FINAL REPORT, EXPLOSION, DANIEL BOONE MINE, STIRLING COAL COMPANY, DANIEL BOONE, HOPKINS COUNTY, KENTUCKY, OCTOBER 27, 1941.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

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By C. A. Herbert, and L. H. McGuire

INTRODUCTION

At about 7:15 a.m., October 27, 1941, an explosion occurred in the Daniel Boone mine of the Stirling Coal Company, Daniel Boone, Hopkins County, Kentucky, resulting in the death of 15 men working in the affected section. At the time of the explosion there were 53 men working in the mine, 33 of whom were at work in an adjoining hand loading section and were not injured by the explosion and made their way to the bottom of the new air shaft from which they were later rescued. Three carpenters who were at work in the new air shaft installing a stairway, were slightly affected by afterdamp before ventilation was restored in the shaft by closing the explosion doors which had been blown open. The main line motorma and the man at work at the bottom of the slope made their way out unassisted. The three carpenters and the 33 men from the hand loading section were taken out through the air shaft with the aid of firemen's ladders from the last flight of stairs to the surface (a distance of about 50 feet).

It is believed that the explosion was caused by the ignition of an accumulation of gas by a workman attempting to smoke. The gas accumulation was doubtless due largely to the shutting down of the ventilating fan the evening previous to the day of the explosion.

No water is used at the face to allay dust. Some hand rock-dusting is said to have been done in the affected section, but no evidence of rock dust was observed and it is not believed there was enough rock dust to play any part in limiting or stopping the explosion.

The Bureau of Mines at Vincennes was advised of the explosion by a telephone message from Mr. James Fugate, State Mine Inspector of Kentucky, about 8:30 a.m. relayed through Madisonville, Kentucky. An unsuccessful attempt was made to communicate with the mine to confirm the message and ascertain the seriousness of the explosion. Mr. L. H. McGuire, who was working at West Frankfort, Illinois, was notified, and arrived at the mine about 2:00 p.m.; Mr. W. O. West, who was working at Terre Haute, Indiana, was notified, and arrived at the mine with the rescue truck and equipment about 5:00 p.m.; Mr. C. A. Herbert left Vincennes about 10:15 a.m. and arrived at the mine about 2:00 p.m.; Messrs. G. T. Powell and W. R. Park of the Norton, Virginia Station, left Norton about 3:30 p.m. and arrived at the mine about 1:00 a.m. the following morning.

GENERAL INFORMATION

Location and Operating Officials

The Daniel Boone mine is located at Daniel Boone, Hopkins County, Kentucky, on the Illinois Central Railroad, and is owned and operated by the Stirling Coal Company. The officials of the company are as follows:

President	Carroll Pattison	Piedmont, W. Va.
Vice President and Secretary	T. H. Rhodes	Daniel Boone, Ky.
Treasurer and General Manager	Paul P. Gannon	Daniel Boone, Ky.

Employees and Production

The mine is operated three 6-hour shifts per day, with a 1-hour interval between shifts. Between 50 and 55 men are employed underground on the first and second shifts, and about 15 men on the third shift. Coal is hoisted only during the first two shifts. A total of 11 men is employed on the surface during the two hoisting shifts; thus, the mine has a total of approximately 135 men employed.

Approximately 800 tons of coal are produced per day.

Openings

The Daniel Boone mine is opened by means of a slope and two air shafts. One of the air shafts was sunk near the slope at the time the mine was first developed and is no longer used except as an additional return air outlet. The second air shaft (at which the ventilating fan is located) was sunk near the active workings and is approximately 100 feet in depth. This latter shaft is also intended as an escapement shaft, and at the time of the explosion three carpenters were at work installing a stairway, the lower half of which had been completed.

Coal Bed

The mine is operating in the Number 9 bed of the West Kentucky Series which averages about 54 inches in thickness, and at this mine lies nearly flat having a dip of about 2-1/2 percent to the east. The coal is bituminous and fairly uniform in character throughout the field.

The following proximate analyses were made from the composite of face samples collected in nearby mines and analyzed at the Pittsburgh laboratory of the Bureau of Mines:

Moisture percent	Volatile percent	Fixed Carbon percent	Ash percent	Sulphur percent	B.t.u.
9.0	37.0	45.7	8.3	3.3	11,870
8.6	37.0	45.0	9.4	3.1	11,820

Experiments by the Bureau of Mines have shown that the relative explosibility of bituminous coal dust is indicated by the empirical formula:

$$\frac{\text{Volatile matter}}{\text{Volatile matter + fixed carbon}} =$$

and that when the ratio of volatile matter to volatile matter plus fixed carbon exceeds 0.12 the coal dust is explosive. Further, that the explosibility of the dust increases with the increase of this ratio.

Substituting the values of 37.0 percent volatile and 45.35 percent fixed carbon in the foregoing formula, we get a ratio of .45. This indicates that coal dust from the Number 9 bed at this mine is highly explosive.

The roof at the Daniel Boone mine is a strong dark grey shale which tends to spawl off along the entries after exposure to the air. The floor is a fairly soft fireclay. The coal being mined at this property lies between two major faults approximately 2,500 feet apart and running N.61°E.

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

Method of Mining

The mine is developed by means of three main entries driven in an easterly direction from the bottom of the slope. Lateral, or room entries, are driven to the right and left of the main entries at irregular intervals. Generally, these laterals consist of three entries.

The production at the present time is from two adjoining sections known as the 6th north entries and the 7th north entries.

The coal in the 6th north entries is hand loaded while in the 7th north entries it is loaded by means of two Goodman Duckbill shaking conveyor loaders.

Entries are driven 12- to 14 feet wide on 25- to 35 foot centers. Rooms in the hand loading section are driven 25 feet wide on 40 foot centers, and about 350 feet long. In the mechanically operated section (where the

explosion occurred) rooms are driven 30 feet wide on 45-foot centers, and about 340 feet long. In this section the rooms are driven singly without connecting crosscuts between rooms.

The coal is undercut to a depth of about 6 feet by shortwall mining machines of the open, or nonpermissible type. Drilling of the coal is done by nonpermissible electric drills, two of which are post-mounted and three are hand held. The motors on the Duckbill loaders are of nonpermissible type.

As a rule little timbering is necessary on the entries in the face sections. On the section of the main entries outby the new air shaft considerable timbering has been done. In the hand loading section the rooms are timbered with four rows of posts set on about 4-foot centers. In the mechanically loaded section two rows of steel jacks are used as temporary support to the roof at the face; as the jacks are moved forward they are replaced by wood posts which are kept on about 4-foot centers the same as in the hand loading section.

Ventilation and Gases

The mine is ventilated by a motor-driven Jeffrey "Aerodyne" fan run blowing. No provision has been made to quickly reverse the direction of the air flow: to do so would necessitate reversing the motor. The fan is installed on the surface at the new air shaft in a brick building and is protected by explosion doors. At the present time the fan is delivering between 30,000 and 33,000 cubic feet of air per minute.

From the bottom of the air shaft the air is split, part flowing inby along the north main air course ventilating the entries on the north side of the main entries. The other part passes through an overcast over the center main, or haulage entry, to the south main air course and ventilates the entries on the south side of the mains. These two splits join at the face of the main entries and return out the haulage road to the slope; thus, the haulage road is on return air its entire length.

