Department of Commerce,

U. S. Bureau of Mines.

Report of Mine Explosion,

FARMVILLE MINE, CAROLINA COAL COMPANY,

Coal Glen, North Carolina,

May 27, 1925.

-By-

J. J. Forbes and C. W. Owings.

MINE EXPLOSION

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COAL GLEN, NORTH CAROLINA.

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Introduction.

An explosion occurred in the Farmville mine, Carolina Coal Company, Coal Glen, Chatham County, North Carolina, about 9:30 a.m., Wednesday, May 27, 1925, resulting in the death of 53 men, at least 3 of whom died from suffocation and 50 from a combination of after damp, burns and violence. None were rescued, although one of two men, who had entered the mine after the first explosion, was caught in a second explosion, and although hurt, managed to crawl out of the slope. Bureau of Mines representatives arrived Thursday and assisted in recovering the bodies. Recovery work was completed by 2:00 a.m. May 30, the Bureau men having recovered about 40 bodies.

General information.

The Farmville mine is situated at Coal Glen, Chatham County, North Carolina, about 8 miles northwest of Sanford, North Carolina, - the Post Office being Sanford, N. C., R.F.D. 4. A spur, connects the mine with the Norfolk Southern Railroad. The nearest railroad station is at Cumnock, 1-1/2 miles west of Coal Glen.

Ownership and operators.

The Farmville mine has been in existence probably since 1775 or earlier, as prospect openings, and as a mine from the time of the

Civil War. In 1921 the Carolina Coal Company was formed and the mine at Farmville (now Coal Glen) was obtained and by the summer of 1922 small quantities of coal were hauled by trucks to Cumnock, North Carolina. Later, a spur three miles long was constructed to connect the mine with the Norfolk Southern Railroad.

The officers of the Carolina Coal Company are as follows:

J. R. McQueen, President, Lakeview, N. C.

B. H. Butler, Vice President, Southern Pines, N.C.

H. N. Butler, Acting Supt., Coal Glen, N. C.

G. F. Hose, Mine Foreman, Coal Glen, N. C.

George Anderson, (deceased) Fireboss.

The only other mine of any importance operating in this district, and in North Carolina, is the Cumnock mine of the Erskine Ramsey Coal Company, which is about 1-1/2 miles west of Coal Glen.

GENERAL INFORMATION.

The mine entrances consist of a rock slope, 500 feet long, driven on a 33 degree pitch to intersect the coal bed, an air shaft 25 feet deep and an aircourse, which is bratticed off, but might be used as an escapeway in case of an emergency.

Coal bed.

The Farmville mine is working in the Cumnock coal bed, Triassic Age of the Carboniferous system. The coal is found in two benches; the top bench being from 36 to 44 inches thick, containing sulfur in form of pebbles, but with no distinct bands; the lower bench is from 22 to 33 inches thick, having two distinct bands of bony coal, from 1 to 3 inches

thick; a black band (carbonate of iron) parting, 18 inches thick, separates the two benches.

Only the coal of the upper bench is mined. It is jet black, very friable and has a highly developed cleavage at right angles to the strike of the bed. This characteristic tends to form considerable slack in mining.

The bed dips about 15 or 16 degrees southwest, near the outcrop, but near the face of the slope is about 10 or 12 degrees. The bed is in a faulted region, a large fault cutting the coal between 2 and 3 right, crossing the main slope at that point. The coal and overlying strata are badly broken on both sides of this fault, increasing mining hazards.

The immediate roof is a draw slate about 6 inches thick, but the main roof is a strong sandstone forming very good support. The floor is fireclay, except in rooms where the black band is left down.

A section measured in first left aircourse is representative of the bed and is as follows:

	ft.	in.
Roof - sand shale		
Draw slate	0	0-6
Coal	3	0
Black band	1	6
Coal	0	10
Bone	0	1
Coal	0	6
Bone	0	3
Coal	1	1
Floor - fireclay		
Total	7	9

The composition of the bed, as determined from analyses of samples collected in 1922 by J. J. Forbes, is given in Table 1 following:

TABLE 1.- Analyses of face samples, Farmville Mine, April 1922.

