FINAL REPORT
GAS AND DUST EXPLOSION, DOCENA MINE, TENNESSEE COAL, IRON AND RAILROAD COMPANY ADAMSVILLE, JEFFERSON COUNTY, ALA.
June 4, 1941

By

E. A. Anundsen
Acting District Engineer
And
M. J. Ankeny
Mining Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

TABLE OF CONTENTS

FINAL REPORT
GAS AND DUST EXPLOSION, DOCENA MINE,
TENNESSEE COAL, IRON AND RAILROAD COMPANY
ADAMSVILLE, JEFFERSON COUNTY, ALA.
June 4, 1941

By
E. A. Anundsen[1] and M. J. Ankeny[2]

INTRODUCTION

On June 4th, 1941, at approximately 11:20 A.M., a local gas and dust explosion occurred in the Docena Mine of the Tennessee Coal, Iron and Railroad Company at Adamsville, Alabama, resulting in the death of five men.

The mine is located in Jefferson County, Alabama, about fourteen miles west of Birmingham on the Tennessee Coal, Iron and Railroad Company Railroad.

The explosion occurred at 11:20 A.M. on the day shift while 432 men were in the mine. Three men were killed outright by burns and afterdamp, four were seriously injured or affected by burns and afterdamp, (two of these died several days later) and nine were less seriously injured, three of them suffering from afterdamp and shock, four from burns, afterdamp and shock, and two from other injuries. Eleven of the survivors in the immediate explosion area were rescued by a section foreman with the aid of four other persons, and the section foreman directed and assisted in the recovery of two of the bodies. The third body was recovered shortly thereafter by an oxygen apparatus crew of the company. Sixty-five men who were at work in a portion of the mine that is on return air from the entries in which the explosion occurred, escaped unassisted without suffering any ill effects. All of the dead and injured were removed from the mine by 2:30 P.M. One of the four seriously injured men died eight days later, and another fifteen days later, bringing the total of those killed to five.

The Birmingham office of the Bureau of Mines was notified by E. J. McCrossin, Chief, Division of Safety and Inspection, Alabama Department of Industrial Relations at 1:15 P.M., June 4th. E. A. Anundsen of the Bureau arrived at the mine at 2:00 P.M., and entered the mine at 2:30 P.M., with Mr. McCrossin, joining officials of the mine who were at the scene of the explosion. Since the explosion area had been cleared of gases, a preliminary examination was completed and the entire party left the mine about 5:00 P.M. On June 5th investigations by the company officials, the Division of Safety and Inspection of the Alabama Department of Industrial Relations, and the U. S. Bureau of Mines were carried

---

1/ Acting District Engineer, Health and Safety Branch, Bureau of Mines Safety Station, Birmingham, Alabama.
2/ Mining Engineer, Health and Safety Branch, Bureau of Mines, Pittsburgh, Pa.

on. C. E. Saxon of the Bureau's Birmingham office, returned from south Alabama on the afternoon of June 5th, and M. J. Ankeny, Mining Engineer of the Bureau, arrived by plane from Pittsburgh, Penna., that evening.

Messrs. Ankeny, Anundsen and Saxon continued the investigation and collected air and dust samples on June 6th. A preliminary report was completed on June 7th and the mine investigation work was resumed on June 9th and completed on June 10th. Survivors of the explosion were questioned on June 11th.

GENERAL INFORMATION

Location, Ownership and Management

The Docena Mine is owned and operated by the Tennessee Coal, Iron and Railroad Company, and is located at Adamsville in Jefferson County, Alabama, Township 17 South, Range 4 West. The mine is served by the Tennessee Coal, Iron and Railroad Company railroad which connects with the Southern Railroad at Pratt City, Alabama. The main office of the Company is in the Brown-Marx Building, Birmingham, Alabama. The main office for coal mines is at Pratt City, Alabama.

Officials of the Company are:

Robert Gregg	President	Birmingham, Ala.
C. E. Abbott	V.-Pres. in Charge of Raw Materials	Birmingham, Ala.
R. E. Kirk	Gen. Supt. of Coal Mines	Pratt City, Ala.
A. Waldman	Asst. Gen. Supt. of Coal Mines	Pratt City, Ala.
H. C. Nyquist	Chief Engineer	Pratt City, Ala.
J. C. Gray	Chief Inspector	Pratt City, Ala.
A. R. Brown	Supt. of Ventilation	Pratt City, Ala.
David Brown	Mine Supt., Docena	Adamsville, Ala.
D. A. Cantley	Gen. Mine Foreman	Adamsville, Ala.

Employment and Production

A total of 1,034 persons are employed at the Docena Mine, as follows:

	Underground	Surface	Total
Day Shift	436	62	498
Afternoon Shift	328	43	371
Night Shift	163	2	165
	927	107	1,034

The average daily production of the mine is 4,172 tons.

Mine Openings

The mine is opened by two vertical shafts and seven rock slopes. The main hoisting shaft is timbered, 211 feet deep, has two 7-foot, 5-inch by

7-foot 10-inch compartments, and balanced skip hoisting is employed. The air shaft is circular, 208 feet deep, has a diameter of 12 feet, is untimbered and unlined.

The rock slopes are driven on grades ranging from 18° to 45°, have 7-foot by 12-foot cross-sections, and range from 383 feet to 702 feet in length. They are unlined and contain no timbers.

One of the slopes is used for passage of men and material, two serve as main returns, and four serve as air intakes and escapeways. The portals of the slopes are concreted and no buildings are located within close proximity to any slope mouth, except the 3rd northwest intake and escapeway, which has a wooden trestle beginning about 15 feet from the slope mouth. This slope and trestle are soon to be employed for dumping rock.

Nature of Coal Bed

Mining is conducted in the Pratt seam which dips slightly to the northwest in the Docena Mine, and averages 42 inches in thickness. There are numerous local dips or "swags". The overburden consists principally of shale and sandstone. The roof is a hard sandy shale and roof conditions, with the exceptions of a few limited areas where thin seams of sandstone are found between layers of shale, or where "horse backs" and "kettle bottoms" are found, are very good. The floor is also a hard shale. Brushing in haulage ways averages two feet and either the floor or roof is brushed, depending on the local rise or fall of the coal bed.

Analysis of Coal

The Pratt seam was sampled in the Docena Mine in 1921 by J. J. Forbes.[3] From coal sample analyses[4] the average content of volatile matter is found to be 30.7 percent and the average fixed carbon content 64.4 percent. The ratio of volatile matter to volatile matter plus fixed carbon is therefore .32. Experiments of the Bureau of Mines have shown that coal dust having a ratio of volatile matter to volatile matter plus fixed carbon of .12 is explosive. Since the explosibility of coal dust increases as this ratio increases, it is evident that the coal dust in the Docena mine is very explosive, and will readily propagate an explosion.

Based on a volatile ratio of .32, the amount of incombustible matter which must be present to render the coal dust non-explosive is 61 percent. Since methane is found in the Docena mine, it is advisable to maintain the incombustible content of the coal dust at 65 percent.

3/ Supervising Engineer, U. S. Bureau of Mines, Safety Division, Pittsburgh, Pennsylvania.

4/ Technical Paper 347, Department of Commerce, Bureau of Mines, "Analysis of Alabama Coals."

UNDERGROUND MINING METHODS, CONDITIONS AND EQUIPMENT

Method of Mining

The map of the mine, Appendix I, shows the general plan of mining in the Docena Mine. Extending from the main openings in a southerly direction, the main south entries were driven a distance of about 6,150 feet to the barrier pillar, using a three entry system. Developing room entries were turned from this main south entry to the right and left at intervals of about 340 feet. Extending from the main openings in a northerly direction, the main north entries were driven in a similar manner, a distance of about 6,900 feet. Room entries were turned to the right and left from the main north entries at intervals of about 350 feet. From these room entries at distances varying from 2,100 to 3,000 feet, main face entries were developed in triplicate, and room entries in turn were developed from these main face entries. The room entries in the advancing portion of the mine are driven in pairs from one set of north entries to the adjacent set. Rooms are turned at right angles on 60 foot centers and driven about 30 feet wide. The rooms are turned from only one entry of each pair of entries and are driven about 275 feet long, leaving a barrier pillar between the faces of the rooms and the adjacent set of entries. Occasional rooms are driven through the barrier pillar to the air course of the adjacent set of entries for ventilation purposes. Rooms are turned and driven from the developing entries to their limits as the entries advance and 45° pillar lines are maintained in panels where pillars are extracted on the retreat.

The coal is undercut by shortwall mining machines. 29.2 percent of the coal mined is loaded by hand, 65.5 percent by shaker and flight conveyors, and 5.3 percent by joy loaders. One long wall face, about 300 feet long, is being operated in the mine. 80.5 percent of the production is from advance work, 12 percent from pillars and 7.5 percent from long wall operations.

With the exception of the occasional appearance of "horse backs" and "kettle bottoms" the natural roof conditions at the Docena Mine are good. Very little timbering is required to support the roof above the haulage roads. In rooms and at the faces of advancing entries, posts are set four feet apart and are kept up to within four feet of the face. A safety post is kept at the head of the conveyor line or ahead of the end of the track in hand loading places. Additional timbers are set in working places wherever the conditions of the roof indicate their necessity. The timbering standards are strictly enforced.

Ventilation and Gases

The mine is ventilated by three exhaust fans as follows:

At No. 1 air shaft, which is near the main hoisting shaft, there is a Jeffrey 6' x 4' centrifugal fan delivering about 85,140 cubic feet per minute against a water gauge of 2.4". This fan is installed in a fireproof building, is belt driven by a 125 h.p. 2300 volt motor, and is equipped with doors for reversing the air current. Explosion doors are

located at the shaft collar and the fan is offset from the shaft. A 125 h.p., 250 volt, d. c. motor is used for "stand by" power. A belt drive and an automatic clutch is provided for transmission of auxiliary power to the fan shaft. No. 1 fan ventilates the section of the mine to the left of the main north entries and outby the 13th left entries.

There is no No. 2 fan at the present time.

