

Some parts of the mine are naturally dry and dusty while others are fairly wet. Considerable water is produced in the main northwest section while the section where the explosion occurred and the workings off the main east haulage entry are dry and dusty.

Approximately a half dozen plunger type pumps are used to remove the water from this mine; three of these are at or near the shaft bottoms while the remainder are scattered through the workings.

Dust

The mine was not very dusty except at the working faces where, naturally, much fine coal is produced during operations incidental to the preparation and loading of the coal. On haulageways, practically the only large accumulations of dust observed were in local dips where bumping of the cars caused some loss of coal in transit. In aircourses and abandoned workings the coal dust present is mixed with fire clay from the bottom and shale from the roof. Water is not used to allay the coal dust as it is produced.

Although excessive accumulations of coal dust were not observed, past experience has proved that the existence of dust constitutes a definite hazard. To lessen this hazard by keeping the dust out of the air by which it is scattered throughout the mine, and to increase the effectiveness of rock-dust, it is recommended that:

(a) Water be used on the cutter bars of the mining machines to wet the dust at its source;

(b) Water should be sprayed on the coal face, ribs, roof, and floor, for at least 40 feet from the face before and after blasting and while loading the coal;

(c) The empty cars should be sprayed as they leave the shaft bottom to prevent fine coal from being distributed along the haulageways and on top of loaded cars before they are hauled from the gathering sidetracks.

Rock-Dust

Some rock-dusting has been done at this mine although its application has not been general. Some evidence of the use of rock-dust was observed along the main east haulage road while none was found in other parts of the mine, especially the face regions. No data covering the use of rock-dust is maintained and when asked about its use the officials "guessed" that some dusting had been done in January 1941. From observations during the investigation it is believed that the rock-dust was applied sparingly and confined to a limited portion of the haulageways.

Samples of the mine dusts were collected at seven points; three of these were face samples, three were taken on haulageways, and the seventh was collected in a trackless entry about 90 feet outby the face of 3 south entry. The dust collected at the face of 5 room 5 south main east was exceptionally fine. The larger amount of the samples readily passed through the 200-mesh screen.

Table 2 is a tabulation of the samples of dust collected during the investigation by representatives of the Bureau of Mines. Determinations were made by the volumeter method at the Vincennes Station of the Bureau. This table follows on next page.

Previous experience has proved that the dust from the Indiana No. 5 coal is highly explosive. Analysis of this coal shows that at least 62, preferably 65 or more, percent of inert material must be present in the mixed dusts to prevent propagation of an explosion by means of the dust, when no methane is present.

TABLE 2. - Determinations by Volumeter Method of non-combustible in mine dusts, Panhandle mine, Bicknell Coal Co., Bicknell, Ind., May 26 and June 3, 1941

Sample No.	Kind	Location	Volumeter Reading	Non-combustible (percent)
168 floor 173 rib-roof	Haulage	About 110 ft. inby main east overcast.	40 76	36 74
108 floor 197 rib-roof	Face	Face 5 room 5 south main east.	17 23	11 17
187 floor 193 rib-roof	Face	Face 3 room 1 west main south.	31-1/2 23	26 17
164 floor 179 rib-roof	Trackless entry	3 south entry about 15 ft. outby last crosscut.	49 22	46 16
151 floor 161 rib-roof	Haulageway	2 south outby parting door.	31 42	26 38
162 floor 159 rib-roof	Haulageway	3 east main north west, about 100 ft. outby 1 north.	49 31-1/2	46 26
178 floor 104 rib-roof	Face	Face 4 north entry main northwest.	25 26	20 21

Note: Samples Nos. 164-179-161-151, were collected by A. U. Miller and W. H. Tomlinson, U. S. Bureau of Mines, Vincennes, Ind., May 26, 1941. The remainder were collected by W. H. Tomlinson and P. P. Senio, of this office, June 3, 1941. All samples were analyzed by W. H. Tomlinson on June 6, 1941.

By referring to table 2 it will be observed that in only one sample, No. 173, collected in this mine was this amount of non-combustible present. This was a rib and roof sample collected on a haulageway where considerable rock-dust had clung to the roof and ribs. The floor sample, 168, collected at the same point contained only 36 percent of inert material. It will be further noted that the amount of non-combustible in the face samples was very low - only 11 percent in one case, sample No. 108, and that reasonable insurance against propagation is not approached except as indicated in one sample, No. 173, noted above.

Since the addition of considerable, large amounts of rock-dust are necessary to provide reasonable protection against propagation of an explosion in this mine it is recommended that:

(a) The workings be rock-dusted immediately;

(b) All accessible portions of the mine should be dusted; aircourses and other parts not used for haulage should be given an extra heavy coating of the dust before the tracks are removed. The first step necessary for adequate rock-dusting should be the thorough cleaning of all passageways and loading out the refuse before applying the dust.

(c) Working places and panel entries should be the first to be treated and the dusting continued outby until the entire mine is covered;

(d) The rock dusting should be kept within two cuts of the face;

(e) Sufficient dust should be applied to provide at least 65 percent inert material in the mixed dusts at all times;

(f) Samples of the mine dusts should be collected and analyzed at periodic intervals to insure that the proper amount of non-combustible is present.

GENERAL SAFETY CONDITIONS

First-Aid and Mine-Rescue

All of the workmen at this mine have been trained at some time or other in methods of first-aid-to-the-injured. However, no training has been done recently. No surface receiving room or underground dressing stations are provided, and very few first-aid materials are kept on hand at the mine. The only materials observed were some stretchers and a few small bandages and disinfecting fluids kept in a cupboard in the lamp house.

No self-contained oxygen breathing apparatus is kept at the mine, but the Company has access to such equipment and the services of a rescue crew from a station maintained jointly by the Coal Operators' Association and the Lynch Coal Operators' Reciprocal Association, at Bicknell, Ind., only three miles from the mine. The latter Association carries the compensation insurance for the Panhandle mine.

A rescue team has been trained by representatives of the Bureau of Mines at this mine but the training has not been kept up to date. The records in the Vincennes office show that the last training with the apparatus was done at this mine in 1940.