Lab. No.	Material	Location.
85590	Coal, top bench	Rib, 1 left aircourse.
85591	Coal, top bench	No. 1 cross 100 ft. inby slope aircourse.
85605	Coal, top bench	Main slope, 100 ft. outby face 750 ft. from mine portal.
85592	Composite	Lab. Nos. 85590, 85591 and 85605.
85593	Coal, bottom bench	1 left off main slope.
85596	Black band	1 left off main slope.
85594	Coal, bottom bench	1 left off main slope.
85595	Composite	Lab. Nos. 85593 and 85594.

ANALYSES - FARMVILLE MINE, APRIL 1922.

Lab.No.	Moisture	Vol. Mat.	Fixed carbon	Ash	Sulphur	B.t.u.	$\frac{V}{V+F.C.}$
85590	2.3	32.4	57.2	8.1	2.2	13630	.362
85591	1.7	32.2	58.4	7.7	2.5	13790	.355
85605	1.9	32.1	58.8	7.2	2.2	13930	.353
85592	2.0	32.4	58.1	7.5	2.3	13810	.358
85596	1.0	35.1	5.6	58.3	3.5	4270	
85593	2.0	29.0	39.2	29.8	2.7	10320	.425
85594	1.7	29.0	41.0	28.3	3.2	10520	.415
85595	1.8	29.0	40.2	29.0	2.9	10450	.419

By referring to Table No. 1 which gives the analyses of coal on "as received" basis it will be noted that the moisture content of the upper bench ranges from 1.7 to 2.3 per cent and an average, as shown in the composite sample No. 85592, of 2.0 per cent. In the black band the moisture is 1.0 per cent and in the lower bench from 1.7 to 2.0 per cent or an average of 1.8 per cent as given in the composite sample No. 85595. Road and rib dust samples, analyses of which are given in Table No. 5, have a moisture content ranging from 2.3 to 2.7 per cent or an average of 2.4 per cent. Compared with the averages of 2.0 and 1.8 per cent in

the upper and lower benches respectively, it is apparent that the dust samples have absorbed less than 1.0 per cent moisture.

The average fixed carbon in the coal of the upper bench averages 58.1 per cent while in the lower bench the average content is 40.2 per cent.

The upper bench has ash ranging from 7.2 to 8.1 per cent and an average of 7.5 per cent, as shown in the composite sample No. 85592. The average percentage of ash in the lower bench is 29.0. Even by washing this may only be reduced about 30 per cent, which is too high for commercial coal.

The heating value of the upper bench is high and compares favorably with competing coals. An average analysis gives this value as 13,810 B.t.u. The lower bench has an average of 10,450 B.t.u., while even the black band analyzed 4270 B.t.u. The heating value of this "middle man" is due to the presence of oil. It is interesting to note that in the Cummock mine an analysis of the bed, including both coal benches and the black band, has shown an average of only 14 per cent ash. If further tests substantiate predictions the entire bed may be mined and used as pulverized fuel.

Moisture and drainage.

Considerable water is found in the upper strata in the rock slope, but little water is made in the mine. The lateral entries and rooms are very dry.

Ditches direct the water from the slope into a sump in first left aircourse. A Cameron centrifugal pump, direct connected to a 35 h.p. Western Electric enclosed type motor, pumps water from this sump

for 6 or 8 hours per day. The capacity of the pump is 140 gallons per minute. Water is pumped from the face of the workings to the main sump by a Myers plunger type pump, the capacity of which is 60 gallons per minute. Immediately following the explosion this pump was replaced by a Cameron No. 5 compressed air pump, as the gaseous condition of the mine made it inadvisable to use an unapproved type electric motor. At the time of the investigation there was water in third left aircourse near the slope and in fourth left aircourse at the left slope aircourse. The face of the slope was filled with water and a "swag" in the fourth right heading at the right slope aircourse contained water level with the bed of the cars on the side track.

Gas.

The mine has been rated as gassy since operations were started by the present company in 1921. A fire boss was employed to make an examination of all working places before the shift of men entered the mine. He reported verbally to the mine foreman but made no written report.

During the investigation third left had to be cleared of gas three times and the rooms to the rise off third left heading contained an explosive mixture of gas. The face of this heading also contained explosive gas.

All gas feeders appeared to be in the lower coal bench and therefore most of the gas comes from that part of the bed. Undoubtedly large quantities of firedamp are liberated in the upper bench also.

The rooms off fourth left heading and the face of the heading itself contained an explosive mixture of gas. Two gas feeders were also

found at the face of this heading. An explosive mixture of gas was found at the face of fourth right heading and practically all of third right was in a similar condition.