No. 3 fan is offset from the mouth of a rock slope connecting with the area near the 1st Northeast entry heading and ventilates the area to the right of the Main North entries. This is a Jeffrey, centrifugal, 8' x 3-1/2' fan equipped with doors for reversing the air current. It is belt driven by a 125 h.p., 2300 volt motor and delivers about 48,000 cubic feet of air per minute against a 3" water gauge. This fan is equipped with a 75 h.p. gasoline engine for emergency power which is applied in the same manner as that at No. 1 fan.

No. 4 fan is offset from the mouth of a rock slope connecting with the 2nd northwest heading area and ventilates the section of the mine to the left of the main northwest entries inby the 13th left entries. This is a La Del, Troller, airplane-type fan, classed as non-reversible by the coal company, is equipped with self-closing explosion doors, and is belt driven by a 75 h.p., 2300-volt motor. It delivers about 86,976 cubic feet of air per minute against a 4" water gauge. A 75 h.p. gasoline engine is available for emergencies. The auxiliary power is applied in the same manner as at No. 1 fan.

No. 3 and No. 4 fans are some distance from the mine plant and are constantly attended. No. 1 fan is at the mine plant and is attended by employees having other duties in addition to their work at the fan. None of the fans have devices which will automatically give warning or cut off the mine power in case the fan slows down or stops.

The ventilation system at the Docena Mine is unusual in that three fans are used and three independent air splits are therefore employed. Although the ventilation method is considered a split system in that air on each fan circuit is further split up into secondary circuits, the objective of the true split system is not attained. A true split system is designed to furnish fresh intake air to each working section, whereas the location of fans and intake airways at the Docena Mine is such that intake air to working sections passes through abandoned and mined out areas, or passes by openings to such areas before reaching the face regions. Since this air may also ventilate more than one working section, the ventilation circuit resembles a continuous system rather than a split system.

For example: No. 4 fan ventilates an area inby the 13th left haulage way as follows: Air intakes into the main north slope just outby the 13th left entries, and splits to the right and left near the face of the main north entries. The left split ventilates all the left entries and rooms off the main north entries inby 13th left, travels to the face of the 1st northwest entry, and returns through all the left entries and rooms off the 1st northwest inby 13th left, thence to the 2nd northwest entry, finally to

the fan slope connecting with the 2nd northwest and to the No. 4 fan. (See appendix II,) While this air follows several paths between the main north entries and the 1st northwest heading where the explosion occurred, it can, nevertheless, become contaminated enroute. Thus, on the day after the explosion, the air intaking to the 1st northwest heading was found to contain .22% methane and the methane content had increased to .38 percent when the air reached the intake side of the line curtain to the 1st northwest heading crosscut.

Main haulage and some secondary haulage is on intake air, however, secondary haulage in the 1st, 2nd, 3rd and 4th northwest heading regions is on air returning from working or abandoned sections as is that in the extreme southwest and northeast sections of the mine.

Further details regarding the ventilation circuits can be observed on the map of the Docena mine (appendix I).

The air is directed through the mine by means of overcasts, doors, and stoppings. A total of 12 overcasts are in use at the present time. Arched brick overcasts were built in the early days of mine operation, concrete construction was later employed, and most recent overcast construction uses steel. Approaches to overcasts are graded. Dry pack wall stoppings plastered on both sides with clay cement mortar have been used extensively, but recent practice is to build the stoppings with Slag-Tex brick. These stoppings are of hollow slag-cement blocks laid in clay cement mortar and hitched into the ribs. A few pack wall type stoppings are still erected, when Slag-Tex Brick is not readily available.

Wooden doors of the self-closing type, erected singly, are used in entries turned off the slope. Two wooden doors forming an airlock are used in the 1st northwest haulage way between 15th and 16th right entries and also in the 1st northeast haulageway between 16th and 19th right entries. Spare doors are provided at the air locks. Doors are not equipped with latches for holding them open.

Face workings are ventilated by means of line brattice. The condition of that used in the 1st northwest heading and crosscut was said to be good prior to the explosion and it was noted that wooden strips were used either at the top, or at both top and bottom of line curtain in places visited after the explosion. Observation indicates that the general method of using line brattice is good. One man is employed at each conveyor unit to maintain line curtain and carry on rock dusting. The extension of line curtain is usually done at the beginning of the shift, the curtain is supposed to be maintained within 15 feet of the face, and it was noted that sufficient brattice cloth is left at each place so that the curtain can readily be extended by the heading crews as the face advances and until the brattice man can make a more permanent extension. The principal flaw in the use of line curtain apparently lies in the practice of carrying on brushing operations beyond the last open crosscut which requires raising the line curtain to dispose of rock obtained by brushing. This practice results in at least partially short circuiting air and is believed to have had an important bearing on the explosion.

A drop curtain is used in the next to the last completed cross-cut and in some cases the two cross-cuts outby the last open cross-cut. In the 2nd northwest heading, however, an excellent practice in this respect was noted. Here stoppings had been so erected that only the last cross-cut was open. The shaker conveyor pan line from the air course heading passed through the second cross-cut where a Slag-Tex brick stopping was erected around it, leaving a small curtained opening just large enough for the pan lines.

The Docena Mine is rated as gassy by the Alabama Department of Industrial Relations. Fire bosses conduct pre-shift examinations for gas, similar examinations are conducted by section foremen on regular visits and examinations are made before and after blasting by shot firers or shift leaders. Examinations are also made by cutting machine operators before and after undercutting the coal.

Seventeen air splits are regularly measured by company engineers. However, as previously mentioned, these are not all true splits and Table 1 shows the results of air readings and air samples obtained by the writers in ventilation returns from the various sections of the mine, including main returns at the fan.

These analyses show that subsequent to the explosion, the Docena Mine was making about 708,768 cubic feet of methane in twenty-four hours. The northwest section inby 13th left entries of the mine produces about 71 percent of the total. The 1st northwest area (plus the left side of the main north) produces about 26 percent of the total methane made in the northwest section of the mine, the 2nd northwest area, about 10 percent, the 3rd northwest area about 26 percent, and the 4th northwest area about 38 percent of this total. At the time these samples were obtained, the methane content of the return from the 4th northwest area was probably more than double its usual amount due to a methane "feeder" which had been encountered in the 14th left entries off the 4th northwest. This "feeder" made it necessary to stop operations in the 14th left entries and work there had not since been resumed. The return from the 14th left entries joins the return from the 1st northwest area and goes directly to the No. 4 fan without passing through any active workings.

The above data shows that the Docena Mine is definitely gassy and that the 1st northwest district produces a substantial part of the methane made in the entire northwest section of the mine. Unfortunately the intake air for the 1st northwest heading already contains methane which was produced in active and abandoned workings between the main north and 1st northwest entries. While it probably was not an important factor in this explosion, the methane in intake air might well have contributed to the accumulation that was ignited. Placing each entry system on a separate fresh air split is obviously desirable for future operation of the Docena mine.

TABLE 1. - Air Analysis - Docena Mine
Tennessee Coal, Iron and Railroad Company
June, 1941

Laboratory No.	Location in Mine	Percent					Quantity of air, cu. ft. per min.	Methane liberated in 24 hours, cu. ft.
		Carbon Dioxide	Oxygen	Carbon Monoxide	Methane	Nitrogen		
67319	End of Curtain in 1 N. W. Heading crosscut.	0.14	20.63	0.00	0.48	78.75	No Vel.	
67320	Face 1 N.W. Hdg. Crosscut	0.17	20.11	0.00	2.70	77.02	No. Vel.	
67326	Intake Side Line Curtain 1 N.W. Heading	0.11	20.76	0.00	0.38	78.75	No. Vel.	
67325	Inby No. 2 Air Room 17 Rt. off 1 N.W.(Intake for 1 N.W.)	0.09	20.81	0.00	0.22	78.88	9,150	
67323	Last open crosscut 1 N.W. Hdg.	0.07	20.71	0.00	0.65	78.57	2,750	
67324	1 N.W. Air Course Inby 18 Left (Return from 1 N.W. Heading)	0.08	20.73	0.00	0.56	78.63	6,400	
67358	Return from Left side of N.W. Outby 13th Left	0.21	20.66	0.00	0.06	79.07	9,420 1/	
67353	Partial Return Left Side 1 N.W.	0.12	20.69	0.00	0.39	78.80	18,500)	130,300 (Min. & 1 N.W. Development area.)
67354	Same as above	0.15	20.57	0.00	0.66	78.62	2,781)	
67368	Same as above (Old workings)	0.48	20.28	0.00	0.11	79.13	10,286	
67362	Return Left Side 2 N.W. Outby 13th Left	0.38	20.52	0.00	0.07	79.03	8,250	
67361	Partial Return 3 N.W.	0.09	20.75	0.00	0.48	78.68	10,292)	130,262 (3 N.W. Devel. Area).
67355	Remainder Return 3 N.W.	0.10	20.70	0.00	0.45	78.75	9,126)	
67357	Return 4 N.W. except 14 L	0.09	20.72	0.00	0.60	78.59	10,304	89,026
67363	Return 4 N.W. Plus 14 Left	0.09	20.68	0.00	0.82	78.41	16,380	193,415 2/
67359) 67360)	Main Return from Rt. Side of Main N. and N. E. Sec. at No. 3 Fan.	0.25	20.65	0.00	0.07	79.03	48,000	48,384

1/ Total volume of two returns

2/ Abnormal methane content due to feeder in 14th Left Entries

TABLE 1. - Air Analysis - Docena Mine
Tennessee Coal, Iron and Railroad Company
June, 1941
(Contd.)