Outby the new air shaft all three of the main entries serve as returns.

In the hand loading section the air is coursed through the rooms. In the mechanical section, however, the rooms are driven singly with no crosscuts between adjoining rooms. Ventilation in these rooms is obtained by means of blower fans set near the mouth of the rooms and a 12-inch fabric tubing (vent tube) extending up into the rooms. These blower fans are connected to the trolley circuit and operate only when the power is on this circuit.

Stoppings along the main entries from the new air shaft inby are of masonry construction and appear to be well built. In the room entries they are built of wood. Doors are of the slam type and are well constructed. It was observed that these doors had no latches for fastening them open, which is commendable.

It has been the practice at this mine to shut down the main ventilating fan on idle days and to start it up shortly before the beginning of the next working shift.

The mine is not rated as gassy but, in common with other mines in this field, does make some gas, particularly when approaching faults which are of frequent occurrence in this part of the West Kentucky coal field.

No regular fire bosses are employed and no regular pre-shift examinations for gas are made. The foreman on each shift has a flame safety lamp but does not carry it with him at all times and makes only such tests as he may deem necessary.

Haulage

Main line haulage from the inside partings to the bottom of the slope is by trolley locomotives. Gathering in the hand loading section is by mule, while in the mechanical section it is by locomotive. Haulage from the bottom of the slope to the tipple is accomplished by means of a single-rope electrically operated hoisting engine. The cars are of composite wood and iron construction with lift endgates and have a capacity of approximately 3,700 pounds when fully loaded. The track appears to be well laid and has a gauge of 42 inches. Roadways appeared to be fairly free of spilled coal and gob material and, in general, there appeared to be ample clearance.

The trolley wire appeared to be well hung but inadequately guarded. Some attempt has been made to guard the wire with strips of fabric or sections of old hose, at points where men are obliged to pass under it. It is very doubtful if the guards would prevent men from coming in contact with the wire.

All haulage is on the return air. Unused crosscuts serve as refuge holes.

Lighting

Lighting consists of electric lights from the trolley circuit at partings and other points along the haulage roads, and the lights carried by the workmen. Of the latter the majority were Edison Model P permissible cap lamps, although there were five open carbide lamps in use on the morning of the explosion. Nonpermissible flame safety lamps are used for gas testing.

Machinery Underground

The underground machinery is all electrically operated. It is all of the nonpermissible type and consists of the following:

7 - CE7 Sullivan shortwall cutting machines with 6-1/2 foot cutter bars, five of which are in use;
2 - 4-ton gathering locomotives;
1 - 10-ton main haulage locomotive;
5 - electric drills, two of which are post-mounted and three hand held;
3 - pumps, two of which are gathering pumps and one located at the bottom of the new air shaft;
2 - blower fans;
2 - Duckbill loaders (the motors on these are dustproof but not permissible).

All of this equipment is operated on 250 volts direct current from the trolley circuit.

Explosives and Blasting Practices

Blasting is by permissible explosives shot electrically. At the present time, Big Red No. 7, manufactured by the Equitable Powder Company, in 1-1/2" x 8" cartridges and No. 6 detonators with 6-foot copper leg wires manufactured by the same company, are used.

Shot holes are 6 feet in depth and 1-3/4 inches in diameter. In the hand loading section three holes are used, while in the mechanical section four holes are used. Not to exceed two sticks (or somewhat less than one pound) of explosives are used per hole. All shot holes are stemmed with damp fireclay dug in the mine. Shots are fired anv time during the shift by the drilling crews.

Two to three days' supply of explosives is taken into the mine at one time. The explosives are hauled into the mine in the original containers, in an insulated car connected to an empty trip. The explosives are stored in a convenient crosscut or an abandoned room. Detonators are taken into the mine by the drillers, in the original containers (detonators manufactured by this company are shorted and placed in individual insulated paper containers). Detonators are stored in a separate location from explosives.

Drainage

The face workings are dry. The main entries outby the new air shaft are damp throughout and in some places, wet and muddy. Water from he wet sections of the mine either flows by gravity or is pumped to a sump at the new air shaft from which it is pumped to the surface.

Coal Dust

In the active sections of the mine there appeared to be considerable fine coal dust on the ribs and on the floor. This dust apparently contained but little inert material. Along the dry sections of the main haulage roads considerable roof shale and fireclay apparently had become mixed with the road dust. No water is used to allay dust.

Rock Dust

It is claimed by the company that the timberman in the mechanical section devoted part of his time to rock-dusting by hand, the two rooms being worked. However, following the explosion, no evidence of any rock-dusting could be seen. No rock-dust barriers are used. The company has a rock-dust distributor and claims to have partially rock-dusted the haulageways with it. No evidence of this rock-dusting was observed.

GENERAL SAFETY CONDITIONS

First-Aid and Mine Rescue

No first-aid training has been done at this mine during the past four years. It is estimated that perhaps 20 percent of the present working force have had such training. The company, however, has always been desirous that their men be trained whenever such training was available.

Some mine rescue training was given to employees in the past whenever such training was available. No such training has been given in recent years.

No first-aid materials are kept underground; however, such materials are kept in the mine office a short distance from the mine entrance.

No oxygen breathing apparatus is maintained at this mine. They do have three All-Service gas masks. The State Mine Rescue Station with breathing apparatus, gas masks, and other rescue apparatus, is located at Madisonville, Kentucky, about 14 miles distant, and is available in case of emergency. In addition, many of the neighboring mines have All-Service gas masks which are available in case of need.

Safety Organization

No safety inspector is employed by the company. No safety meetings of any kind are held at the mine at the present time, and no safety committees are appointed as yet. The management will cooperate fully in any safety program that the men desire; however, the men must show an interest or willingness on their part first. The new mine foreman, Mr. Wynn McCormick, has expressed his desire to hold classes for the purpose of educating the men in the use and care of a flame safety lamp and the hazards of gas so that the men will become "gas conscious."

Supervision and Discipline

It is apparent that proper supervision cannot be given by one man looking after both a hand loading and a mechanical loading section. At this mine the general mine foreman was acting as section foreman for both the hand loading and mechanical sections, as well as being chief electrician and doing the fire-bossing that was done. He had a total of 55 men under his supervision. The foreman on the second shift had almost as many men to supervise. Since there were only 13 men on the third shift effective supervision could be provided for those men.

According to the management the foreman made one visit to each working place during the shift and enforced rules prohibiting flying switches and other dangerous practices, to the best of his ability. There is no book or booklet containing printed safety rules. Enforcement of rules is carried out by a "lay-off" or discharge, depending on the seriousness of the offense.

Fire Fighting

No fire-fighting organization is maintained, or fire drills held. Fire-fighting equipment on the surface consists of 12, 1-pint glass chemical fire extinguishers at points in the mine office, tipple, and store. A fire pump drawing its water supply from a 500-gallon storage tank, together with pipe lines and hose connections, is now being installed to afford protection for the surface buildings.

For fighting fires underground dependence is placed on a supply of rock dust and on making pipe and hose connections to existing pumps.