A sample of air taken in the main return at the air shaft indicates (Table No. 2) that 0.34 per cent methane was present in the air, or 133,400 cubic feet was being liberated in 24 hours. Analyses also show that 0.98 per cent methane was found on the return slope aircourse below second right and 0.77 per cent methane below fourth right on the same aircourse.

Ventilation was completely destroyed by the explosion, and therefore on June 1 when these samples were taken it was impossible to obtain representative mine air samples. There was excessive leakage of air from the main slope to the return aircourse, in the upper part of the mine and therefore the sample taken at the fan shows too small a percentage of methane. Due to the existing conditions, no velocity readings were taken at other points where samples were collected. It is estimated that the 0.98 per cent methane found between second and third right is more nearly representative of the mine under normal conditions.

Development and mining system.

The mine is opened by a rock slope and two aircourses, which are driven in the coal. An air shaft, 25 feet deep, is located at the entrance to the right aircourse. The rock slope is driven 500 feet on an angle of from 33 to 36 degrees, to intersect the coal bed; the slope then continues on the dip of the coal, which is about 15 to 16 degrees at this point, but at the foot of the main slope is from 10 to 12 degrees.

The general method of mining has been the room and pillar system,

with rooms driven to the rise off the heading side of the cross or lateral entries. An occasional room has been driven down the dip from the aircourse side of the lateral entries. Due to the large number of faults and rolls encountered in the bed, development of the mine has been carried on very unsystematically. The right slope aircourse has been carried to the foot of the main slope. An aircourse on the left side of the slope has been driven about 150 feet below the second left aircourse. Continuations of this aircourse have been started in third and fourth left entries but they have not been connected.

The slope entries are driven on 60-foot centers, 10 feet wide and with 50-foot pillars between entries. Barrier pillars vary from 70 to 200 feet in width, but average about 100 feet. The lateral entries, driven along the strike of the bed are from 200 to 500 feet apart. Lifts or laterals, four each, are turned off the slope double with the exception of third right which is a single entry. Rooms are driven double to the rise of third and fourth left headings. They are about 40 feet wide, with a 30 to 40 foot pillar between rooms.

A pair of diagonal entries have been started on fourth left aircourse. They were undercut by a Goodman mining machine, which had been in use for only about a week prior to the explosion. It is intended to extend the use of this machine to other parts of the mine.

The black band and lower bench is taken up on the headings to provide proper height for haulage, and is also taken up in the room necks to make an even grade into the rooms.

Explosives.

Coal is shot from the solid with 1-1/4 by 8 inch sticks of Monobel No. 9 L.F. permissible explosive.

No. 6 electric detonators were used. Shots were fired with 2 cell and 4 cell batteries (Hot shot batteries). In selling explosives one cap was charged to the contractor for each stick of explosive purchased. The shooting was done by 4 contractors.

Holes were drilled from 1-3/4 to 2 inches in diameter. Clay tamping was found in the "guns" at several working places and it was the practice to bring in clay from outside for tamping purposes. However, in at least two places coal dust was used for tamping.

No restrictions were placed on the amount of explosives one man could carry into the mine at one time. The maximum charge for one hole was 3 sticks of explosive. Each contractor carried his own explosive into the mine in cloth sacks and the fire boss brought in the electric detonators when he entered the mine for his second examination. He (the fire boss) was supposed to examine every shot before it was fired.

Ventilation.

At the time of the explosion the mine was ventilated by the exhaust system, the main hoisting slope (rock slope) acting as the intake and the fan shaft as the upcast. The shaft is located at the top of an old slope and is about 25 feet deep, the fan being on the side opposite the explosion door. At the foot of the shaft is a single wooden door, acting as an explosion door, which was blown open, but not damaged, by each of the explosions. The fan, which was not disturbed and continued to operate after each explosion, is a Robinson 5 foot disc type fan, protected by a wooden shed, delivering about 25,000 cubic feet per minute.

The right slope aircourse is extended the full depth of the main slope, but the left aircourse is discontinued about 150 feet below second left aircourse. This portion of the mine is ventilated on a separate split taken from the main intake through the second left laterals, the quantity being controlled by a regulator in an undercast located above first left. This undercast connects with the right aircourse above the first right.