It is recommended that all persons employed at this mine again be trained in first-aid and that they be retrained at intervals not exceeding a year. No argument is now needed to prove that first-aid training of all employees is a valuable adjunct to any safety program.

Although the Company has access to the equipment and services of a rescue team from the station jointly maintained only three miles from the mine, at least one or more teams composed of workmen from this mine should be kept trained. Trained men make better and safer workmen and this team would be available to work in cooperation with other teams in case of emergency. At the time of the disaster at this mine only one team was available and had the services of other trained men been required during the rescue and recovery work they could not have been obtained in this part of the State.

Safety Organization

No safety organization is maintained and no safety inspector is employed. A Holmes Safety Association Chapter was established at this mine some years ago and regular meetings held for a time; however, interest soon lagged and the meetings were discontinued.

Supervision and Discipline

Judging from observations made during the investigation and from testimony given at the inquest covering the conditions existing in the mine which contributed directly to the explosion, it is evident that the supervision was anything but good. In the first place, an insufficient number of supervisors was employed. The mine Superintendent is also president of the Company and in addition to the duties of these two offices he also looks after the engineering work underground; consequently, very little attention was given by this individual to the operation of the mine. The mine Foreman also had too many responsibilities. In addition to the night boss only one assistant, or section foreman, was employed; the night boss also acted in the capacity of fire boss. Since no method of checking on the work of the night boss was employed, it is believed that many dangerous practices were followed on the night shift. Testimony given by various witnesses at the inquest substantiates this belief. It is reported that the employees were constantly complaining of "too much supervision" when in reality, the supervision was far from being thorough and competent.

Discipline was also lacking at this mine; in fact, the foreman stated publicly at a safety meeting held following the explosion, that he was not permitted to discipline the workmen for any cause. This is a sad state of affairs in any mine and especially so in a mine as dangerous as this one, but is to be expected in a cooperative organization where each man feels that he should have as much authority as the one elected superintendent or foreman. The deputy State Mine Inspector in whose district this mine is located, has often commented on the absence of discipline and disregard for the foreman's instructions by the employees of this mine.

Additional foremen should be employed so the working places can be examined at intervals of at least two hours; further, the officials should be given definite control over the operation of the mine and the direction of the working forces. Rigid discipline should be enforced and when necessary to inflict reasonable penalties on any workman the Board of Directors should cooperate with the supervising officials. The mine foreman should check the work of the other officials, especially on the night shift, and the person placed in charge of this shift should be thoroughly competent and be familiar with the ventilation and know how to take care of explosive gas properly.

PREVIOUS EXPLOSIONS IN THIS OR NEARBY MINES

An explosion of gas in which two workmen were killed occurred in the workings in the upper bed in this mine about two weeks previous to the present catastrophe. This explosion also resulted from the ignition of an accumulation of gas, presumably by a non-permissible cutting machine. It is reported that the conditions at the point of origin of this explosion were similar in many respects to those existing at the time of the last explosion, in that the machine had just been moved into the place and all arrangements made to move the machine off the truck when the gas was ignited.

Another instance is reported in which gas was ignited in this mine by electrical machinery several years ago. In this case two drillers were burned when an arc from their electrically operated drill set fire to the gas.

In addition to the above numerous other ignitions of gas and dust have occurred in mines working the No. 5 coal bed in this part of the State.

EXPLOSION INFORMATION

STORY OF THE EXPLOSION AND RECOVERY OPERATIONS

The first intimation of any unusual occurrence in the mine was noticed by Louis Mackey, main line motorman who had taken an empty trip into the main northwest section a few minutes before the explosion occurred, leaving the door open at the junction with the main south entries as was his usual practice. Mackey reports that as he reached the tenth car while counting his loads on a parting a short distance inby the junction with the main south entries, he felt a rush of air and saw a heavy cloud of dust pass swiftly by him. Sensing that something was wrong he ran his trip of 19 cars down the hill to the above-mentioned door, which he observed was off its lower hinge. He replaced the door, then tried to continue on foot to the shaft, approximately 800 feet distant, through the return air from the main south entries. Finding this impossible Mackey then retreated into the main northwest where he met the shot firer, Lester Cox, near the entrance to the "A" and "B" entries. The two then notified the men working in the main northwest section and all, variously reported

to include from 14 to 17 persons, traveled toward the shaft through the intake airways. On their way out these men met the mine foreman and superintendent coming in, the latter having been notified by telephone from inside the mine that something was wrong. The foreman and superintendent went into the mine while the other continued to the surface to spread the alarm. Officials from adjacent mines and the rescue team at Bicknell were notified and the team arrived at the mine a short time later. The foreman and superintendent traveled through the intake entries to the entrance to the main south entries but could go no further. They then called the surface for help.

By the time the Bureau of Mines representatives arrived at the mine, about 11:30 p.m., the rescue team, an ex-official of this mine, and an insurance company inspector, together with the mine foreman and superintendent, were already underground. After assisting with the completion of a surface organization the writer and P. P. Senio of the Vincennes office of the Bureau of Mines, entered the mine through the hoisting shaft, with Mr. Ed. Rogers, State Deputy Mine Inspector, and several volunteer workers. Messrs. Herbert, Miller, and West, of the Bureau, recruited another rescue team from employees of this mine who had been trained sometime ago by West, and got this team and the Bureau apparatus ready in case of need. Mr. Senio was stationed at the shaft bottom to assist with procuring men and materials while the writer, the mine inspector, and the others, proceeded through the return airway to the entrance to the main south entries, a distance of approximately 800 feet from the shaft, where a fresh air base had been established. By this time the rescue crew had explored the workings in 1-2 west entries and finding no one they advanced to 3 west where two bodies, the night boss and a loader, were found about 50 feet inby 3 west entry. A third body, that of a loader, was found beside a partly loaded car at the face of No. 2 room on this entry. Six others were located a short time later grouped about a locomotive on 4 west entry opposite the point where the first two bodies were found on 3 west. The six included a triprider, a motorman, and four loaders working in 4 west. It is believed that these six persons were congregated at this point at the time of the explosion or, at least, were nearby since it is very unlikely that any of the victims traveled very far from their work after the explosion. The recovery work up to this point was done with the use of gas masks, the crew carrying the air forward as much as possible by making temporary repairs to doors and stoppings by use of brattice cloth.