Laboratory No.	Location in Mine	Percent					Quantity of air, cu. ft. per Min.	Methane liberated in 24 hours, cu. ft.
		Carbon Dioxide	Oxygen	Carbon Monoxide	Methane	Nitrogen		
67364) 67365)	Main Return from S.W. Section of Mine at No. 1 Fan	0.29	20.51	0.00	0.13	79.07	85,140	159,408
67366) 67367)	Main Return from N.W. Section at No. 4 Fan	0.10	20.73	0.00	0.40	78.77	86,976	500,976
67356	Total Return Left side 3 N.W. All of 4 N.W.	0.05	20.80	0.00	0.05	79.10	41,412	This sample apparently contaminated

Haulage

Trolley locomotives are used for haulage throughout the mine. Sixty-pound rails are used on main haulage roads and 40-pound rails in cross headings. Sixteen and twenty-five pound rails are used in rooms. The track gauge is 36 inches. Adequate clearance is not maintained along haulage roads, and shelter holes are too few. Three-ton steel cars without end gates or floor doors are used. Company rules prohibit flying switches, and men are not permitted to ride on bumpers of cars or to couple cars while they are in motion. When it is necessary to push trips, the brakeman is required to walk ahead of the trip being pushed. Trolley wires are effectively guarded at track turnouts, and all other places where men are required to work or pass under them on main and secondary haulage roads. In mechanical sections where there is considerable activity on the haulage road near the face regions, trolley wires are guarded throughout their entire length in the active regions near the face.

Main haulage entries and their trolley wire systems are located on intake air, but developing main entries and room entries in which trolley wire has been installed are ventilated by air which has passed through active workings or through abandoned areas or by the unsealed entrances to abandoned areas.

Lighting

Fixed incandescent lights are used at all permanent electrical installations underground, at side tracks and at switches. The lights are installed in weatherproof sockets and each lighting circuit is provided with a switch so that the power can be cut off while the bulbs are being changed. Portable Edison trip lamps are used for tail lights on trips and Edison Model K permissible electric cap lamps are used by the miners for illumination. Permissible Wolf flame safety lamps are used for gas testing by all underground officials, shift leaders, cutting machine operators and shot firers. Their lamps are maintained in good condition by a full-time employee working in the lamp house.

Machinery Underground

All mechanical equipment in the mine is electrically driven. This equipment includes 17 trolley locomotives, 35 mining machines, 30 shaker conveyor drive motors, 42 car hoists, 31 mine pumps, 7 portable air compressors for rock drills, 50 coal drills, 2 Joy loaders, 5 transformers, 2 motor generator sets, 1 rock dusting machine and some miscellaneous equipment. All equipment used in face regions, as well as locomotives, pumps, compressors, etc., operate on 250 volts d.c. Motor generator sets operate on a potential of 2200 volts a.c. Armoured cable suspended in main haulage ways supplies the 2200 volts potential. Large diameter bare feeder lines supported above the trolley wire by the trolley hangers supply the 250 volts potential. These 250 volt lines together with the trolley wire are extended into areas ventilated by return air currents.

Face electrical equipment is of particular interest in connection with this explosion. 65.5 percent of the coal is mined by conveyor methods and

each conveyor unit is equipped with a control panel through which the conveyors, a car spotter hoist, a mining machine and an electric coal drill are operated. The panel is of local design and feeds three or more circuits from the single power intake line. Each circuit including the main power circuit is equipped with a circuit breaker. The main circuit breaker is automatic and the others are reset by hand. Switches and wiring are enclosed and the panel is mounted on steel skids for portability. Power reaches the mechanical equipment through rubber-covered three-conductor cable. One cable extends to the mining machine at the face and the drill is operated by plugging the drill cable into a connection on the mining machine. Non-permissible Miller plugs are used for making this connection. Cables are not sectionalized and temporary cable repairs are therefore made in the mine. Some thought has been given to the use of sectionalized cable if a suitable connector can be developed. Defective cable can then be sent to the surface for repairs and underground repairs would not be necessary.

The two Joy loaders, the 5 portable compressors and 16 of the 50 electrical coal drills are the only pieces of electrical equipment bearing approval plates of the Bureau of Mines. Twenty-eight Sullivan mining machines are of the enclosed type, but do not bear the approval plates. Three of these were inspected and all three were found to have bolts missing from the control and resistor compartments. Two electrical coal drills were in the heading cross-cut where the explosion occurred. One of these carried the approval plate of the Bureau of Mines, but had a short circuit in the cable near the drill and was not in operating condition. The other was an open-type drill and was operating at the time the explosion occurred.

Decision 13 of the Mine Safety Board of the U. S. Bureau of Mines states[5]: "The United States Bureau of Mines recommends that when electricity is used in coal mines rated as gassy or whenever in any mine the atmosphere may become gassy:

1. Electrical equipment shall be permissible.[6]

2. Non-permissible equipment shall be used only in pure intake air.

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

Actually, little, if any, of the equipment used in the Docena Mine fully meets the requirements for permissibility. Had the mining machines originally been permissible, the missing bolts would still have rendered them non-permissible. Furthermore, the "plug-in" arrangement on the mining machines for operation of drills, defeats the purpose of permissibility as far as the drills are concerned.

5/ Information Circular No. 6946, Department of the Interior, U. S. Bureau of Mines "Recommendations of the United States Bureau of Mines on Certain Questions of Safety as of October 1, 1936."

6/ Any equipment that has successfully passed scheduled tests and is officially approved by the U. S. Bureau of Mines is termed "permissible."

The electrical equipment used is well maintained in other respects, and a safety inspection of all electrical equipment is made each month. Sufficient spare equipment is kept available so that the operation of defective electrical equipment is not required. All electrical equipment, including portable electrical equipment is grounded.

Explosives

Permissible explosives, Hercoal C-1, 1-1/4" x 8" cartridges are used exclusively for blasting coal and rock. In hand loading sections the explosives are charged and fired by authorized shot firers and in conveyor sections, by shift leaders. In brushing top or bottom, the explosive is also charged and fired by shift leaders. Shots are stemmed to the collar of the hole with clay or rock dust in paper cartridges, and fired electrically with a 10-shot non-permissible, magneto-type blasting unit. Not more than one and one-half pounds of explosive are used in any one hole, but all holes are charged in a working place before any shot is fired. The shots are connected in series and fired simultaneously. Blasting cables of less than 100 feet in length are not permitted and the battery end of the cable is kept short circuited until connected to the blasting unit. Wooden tamping sticks are used for tamping the holes. Shots are fired at any time during the working shift.

Explosive is transported into the mine in an insulated explosive car. The supply crew brings in the explosive on the night shift, and distributes it to the working sections. The explosive is stored in 1-foot cubical wooden boxes with hinged lids and provided with padlocks. The explosive boxes are placed along the ribs in cross cuts and room necks, out of line of fire and a safe distance from the face. Detonators are carried into the mine in special leather bags and distributed to the working faces, where they are kept in a wooden detonator box until needed.

Drainage

The mine is moderately dry, but is wet in many places and the face regions are kept in a damp condition by watering methods. At the present time, water is being pumped out of the mine at one location and facilities have been provided for pumping water out of the mine at two other locations.

Dust

Much fine coal dust is made in the mining, loading, transportation and dumping of coal. Moreover, there is considerable spillage of coal at the conveyor loading points on the entries, and spillage of coal from the cars along the haulage roads, the coal being ground to dust by the haulage operations. This dusty condition is largely taken care of by regular track cleaning crews who keep the haulage roads fairly clean. The face regions are kept moderately damp by the application of water on the cutter heads of all mining machines while cutting coal. Pipe lines are laid to the face in all working places and no one is permitted to operate a mining machine under any circumstances without water being applied. This rule

is strictly enforced, and any infraction discovered results in immediate discharge of the person found operating a cutting machine without water. Water is not used in any of the other face operations, but some experimenting has been done in connection with the possible application of water by means of sprays at the conveyor loading heads. The company was seriously considering this measure at the time of the explosion.

Water sprays are used to spray the loaded cars as they approach the rotary dump at the bottom of the main shaft and the empty cars are sprayed with water as they leave the dump. Sprays are also installed under the dump to wet the coal as it discharges from the cars. The roof, ribs and floor of the entry in the vicinity of the dump are kept free of dust and thoroughly wet by the application of water from a hose. Shaft bottom dust conditions in the vicinity of the dump are therefore excellent.

Rock dust

The rock-dusting practices at this mine are good, and in most respects compare favorably with the best rock-dusting practices anywhere. Rock dust is applied to the roof, ribs and floor of all working places by hand as the faces advance. The hand rock-dusting is done by persons especially designated to do this work, usually the brattice man, who applies dust in the face of each working place every shift. No working place was observed during the investigation where the rock-dusting was more than three cuts back from the face.

In the haulage entries, hand rock-dusting is followed up by the application of rock dust by machine. A high-pressure rock-dusting machine is used for this purpose, and rock dust is introduced into the trackless entries near the face regions through a hose connected to the dusting machine.

Rock-dust samples are collected at numerous locations along haulage roads each month, and the incombustible content is determined by means of a volumeter. A review of the official report of this sampling and analysis for the month of May indicated that samples were collected at 42 locations in the mine. The highest incombustible content on the roof and ribs was 86.2 percent, and the lowest was 57.0 percent. Only one of these roof-and-rib-samples was below the required 65 percent; the highest incombustible content on the bottom was 86.2 and the lowest 35.4. Twenty of these bottom samples had an incombustible content in excess of the required 65 percent, and 16 had less than the required incombustible content. However, none of the above samples were collected in air courses.

Dust samples were also collected by representatives of the Bureau of Mines in connection with this investigation and are shown in Table 2.

TABLE 2. - Analyses of Dust Samples Collected in the Docena Mine Tennessee Coal, Iron and Railroad Company, Adamsville, Ala. June 4 to June 10, 1941.