The rest of the mine is ventilated on a continuous circuit, the air current being deflected by curtains hung between the pair of laterals on the slope entries. The air is thus caused to sweep the lateral entries.

Stoppings on the main slope and slope aircourse were gob with about 6 inches of poured concrete. On the lateral entries stoppings were of gob, wood or brattice cloth. Wooden doors were used on first and second right and brattice cloth at third right, between the slope and slope aircourse.

Lighting.

Edison electric cap lamps of both model D and E types were used. The fire boss and mine foreman carried flame safety lamps. There were 18 magnetic lock, approved type Wolf flame safety lamps in the lamp house, but as the mine foreman and the fire boss each had his own lamp, those belonging to the company were not used and consequently not kept in good condition. The lamp man did not clean any safety lamps, the officials cleaning their own. The electric cap lamps were given attention by the lamp attendant.

Extra batteries and lamps were kept at an underground lamp station at second right, the hoistman having a key and exchanging batteries

at this point. A checking system had been in effect but was not being enforced at the time of the explosion. Each underground employee was given a brass check, which he was required to deposit with the lamp attendant on receiving a lamp. A fine was imposed in case a check was lost.

Along the slope electric lights were maintained at each lateral entry. As 440 volt alternating current was used in the mine, two 220 volt lights were connected in series to give the required voltage. Electric lights were installed at each pair of entries.

Haulage.

Rope haulage was used entirely in the mine. Haulage in the lateral entries is accomplished by small electric gathering hoists. They are usually placed near the inby end of the parting or turnout. A pulley is placed close to the face of rise rooms and empty cars are hoisted to the face by a 3/4 inch wire rope. The loaded cars gravitate to the heading and are then pulled to parting if necessary. In dip workings the empty cars gravitate to the face under control of the hoist, which then pulls the loads directly to the lateral aircourse and then through a slant or crossover to the parting on the heading.

The small hoist on the main slope hauls loaded cars from the partings in fourth left and right headings and from the face of the main slope and aircourse to a point between third and fourth lefts where the main hoisting cable was connected to the loaded trip to hoist to the tipple. The main cable was used to haul loaded trips from second and third right and third left laterals.

The trip of empty cars on the main slope opposite the mule barn - located in a slant 50 feet inby third left aircourse on the main slope and

60 feet in the slant is the gathering point for main cable, which explains why the cars were at this location.

A 35 h.p. electric hoist was located in second right heading, and 5 h.p. hoists were used in third and fourth left laterals on the main slope between third and fourth right and one in third right. Two mules were kept in an underground barn, but were not being used.

Wiring.

Electric power at 11,000 volts alternating current is purchased from the Carolina Power Company. An oil transformer situated several hundred feet from the mine portal steps this voltage down to 2300 volts alternating current. Three lines carry the 2300 volt current from here, two of them leading to 2 transformers, located near the slope mouth, which again step down the 2300 volts to 110 and 220 volts respectively. A third line carries 2300 volts to a bore hole. Before entering the mine, the voltage is reduced to 440 volts. Only alternating current is in use. All surface equipment used 220 volts. Lighting was formally on the 110 volt circuit, but the removal of bulbs by occupants of the houses necessitated changing to 220 volt current.

From the surface, the 440 volt alternating current is carried into the mine through a bore hole intersecting the main slope by a 3 conductor armored pick-proof submarine cable at second left heading thereon down the slope as far as fourth right. This cable is also extended 60 feet into second right to the 35 h.p. hoist motor and into the pump in first left aircourse. Tirex, 3 conductor cable, is extended 50 feet into third right, 150 feet into third left, and 150 feet into fourth left to the hoists, located in these entries.

A switch box located at the bottom of the bore hole, contained 150 amperes, 600 volts fuses. These fuses were not blown out at the time of the explosion, indicating there was not an excessive load on the power line below second right lateral.

Electrical equipment.

One Goodman mining machine was in use at the mine, and 5 electric hoists. The main and gathering pumps were also run by electric motors.

It was observed that the transformers which reduced the 11,000 volt current to 2300 volts, were only protected by a 4 foot wire fence. A wooden gate was locked with a pad lock.

Coal dust.

The mine is very dry and dusty. The friable nature of the coal and hard shooting have formed excessive quantities of dust. The black band and bottom bench are taken up to provide for haulage height on entries. This material is gobbed, a condition which adds to the dustiness of the mine.

STORY OF THE EXPLOSION.