The rescue crew then explored the 3 main south entry, traveling on the intake side up to the last open crosscut. Then, discovering that both entries were filled with gas from the crosscut inby the crew returned to the fresh air base which by this time had been moved up to 1 west, put on the breathing apparatus and explored 3 main south entry where the bodies of two loaders were located near a partly loaded car at the face. The two machinemen were found beside their machine at the face of 2 south entry. The bodies found in the south entries were brought out by the rescue team to a point where the air was fairly "good", then

these, together with the others previously found, were carried out by volunteer workers to the junction of these entries with the main northwest.

While the rescue crew was exploring the faces of the entries the writer, together with the insurance company inspector, wearing gas masks, found the last body on 2 south entry about 10 feet inby the entrance to 1 west. It is believed that this man was the only one that traveled for any appreciable distance following the explosion. He was engaged in loading refuse along the entry near the face of 1 west and was the only man working in 1-2 west on the night shift. A locomotive and two cars, one partly loaded, were found near the face of the entry and the man's shovel was filled, indicating that he was in the act of loading the car at the time. Assuming that this man was working at this point at the time he traveled for a distance of approximately 450 feet after the explosion. Instead of turning into the intake airway on the 3 south entry he continued through the door (damaged) onto the return side where his body was found. There is some possibility that this man may have had some slight chance to have saved his life had he turned into the intake side rather than proceeding to the return; however, by the time that he traveled from the face to the foot of the entry very likely he was so affected by the afterdamp that his judgment was impaired and his sense of direction lost.

Of the 14 killed, only three were burned; one, the cutting machine operator, received third degree burns of the arms, face and shoulders. This man's hair was also burned and his eyebrows singed off. The machine helper was also badly (though not fatally) burned. The third man burned was one of the loaders working in 3 south entry.

The first two bodies found were taken out of the mine immediately following their discovery, reaching the surface about 2:15 a.m. on the morning following the explosion. They were removed by way of the return airway. The others were kept at the junction of main south and main northwest entries for some time after their discovery, since changes in the ventilation had been made so as to provide more air for the rescue party and the return air from this point to the shaft was contaminated by afterdamp to such an extent that it was unsafe to travel. By the time the last bodies were brought from the face workings the return air had cleared sufficiently to permit the removal of the bodies through the main haulageway to the shaft. The air was then short-circuited at this junction and the bodies transported on a small truck to the hoisting shaft. Had this not been possible the removal of the bodies would have required several hours longer since they would have had to be carried through the intake airways for a distance of considerably over 6,000 feet, much of it through trackless entries.

The last body was taken out of the mine about 8:30 a.m. May 23, about ten hours after the explosion.

As usual, in such emergencies, no definite check had been made of the persons entering and leaving the mine. Since it was not absolutely certain that all bodies had been recovered the rescue crew continued to explore the 1-2 south entries and finding no other bodies it was assumed that all had been recovered. A further check on the surface proved this to be true. It was then decided to wait two or three days until the workings were clear of afterdamp before making the official investigation which was set for Monday, May 26.

PROPERTY DAMAGE

The property damage was slight. Starting at the face of the south entries the first stopping was intact; the next two outby stoppings were blown out. The "wings", or partition at the side of a door on 3 south entry between 3-4 west entries, were blown out though the door itself was not damaged. Evidently this door was open at the time of the explosion. A curtain in the first crosscut and a stopping in the second between 3-4 west entries were blown down. All stoppings (three) in crosscuts between 2-3 south entries from 3-4 west outby to 1-2 west were out, though a door in the second crosscut inby 2 west was undamaged. This is the door that was found blocked open by loaded cars. Two stoppings were in and two were out in crosscuts between 2-3 south entries from 1 west outby to the junction of the south entries with the main northwest. No damage was done in the 1-2 west entries except that the trolley wire which was anchored a few feet inby the entrance to 1 west was down. The condition of the door at the entrance to these entries was similar to that of the door at the 3-4 west. Evidently this door was also open at the time of the explosion. The trolley wire at the head of 2 south entry was down for some distance, however, the machine line was in place.

No other damage was done except a small fall of roof in 3 south entry inby 4 west. Since the roof in these entries was "good" no timbers were used which accounts for the absence of falls.

FORCES

Evidence indicates that the forces came out of the 2 south entry. All stoppings on this entry that were out were blown toward 3 south entry. The pressure wave evidently crossed from 2 south to 3 south inby 3-4 west since the door on 3 south between the west entries, the curtain and stopping in the first and second crosscuts were blown outby. A curtain used in place of a stopping across 3 south at 3 west was also blown in the same direction. This curtain stopping was placed to direct the air up the 3 west entry (see map).

INVESTIGATION OF CAUSE OF EXPLOSION

An investigation to determine the cause of the explosion was begun Monday, May 26, 1941. The joint investigation was started on the above date, the party including the following persons:

Representing: Indiana Bureau of Mines and Mining

Fred Ferguson,	Chief Inspector
Ed. Rogers,	Deputy Inspector
Pat McGuigan,	ditto
Lee Graves,	"
Henry Wallace,	"

Representing: Lynch Coal Operators' Reciprocal Association

Fred Conrad,	Inspector
Nick Anderson,	"
Jack Ogilvie,	Rescue Station Superintendent

Representing: Bicknell Coal Company

Frank Pearce,	President and Mine Superintendent
John Milligan,	Mine Foreman
Wm. Easton,	Section Foreman
Walter Pollock,	Fire Boss
O. L. Rottet,	Board Member
Benny Green,	ditto
John Silvers,	"

Representing: U. S. Bureau of Mines

A. U. Miller,	Mining Engineer
W. H. Tomlinson,	Associate Mining Engineer
P. P. Senio,	Assistant Safety Instructor

The above party, on the date mentioned, entered the mine and examined the 1-2 west, 3-4 west, and main south entries up to the last crosscut, but could safely go no farther since the entries were still full of gas from this point to the face. Of chief interest to the investigating party were the conditions surrounding the cutting machine at the face of 2 south entry, the machine being suspected of igniting the gas. It was then decided to remove the gas before inspecting the machine. However, when this was attempted it was found that there was not enough air traveling in these entries to accomplish this result. Several of the party then crawled on their hands and knees into this gas to the machine. The writer, who made the official investigation for the Bureau of

Mines, refused to do this, preferring to wait until the gas could be removed so a thorough inspection could be made. Several of the party who went into the gas complained of being dizzy and "light headed" after returning to fresh air. The entire party then returned to the surface.