Laboratory No.	Location in Mine	Kind of Sample	Percent			Remarks
			Combustible V+F.C.	Incombus. Moist. & Ash	Through 20-mesh	
64004	Right Aircourse 1 N.W. Entries 180' inby 18th Right.	Rib and Roof	70.5	29.5	77.9	In Explosion Area
64005	Do.	Road	72.1	27.9	71.3	Do.
64006	Between 1 N.W. Entry & Right Aircourse in 19th Right	Rib & Roof	56.4	33.6	74.9	Do.
64007	Do.	Road	73.8	26.2	73.9	Do.
64008	In 1 N.W. Entry 25' inby Last Open Crosscut	Rib & Roof	68.9	31.1	85.3	Do.
64009	Do.	Road	72.9	27.1	62.9	Do.
64012	Last open crosscut between 1 N.W. Entry and Aircourse.	Rib & Roof	29.6	70.4	73.3	Do.
64013	Do.	Road	72.1	27.9	80.0	Do.
64034	Left Aircourse 1 N.W. 30' inby 18th Left	Road	55.4	44.6	69.4	Do. (Rib & Roof too moist to sample)
64028	#2 Rt. Aircourse 1 N.W. Outby last crosscut	Rib & Roof	60.8	39.2	18.2	In Explosion Area
64029	Do.	Road	73.9	26.1	21.8	Do.
64002	1 N.W. Entry 10' inby 17th Right	Rib & Roof	17.0	83.0	85.6	Near and outside Explosion Area
64003	Do.	Road	24.9	75.1	83.4	Do.
64014	1 N.W. No. 1 Right Air-Course at 17th Right	Roof & Rib	31.9	68.1	72.8	Do.
64015	Do.	Road	71.6	28.4	75.5	Do.
64030	1 N.W. No. 2 Right Aircourse at 17th Right	Rib & Roof	24.1	75.9	90.1	Do.
64031	Do.	Road	38.5	61.5	83.6	Do.

TABLE 2. - Analyses of Dust Samples Collected in the Docena Mine Tennessee Coal, Iron and Railroad Company, Adamsville, Ala. June 4 to June 10, 1941. (Cont'd.)

Laboratory No.	Location in Mine	Kind of Sample	Percent			Remarks
			Combustible V+F.C.	Incombus. Moist. & Ash	Through 20-mesh	
64010	1 N.W. Left Aircourse 40' inby 17th Left	Rib & Roof	57.4	42.6	49.5	Near and outside explosion area
64011	Do.	Road	66.9	33.1	82.1	Do.
64016	270' from face 18th Left Entry off 1 N.W.	Rib & Roof	42.3	57.7	41.2	Do.
64017	Do.	Road	39.5	60.5	72.6	Do.
64018	270' from face 18th left Aircourse off 1 N.W.	Rib & Roof	32.9	67.1	37.5	Do.
64019	Do.	Road	56.5	43.5	20.0	Do. Development similar to that in explo. area and not affected by explosion.
63990	50' from face of 4 N.W. Aircourse	Rib & Roof	40.6	59.4	71.8	Same - (Hand rock dusted)
63991	Do.	Road	41.5	58.5	57.2	Do.
64022	45' from face of 4 N.W. Entry	Rib & Roof	60.1	39.9	65.7	Do.
64023	Do.	Road	52.2	47.8	60.3	Do.
64020	4th N.W. Entry 10' inby 18 Right	Rib & Roof	8.3	91.7	83.0	Same - (Machine dusted)
64021	Do.	Road	28.2	71.8	88.4	Do.
63996	4th N.W. Aircourse inby 17th Left	Rib & Roof	45.8	54.2	64.2	Do.
63997	Do.	Road	49.5	50.5	46.5	Do.
63992	Main North Left Aircourse inby 7th Right	Rib & Roof	59.9	40.1	44.9	Unaffected portions of Mine.
63993	Do.	Road	60.5	39.5	40.7	Do.
63994	Main North Entry inby 7th Right	Rib & Roof	8.1	91.9	79.1	Do.
63995	Do.	Road	48.3	51.7	59.4	Do.

TABLE 2. - Analyses of Dust Samples Collected in the Docena Mine
Tennessee Coal, Iron and Railroad Company, Adamsville, Ala.
June 4 to June 10, 1941. (Cont'd.)

Laboratory No.	Location in Mine	Kind of Sample	Percent			Remarks
			Combustible V+F.C.	Incombus. Moisture & Ash	Through 20-mesh	
64024	Main North Right Aircourse inby 7th Right	Rib & Roof	33.7	66.3	53.7	Unaffected portions of mine.
64025	Do.	Road	31.3	68.7	61.0	Do.
63998	Aircourse of 4th Left off Main North	Rib & Roof	64.8	35.2	33.6	Unaffected portions of the mine.
63999	Do.	Road	73.9	26.1	12.3	Do.
64000	4th Left off Main North (Entry)	Rib & Roof	11.2	88.8	94.1	Do.
64001	Do.	Road	22.2	77.8	75.4	Do.
64026	13th Left Entry 250' inby 3 N.W.	Rib & Roof	19.7	80.3	82.3	Do.
64027	Do.	Road	21.3	78.7	80.0	Do.
64032	1/2 N.W. Entry 25' outby 8th Left.	Rib	7.1	92.9	95.7	Do.
64033	Do.	Road	7.4	92.6	88.1	Do.
64035	3rd N.W. Entry at 15th Left	Rib & Roof	13.6	86.4	90.9	Do.
64036	Do.	Road	56.9	43.1	49.4	Do.

These analyses emphasize certain weaknesses in these rock-dusting practices such as failure to re-rock-dust trackless entries, failure to keep haulageways cleaned up in face regions, and, apparently, failure to apply a sufficiently heavy coating of rock dust where hand rock-dusting is done. Analyses of rock dust samples collected by the writers show that in a face region similar to that in which the explosion occurred (4th N.W. Entries) the incombustible content of the dust sampled, was, with two exceptions, well below that believed necessary to render the dust non-explosive. Of the 36 samples collected outside the area affected by the explosion, 19 contained less than 65 percent incombustible material and ranged from 61.5 percent down to 26.1 percent. Samples in main haulage entries (both haulageways and air courses) were generally higher in incombustible content than samples collected near face regions. Very few of the haulage entry samples contained less than 65 percent incombustible, but a notable exception were two samples collected in the face region previously mentioned. These two samples contained 39.9 percent and 47.8 percent respectively. Furthermore, only a few of the samples obtained in aircourses exceeded 65 percent incombustible content.

These data indicate that face regions and aircourses need more attention than they are now receiving. At the present time there are no means for re-rock-dusting aircourses and they thus provide a possible avenue for dust explosions. Immediate steps should be taken to correct this condition.

Samples collected near and outside the explosion area indicate that there was sufficient rock dust present in both entries and aircourses to have played an important part in arresting the explosion and it is therefore believed that the rock dust, aided by general dampness and pools of water, did actually stop the explosion. Thus the foresight displayed in rock-dusting the Docena Mine was substantially rewarded.

First Aid and Mine Rescue Training

First aid training has been conducted at the Docena Mine by the Company for a number of years. A co-operative program with the Bureau of Mines was begun in May 1940, and in the period beginning July 1, 1940 to the present time, 201 certificates have been recommended for Docena employees by the Bureau. The training is supervised by Dr. O. E. Wilson of the Company and a full-time instructor holding a Bureau of Mines' First Aid Instructor's Certificate is employed to conduct classes and maintain first aid equipment. Cylindrical tubes containing blankets, splints and bandages are located in every working section and at some other locations. Splint stretchers are limilarly located. The first-aid instructor inspects and reports on the condition of this equipment every month. First-aid kits are carried on all locomotives and motormen are held responsible for them.

Mine rescue training has been conducted by the Bureau of Mines at Docena for a number of years. Early in 1940 the Central Mine Rescue Station for the Tennessee Coal Iron and Railroad Company, which is located at the Docena Mine, was overhauled and the mine rescue equipment

placed in first class condition. Arrangements were made with the Bureau of Mines to conduct mine rescue training two days a month and train 12 employees from each of the four mines of the Company. The training schedule is so arranged that each member receives 7 hours of mine rescue training every two months. The team members are carefully selected and receive physical examinations every six months.

Mine rescue equipment consists of 19 Gibbs, 2-hour oxygen breathing apparatus (18 in good condition), 25 all-service gas masks, a high pressure oxygen pump, carbon monoxide detector, methane detector, flame safety lamps, oxygen inhalator, field telephone, an adequate supply of spare parts, oxygen and cardoxide. An excellent "smoke room" is provided for training purposes and part of the training is conducted underground. Since the equipment is used two days a month, it remains in good operating condition.

Safety Organization

The Tennessee Coal, Iron and Railroad Company maintains an elaborate safety organization headed by the Chief Inspector of Coal Mines, who is directly under the general superintendent. For safety inspections, an assistant chief inspector, 2 safety inspectors, and an electrical and mechanical inspector are employed. A superintendent of ventilation, head ventilation inspector and local ventilation inspectors (one at the Docena Mine) are also part of the chief inspector's staff.

The report system is also very complete. Some of the reports handled by this staff are as follows:

1. Individual fire boss' report.
2. Daily report of occurrence of methane for each mine and for all mines.
3. Section ventilation report by section foreman (twice monthly).
4. Monthly ventilation report showing air quantities at intakes, last crosscuts and returns of each split, including methane detector readings, also report on condition of fans and auxiliary fan drives, fan explosion doors, etc.
5. Daily report by rock dust machine operator showing all places machine rock-dusted each day.
6. Monthly reports of electrical and mechanical inspector showing condition of equipment at each mine.
7. Monthly report of dust sampling and analyses for incombustible matter.
8. Monthly inspection reports by safety inspectors.
9. Accident investigation reports.

Some of the above reports such as that for accident investigation actually involve the making and assembling of several reports from various sources.

The report system of this department is the most complete that either of the writers has seen and was the source of valuable information concerning mine conditions prior to the explosion.

Of special interest is an evaluation system used to determine the relative standing of mines and sections as regards safety. Features of mine and equipment condition, as well as practices, are weighted according to their importance and by following an inspection form, the inspector is able to set a figure (percentage) which shows the extent to which a section or mine meets the company requirements for safety.

Data from the reports of the safety staff are sent direct to the general superintendent.

Supervision and Discipline

Excellent supervision is maintained at the coal mines of this company. The regular supervisory force in the Docena mine on day shift (436 men) includes the superintendent, general mine foreman, assistant mine foreman, 5 district foremen and 6 section foremen. In addition, an engineer, a mine electrician, assistant mine electrician, dispatcher, and ventilation inspector are employed. In conveyor loading sections, each conveyor crew is headed by a shift leader. A fire boss examination is made prior to the day shift. The section foremen on day and afternoon shifts conduct the fire boss examinations for the subsequent shifts.