About 9:30 a.m. May 27, 1925 smoke was noticed issuing from the fan of the Farmville mine. H. N. Butler, acting mine superintendent and Richardson, mine mechanic, proceeded down the slope to second right to determine what was wrong. The door on this heading was intact but jammed tightly. Upon opening it, 4 men were found about 8 feet inby, and the chainer and hoisting engineer were found a few feet further inby, behind the hoist. These men were all alive, one man being heard to mumble and pulse being detected on three others, while the remaining two were still warm. Butler and Richardson carried the six men out to fresh air on the slope.

The rescuers then proceeded up the slope to the telephone in a "dog house" or shanty just below first right aircourse. Butler telephoned Mathews, outside, telling him that there had been an explosion and at the same time giving instructions to close the explosion door at the fan, then to call the Erskine Ramsey Coal Company at Cumnock, N. C.(Cumnock mine is situated about 1-1/2 miles from Farmville mine) requesting help together with gas masks and first aid equipment. After giving these orders Butler instructed Richardson to repair the door at first left heading. Butler then passed through the door on first right and proceeded up the right slope aircourse to the undercast. He could detect or sense the presence of afterdamp, so passing through the regulator in the undercast, he shut the door, waded through mud ankle deep and came back through first left to the main slope. He had gone up the slope about 150 feet outby first right when the second explosion occurred. Dropping to the floor he grasped hold of rails with

each hand and hooked feet around tie. Most of the debris passed over him, probably being deflected upward due to the abrupt rise of the rock slope. He was slightly injured and affected to some extent from breathing afterdamp but managed to crawl up the slope to the surface. Butler was probably in fresh air when he reached the main slope, as there was practically no damage done above first right. Richardson had preceded Butler up the slope and was on the surface when the second explosion occurred.

Request for help was sent to the Bureau of Mines at Washington, D. C., Pittsburgh, Pa. and Birmingham, Ala. Car 7 with T. T. Read, E. H. Graf and T. G. Hunt on board, arrived at 9 a.m. May 28, while D. J. Parker, G..S. McCaa, Geo. Groves and W. H. Forbes arrived at 5:30 p.m.; J. J. Forbes and C. E. Saxon arrived about 9:00 p.m.

The first explosion developed little velocity, as there were only slight signs of violence. H. N. Butler was able to see the electric lights burning at third right heading when recovering the men in second right. The door in second right was not damaged and the door on the slope aircourse at first left was only slightly damaged, but after the second explosion this door was demolished and blown 75 feet into first left.

The explosion and its extent.

After the first explosion, there was little damage done in the upper part of the mine. The lights as far down as third right were still burning. No debris was noted by Butler.

The second explosion obscured the evidence of the preceding one. The force was up the slope. Evidence of flame was found from

second right aircourse to the foot of the slope, as indicated by burned insulation on power cable and by caked and coked dust on the timbers. Coke was found in second right evidencing flame and force into this entry. Similar evidence establishes the fact that flame and slight force went into the third and fourth left and fourth right entries, but the greater movement was out of these entries. In fourth right heading there was extremely heavy coking and slight violence near the face. The bodies of 3 men found near the last crosscut were badly burned. A blown out shot was found at the face of this entry and additional evidence indicates the origin to have been at this point.

One theory, prevalent after the disaster, was that matches were the source of ignition of the explosion. One undertaker found matches on at least 5 bodies, one of whom was the fire boss, George Anderson, who had 5 matches in a box. One match was found in a miner's clothing in the second room on fourth left aircourse. However, no evidence was found showing an origin due to this cause.

The second explosion was probably caused by the detonation of explosives in a car in fourth left heading. There is evidence that flame entered this pair of entries. Either the flame or heat from the first explosion ignited the explosives, which burned slowly possibly for one-half hour and then detonated or else the frayed bag or part of the check curtain, used at this point to deflect the air into the double room, may have ignited and smoldered until fresh air being forced into the entry by repairing the door at first left, it burned more rapidly, thereby igniting and detonating the explosive.

Statements that a third explosion took place appears to be without foundation. Mr. Butler who was in the mine at the time of the second explosion is positive that there were only two. Another statement giving rise to the belief that the first explosion did not originate in the lower part of the mine was that before Butler entered the mine, Mathews rang 5 times, calling third right, where a telephone was installed. Receiving an answer from whom he thought was the trip rider who came up from fourth left, he asked "What's wrong down there?" To which he received the reply,"Nothing is wrong here". It appears that the 5 rings, signal for third right, sounded as one and the hoisting engineer on the outside answered and gave the above reply.