MINE CONDITIONS IMMEDIATELY PRIOR TO EXPLOSION

The ventilating fan was shut down from midnight Saturday, October 25th, until about 6:00 a.m. Sunday, October 26th, at which time it was again started and run until about 2:30 p.m. At this time it was again shut down and remained idle until about 6:00 a.m. the morning of the explosion when it was again started.

The weather for twenty-four hours prior to the explosion had been alternately clear and stormy. Beginning about 8:00 a.m. Sunday the barometer started falling and reached its low point about 6:00 a.m. the morning of the explosion. (See barograph from Evansville, Ind. Station of Weather Bureau, in the Appendix of this report.)

PREVIOUS EXPLOSIONS IN THIS OR NEARBY MINES

There had been no previous explosions in the Daniel Boone mine. However, an explosion occurred in the adjoining Crab Tree mine of the Norton Coal Mining Company in January, 1927, in which four men were killed. This explosion was believed to have been due to the ignition of a body of gas by electric arc when a blower fan was started.

STORY OF EXPLOSION AND RECOVERY OPERATIONS

The explosion was of sufficient violence to be felt on the surface at both the main slope and the new air shaft. At the latter the explosion doors were blown open. The main line motorman and the man employed at the bottom of the slope felt the force of the explosion but were uninjured and made their way out the slope. The first thought of Mr. Paul P. Gannon, General Manager, and Mr. A. H. Kelly, outside foreman, was to go to the fan to make sure it was operating. They found the explosion doors blown open but the fan was undamaged and still operating. The explosion doors were closed as quickly as possible and ventilation to the mine restored.

The three carpenters working on the escapement stairs in the air shaft, called to the men closing the explosion doors and were assured that they would be rescued promptly. However, there was no way to get these men out or to get down the air shaft until ladders and rope could be obtained to bridge the distance between the top of the stairs and the top of the shaft a distance of about 50 feet. In the meantime, James Fugate, District State Mine Inspector, Madisonville, Ky., and the Madisonville Fire Department, were notified of the explosion and responded immediately. As soon as James Fugate and the fire department truck arrived the fire ladders were roped together and lowered down the shaft to the top of the last flight of stairs. With the aid of these ladders and a rope life line handled by the firemen it was possible to get up and down the shaft with a reasonable degree of ease and safety. It was in this way that recovery operations were conducted.

As soon as the ladders were installed the three carpenters were first brought out. These men had been slightly affected by carbon monoxide during the time the air had been shut off because of the explosion doors being open. During the interval between the time of the explosion and the installation of the ladders the 33 men who had been at work in the 6th north entries, or hand loading section, made their way to the bottom of the air shaft. They were told that they were in no immediate danger and to remain at the bottom of the shaft and that they would be helped out just as soon as the ladders were installed. These men had not been injured or affected by the explosion and by following the north intake had made their way to the shaft in fresh air.

The Bureau of Mines at Vincennes received word of the disaster about 8:30 a.m., Mr. James Fugate, District State Mine Inspector, having left word with Mrs. Fugate to call the Bureau at the time he left for Daniel Boone. A short time later a telephone call was received from Mr. J. J. Forbes, Pittsburgh, who had received word of the explosion from the Associated Press.

An unsuccessful attempt was made to communicate with the mine to ascertain the seriousness of the explosion in order that the Washington and Pittsburgh offices of the Bureau might be advised. In the meantime, Mr. L. H. McGuire, Associate Mining Engineer, who was, at the time, underground at the No. 8 mine of the Old Ben Coal Corporation, West Frankfort, Illinois, and Mr. W. O. West, Senior Safety Instructor, who was conducting mine rescue training at Terre Haute, Indiana, were advised. Mr. J. C. Reardon, Junior Mining Engineer, stationed at Vincennes, was confined to his home because of illness and was not available.

In Mr. Forbes' telephone communication he suggested sending additional help, and failing to get authentic information concerning the seriousness of the disaster, C. A. Herbert in a subsequent telegram suggested to him that Messrs. Powell and Park of the Norton, Virginia Station be sent to Daniel Boone.

Mr. C. A. Herbert left Vincennes about 10:15 a.m. and arrived at the mine about 2:00 p.m. Mr. L. H. McGuire arrived from West Frankfort, Illinois about the same time. Mr. W. O. West arrived at the mine with the rescue truck and equipment about 5:00 p.m. Messrs. Powell and Park left Norton, Va. Station about 3:30 p.m. and arrived at the mine about 1:00 a.m. the following morning.

Messrs. L. H. McGuire and W. O. West went below soon after their arrival and remained below assisting with recovery operations until completed, about 4:00 a.m. October 28.

Mr. James Fugate, State Mine Inspector, arrived at the mine shortly after 8:00 a.m. with the State rescue truck and equipment, and was met by officials from adjoining mines with their rescue equipment.

Mr. G. M. Patterson, Chief Inspector, Department of Mines and Minerals of Kentucky, in company with Mr. L. W. Huber of the Mine Safety Appliances Company, arrived at the mine shortly after 3:00 p.m. and went into the mine immediately. Mr. Patterson assumed charge of recovery operations.

After the men had been rescued from the shaft bottom, Mr. Fugate, together with a picked crew of mine officials and men started recovery

operations. The fact that none of the brick stoppings along the main east entries had been disturbed between the air shaft and the 7th north entries, greatly facilitated these operations. A canvas curtain was first erected across the overcast near the bottom of the air shaft to divert most of the air up the north air course. A curtain was then hung in the opening between the main haulage road and the north air course at the 6th south to replace a door which had been damaged. At the 6-1/2 north it was again necessary to curtain over a damaged door which was permitting air to short-circuit. At this point three bodies were located, one of which was that of William Compton, mine foreman. Compton was wearing an electric cap lamp while the other two men each had carbide lamps.

From the 6-1/2 north to the 7th north rapid progress was made as none of the masonry stoppings along this entry had been disturbed.

A telephone was then installed in the air course between the 6 and 6-1/2 north entries establishing communication between this point and the surface, which was of material assistance.

All stoppings in the 7th north entries had been blown out and progress from this point was slow and required the extensive use of All-Service gas masks.

After Mr. Patterson and fresh crew members arrived at the scene of recovery work, James Fugate, State Mine Inspector, and others who had been underground since shortly after the explosion, went on top.

As a line curtain was being extended up the room parallel to the 7th north a smoke haze was observed and as this room was suspected of making gas because of a fault that had been encountered, it was deemed advisable to explore this room for possible fire before advancing the air farther. Accordingly, Messrs. Patterson, Huber, and McGuire, wearing gas masks made a careful exploration before any additional air was turned into this room. The methane tester showed an explosive mixture of gas for a distance of 30 feet back from the face. The CO detector also indicated the presence of 0.5 percent of carbon monoxide. This methane had accumulated following the explosion during a period of approximately 9 hours and indicated conclusively, that considerable methane was being liberated in this room. No fire was found and the ventilation was restored by extending a line curtain to within a short distance of the face. Four bodies were then recovered from the room and electric cap lamps were found on all of them.