The regular supervisory force is supplemented by the general superintendent's staff, and the chief inspector's staff so that all working places receive two or more daily visits from some supervisory official.

Observations while in the mine indicate that supervision is effective since few violations of state law or company rules were noted. Violations of certain rules call for discharge, and the machine operator in the 1st N.W. slope heading had been discharged two days prior to the explosion for failing to use water on the cutter bar of the machine when cutting the place. New rule books now partially completed specify the disciplinary action which must be applied for rule violations.

Commendable Safety Practices

Many excellent safety practices are followed at the Docena Mine. The following are commendable practices observed or brought to the attention of the writers:

General

1. All underground employees wear hard hats and hard-toed shoes.
2. Permissible electrical cap lamps are used by all mine employees, and permissible flame safety lamps are used for gas testing.

3. No smoking, cigarettes, matches, or open lights are permitted in the mine.
4. Safety bulletin boards are installed at the mine entrance.
5. A monthly safety magazine is distributed to all employees.
6. Directional signs are installed underground.
7. All lost time accidents are thoroughly investigated and reports made showing cause and responsibility.
8. A man is employed to conduct first aid training and maintain first aid equipment underground.
9. Monthly safety inspections are conducted, including inspections of mechanical and electrical equipment.

Haulage:

1. Men walk to the bottom of the main slope and special cars equipped with drags are used for hoisting men out of the mine.
2. Drags are provided for trips operating on grades.
3. Locomotives are equipped with headlights and warning signals.
4. Trip lights are used on the rear end of all trips.
5. No one is permitted to ride loaded trips except the haulage crew, unless an empty car is provided.
6. Flying switches and coupling moving cars are prohibited.
7. Pushed trips are preceded by the trip rider on foot.
8. Good switch throws are provided.
9. Movement of main line trips is controlled by a dispatcher and block signals are used.
10. A first aid kit is kept on each locomotive.
11. Trolley wires are guarded at all points where men ordinarily pass under them, and are guarded full length in working entries.
12. Trolley wire is exceptionally well suspended.

Mining:

1. A systematic timbering system is used.
2. Face examinations for inflammable gas are made before and after cutting, and before and after shooting.
3. Permissible explosive fired electrically is used.
4. Drill holes are stemmed to the collar with incombustible material.
5. Enclosed type electrical equipment is used to some extent.
6. Electrical control panels placing face equipment on separate protected circuits are used.
7. All electrical equipment including portable electrical equipment is grounded.

Ventilation and Dust:

1. Line curtains are erected with wooden strips at the top and sometimes at both top and bottom.
2. Monthly methane determinations and ventilation readings are made by engineers and twice monthly ventilation readings are obtained by section foremen.
3. A very complete system of ventilation and gas reports is in use.
4. Hollow block stoppings hitched into the rib are used extensively.
5. Spare doors are provided at air locks.
6. Fans have auxiliary drives, explosion doors, and two of the three fans are reversible.
7. Fan auxiliary drives are operated for two hours or more each week.
8. Water is used on the cutter head of all mining machines.
9. Rock dust is maintained within three cuts of the face by hand dusting methods..
10. Machine rock dusting is done regularly on haulageways and air courses are machine rock dusted at least once.
11. Track cleaning is carried on continuously on all shifts.
12. Rock dust samples are collected each month and analyzed for incombustible content.

Fire Fighting

No definite fire-fighting organization is maintained and fire drills are not held. Carbon dioxide fire extinguishers are installed at the rotary dump, at all main pump rooms, at all motor generator sets, and all other permanent electrical stations. Fire extinguishers are not provided or carried on mine locomotives, mining machines, or other portable electrical equipment.

Surface fire-fighting equipment consists of seven water hydrants and 1500 feet of 2-1/2 inch rubber-lined fire hose distributed about the surface plant. In addition, a total of twenty-six 2-1/2-gallon soda-acid type fire extinguishers, nine 20-pound carbon dioxide extinguishers, one 1-gallon carbon-tetrachloride, and two 2-1/2-gallon Foamite extinguishers, are distributed through the surface plant.

An adequate supply of water for fire fighting is assured by means of connection with the supply for the City of Birmingham, Alabama.

All of the fire-fighting equipment is inspected and quarterly reports submitted by the Tennessee Coal, Iron and Railroad Company fire chief.

No fire drills are conducted.

Mine Conditions Immediately Prior to Disaster

The mine was operating normally at the time of the disaster. Government weather reports for the Birmingham District showed no abnormal weather condition. .19 inches of rain fell on the 3rd, but the weather was warm and clear on June 4th, and a barometer of 29.15 inches rose in a normal manner to 29.30 from 6:00 A.M. to 9:00A.M. At 10:00 A.M., the barometer began to fall slowly but had reached only 29:00 inches by mid-afternoon. Temperatures were also normal.

No abnormal mine conditions such as falls or ventilation interruptions were reported and it is therefore assumed that the explosion was a direct result of face conditions prior to and at the time of the ignition.

Fire boss reports on the explosion area showed few recent occurrences of gas in any of the entry headings until a few days prior to the disaster. Methane was detected with a safety lamp in the 1st N.W. heading on May 30th, at 3:00 A.M. by the fire boss; at 1:00 P.M. on the same day by the section foreman; again on May 31st, by the fire boss and on June 4th, about 8:30 A.M., by the section foreman. Methane was also detected by the fire boss in the face of No. 2 air room, 18th right off the 1st N.W. on May 30th and June 2nd. This point is on the intake for the 1st N.W. heading.

All of the above reports show the gas to have been readily cleared by extending or improving the line curtain.

The fire boss' report for June 4th showed the 1st N.W. section to be clear throughout. However, as previously mentioned, the section foreman detected gas in the face of the last cross cut at about 8:30 A.M. and immediately after shooting took place. He stated that the place was clear about two minutes later. Nevertheless, these fairly numerous gas occurrences in this area should have indicated the need for extra precaution and there is no evidence that extra precautions were adopted.

Previous Explosions

A localized methane explosion occurred in the Docena Mine about 7:45 A.M., December 31st, 1921, causing the death of 5 men, two of whom were killed by afterdamp. The methane accumulation was a result of interrupted ventilation and was ignited by an open carbide lamp.

Property Damage

Property damage was very slight. The discharge ends of the conveyors were disturbed and electrical cables were torn down. Five line and drop curtains in the face region were destroyed, three pack wall stoppings were blown out and a Slag-Tex brick stopping was slightly damaged.

Work was resumed in the 1st N.W. aircourse on the afternoon shift of June 5th, and work was to be resumed at slope heading as soon as the

aircourse had connected with the last cross cut. Operations in the rest of the mine were also resumed on the afternoon of June 5th.

Story of Explosion

On the day of the explosion, fourteen men were employed in the 1st N.W. entries. These men were as follows:

Entry Conveyor Crew	Air Course Conveyor Crew
Carl Wolfe, Shift Leader	Henry Barnett, Shift Leader
Henry C. Meyers	Ernest Washington (Colored)
Will Hamilton (Colored)	Jimmie Lee Daniel (Colored)
	Albert Jones (Colored)
Rock Crew	**Miscellaneous**
J. L. Mann, Shift Leader	William Trammell, Brattice man
Chester Wright	John Walker, Electrical Insp.
George Calloway (Colored)	Garfield Sudduth (Colored)
Leroy McWharter (Colored)	Car Trimmer

From evidence observed and from the testimony of witnesses and mine officials, the events prior to the explosion were established as follows: Between 8:30 and 9:00 A.M., A. L. Nicholson, Section Foreman, visited the 1st N.W. entry and aircourse headings. The entry heading itself had been stopped on a previous shift and the entry crew was engaged in driving a crosscut to the aircourse. Mr. Nicholson arrived immediately after crosscut shots had been fired, detected gas in the face of the crosscut with a safety lamp, requested that the line curtain be checked and about two minutes later made a second test which indicated that the place was clear. Work subsequent to that time appeared to have been normal in every respect.

The brattice man had been engaged in extending line curtains at the face of the crosscut, and later, in the air course. The position of the line curtains and the path of the ventilation circuit at the time of the explosion is indicated on Appendix III.

At the time of the explosion, the aircourse conveyor crew had "cleaned up" and was preparing to undercut the coal face. One man of this crew, Albert Jones, had gone to the last open crosscut for timber. One man was setting timber near the right rib and behind the mining machine. One man was operating the machine and the other had set the machine jack and then retreated a short distance to be "in the clear". The machine had "sumped in" for a distance of two feet when the explosion occurred. The three men at the face believed the crosscut crew had shot without warning them and that the shot had broken through to the aircourse. They immediately made their way toward the entry through the last open crosscut. All four of these men survived the explosion, and although they were affected by afterdamp and shock, only Albert Jones was burned.

The crew in the crosscut had completed undercutting. The machine had been pulled back and "parked" along the right rib. One man had been drilling, and very probably had begun drilling before the machine finished

its cut. In this case his drilling would have been interrupted when the machine finished cutting and was moved back to the right side for "parking".

About four tons of machine cuttings had been shoveled back at a point near the left rib and had not been removed from the crosscut. Dust from this pile is believed to have entered into and to have aided in propagating this explosion.

The number of holes drilled prior to "parking" the machine is impossible to determine, but the driller had completed four 6-foot bore holes, from right to left, and had drilled 6 inches of the fifth and last bore hole near the left rib when the explosion occurred. The holes were drilled near the roof and spaced about 5' apart.

The driller, Henry Meyers, was using a Chicago Pneumatic Tool Company's electric coal drill, size 471, Serial No. 8073. This is an open type drill operating on a potential of 250 volts, direct current. As is usual in the Docena mine, the immediate source of power was an electrical outlet on the mining machine. The drill was equipped with a rubber-covered, three-conductor cable (positive, negative, and safety ground) which had been spliced at a point near the drill. The splice was taped.