As far as is known, the officials representing the State Inspection Department came to no conclusion as to the cause of the ignition.

The writer, with P. P. Senio of the Vincennes office, returned to the mine on the following day and, together with Mr. Ed. Rogers, Deputy State Mine Inspector, again visited the main south entries, which by this time had been sufficiently cleared of gas to permit a more thorough investigation. The conditions found were as follows: the machine had evidently just been moved into the entry a few minutes prior to the explosion; three places were cleaned up and ready for cutting, the face of the entry, a crosscut to the left, the inby corner of which was about three cuts back from the face of the entry, and a crosscut on the right side about 12 feet away from the face of the entry. The crosscut on the left had two cuts taken out of it; one cut had been taken out of the crosscut on the right. This one cut, in addition to one made from the other entry, should have put this crosscut through since the entry pillar is only 12 feet in thickness. It developed later that only 4 to 6 inches of coal remained in this place. Had this fact been known the few inches of coal remaining would probably have been removed, providing some circulation at the face which would likely have prevented the accumulation of gas.

The mine foreman reports that he left instructions with the night boss to order the machine crew to cut the crosscut on the right and hole it through to the other entry and not to cut the face of 2 south entry. However, the position of the machine and equipment indicated that the crew very likely intended to cut the face of the entry and this crosscut at one unloading. The chain used in pulling the machine off the truck was hooked over the "dog" on the end of the "pan", then stretched out toward the face of the entry. A "jack pipe" used to anchor the chain as the machine is pulled along the floor after leaving the truck, was lying at the end of the chain. The position of the chain and jack pipe indicated that the machine was to be moved to the face of the entry rather than into the crosscut on the right. Further, proof that the crew intended to also cut the face of the entry is given by the fact that, a few hours before the explosion the drillers had drilled this place and left the necessary explosives for blasting it.

The machine was found with the controller in the "off" position. It will be remembered that this is an alternating current machine. The neutral, or "off" position of the controller is in the center, the "starting" contacts on the right, and the "running" position on the extreme left side of the controller box. In starting the machine the controller handle is first pulled to the right to the "starting" position and held momentarily until the motor attains speed, then the

controller is thrown past the neutral to the "running" position. The machine had been uncoupled from the truck at the rear end and disconnected from the pan at the side and the lever controlling the "feed chain" was in operating position. In other words, all evidence pointed to the fact that, at the time of the explosion all arrangements had been made to remove the machine off the truck. Also, apparently some little tension had been placed on the chain necessary for this movement.

Matches and cigarettes were taken from several coats found at the entrance to, and in 4 west entry. Matches were also found by the undertaker in the trousers pockets of the machine helper.

The night boss did not have his safety lamp with him at the time of the explosion. His lamp, together with his time book and dinner pail, were found at the shaft bottom. There is good reason to doubt that he visited the faces of the main south entries on the night of the explosion, despite the fact that he knew that these entries had gas accumulations. The mine foreman reports that just before the night boss entered the mine on the day of the explosion he gave the night boss a note advising of the gas in the south entries and also told him verbally in the presence of the assistant foreman, that someone had left the main south door open and that the entries were "full of gas" and further instructed the night boss to give particular attention to these entries. From this evidence it appears that the night boss was forgetful or he was the kind of individual willing to take a chance and if he did examine the entries in question at the beginning of the shift he did not make subsequent examinations or he would have discovered the gas. Further, since the entries had gas accumulations at the beginning of the shift and certainly must have contained a large accumulation at the time of the explosion, the assumption naturally occurs that he made no examination of these entries. Also, since a heavy "feeder" of gas existed in the crosscut to the left at the face of the 2 south entry and this entry is going to the rise (about 4 or 5 percent), and the face was approximately 77 feet from the last open crosscut, it is very probable that if the night boss did examine this place he permitted the machine to be taken into it knowing that gas was present.

The mine foreman cannot be absolved of all responsibility. Naturally, no foreman can be in the mine both day and night; however, since he was aware that a large accumulation of gas existed in the mine it appears that he should have given his personal attention to this matter. The foreman personally told the writer that he knew from past experience that the night boss could not be trusted, a further reason supporting the opinion that the foreman cannot be absolved of blame.

Testimony given at the inquest brought out the fact that it was not at all unusual for doors to be left open in this mine for long periods at a time, especially on the night shift. The main line motorman on the night shift testified that it was the usual practice to get his empty trip ready at the shaft bottom,

then with the locomotive, run light to the junction of the main south entries, prop the door open, then return to the shaft bottom and push the trip into the main northwest section with the door still open. The door would not be closed until the return trip. The motorman would then knock the latch from the door as the locomotive passed through. He was never certain that the door had closed after he knocked the latch open as he could not see over a 19-car trip. Under normal operations this door would be standing open about half the time and should the motorman be delayed for any reason while in the northwest section this door would be open even more than half the time, despite the fact that the entire ventilating current for the main south section was then short-circuited at this point.