The air was next conducted into No. 3 room off the right hand air course of 7th north, by means of a line curtain, and five additional bodies recovered. Two bodies were recovered on the 7th north entries and the last body was found about 10:00 p.m. on the main east haulage road between the 6th and 6-1/2 north entries. By 1:30 a.m. October 28, all of the bodies had been brought out to the mouth of the 6th north entries.

In order that the bodies could be taken out the main haulage road in cars it was necessary to clear this entry of afterdamp. This was accomplished by short-circuiting all of the air out the main haulage road at the 6th north. Messrs. Patterson, Huber, and McGuire, walked out the main haulage road to the slope and made tests of the air to make sure it was safe for the crews to bring the bodies out that way. Mules were then taken into the mine and the bodies were hauled out in mine cars arriving at the outside about 4:00 a.m.

INVESTIGATION OF CAUSE OF EXPLOSION

An investigation to attempt to determine the cause of the explosion was started at 2:30 p.m. on October 28, 1941, by the following investigators: G. M. Patterson, Chief Mine Inspector, and James Fugate, District Mine Inspector, of the Kentucky Department of Mines and Minerals; L. W. Huber, Mine Safety Appliances Company; L. H. McGuire, G. T. Powell, W. R. Park, of the Bureau of Mines.

The evidence of force disclosed the fact that the explosion had come out of the room parallel to the 7th north entry and it was agreed by all parties to the investigation that it had been due to the ignition of a body of explosive gas in this room. In fact, gas could be detected at the face of this room despite the line curtain extending up nearly to the face. The analysis of a sample of air collected at this time showed 3.8 percent methane. Heavy deposits of coke were also observed in this room.

The coal had all been loaded out of this room on the previous shift and the pan line was empty. It is very unlikely, therefore, that the Duckbill loader in this room had been started.

The cutting machine in this room had been sumped in and was in position to start cutting across the face, and at the time of the investigation it was thought that the controller was in the "on" position. A more thorough subsequent inspection, however, disclosed the fact that the controller was in the "off" position and that the bit clutch was in a neutral position. In other words, the machine was not in operation. The machine runner on the previous shift stated that the machine was in exactly the same position in which he had left it and that he was certain it had not been operated since he left it.

At the time of the investigation it was reported that Dan Pearson, colored timberman whose body was found along the rib and about 100 feet back from the face, had been wearing an open light and it was therefore believed that this open light might have been the source of ignition. Subsequent information and investigation proved that this was incorrect and that he had been wearing an Edison electric cap lamp. This error was due to the fact that the man's cap, together with the headpiece and part of the lamp cord, had been blown away and the battery was hidden by his jacket.

The undertaker at Madisonville, found the battery with the short piece of cord on the body and returned it to the mine.

No holes had been drilled at the face and no electric drill was in the room. No explosives or detonators were found.

It would appear, therefore, that open lights, electric arc, and explosives are eliminated as possible sources of ignition.

The men at this mine were permitted to smoke at will and it was disclosed by the management that Dan Pearson, the colored timberman who was at first thought to have been wearing an open light was an inveterate pipe smoker and it is thought that possibly he or one of the other men in this room may have ignited the gas when attempting to smoke.

The key-locked Koehler flame safety lamp belonging to the mine foreman was found at the junction of the 7th north and the crossover to the parallel room entry, approximately 625 feet outby the face. While the globe had been broken by the force of the explosion it is not thought that the lamp had been moved very far from its position before the explosion. The foreman's body was found on the main air course at the 6-1/2 north and it is thought likely he had sent the lamp in with someone, to the point where it was found and had not as yet been in the 7th north entries to make an inspection for gas.

The rotary converter supplying power to the mine was started directly after the fan had been started shortly after 6:00 a.m. The blower fans were supposed to be left connected to the trolley circuit to start operating as soon as the power came on. If this were the case the blower fan at the place where the explosion occurred had been in operation about an hour when the explosion occurred and should have had the place cleared of gas. However, there is no certainty that the fan had been in operation for that length of time. In any event, it is certain that an accumulation of explosive gas had formed in the room parallel to the 7th and was ignited. The most likely source of ignition would appear to have been a lighted match in the hands of one of the workmen when attempting to smoke.

The direction of forces had all been outby from the room in which the explosion originated. Heavy deposits of coke were observed in this room and also in the rooms off the right entry. Lighter deposits were observed along the 7th north entries, thus showing conclusively, that coal dust had entered into the explosion.

Flame extended out onto the main entries for a short distance but had died out before reaching the 6-1/2 north entries as none of the three bodies found at this point had been burned.

The force had also rapidly died out along the main entries. Damage to the door at the 6th north and the blown-out wood stopping in the air course at these entries were the last evidence of violence observed.

It is believed that expansion played an important part in stopping the explosion as it is certain that there had not been enough rock-dusting done to materially affect the incombustible content of the coal dust.

Property damage as a result of this explosion was confined almost entirely to the 7th north entries in which it originated and was exceedingly small considering the number of lives lost. The damage could be repaired and work resumed in the affected section in a few days.

LESSONS TO BE LEARNED FROM THIS EXPLOSION

1. The field in which this mine is operating is badly faulted and it is known that gas is often encountered when approaching or passing through such faults. In fact, gas had been encountered in an adjoining section to the one in which the explosion occurred, when passing through a minor fault. Where such conditions are known to exist a mine should be considered gassy and operated accordingly, even though gas may be encountered infrequently.

2. Shutting the main ventilating fan down during short periods of idleness to save power costs usually proves to be extremely costly.

3. If the main ventilating fan has been shut down for any reason it should be run for a sufficient length of time to ventilate the mine, after which a thorough examination should be made for gas before the power is turned on and the shift permitted to enter the mine.

4. A pre-shift examination for gas and other hazardous conditions should be made at all coal mines.

5. Long, single rooms or entries are difficult to ventilate and invite gas accumulations should gas feeders be encountered.

6. Blower fans are a poor substitute for the coursing of the ventilating current along the working faces.

7. One official should not attempt to serve in too many capacities, for example, the mine foreman attempting also to act as fire boss and mine electrician.

8. The desirability of allaying dust at the face by the use of water is brought out.

9. The necessity of rendering coal dust non-explosive by the liberal use of rock dust is also brought definitely to attention.

COMMENDABLE SAFETY PRACTICES

Since the explosion the company has put into effect the following safety practices:

1. Continuous operation of the main ventilating fan.

2. The use of one hundred percent permissible closed lights.

3. The practice of carrying matches and smokers' articles underground has been prohibited.

4. Pre-shift examination for methane gas before men are allowed to enter the mine.

5. The use of masonry stoppings along the main entries is a commendable practice and probably contributed largely to the saving of 33 lives because these stoppings were not blown out and thus the men were able to escape out through intake air.

6. Explosion doors to safeguard the main ventilating fan probably saved the fan and the lives of 36 men.

RECOMMENDATIONS

The following recommendations are made with the desire of being helpful and to reduce the explosion hazards at this mine, and it is the belief that they could be put into effect without undue departure from the present plan of mining and without undue expenditure of money.

1. Because the mine does at times liberate gas, particularly when approaching or passing through faults, it should be recognized as a gassy mine and be operated as such.