The drill is provided with spring type switch which must be held down while the drill is operating, and because of low coal, it is common practice in the mine for the drill to be started with the drill handle resting on the ground. After a hole of sufficient depth to safely support the augur has been drilled, the drill is raised to the shoulder and drilling continued. This practice may have been followed here and in raising the drill after drilling to a depth of six inches, the switch would probably be opened. At any rate, the explosion occurred after the drill hole reached a depth of six inches.

In the meantime, after parking the machine, the two remaining members of this crew began to eat lunch on the intake side of the line curtain just to the rear of the machine. Their dinner buckets were found with the lids off and food in the buckets was burned and blackened by the explosion. After the explosion, the driller reached a point near the center of the crosscut at the face before collapsing and the two others reached the outby end of the crosscut and fell across the pan line. All three were dead when found. The drill was found beside the left rib and the end of the augur was still resting in the drill hole. The coke on timbers indicated an enveloping flame in the crosscut and lack of violence at this point was further indication that this was the point of ignition.

The rock crew was engaged in brushing rock from the bottom of the entry heading and this work had progressed to a point where the face of the grade work was about 25 feet past the inby rib of the last open crosscut. The grade work was about 12 feet wide, carried along the right rib of the entry and on the intake side of the line curtain. The slope heading is about 30 feet wide and rock from brushing operations is "gobbed" along the left rib. In order to dispose of the rock from brushing operations

which have advanced beyond the last open crosscut, it was customary to raise the line curtain for short periods. On the day of the explosion the curtain had been raised at two points a short distance apart. At the outby point, rock was being shoveled under the conveyor and at the inby point, over the conveyor. Two men on the opposite side of the conveyor relayed the rock to the gob pile.

The curtain was raised by catching the lower edge over the top of the timber on which the curtain was hung, or on a nail near the top of the timber. Testimony of the rock crew failed to show definitely whether or not the curtain was still in the raised position immediately prior to the explosion or at the time it occurred, or show how long it had been raised. At any rate, such openings in the curtain would short circuit much, if not all, of the air and an accumulation of methane at the face of the cross-cut would be likely to result.

In addition to the above disturbance of the line curtain, testimony brought out the fact that it was subsequently moved about two feet toward the pan line for a length of at least 12 feet inby the point where it had been raised by the brattice man and the rock crew shift leader, J. L. Mann. This rearrangement took place during the early part of the lunch hour which would bring it within twenty minutes of the time of the explosion. Since the bratticeman was seen to leave the face of the heading a few minutes before the explosion, he had presumably continued his adjustment of the line curtain after moving it as described above.

Thus, there is additional liklihood that the methane accumulated in the face of the cross-cut as a result of air leakage or short circuit through openings in the line curtain.

An open door in the 18th left presents another possibility for a ventilation short circuit. Air would then be permitted to pass directly from the 19th right entry to the 18th left entry without reaching the face of the 1st N.W. heading cross-cut or the face of the left aircourse. This door was not completely self-closing following the explosion, but may have been out of adjustment as a result of the explosion.

Leakage or openings through the drop curtains in the 19th left entry and aircourse would also have reduced the volume of air reaching the heading.

Disturbance of the line curtain remains the most likely cause of the methane accumulation; however, the other possibilities suggested reveal several weaknesses in the face ventilation system.

There was also testimony that Carl Wolfe, Shift Leader of the cross-cut conveyor crew, was not thoroughly familiar with the use of the flame safety lamp. Wolfe replaced the shift leader discharged two days previously for operating the cutting machine without water on the cutter bar. Mann testified that the section foreman had asked him (Mann) to examine Wolfe's place on Monday because of the latter's inability to properly use a lamp, and that he had not only examined the place, but had "lost his light" in an explosive mixture of methane. This indicates

that Mann's skill with the lamp is questionable, and discloses that at least one occurrence of methane in this crosscut was not reported. It may explain why the explosive mixture of methane and air which was ignited was not discovered, since Wolfe may have been incapable of making a proper examination, or may have failed to do so, after undercutting.

About 11:00 A.M., the rock crew retired to a point between the 19th right entry and aircourse (see Appendix III) for lunch. According to testimony they had nearly finished lunch and would soon have returned to work when the explosion took place.

The "car trimmer" had loaded four cars which remained at the loading point, had shut down the conveyors and was preparing "dummies" for stemming at a point just inby the loading point and the loaded cars.

Since the bratticeman and electrical inspector were not able to testify because of injuries (the former died eight days and the latter fifteen days after the explosion) their position just prior to the explosion has not been established. Their location after the accident indicates that they were probably on their way out of the 1st N.W. entry at the time of the explosion.

The section foreman was in the last crosscut of the 18th right with two engineers who were obtaining ventilation readings. The force of the explosion knocked the anemometer from the hand of one engineer and bent the vanes but did no other damage. The section foreman instructed one engineer to call out the 15 men employed in the 18th right entries and proceeded to the 1st N.W. entry where he encountered the bratticeman, who was seriously burned. The bratticeman was sent to the main haulage road on 13th left off the main north entries. A man was sent to call out the 19 men in 18th left entries, 20 men in the 17th right, 16 in 17th left and 18 in 16th left.

The section foreman then proceeded toward the face of the 1st N.W. entry, heard cries, and located the electrical inspector, also badly burned, at the car hoist. He returned to 18th right with this man, then started again toward the face, making his way as far as the loaded cars before finding a third man (Daniels) "down" at the outby end of the cars. He was unable to lift this man. One of the engineers joined him at this point and the two men were unable to handle Daniels. At this time, a third man arrived and the injured man was returned to 18th right.

Help continued to arrive and the rescue work proceeded with the remainder of the injured found as indicated on the attached map. These men were placed in the 19th right aircourse where they received first aid before they were moved further.

All of the men except the three working in the face of the last crosscut were thus accounted for and it was necessary to restore the line curtain from the last open crosscut to the entry heading before these men could be reached. Two were found dead in the entry heading as shown on the map. The body of the third man was recovered from the face of the crosscut by men wearing oxygen breathing apparatus.

The line curtain was later extended into the crosscut clearing it sufficiently for inspection within a short time.

The time of the explosion was definitely fixed at 11:20 A.M., since one of the engineers had just set down the time for beginning his anemometer reading. Recovery work was completed shortly after 2:00 P.M. and the last of the injured and dead were brought to the surface at 2:30 P.M. A.L. Nicholson, section foreman, who directed the recovery operations, rescued or assisted in rescuing all of the injured and assisted in recovering two of the bodies, showed commendable courage and resourcefulness. C.N. Van Houton, Junior Engineer, who was first to assist Mr. Nicholson, and assisted throughout with the recovery operations, had only three months experience in coal mines. His courage was, therefore, also commendable.

The two men slightly injured in the 17th right were unloading a car of timbers in No. 2 room and just off the haulageway. The force of the explosion knocked both men down. One was struck by flying debris and the car rolled against the leg of the other. Both made their way out to the main haulageway unassisted.

Rescue Crew

The oxygen breathing apparatus crew, composed of Docena mine employees, some of whom were working in the mine at the time of the explosion, began arriving at the rescue station at 12:10 P.M. Two fully equipped six-man crews were at the scene of the accident about 12:50 P.M., one crew went under oxygen at 12:55 P.M. and had recovered the body of Henry Meyers ten minutes later.

The other crew began an exploration on the return side from the explosion at 2:00 P.M., traveling under oxygen. This exploration was completed at 4:00 P.M., and since they were no longer needed the crew members then left the mine.

During the period, five additional members were standing by at the rescue station and thirty-three additional rescue men were available at other mines of the company.

P. M. Cassidy, Assistant Chief Safety Inspector, was in charge of the rescue station while Arthur Waldman, Assistant General Superintendent of Coal Mines, directed the rescue crew at the scene of the accident.

Forces, Heat and Flame

After study of the evidence, the action of the explosion itself is believed to have been as follows: The gas ignition at the face raised coal dust in the immediate face area and from the pile of machine cuttings. This dust entered into the explosion aiding it in traveling outby to where the rock crew was located. The line curtain was torn down but up to this point the violence was limited although the rock crew members and the "car trimmer" were knocked down and burned. The coke found in the last open crosscut indicated that the flame or heat had also greatly decreased before reaching the left aircourse, and a sack containing 39 sticks of

permissible explosive, lying along the left rib of this crosscut, was undisturbed. However, new fuel appeared to have been picked up from the roadway at the discharge point of the conveyors and from the loaded cars. Somewhat increased heat or flame and violence appeared to radiate outby from this point and the two most seriously burned survivors (brattice man and electrical inspector) were outby this point. The explosion entered both right and left aircourses through 19th right and 19th left, traveling out to the 18th right and left entries. At the same time, it continued to the 18th right in the main entry. Lack of fuel due to rock dusting apparently caused it to die out without passing the 18th right and left entries. The explosion apparently did not enter the extreme right or "barrier" aircourse due to the pools of water which are indicated on Appendix III.

The force of the explosion carried as far as the 17th right and left entries; two men were slightly injured at No. 2 room in the former and a stopping was blown out in the 4th crosscut from the face in the latter. Dust and smoke traveled as far as the 14th right and left entries.

Factors that Prevented the Spread of the Explosion

The explosion was confined to the first northwest entry and its right and left aircourse and did not extend beyond 18th right entry or 18th left. It was undoubtedly started by the ignition of a small body of methane in the face of the last crosscut off 1st northwest entry and was propagated by coal dust from the slack pile at the face of this entry, coal dust from the tops of the loaded cars at the conveyor loading point, and from the road in the vicinity of the conveyor loading point where considerable coal dust had accumulated from spillage.

The explosion was prevented from spreading further by the liberal application of rock dust in the 1st N.W. entry and in the 18th right entry, and by the somewhat limited application of rock dust in the parallel air courses. Another factor was the presence of moisture in the section. The roof and ribs were fairly damp, and there was a pool of water at the intersection of the 1st N.W. left aircourse and the 18th left aircourse. There were also pools of water in the last crosscut between the 1st N.W. right aircourse and the barrier aircourse and at two locations in the barrier aircourse. The writers are of the opinion that had it not been for the use of rock dust, and the presence of moisture, mainly due to the use of water on the cutter bars of the mining machine, the explosion probably would have spread throughout the mine. Had the explosion been only slightly more intense it is probable that 65 men who were working in another section on the return air circuit from the affected area would have been killed.