Details of investigation.

The door on the left slope aircourse, 6 feet inby first left heading, slightly damaged by the first explosion, was demolished and blown about 75 feet into first left heading. At first right a compressed air galvanized iron storage tank was found with a 1 inch pipe, which had been screwed in the side, driven through the opposite wall. This tank had been brought up the slope about 60 feet by the second explosion, as Butler found it intact after the first explosion. The telephone, which was in the hoisting engineer's shanty 60 feet below first right aircourse, was demolished by the second explosion.

The stoppings between the main slope and the left aircourse were intact, though showing force toward the aircourse. Those on the right were of gob poured with concrete and showed force toward the right aircourse. The submarine cable hung near the roof on the left side of

the slope was charred and the fiber insulation burned off, from a point about 70 feet inby second right to 50 outby 3 right. Just outby third right was found the first caked dust. Ten feet inby this point was found a timber with the right end blown outby indicating an outward force. The telephone at third right had been blown from the left to the right rib and the post to which it had been attached was blown outby.

Heavy coking was observed on the outby side of a cross bar, which was 15 feet inby third left, showing outby force. About 50 feet outby third left aircourse coke was found only on the outby side of timbers and crossbars. Hay from the mule barn was found wedged between the cross bar and roof on the inby side. A switch box located at this point was found blown about 50 feet outby. For 50 feet outby third left aircourse, no coke was found. Hay was wedged on the inby side of cross bars from third left aircourse to the slant to the mule barn, 50 feet inby this entry. A pile of unburned hay was found on the slope opposite the slant. Six empty cars were found at this point, wrecked, but not damaged. Hay was found on the outby end of the last 4 cars, all of which were below the slant crosscut, indicating inby force. Just below the last car, coke was found on the inby side of a cross bar, with none on the outby side. A switch box was found on the left rib, still in place, with two phases on. The door was open and a dent showed that the direction had been outward. At fourth left, a timber was blown up the slope indicating outward force. Below fourth right the slope was filled with water.

Second right.

There was considerable wreckage in this entry. Cars at the parting were badly wrecked and indicated an inward force.

Third right.

A curtain between slope and right slope aircourse and the cross bar from which it hung were blown outward. The inby side of cross bars contained heavy deposits of coke with less heavy coke on outby side. At the slope aircourse coke was found only on the inby side of the timbers. At the second room were found 3 cars. The first 2 were loaded, and the last one half loaded in the inby end. The cars were jammed and indicated an inward force. The coke was heavy on both sides of the timbers at this point.

Third left.

This entry turns on a 150 foot radius for 200 feet. On the first cross bar there was heavy coking on the inby side on the left end while only a light deposit was on the outby side. A cross bar, 50 feet inby was thrown down by an inward force. The coke was on both sides but less heavy on inby side. Debris indicates inward force. At left slope aircourse, debris was thrown outward. Just inby this point wires on timber were thrown outward. A cross bar thrown inward had heavy coke on outby side. At switch of parting, timbers indicated inward force. A trip of 5 empty cars were off the track with the inby bumpers on outby bumpers of next car.

At the end of the parting a booster fan motor and an electric hoist together with its motor indicated outward force. The rooms on this entry were full of gas. At last crosscut right coke was found on

inby side of rib and roof projections. A car at this point gave evidence of outward force.

The entrance to 3 left aircourse contained hay driven into roof projections and wedged against timber showing inward force. A cross bar showed slight inward movement.

Fourth left.

The first timber was fallen indicating outward force. Six loaded rs were on the side tracks with one empty thrown against second loaded r, indicating outward force. An empty car, 5 feet inby left slope air- urse, had its outby bumper wedged against inby side of a sheave wheel, owing outward force. A gob stopping in the second crosscut was blown ward the heading. Opposite the third crosscut was found a partly maged hoist showing outward force and 3 cars were badly broken, frames twisted and showing great outward force. The middle car showed evidence of explosives having been detonated. The drawbar was bent downward, the iron frames were bowed outward; the side boards badly splintered and blown from the frames; pieces of paper, evidently cartridge wrappings, were found on the inside of car; the end gate was found 20 feet outby. The inby end of the first car was bent inward, indicating an outward force. The force was into the breakthrough, toward the air course, whereas in all the other breakthroughs up to this point the force had been from the aircourse toward the heading. Violence at this point was greater than at any point in the mine.