2. The main ventilating fan should be operated continuously.

3. The fan should be equipped with a recording water gauge.

4. The fan should be equipped with an automatic signaling device to give warning in case the fan should slow down or stop.

5. In case of stoppage of the fan the power should be shut off the mine and the men promptly removed from the mine.

6. If for any reason the fan has been stopped it should be operated for a long enough period to insure a resumption of ventilation throughout the mine before anyone is permitted to enter, after which a thorough examination for gas should be made by competent certified fire bosses and the mine reported safe by them before anyone other than the fire bosses is permitted to enter.

7. A pre-shift examination for gas or other hazardous conditions should be made by a competent certified fire boss not over three hours before the beginning of the shift and the mine reported safe by him before the men are allowed to enter the mine.

8. The present plan of driving long single rooms or entries, requiring the use of blower fans should be discontinued. Instead, rooms and entries should be driven in multiple with crosscuts between the rooms or entries and the ventilating current coursed along the face of the rooms. Where necessary to carry the air to the face from the last crosscut line curtains should be used.

9. The practice of building strong masonry stoppings on the main entries is commendable and should be continued.

10. It would be desirable to drive crosscuts across the face of the long worked out rooms off the left hand 7th north entry, to insure ventilation in these rooms.

11. Abandoned or worked out sections of the mine should be ventilated and examined daily or should be sealed off with strong, tight incombustible stoppings.

12. In addition to the pre-shift examination by the fire boss, the foreman should be required to carry a permissible flame safety lamp with him at all times and to make frequent inspections for gas during the working shift.

13. Ventilating doors should open against the air and should be tight and so hung as to be self-closing. Where possible, these doors should be hung in pairs to form an air lock, and every effort should be made to prevent their being left open by the haulage crews or others.

14. Fire bosses should be required to date and initial with chalk, the faces of all places examined as evidence that such places were examined, and should be required to report their findings daily in a report book kept on top for that purpose.

15. A regulator should be installed near the overcast in order that a greater percentage of the air might be sent through the active workings on the north side.

16. A barometer should be kept at the mine office and the foreman or fire bosses required to read the pressure at the beginning and end of each shift and the readings thus taken recorded in the report book. In the event of a sudden drop in barometric pressure added precautions should be taken to guard against an accumulation of explosive gas.

Allaying Coal Dust

1. Water should be used on mining machines while undercutting. The face and the ribs for a distance of at least 20 feet back from the face should be wetted down before blasting and the broken coal should be sprinkled after blasting.

2. The floor in both rooms and entries should be kept clean and free of small coal to prevent its being ground up and thus adding to the dust hazard.

Rock-Dusting

1. Rock dust should be applied to the surface of all mine openings inby the new air shaft. The rock dust should be kept as close to the working face as possible.

2. The rock dust should be applied in such quantities and at frequent enough intervals to maintain an incombustible content of not less than 65 percent in all dust that will pass through a 20-mesh to the inch sieve.

Explosives and Blasting

1. The present practice of using permissible explosives shot electrically is commendable and should be continued.

2. The present practice of using damp fire clay dug in the mine for stemming is commendable. However, care should be exercised to insure that only clean fire clay, free from drill cuttings or other fine coal, is used. If it is found impossible to make sure that only clean fire clay is used it might be better to substitute clay dug on the outside.

3. The amount of explosives taken into the mine should be limited so far as possible to one day's supply.

4. The explosives should be taken underground in either an insulated covered car built for that purpose, with which an insulated coupling is used, or should be delivered by mule when the electric power is off the mine.

5. Explosives underground should be kept in a strong insulated wood box with lid and padlock. The box should be located in a safe place as far from power lines or cables as practicable.

Detonators should not be taken into the mine with the explosives and should be stored in a separate place at least 30 feet from the explosives, and preferably in a niche cut in the rib.

6. Explosives should be carried to the face from the storage box in a waterproof insulated container.

7. The detonator should be inserted in the explosives at the face just before the explosives are inserted into the shot hole. The leg wires should remain "shorted" until ready to connect with the shooting cable.

8. Shot-firing cables should be at least 100 feet long and the battery end of the cable should be kept "shorted" at all times except when a shot is being fired.

9. Shot holes should not be drilled until after the face is cut.

Electricity

1. The Bureau of Mines recommends that all underground electrical equipment not used in strictly fresh intake air be of the permissible type. It is therefore suggested that any underground electrical equipment purchased in the future, be of the permissible type.

2. Only permissible electric cap lamps should be used underground. The present practice of using mixed lights should be discontinued.

3. Trolley or other bare power lines should be guarded whenever they are less than 6-1/2 feet above the rail, particularly at points where men or animals are required to cross under them.

4. Cables of mining machines, drills, and other electrical equipment, should be suspended on posts or hangers and not left lying on the ground.

5. Hand held drills using 250 volts, or over, should be provided with a ground conductor to reduce the electric shock hazard.

6. Automatic re-closing sectional switches should be installed for each active section and all equipment should be properly fused.

7. All trailing cables on which temporary splices have been made should be replaced as soon as possible and the spliced cable sent to the outside where a permanent splice should be made and the splice vulcanized.

8. An underground telephone system (communicating with the outside) of the complete wire circuit type, should be installed. Telephone wires should be on the side of the entry opposite to the trolley wire.

9. As a measure of both safety and economy, both rails should be bonded throughout instead of just one rail as at present. Cross bonds should also be installed at frequent intervals. The present practice of using the welded type of bond is commendable and should be continued.

General

1. The practice of smoking underground should be prohibited and the employees should be searched at intervals for matches and smoking materials.

2. A positive system of checking the men into and out of the mine should be established.

3. Six All-Service gas masks (or equivalent) with extra canisters should be maintained at the mine. A selected crew should also be trained in the use of these gas masks and in the use and care of oxygen breathing apparatus whenever such training is available.

4. All employees should be given a course in first aid training whenever such training is available.

5. There should be at least six permissible flame safety lamps at the mine. These should be maintained in proper condition by the man in charge of the electric lamps and should be issued by him to the proper officials as needed.

This mine was not visited during normal operation and doubtless some of the foregoing recommendations are already in force.

ACKNOWLEDGMENTS

Acknowledgment is made of the courtesies shown the representatives of the Bureau of Mines by Mr. Paul P. Gannon, General Manager of the Stirling Coal Company, and Mr. G. M. Patterson, Chief, and Mr. James Fugate, District Inspector, of the Kentucky Department of Mines and Minerals. Messrs. Patterson and Fugate are to be commended for the efficient manner in which the arduous and dangerous work of recovery operations was performed under their supervision.

Mr. L. W. Huber of the Mine Safety Appliances Company, and the officials and men of the nearby mines, are also to be commended for their valiant and efficient work during the recovery operations. Mr. Huber also assisted during the joint investigation.

In the Appendix to this report will be found the following: analytical reports of dust and air samples collected subsequent to the explosion; copy of the mine map and an enlarged section of the map showing the section affected by the explosion with pertinent data; barographs from the U. S. Weather Bureau Station, Evansville, Ind., showing barometric pressures from 12 noon October 25, 1941 to 12 noon October 29, 1941; a list of the names of the victims of this explosion.