Investigation of Cause of Explosion

An investigation of this disaster for the State of Alabama was conducted by E. J. McCrossin, Chief, Division of Safety and Inspection, Alabama Department of Industrial Relations, assisted by District Mine Inspectors J. H. Chapman and J. A. Ivie.

The investigation for the company was conducted by a group of officials headed by Mr. R. E. Kirk, General Superintendent of Coal Mines, Tennessee Coal, Iron and Railroad Company.

M. J. Ankeny, Mining Engineer, and E. A. Anundsen, Acting District Engineer, of the United States Department of the Interior, Bureau of Mines, conducted the investigation for the Bureau of Mines. Complete cooperation existed among the Bureau of Mines, the Alabama Department of Industrial Relations, and the operating company in conducting the investigation.

Summary of Evidence as to Cause, Origin and Propagation.

The operating company, the Alabama Department of Industrial Relations, and the Bureau of Mines investigators are in complete agreement as to the cause of this explosion.

The absence of roof falls, the lack of destructive forces in the mine at the time of the explosion, and the opportunity to interview numerous survivors who were in the midst of the explosion leave little doubt as to its cause and origin.

Explosive gas was being liberated in the 1st N.W. entry previous to the explosion. An examination of the fire boss records show that methane was detected in this working place on several occasions prior to the explosion. A sample of air taken by a Bureau of Mines investigator at the intake to the section at 9:45 P.M. on the day of the explosion contained .22 percent methane in 9,150 cubic feet of air. A sample of air taken in the left aircourse, 30 feet inby 18 left aircourse, the return from the explosion area, at 3:15 P.M., on the following day, contained .56 percent methane in 6,400 cubic feet of air. A sample of air taken at the face of the last crosscut of 1st N.W. entry, the point where the explosion originated, at 3:30 P.M. on the day of the explosion, contained 2.70 percent methane.

The cutting machine at the face of the left aircourse, 1st N.W. entry, was in operation at the time of the explosion: but the men who were at the face were not burned, and their testimony that the explosion did not originate at the face of the aircourse was conclusive.

No coal was being loaded at the time of the explosion, and it is evident that the open-type motor drives for the shaker conveyors were not in operation. Further proof of this was the fact, established upon questioning the survivors, that no one was at the controls of the conveyor system when the explosion occurred.

The mining machine at the face of the last crosscut off 1st N.W. entry was not in operation. This machine had finished its work of undercutting the coal and was stationed on the right side of the place in its normal position while idle. Four 6-foot boreholes were drilled in the face, and the fifth hole which was to be the last, was just started and

in about 6 inches. The auger was found up against the hole with the open-type drill still attached. The body of the man who was operating the drill was found about 10 feet away near the face.

The blasting unit, and blasting unit cable which was rolled up, were found on the right corner or the rib at the intersection of the left air-course and the last open crosscut. No blasting was being done at the time of the explosion.

While there is no survivor who can testify that the drill actually was in operation at the time of the explosion, circumstantial evidence indicates that it was, and further, an accumulation of methane was ignited by a spark or arc from the starting switch or from the commutator of the drill. The non-permissible coal drill repeatedly ignited methane in a test chamber when its starting switch was opened.

A flame safety lamp found near the drill was tested in a gas chamber and found to be in safe condition.

Clothing of the men killed and injured in the explosion was searched without finding matches or any smoking material.

As to the cause of the accumulation of explosive gas, no evidence could be found that would indicate a general interruption of the ventilating current; moreover, the recording pressure gage chart from the fan shows that the fan was in continuous operation before and after the explosion. An interruption of the ventilating current for the whole split is highly unlikely, as the air circuit is effectively locked on this split. The doors are designed to be self-closing, and they are not equipped with latches for holding them open.

There is ample evidence to indicate that there was a short circuit of the ventilating current at the face of the last crosscut off the 1st N.W. entry a short time previous to the explosion. A line brattice was installed from the last open crosscut, across the conveyor, and paralelling the conveyor to a point near the face of 1st N.W. entry. From there it extended into the crosscut to within about 15 feet from the face. The brushing on the entry had progressed to a point about 25 feet beyond the inby rib of the last open crosscut. To dispose of the rock that was being moved in the grading operation, it was the practice to raise the line brattice by fastening its bottom edge to the cap pieces on the timber and throw the rock over or under the pan line into the gob. This practice resulted in intermittent short circuits of air, and the seriousness of the interruptions would depend upon the length of time the line brattice was disarranged and the rate of liberation of gas at the face. Subsequent shifting of a section of this line brattice by the bratticeman and rock crew shift leader probably aggravated the conditions.

Questioning of the survivors who were members of the rock crew revealed that rock was being handled in this fashion up to about 11:00 A.M., when they ceased work to eat their lunch. Conflicting testimony was given as to whether or not the line brattice was put back in place when the men

stopped to eat. The explosion occurred at 11:20 while the men were still at the positions they had taken to eat their lunch. There is no doubt that the raising of the line brattice to enable the rock men to shovel rock into the gob, (and possibly the subsequent shifting of this line brattice) caused a short circuit of air and permitted the accumulation of gas at the face of the last crosscut off 1st N.W. entry.

It would seem that a properly conducted examination with a flame safety lamp at the face of the crosscut, subsequent to undercutting, should have detected the presence of methane. The testimony concerning Wolfe's lack of familiarity with the safety lamp introduces the possibility that Wolfe failed to make the required examination or did not make it properly.

Probable Cause of the Explosion

After carefully considering evidence and information obtained throughout the investigation, the results of analysis of dust and air samples collected in the mine, and the careful questioning of survivors in the hospital, the Bureau investigators are of the opinion that this explosion originated in the face of the last crosscut off 1st N.W. entry, that the ignition of gas was caused by an arc or spark from a non-permissible electric drill, that the explosion was propagated to a limited extent by coal dust, and that the accumulation of gas was caused by an interruption of the ventilating current at the face resulting from the disarrangement of a line brattice to enable the transfer of rock from the haulage road into the gob.

Lessons to be Learned from the Conditions As They Relate to This Explosion.

Numerous increased explosion hazards are introduced by the extensive mechanization of coal mines; therefore, increased precautions must be taken if gas and coal-dust ignitions and explosions are to be prevented. The rapid advancement of working faces, the opening up of new territory, and the fast penetration of workings into new coal liberate methane much more rapidly than under previous hand-loading methods. The coal-dust explosion hazard is also increased by the production of greater quantities of dust in a shorter time due to the more rapid advancement of the faces and the mechanical handling of coal. Accompanying these increased hazards of gas and dust are additional ignition hazards introduced by mechanization. Unless adequate precautions are taken to remove the possibility of electrical arcs and sparks from the working faces, explosions such as this cannot be avoided.

The most outstanding lesson to be learned from this explosion is the obvious fact that no electrical equipment that will produce arcs or sparks that will ignite gas or coal dust should be used at or near any working face; moreover, the Bureau of Mines believes that only permissible electrical equipment should be used in other than pure intake air fresh from the outside. Permissible equipment, however, will give protection against gas and dust ignitions only if it is regularly inspected and maintained in a permissible condition at all times.

Another lesson that should be of outstanding value is the importance of maintaining a continuous flow of air at the working faces. General interruptions of the ventilating current due to the stoppage of a fan or doors being left open are serious occurrences, but almost as serious is the local interruption of the air current at a working face. Operations must be conducted in such a way that line brattices, check doors, and check curtains will not be disturbed, but will remain continuously effective.

Another striking lesson that has come out of this explosion is the use of rock dust and water as a means of preventing widespread mine disasters. Local gas ignitions from one cause or another are difficult to prevent with absolute certainty because of the extent to which the human element is involved. This explosion, however, as well as many others, has demonstrated that the propagation of an explosion throughout the mine by coal dust can absolutely be prevented by the application of rock dust to the ribs, roof and floor of all excavations, and the liberal use of water at the working faces to control the production of dust. It is believed by the investigators that the use of rock dust and the application of water at the working faces prevented the spread of this explosion and saved the lives of the 65 men who were working on the return side of the air split in which this explosion occurred. Had this mine not been rock-dusted and no water used, it is conceivable that the 432 men who were in the mine at the time of the explosion may have been killed.

Recommendations

The following recommendations, based on the circumstances surrounding this explosion and other conditions observed during the investigation, are made with the belief that their adoption will materially reduce the chances of an explosion occurring in this mine in the future.

Ventilation and Gas

1. All ventilating fans should be capable of allowing reversing of direction of air flow.

2. A warning device that will give both visual and audible warning, and a relay switch to cut off the electric power from the mine in the event of stopping or slowing down of the fan should be provided on each fan.

3. The ventilating current should be split so that not more than one set of main northwest entries will be on one primary split of air, and secondary splits should be provided for each set of room entries.

4. The use of doors for controlling ventilation should be eliminated as far as possible by the use of overcasts, but where it is necessary to use doors they should be installed in pairs to form an air lock in such a way that when one door is open the other, having the same effect on the ventilating current, will remain closed.

5. Abandoned or worked-out sections of the mine that cannot be thoroughly ventilated and inspected should be sealed with tight incombustible stoppings.

6. To avoid interference with the line brattice, brushing or grading operations should not be permitted beyond the last open crosscut.

7. Permanent stoppings in crosscuts between intake and return airways should be maintained within two open crosscuts of the face.

8. No one should be permitted to use a flame safety lamp without first demonstrating that he is fully qualified to do so.

Explosives

1. Blasting practices should be improved so as to retain the permissibility of explosives used in this mine. Requirements in addition to those now in effect are:

(a) Not more than one shot shall be charged, stemmed, or fired at any one time.
(b) Shots shall be fired with a permissible battery or other permissible firing device.

2. Consideration should be given to the use of sheathed permissible explosives, a new type of "extra safe" permissible explosive for use in coal mines.