Equal carelessness was followed in connection with the leaving of doors open in the main south section. The drillers who left the mine before the explosion testified that a door, called the "parting door", between the 2-3 south entries inby 3-4 west, was open as they moved their drill truck into 2 south entry at 5:00 p.m. and that this door was still open as they came out of the entry at 5:45 p.m. They also testified that as they went into 3-4 west entries at 6:00 p.m. the door controlling the ventilation in these entries was open and that it was still open when they left these entries at 7:05 p.m. Several other persons, including the shot firer, testified that it was the common practice to leave the doors open on the night shift. In fact, the shot firer testified that he found the doors in the main south section closed only once during two shifts. Credence is given the story by the drillers that the door at 3-4 west was open at the time of the explosion since the cable attached to the locomotive found in 4 west entry, extended through this door and was connected to the trolley wire on the 2 south (middle) entry. Further, since the door between 2-3 south at the entrance to 1-2 west was not damaged (although the "wings" were damaged), it appears that this door was also open at the time of the explosion.

Judging from the testimony as given above, and from personal observations in the mine, which at least partially substantiate this testimony, it is believed that all three doors used in controlling the ventilation in the main south section were open at the time of the explosion, and that a fourth door controlling the air to the 3-4 west entries, was also open at the time.

CORONER'S INQUEST

The State of Indiana does not require a formal inquest in which the testimony of witnesses is taken before a jury. The inquest conducted in this State consists merely of the compilation of data by the coroner from sworn statements of witnesses and from these data the cause of death is given. In the case under discussion the cause is given as follows:

"I, _____, representative of the _____, state that after my investigation of the mine explosion at the Panhandle mine near Bicknell, Ind.,

on May 22, 1941, it is my opinion that the explosion resulted from the ignition, in some manner, of an explosive mixture of methane and air. Following said explosion there would be an insufficient amount of oxygen present to sustain life and there would be the formation of carbon monoxide in the explosion area. Such a mixture would be deadly and the inhalation of any appreciable amount would be fatal. June 9, 1941.

Signed:_____
Witness

Dr. Paul B. Arbogast, M. D.,
Coroner, Knox County, Indiana.

Statements similar to the above were signed by the Chief and Deputy Inspectors of the Mine Inspection Department, and also by the writer.

SUMMARY OF EVIDENCE AS TO ORIGIN OR CAUSE OF EXPLOSION

There is some difference of opinion as to the source of ignition, although all persons present at the investigation agreed that the explosion resulted from the ignition of an accumulation of gas. As stated previously, the representatives of the State Inspection Department came to no conclusion as to the source of ignition, however, later two of them stated privately that they were of the opinion that an arc from the machine caused the ignition. A representative of the insurance company stated definitely that he believed that the gas was ignited by smoking although he had no evidence to prove this other than that matches, cigarettes, and tobacco, were found in the pockets of some of the victims and in some of their dinner buckets. It was reported that the machine helper was an incessant smoker as was one of the loaders working in the parallel entry. These facts of themselves do not prove that smoking was the cause.

No evidence is sufficiently strong to point definitely to the source of ignition though it seems logical to place the blame on the machine. An argument made by the insurance company inspector and others stressed the fact that since the controller was at the "off" position no arc would have occurred at this time; consequently, that the gas could not have been thus ignited by the machine. This argument loses sight of the fact that very likely no arc would occur as the controller was placed in the "start" position, but, an arc likely would occur as contact was broken while the controller was being moved toward the "running" position; it would be natural for the operator to stop the controller at the neutral position in case the gas was ignited while moving the controller from the "start" to the "run" position. This action would be more or less involuntary on the part of anyone under similar conditions. Gas could easily have gotten into the starting box since the machine is not of the closed type; furthermore, of a total of 10 studs used to hold the box in place, four were missing, permitting the cover to stand out at least a quarter of an inch from the side of the machine.

The controller cover was removed and the contact buttons examined; those on the "starting" position were badly burned, showing that constant arcing had taken place at these points. Although the machine cable was found in bad condition no evidence was found of arcing or short-circuiting.

The possibility that explosives may have ignited the gas was, of course, considered. Although many careless and dangerous practices were observed in connection with the storage and use of explosives, (practices which should be stopped), no evidence was found indicating that explosives had played any active part in the explosion. Testimony was given at the inquest that shots were being fired on shift; however, none were being fired in the main south section at the time of the explosion. The shot firer stated that if the explosion had occurred ten minutes later he would have been in it since he had just fired a shot in the "A" and "B" entries and was on his way to the main south section when the explosion occurred.

EVIDENCE OF HEAT AND FLAME

It is believed that coal dust played a minor part, if any, in the explosion. No definite indication of coke was found anywhere in the area except that a small amount of substance resembling coke was observed on top of the machine at the point of origin of the explosion. Long streamers of soot were found, principally on the ribs along 2-3 south entries, almost to the entrance to 3-4 west, possibly indicating that the gas had burned in a limited supply of oxygen. Small bits of burned paper were found, together with fine dust in the headlight of the locomotive in 4 west entry. It is doubtful that the flame traveled this far. The charred paper was possibly blown to the position where found.

An outstanding factor pointing to the weakness of the flame at the point of ignition is that the primers and other explosives left on the gob by the drillers at the face of 2 south entry had been subjected to sufficient heat to char the paper and yet not detonate the explosives. At least one of the primers (stick of explosive with a detonator in it), was charred so badly that the wrapper was black and almost completely disintegrated when handled. The same is true of several of the "dummies" of stemming material. If argument is needed as to the relative safety of permissible explosives one need look no further.

PROBABLE CAUSE OF THE EXPLOSION

After careful consideration of information gathered during the recovery work and investigation, and the testimony given at the inquest, it seems probable that the explosion originated at the face of the 2 south entry; that the explosion resulted from the ignition of an accumulation of methane; that the source of the ignition is not known definitely but that the evidence points strongly to the non-permissible cutting machine found at the face of the entry in which the explosion originated; that coal dust played little, if any, part in the explosion;

that, although explosives were carelessly left lying about the entry in which the explosion occurred, they did not contribute to the cause of the explosion.

LESSONS TO BE LEARNED FROM THE CONDITIONS AS THEY RELATE TO THIS EXPLOSION

Several lessons are to be learned from this explosion, among them:

1. Mines in which explosive gas is liberated should be classed as gassy and worked as such with permissible equipment, including locomotives, cutting machines, drills, and any and all other stationary or mobile electrical equipment placed or operated in any but fresh intake air. In addition to the gas regularly given off, sudden and unusual liberations of gas in large quantities may occur at any time, therefore, such mines should be so developed and operated that no arc or open flame is present in the event that accumulations of gas occur, whether suddenly or otherwise.