The curtain in the crossover or slant, was blown into the heading. Debris showing outward force was found from this point to the last crosscut. At the face of the heading were 2 gas feeders. One was also

found at the face of the 4 left aircourse. There were also large quantities of coke on the ribs, roof and floor. A gas feeder was found in the last room. A shovel at the last crosscut showed outward force. The second room from the face contained coke on the floor and roof. A dummy in one of the "guns" from a shot showed that coal dust had been used. At the slant leading to the heading, 2 rails were found blown against the rib indicating outward force.

A Goodman mining machine was found in by the next room (second from the slope) with the controller in an off position, evidently having just finished cutting the room, where 2 men were found, one presumably drilling a hole, (as two holes had already been drilled in the face), the other cleaning up the cuttings. A match was found in the jacket of one of these men. Out by this room 30 feet was found a car wrecked by an outward force. Coke was only on the inby end.

Fourth right.

Ten feet inby main slope timbers were fairly heavily coated with coke on the inby side and the outby side of rib projections heavily coked. A cross bar was thrown inby at this point. At the slope aircourse a brattice cloth was found wrapped around a post showing force from aircourse into the heading. A trip of loaded cars was on the lower track and 3 empty cars wereon the upper track. The third empty car showed unmistakable outward force. At the end of the side track heavy coke was observed on both sides of cross bars and timbers, while 10 feet inby coke was 3/4 inch thick on outby side. On the inby end of the parting the line brattice, used to conduct air to the face, was found wrapped against a post showing outward force.

In the first crosscut was found a wooden box containing 63 sticks of Monobel No. 9 LF explosives and in a partition at the end of the box were about 75 No. 6 electric detonators. A page from a magazine lying beside this box was badly burned. Coke was found 10 feet inby this point with a heavy deposit outby and small deposits on inby side of posts and crossbars.

The badly burned bodies of Dillingham, the contractor, and Martin, his assistant, were found in the second left crosscut, just inby the corner, while a third body was a few feet distant. The cap of one of the men was found at this point, beside a 4 cell, Hot Shot battery. The end of the shooting cable was about 6 inches from the battery and lead around the corner of the crosscut toward the face of the heading. Coking was extremely heavy, being about 1 inch thick on the timbers. From the crosscut to the face of the aircourse and the room turned to the left, heavy coking was found on roof, ribs and floor. A car 25 feet from the face of the heading showed no evidence of violence. The room driven to the rise 20 feet from the face was filled with gas at the time of the investigation. On the day preceding the explosion the man working in this room had been overcome by fumes, upon entering too soon after shooting down the coal.

At the face of the heading was unmistakable evidence of a blown out shot. On the right rib were 2 holes, about 16 inches apart vertically, drilled on the solid, no attempt being made to undercut or snub the coal. The upper shot had blown out as shown by the fact that it was enlarged and contained coke on the sides. The lower hole contained a piece of compressed coal dust stemming, about 16 inches

from the collar of the hole, and 2 lead wires extending from the hole. At the time of the investigation it was thought that this charge had failed to detonate. but it was later proven that it had at least partially exploded and probably had burned, the gases escaping through a crevice in the coal beside the stemming. A crossbar 5 feet from the face showed no coking, but on the left end of a crossbar, and the rib opposite the hole, 18 feet from the face was abundant coke. This point was directly in line with the direction of the hole. From this point outby for 130 feet coke was found in increasing quantities on the ribs and roof. Two holes drilled on the left side of the cut had not even been loaded or tamped.

Tests of bore hole scrapings from each of the holes on the right side of the cut, show from .25 to .50 grams of water soluble material, which may indicate that part of the charge burned. The evidence although not strong enough to prove that there was partial burning of the charges, indicates a possibility of this occurring. If such were the case, the blown-out shot in the upper hole, projecting flame into a dust laden and gaseous atmosphere, would easily ignite the mixture. The lower hole might also send forth flame as well as raising the thick dust deposit on the bench, into a cloud, adding to the explosive condition.

Source of the explosion.

Reference should be made to the sketch showing the details of 4 right.