Respectfully submitted

C. A. Herbert,
Supervising Engineer

L. H. McGuire,
Associate Mining Engineer

APPENDIX

DISCUSSION OF DUST SAMPLES TAKEN FOLLOWING THE DANIEL BOONE MINE EXPLOSION OF THE STIRLING COAL CO., DANIEL BOONE, KY.

Five samples of dust were collected at three points outside of the explosion area (at locations shown on the map in the appendix) in the Daniel Boone mine during the investigation; the analyses are shown in Table 1.

A study of the analysis of these samples shows:

1. That all samples collected with the exception of one are sufficiently high in combustible material to propagate a mine explosion;

2. Sizing tests of the dust samples show that an average of 81.4 percent of the rib dust and 77.7 percent of the road dust is less than 20-mesh size, and that an average of 55.8 percent of the rib dust and 29.2 percent of the road dust is less than 200-mesh size. Experiments have shown that any coal dust (with the exception of anthracite dust) that will pass through a 20-mesh screen may enter into an explosion, and that the finer the dust the greater the ease with which it is able to propagate the explosion. This indicates that so far as the dust samples are concerned, the dust accumulations along the roadways, air courses, and rooms were sufficiently high in combustible material and of sufficient fineness to have carried the explosion beyond its present limits.

In examining the surrounding conditions it would appear that the explosion wave preceding the flame had the opportunity of expanding quickly by reason of rooms, entries, and the new air shaft located relatively close to the active workings, which in turn caused the explosion to slow down and stop. In fact, the new air shaft equipped with explosion doors allowed the sudden expansion to take place with relative ease and no doubt played the most important part in stopping the explosion before it had sufficient time to gather enough momentum.

ANALYSES OF MINE AIR SAMPLES

During the investigation air samples were collected at points shown on the accompanying map. The analyses of these samples together with other data are shown in Table 2.

TABLE 1 - Analysis of dust samples collected in Daniel Boone Mine
Stirling Coal Company, Daniel Boone, Ky.,
November 4, 1941 1/

Laboratory No.	Can No.	Location in mine	Kind of Sample	Percent					Remarks
				Combustible, V. + F.C.	In comb., moisture	Incomb., Ash	Through 20-mesh	Through 200-mesh	
B-67936	F-53	Main east haulway, 1/2 way between 6 north and 6 south	Road Dust	31.4	2.7	65.9	80.4	20.9	Unaffected portion of mine
B-67937	F-219	Same as B-67936	Rib Dust	60.7	5.3	34.0	95.8	78.0	do.
B-67938	F-113	425' inby, mouth of 6 north haulway, off east mains	Road Dust	60.2	6.4	33.4	75.0	37.5	do.
B-67939	F-114	Same as B-67938	Rib Dust	67.6	8.4	24.0	69.3	42.6	do.
B-67940	F-211	Left air course, main east, 75' outby stopping mouth of 6 north left air course	Rib Dust	59.9	8.9	31.2	79.0	46.8	do.

1/ The analyses were made by the Bureau of Mines, Pittsburgh, Pa.

TABLE 2 - Analysis of air samples collected in Daniel Boone Mine, Stirling Coal Company, Daniel Boone, Ky., Nov. 4, 1941 1/

Laboratory No.	Location in mine	Percent					Cu. Ft. air per minute	Cu. ft. methane in 24 hours
		Carbon dioxide	Oxygen	Carbon monoxide	Methane	Nitrogen		
67941	Underneath overcast at new air shaft, main haulway, east mains, return air from entire mine inby.	0.08	20.72	0.0	0.04	79.16	32,994	19,004.54
67942	Duplicate of 67941.	0.10	20.70	0.0	0.05	79.15	32,994	23,755.68
67943	Parallel room, 7 north, off main east, return air at last open breakthrough coming from face of room.	0.09	20.68	0.0	0.08	79.15	4,860	5,598.7
67944	Duplicate of 67943.	0.09	20.69	0.0	0.08	79.14	4,860	5,598.7
67945	Mouth of parallel room at 12 room left, 7 north off main east, intake air.	0.10	20.74	0.0	0.05	79.11	Anemometer would not turn over. Calculate at 4,860	3,499.2
67946	Duplicate of 67945.	0.12	20.72	0.0	0.05	79.11	4,860	3,499.2
67947	At 7 north, off east mains, haulway, under R.R. right of way, 300 feet inby (approximate) mouth of 7 north. Return air of section.	0.13	20.70	0.0	0.09	79.08	3,952 which is calculated at 11,700 because air comes down two entries at this point.	15,163.
67948	At 7 north, off east mains, left air course, under R.R. right of way, 275 feet inby (approximate) mouth of 7 north, intake air of section.	0.10	20.71	0.0	0.04	79.15	11,700	6,739.

1/ The analyses were made in the Gas and Dust Laboratory of the Health Division of the Bureau of Mines at the Central Experiment Station, Pittsburgh, Pa.

At the time the samples were taken, ventilation had not been entirely restored to normal in the section affected by the explosion. In addition, eight days had elapsed between the time of the explosion and the time the samples were taken, and during that time no fresh coal faces had been exposed and any gas feeders existing prior to the time of the explosion had had time to bleed off to at least some extent. The barometric pressure was also practically normal at the time the samples were taken. It is believed, therefore, that the percentages of methane shown in these analyses are probably much lower than the percentages in the air current prior to the explosion.

It will be observed from Table 2 that at the time the samples were taken the mine was liberating a relatively small amount of methane. Notwithstanding this fact, dangerous accumulations of methane could occur should ventilation be interrupted for any appreciable length of time. Should gas feeders be encountered when approaching or passing through faults the accumulations could occur rapidly.

Samples bearing laboratory numbers 67941 and 67942 were collected under the overcast in the main return of the active section of the mine. These samples contained 0.04 and 0.05 percent methane, respectively. The volume of air per minute at this point was 32,994 cubic feet, and indicates that the mine inby this point was liberating an average of 21,380 cubic feet of methane in 24 hours.

Samples bearing laboratory numbers 67943 and 67944 were taken in the room parallel to the 7th north where the explosion occurred, at the last crosscut to the 7th and on the return side of the line curtain. These samples showed 0.08 percent methane.

Samples bearing laboratory numbers 67945 and 67946 were taken about 100 feet outby the next above samples on the intake and showed 0.05 percent methane. The volume of air at this point is estimated to be approximately 4,860 cubic feet per minute. The difference between the above 0.05 percent methane and the 0.08 percent in the previous samples indicates that 0.03 percent methane was added to the air current by its passage into the room where the explosion occurred. With an estimated air volume of 4,860 cubic feet of air per minute, this would indicate that at the time the samples were taken 2,099 cubic feet of methane was being liberated in this room each 24 hours. If the ventilation were cut off this room entirely, this amount of methane would make nearly 21,000 cubic feet of a 10 percent mixture of methane and air which is the highest explosive proportion. This amount of explosive mixture would fill the room for a distance of 140 feet from the face in 24 hours.

The above indicates the hazards attendant to interrupted ventilation even in a mine which ordinarily liberates only a small amount of methane.

Tests conducted by the Bureau of Mines show that under favorable conditions the ignition of as little as 150 cubic feet of a gas-air mixture is sufficient to initiate a coal dust explosion.