2. Pure intake air should be taken into the mine and conducted directly to the active workings in quantities sufficient to dilute, carry off, and render harmless all gas liberated. The amount of air furnished to each section should be somewhat in excess of the minimum requirements in order to take care of unusual conditions.

3. The air currents should be split and each section furnished its own current of air; more economical and better ventilation can be provided in this manner since the hazards of explosion or fire, or the sudden liberation of large quantities of gas are more likely to be confined largely to some one section of the mine.

4. Worked-out and abandoned sections should be sealed promptly. The air should not be circulated through abandoned workings before ventilating active workings; and after ventilating the live workings the air should be conducted directly to the main return airways.

5. Doors used to guide and control the ventilating current should be so hung, adjusted, and operated, as to fulfill the purpose of their erection. It is extremely dangerous to place a door in a mine to control the air currents and then permit this door to remain open during the greater part of the time. An important contributing cause to this explosion was the leaving open of two, or possibly more, doors. Leaving these doors open was little short of gross negligence and it seems evident that the practice could not have been pursued for long without the knowledge of the supervising officials.

6. The use of curtains in place of doors is a makeshift arrangement which should not be tolerated in any mine, particularly one in which explosive gas is known to occur.

7. Carelessness and indifference to the presence of accumulations of gas invites disaster in any mine. The workmen should not be permitted to enter any mine when considerable accumulations of gas are discovered therein and the gas should be removed as soon as practicable after its discovery. No persons should be in the mine while gas is being removed, except those engaged in the work of removing it.

8. Great responsibility rests upon the supervising officials in connection with the safeguarding of the lives of the workmen and when little or not effort is made to check on the activities of the officials, especially those known to be derelict in their duty, sooner or later disaster results. Checking on the work of officials on the night shift is especially necessary in view of the comparatively large number of accidents and catastrophes now occurring on these shifts.

9. The use of non-permissible flame safety lamps by officials for the detecting of gas is an indication of the lack of progress since there are available today much safer types of lamps for this purpose.

10. The use of machines operated electrically in places known to contain accumulations of gas and the failure to have these places tested immediately before the machines enter, together with the permitting of smoking, are practices which every well informed mining man knows to be highly dangerous. The mining laws of all coal-producing states should require proper examinations for gas and should prohibit smoking in mines, especially those in which explosive gas is produced.

RECOMMENDATIONS

Though many conditions and practices were observed during the investigation that are detrimental to the welfare of the employees and the safety of the mine, the recommendations that follow cover only such conditions and practices as refer more or less directly to this or other possible similar disasters. They are made with the belief that if carried out the safety of the employees and the mine will be considerably improved and the chances of the recurrence of a similar disaster materially lessened.

Ventilation and Gas

1. The quantity of air entering the mine should be increased considerably.

2. The air should not be coursed through abandoned workings before reaching active workings.

3. Each set of panel entries should be ventilated by a separate split of air.

4. Enough air should be provided so at least 10,000 cubic feet per minute passes through the last open crosscut in all working sections.

5. Stoppings, at least those separating main intake and return air currents, should be constructed of masonry or concrete.

6. All doors should be made to close one way only and the closing should be automatic and "with the air".

7. Doors should not be fitted with any device for holding them open.

8. Where practicable, doors should be hung in pairs.

9. Trappers should be employed at all main doors unless said doors are self-acting.

10. Curtains should not be used in place of permanent stoppings or doors.

11. Any place in which explosive gas is present in quantities sufficient to be detected by a flame safety lamp should be considered to be in a dangerous condition and to require improved ventilation immediately.

12. Examinations of the mine by the fire boss should be made within three hours of the appointed time for the shift to enter the mine or any place in the mine.

13. A fire boss should be employed to examine the workings during the day shift; the same requirement should apply to the night shift.

14. Only permissible flame safety lamps should be permitted in the mine.

15. The flame safety lamps should be properly serviced by a competent person on the surface and tested in explosive gas before being taken underground.

16. All officials should be required to have their flame safety lamps or other gas detector, with them at all times in proper condition for testing for gas; they should carry the flame safety lamps in their clothing.

17. Flame safety lamps should be furnished the operators of all electrically-operated machines who should be carefully instructed in the limitations and use of the lamps.

18. Such operators should be required to make tests for gas before taking their machines beyond the last open crosscut in any working place.

19. Before being given a flame safety lamp workmen should be required to give satisfactory evidence that they understand the lamp, the manner of its use, and the danger of tampering with it.

20. In addition to the fire boss all other officials should be required to leave a suitable mark at the face of all places visited during the shift indicating that they have inspected the place.

21. Accumulations of gas should be removed as soon as practicable after discovery and preferably with all persons out of the mine, except those engaged in moving the gas.

22. Smoking underground should be prohibited and a heavy penalty provided for those caught in the act or with smoking materials on their person or in their working place.

Haulage

1. Haulage and hoisting should be performed on intake air.

Electricity Underground

1. High tension electric cables, if taken underground on haulageways, should preferably be buried.

2. Transformers and other stationary electrical apparatus should be in fire-resistant enclosures.

3. The high tension side of the transformers should be protected by fuses and circuit-breakers, and/or oil-break switches.

4. Transformer cases and the frames of other stationary electrical apparatus should be efficiently grounded.

5. Both rails should be bonded to the ends of the trolley wires in the main south and main northwest sections, and also in all other parts of the mine where trolley wires are used.

6. The cables on cutting machines should be maintained in safe condition.

7. Workmen should be required to make temporary splices which are safe and efficient for use to the end of the shift.

8. Permanent splicing should be done in the repair shop and the splices vulcanized.

Explosives and Blasting

1. The provisions of the mining law with respect to the storage of explosives and detonators should be enforced.

2. The drillers should be prohibited from drilling places before they are cut.

3. The preparation of the primers, loading and tamping of the holes, should be done by the shot firers.

4. Primers should not be prepared until just before charging the explosives in the holes.

5. Any person guilty of leaving explosives scattered on the gob or about the working places should be discharged.

6. The legs of the detonator wires should be kept short-circuited until the time of attaching them to the battery for firing.