Coal Dust

1. Machine cuttings should be loaded out of each working place before blasting.

2. The coal should be wet with water before it is loaded out.

3. Water sprays should be installed at the transfer points and at the loading head on conveyor systems.

4. Loose coal in aircourses and trackless entries should be cleaned up before machine rock-dusting is done.

Rock Dust

1. Provisions should be made for the re-dusting of trackless entries after the working faces have advanced beyond the point where it is possible to rock dust these entries through the open crosscuts.

2. In addition to the sampling of dust at points along the haulage roads, dust samples should also be collected in trackless entries.

Electricity

1. All electrical equipment used at or near the face of workings should be of the permissible type. Such equipment should be inspected for defects regularly and maintained in a permissible condition continuously.

2. Open-type electrical equipment including trolley and cable-reel locomotives should not be operated except on pure intake air (containing not less than 20 percent of oxygen and not over 0.05 percent of inflammable gas) and in no event should they be operated beyond the last open crosscut.

Acknowledgment

The writers wish to acknowledge the courtesies extended and the help given by the officials of the Tennessee Coal, Iron and Railroad Company. All information requested from the company in connection with this investigation was given without reservation. The cooperation of the Division of Safety and Inspection, Alabama Department of Industrial Relations is also gratefully acknowledged.

Respectfully submitted,

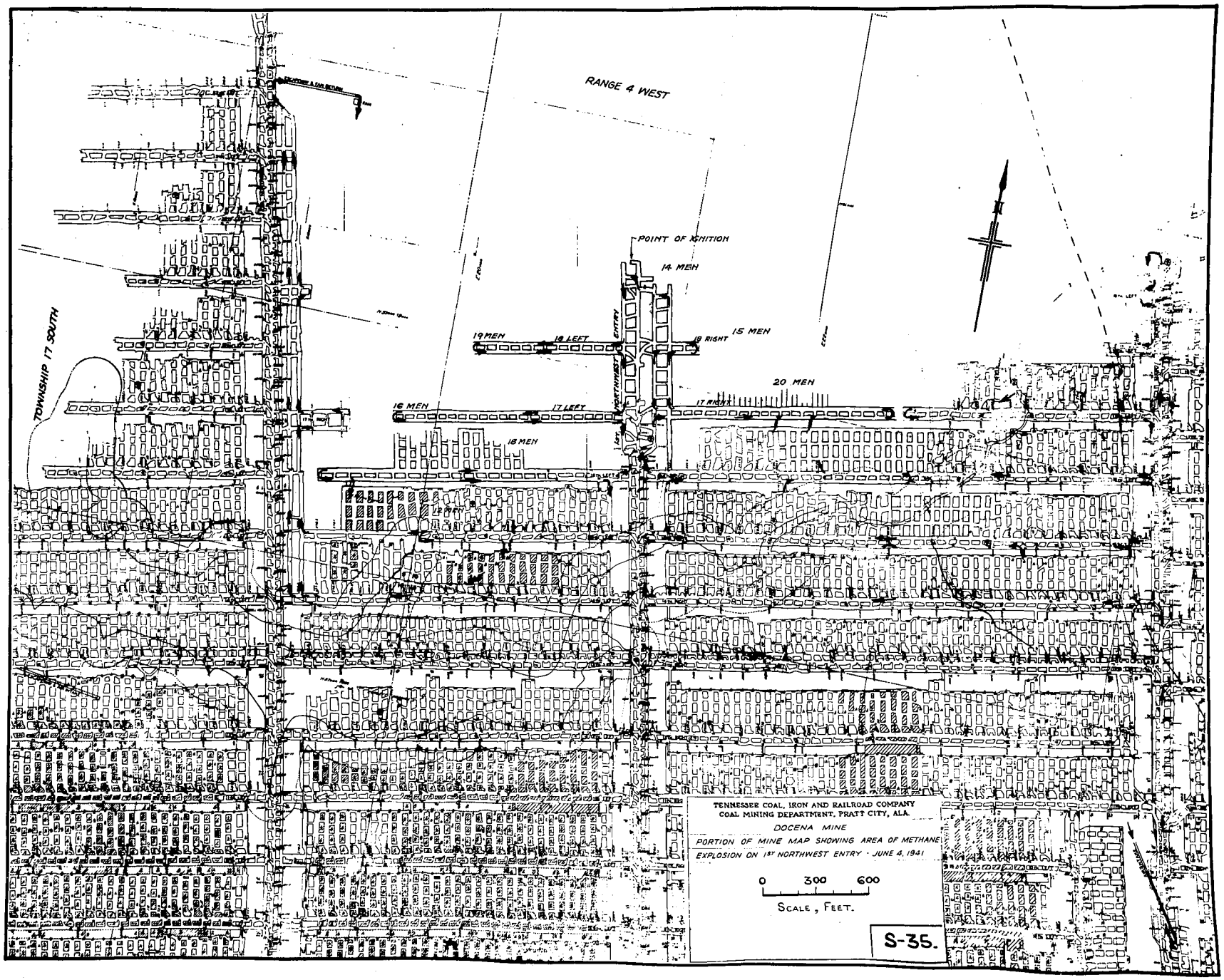
(Signed) E. A. Anundsen

E. A. Anundsen
Acting District Engineer

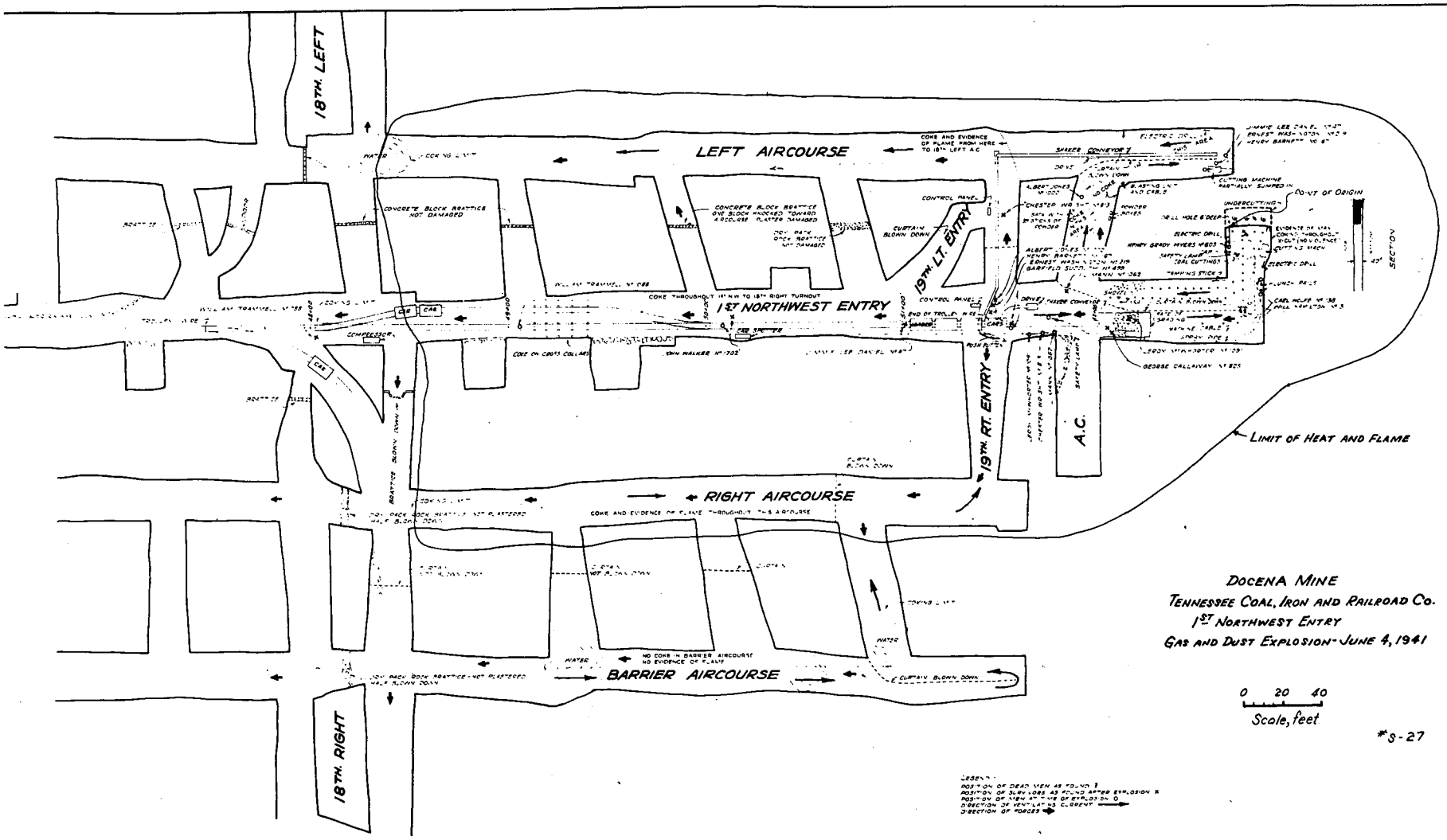
(Signed M. J. Ankeny

M. J. Ankeny
Mining Engineer

A P P E N D I X I


RANGE 4 WEST
TOWNSHIP 17 SOUTH
POINT OF ADMITTION
14 MEN
19 MEN
18 LEFT
18 RIGHT
15 MEN
20 MEN
16 MEN
17 LEFT
17 RIGHT
18 MEN
NORTHWEST ENTRY
TENNESSEE COAL, IRON AND RAILROAD COMPANY
COAL MINING DEPARTMENT, PRATT CITY, ALA.
DOCENA MINE
PORTION OF MINE MAP SHOWING AREA OF METHANE
EXPLOSION ON 1ST NORTHWEST ENTRY - JUNE 4, 1941
0 300 600
SCALE, FEET.
S-35.

A P P E N D I X II



DOCENA MINE
TENNESSEE COAL, IRON AND RAILROAD CO.
1ST NORTHWEST ENTRY
GAS AND DUST EXPLOSION - JUNE 4, 1941

0 20 40
Scale, feet

#S-27