Sample bearing laboratory number 67947 was taken about 300 feet inby the mouth of the 7th north return entry, while sample bearing laboratory number 67948 was taken on the 7 north intake entry about the same distance inby the mouth of the entry. These show 0.09 and 0.04 percent methane, respectively. The volume of air in the return of these entries was 11,700 cubic feet per minute. Thus 8,424 cubic feet of methane was being liberated in the 7th north section each 24 hours, or enough to form 84,240 cubic feet of a 10 percent methane-air mixture, one which is highly explosive if or when ignited.

BAROMETRIC PRESSURE

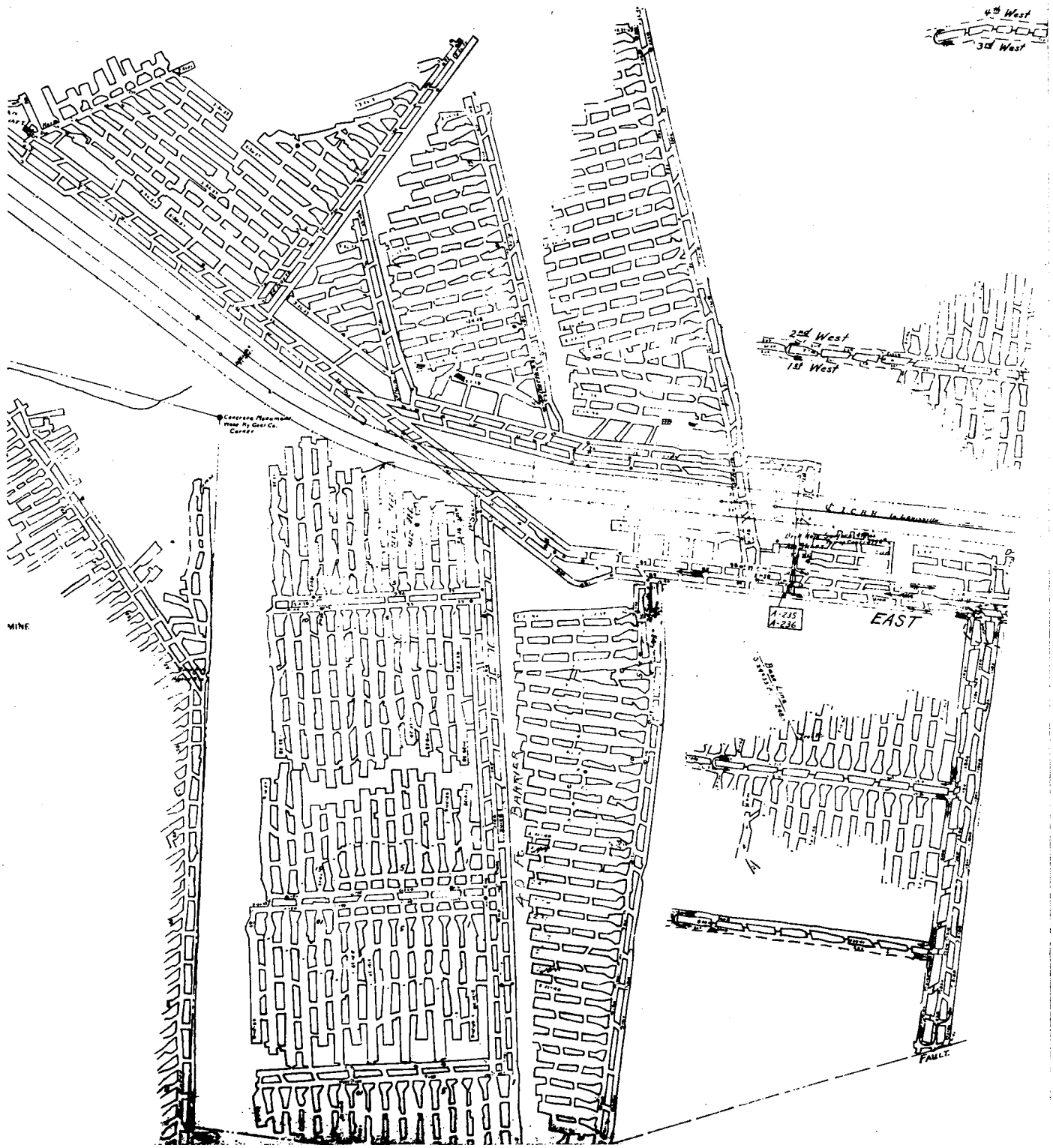
The barograph which is a part of this report was obtained through the courtesy of the Weather Bureau, Evansville, Indiana, and shows graphically the barometric pressures at Evansville, Indiana, between noon, October 25, 1941, and noon, October 29, 1941.

It is interesting to note that there had been a rather rapid drop in pressure beginning about 9 a.m. Sunday, October 26, the day previous to the explosion, with the low point of pressure about coincident with the time of the explosion, namely 7:11 a.m., October 27.

Evansville, Indiana, is about 60 miles north of the Daniel Boone mine, and it is true that barometric pressures might not have been identical during this period at both places. It is known, however, that the barometer was low in the Franklin County, Illinois, coal field about 90 miles northwest on the morning of the explosion. In this field close attention is given to the barometer, because from past experience the gas hazards accompanying low barometric pressures have long been recognized. It would appear, therefore, that the low pressure area was quite extensive and no doubt included Daniel Boone.