7. The tamping bar should be of wood.

8. Permissible devices should be used for firing all shots.

9. Tests for gas with a flame safety lamp should be made before and after firing of shots and no shots should be fired unless the place is free of gas.

10. All persons engaged in handling or using explosives should be thoroughly instructed regarding the hazards involved.

11. Written rules regarding the handling and use of explosives should be formulated and enforced.

Dust

1. Water should be used on the cutter bars of the mining machines.

2. The faces of all working places and the ribs, roof, and floor should be thoroughly wetted for at least 40 feet from the face before and after blasting and kept wet while loading the coal.

3. The empty cars should be sprayed as they leave the shaft bottom.

Rock-Dust

1. All accessible parts of the mine should be thoroughly rock-dusted.

2. Rock-dust should be kept within two cuts of the face if water is not used in the face region.

3. Enough rock-dust should be applied so the mixed dusts contain at least 65 percent non-combustible material.

4. Samples of dust on mine surfaces should be collected and analyzed at periodic intervals to insure that the proper amount of inert material is present at all times.

First-Aid and Mine-Rescue

1. All persons employed at this mine should be kept trained in first-aid.

2. Retraining of all employees should be conducted at least annually.

3. At least one, preferably two, rescue teams should be trained at this mine.

4. The mine-rescue team, or teams, should be retrained at least monthly.

Supervision and Discipline

1. Additional supervising officials should be employed so there will be a supervisor for approximately every 25 workers.

2. Rigid discipline should be enforced.

3. When necessary to discipline a workman for any cause the board of directors should give full cooperation to the mine foreman and other supervisory officials.

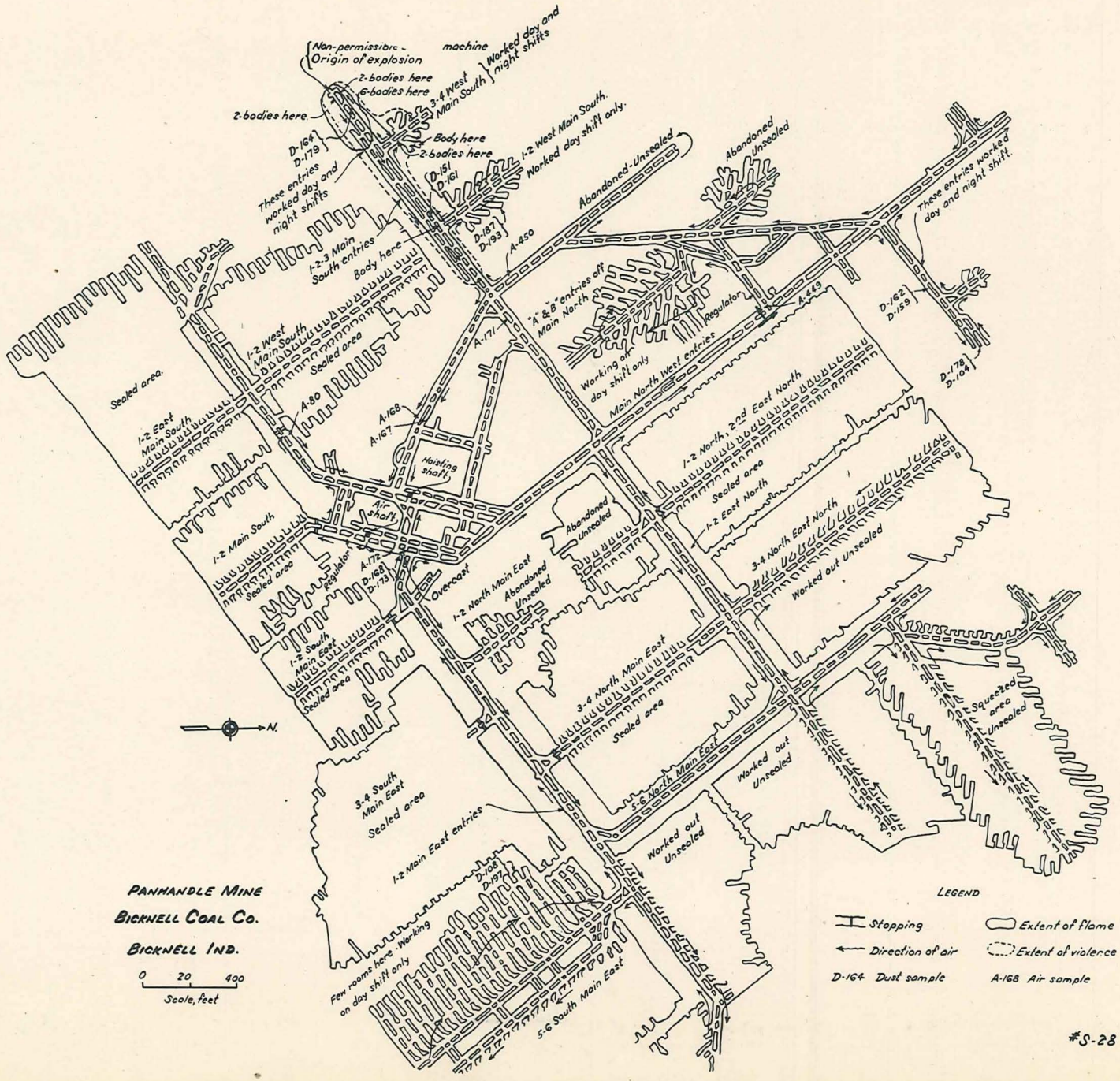
ACKNOWLEDGMENT

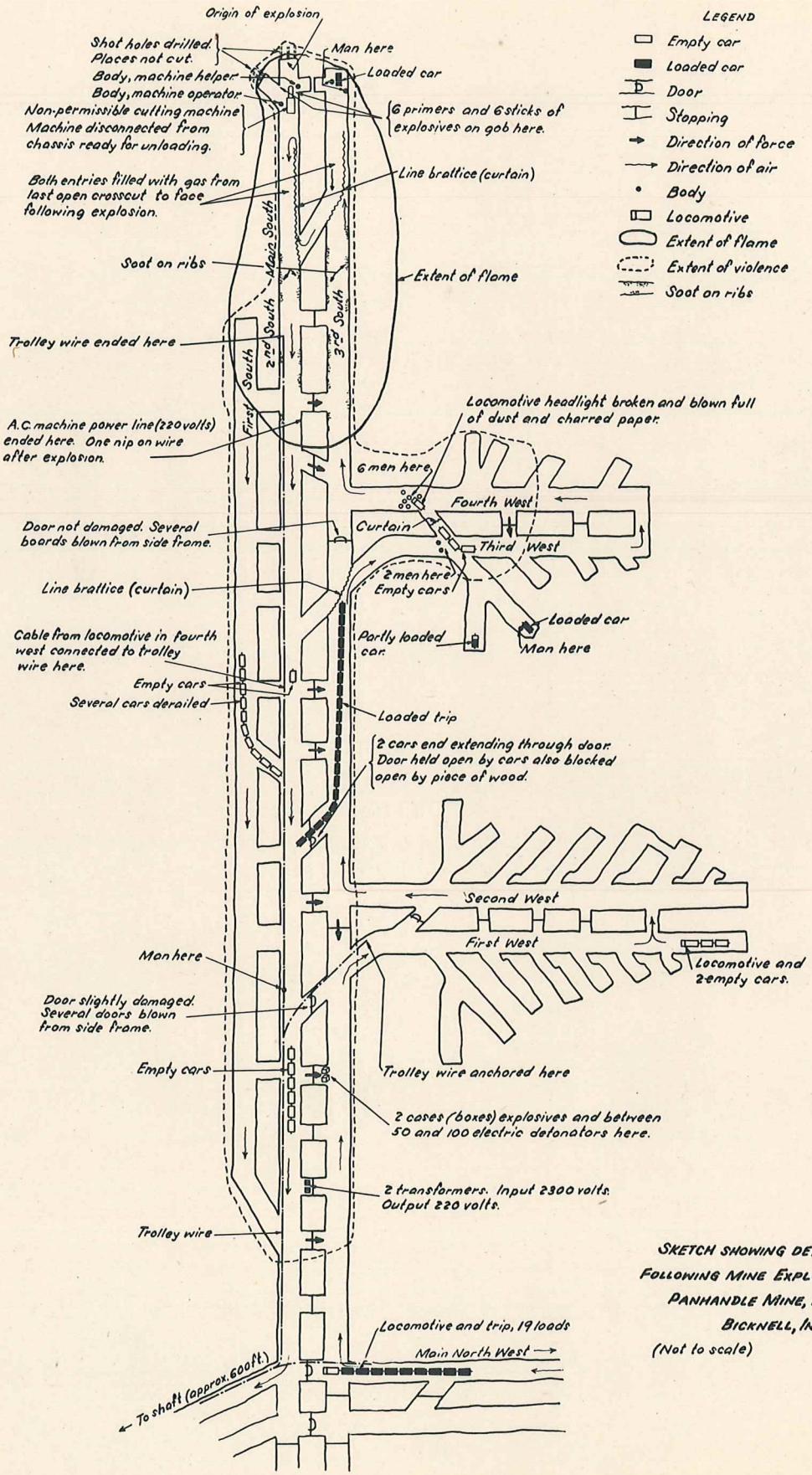
The writer acknowledges the courtesies extended and assistance given by the officials of the Bicknell Coal Company, especially by Mr. John Milligan, mine foreman, and Mr. Walter Pollock, fire boss, in connection with the investigation of the cause of the explosion and with obtaining data covering the operation of the mine. The cooperation of the Chief and Deputy Mine Inspectors of the Indiana State Bureau of Mines and Mining is also acknowledged.

Respectfully submitted,

W. H. Tomlinson,
Associate Mining Engineer.

APPENDIX


Non-permissible machine
Origin of explosion
Worked day and night shifts
2-bodies here
6-bodies here
3-4 West Main South
2-bodies here
D-164
D-179
These entries worked day and night shifts
Body here
2-bodies here
D-151
D-161
1-2 West Main South. Worked day shift only.
D-187
D-193
A-450
Abandoned-Unsealed
Abandoned Unsealed
These entries worked day and night shift.
1-2-3 Main South entries
Body here
"A" & "B" entries off Main North
Regulator
A-449
D-162
D-159
D-178
D-104
A-171
1-2 West Main South
Sealed area
Working on day shift only
Main North West entries
Sealed area.
1-2 East Main South
A-80
A-168
A-167
Hoisting shaft
Air shaft
1-2 North 2nd East North
Sealed area
1-2 East North
3-4 North East North
Worked out Unsealed
1-2 Main South
Sealed area
Regulator
A-172
D-168
D-173
Overcast
Abandoned Unsealed
1-2 North Main East Abandoned Unsealed
1-2 South Main East
Sealed area
3-4 North Main East
Sealed area
Squeezed area Unsealed
N.
5-6 North Main East
Worked out Unsealed
Worked out Unsealed
3-4 South Main East
Sealed area
1-2 Main East entries
D-105
D-197
Few rooms here - Working on day shift only
5-6 South Main East
Worked out Unsealed
PANHANDLE MINE
BICKNELL COAL CO.
BICKNELL IND.
0 20 400
Scale, feet
LEGEND
Stopping
Extent of flame
Direction of air
Extent of violence
D-164 Dust sample
A-168 Air sample
#S-28



SKETCH SHOWING DETAIL OF EVIDENCE
FOLLOWING MINE EXPLOSION OF MAY 22, 1941.
PANHANDLE MINE, BICKNELL COAL CO.
BICKNELL, INDIANA.
(Not to scale)

#S-29