LIST OF DECEASED MINERS

1. Will Compton	General Mine Foreman	Married
2. Obie Wells	Machineman	Married, one child
3. Ike Whitfield	Machine Helper	Married, eight children
4. Edgar Adams	Brakeman	Married, three children
5. Dan Pearson, Colored	Timberman	Married
6. Robert Dunning	Driller	Single
7. Junior Gamblin	Duck Bill Operator	Married, two children
8. Neely Todd	Machineman	Married, three children
9. Robert Josie	Duck Bill Head Operator	Married, one child
10. Elbertrice Keys	Motorman	Married, four children
11. Otho Sisk	Machineman	Married
12. Goldie Gamblin	Duck Bill Operator	Widower, two children
13. Bart Cunningham	Loader	Married, four children
14. Bennie Martin, Colored	Driller	Married, one child
15. Gus Pryor	Mine Electrician	Married, four children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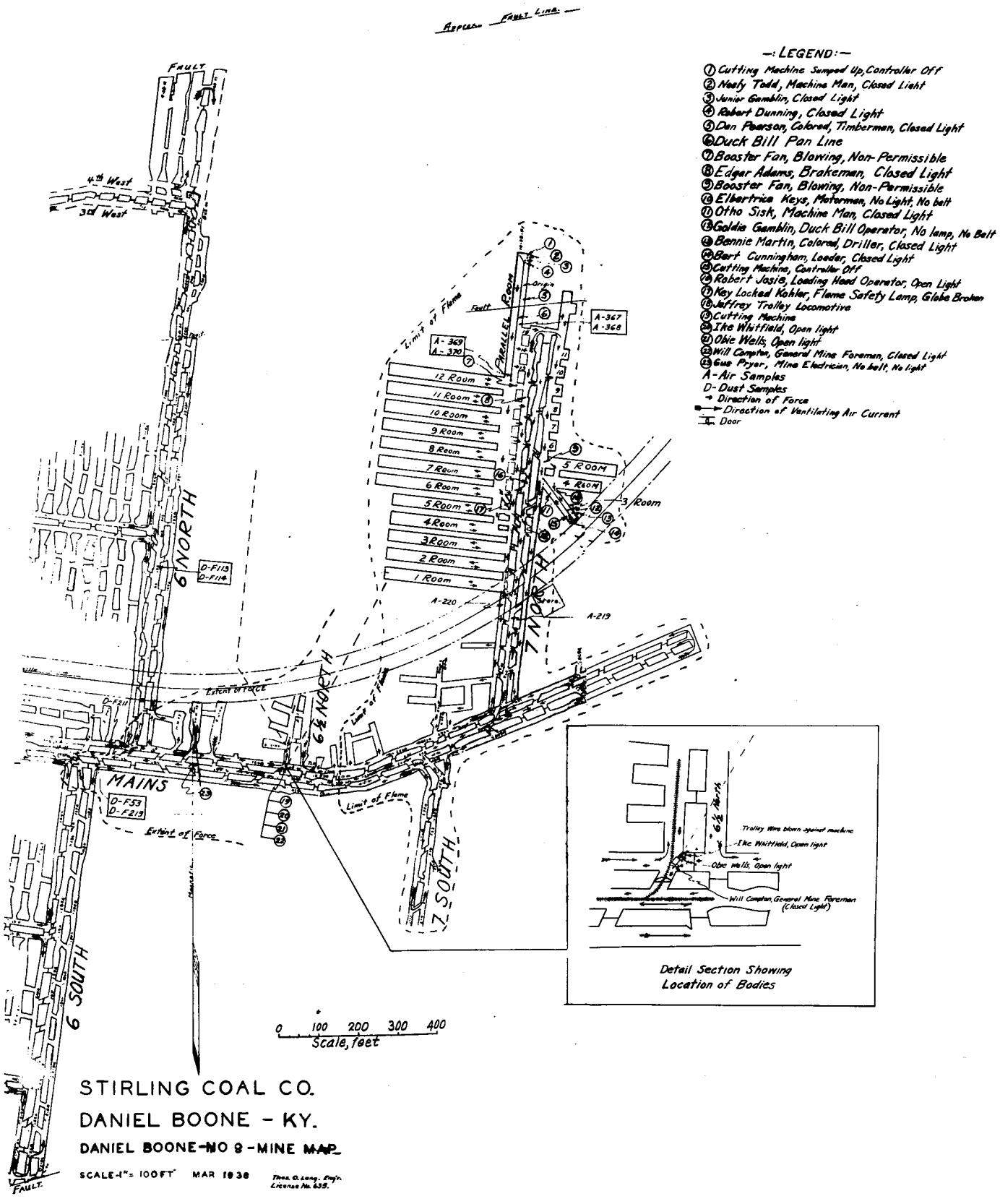

STIRLING COAL CO.

DANIEL BOONE - KY.

DANIEL BOONE-NO 8-MINE MAP

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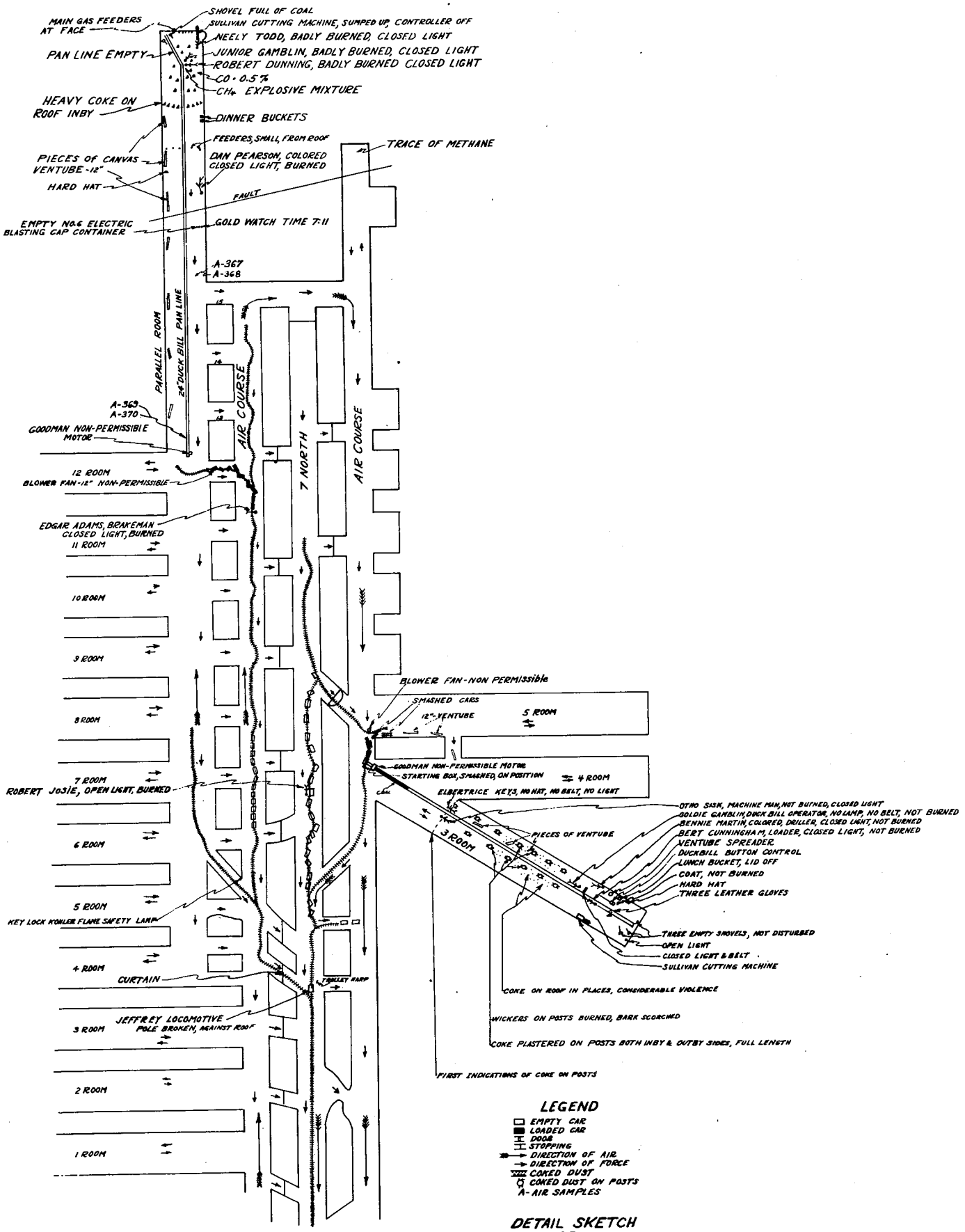

DETAIL SKETCH OF 7 NORTH EXPLOSION ZONE DANIEL BOONE MINE STIRLING COAL COMPANY DANIEL BOONE, KY.

OCTOBER 27, 1941

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