The presence of large volumes of firedamp and dry fine coal dust presents an extremely hazardous condition. The fact that a miner was overcome in this entry the day prior to the explosion most certainly indicates poor and sluggish ventilation, and it is very probable that

standing gas was present in explosive quantities, especially so since the last open crosscut was over fifty feet from the face of the heading.

The position of the coke is strong evidence, as most of it is on the outby exposures. The explosion was slow, and the large area for expansion prevented building up enough pressure for a violent explosion.

The evidence of the blown out shot, the location of the battery, and shooting cable and the men are the strongest evidence that this was the origin of the first explosion.

The indications were, therefore, that at the time the two shots were fired there was present an explosive mixture of gas and air, and that the upper shot having an overcharge of explosive, blew out, stirred up the coal dust, which, with the gas present, became ignited and initiated the explosion.

Source of second explosion.

When the explosion reached the slope aircourse and the slope there was large area for expansion, causing a decrease in velocity. Rock falls along the aircourse would furnish inert material to render the coal dust less explosive, and the same condition would prevail on the slope, which was probably also damp due to the water coming down from the rock slope. Therefore the flame probably died out near fourth left on the slope, and in fourth left near the location of the electric hoist. Coke indicates that flame entered this entry during the first explosion. It probably reached the cars opposite the first room on this heading. The brattice cloth curtain which deflected the air into this room may have caught on fire and blown into the middle car standing just beyond,

or the frayed powder sack may have ignited. Probably both smoldered until fresh air was forced into the entry when the door at first left was repaired, and the burning proceeded at an increased rate. A large number of sticks of Monobel No. 9 L.F. explosives were probably in the car and finally detonated. In detonating coal dust was thrown into suspension, ignited and caused the second explosion.

TABLE 2. - MINE AIR ANALYSES, FARMVILLE MINE, JUNE 1925.

Lab. No.	Location of samples.
42350	Slope aircourse below 2 right.
42351	Slope aircourse below 4 right.
42361-2	Upcast, main return from mine.

Analyses.

Lab. No.	42350 %	42351 %	42361 %	42362 %
Carbon dioxide (CO_2)	0.07	0.05	0.08	0.06
Oxygen (O_2)	20.66	20.77	20.74	20.83
Carbon monoxide (CO)	0.00	0.00	0.00	0.00
Methane (CH_4)	0.98	0.77	0.34	0.15
Nitrogen (N_2)	78.29	78.41	78.84	78.96
Total	100.00	100.00	100.00	100.00

Air samples

Table No. 2 gives analyses of mine air samples collected during the investigation. Ventilation was completely destroyed by the explosion, and had been only temporarily restored when the samples were taken, five days after the explosion.

Analyses Nos. 42361 and 42362 contained 0.34 and 0.15 per

cent methane. They were collected at the upcast shaft and plainly show the affect of the large air leakage in the upper portion of the mine. They are not representative of the condition of the mine air, either normally nor during the investigation.

Analyses Nos. 42350 and 42351 taken on the main slope between second and third right and below fourth right respectively. No. 42350 contained 0.98 per cent methane and No. 42351, 0.77 per cent. The higher concentration of these samples is more indicative of normal conditions, although when fresh coal faces are constantly broken in daily mining large quantities of firedamp are given off.

A mine liberating so much gas should have adequate and dependable ventilation. It is unsafe to ventilate the whole mine on a single split.

The investigation showed that many working places were far ahead of air, with no indication of ventilation having been carried to the face, except in fourth right. It is recommended that in lateral entries good substantial stopping such as gob faced with a mixture of clay and cement should be maintained and frequent use made of line curtains to conduct air to face of workings. It is important that all line curtains be kept in good condition.

Ventilation.

The investigation plainly revealed that insufficient volumes of air were reaching the working faces and that large quantities of gas were being liberated. In order to secure better distribution of air, it is desirable to maintain the left slope aircourse as well as the right aircourse. This increased area would give a larger volume of air without increased fan power. Each pair of lateral entries should be on

a separate split, necessitating building of overcasts at these points. The building of permanent, air-tight, fire-proof stoppings in the slope breakthroughs would greatly reduce the leakage of air.

Well built stoppings are necessary to prevent leakage of air and to provide adequate ventilation. Use of properly constructed and maintained line brattices are required to dilute and remove gas from the face of workings.

TABLE 3. - ANALYSES OF RIB AND ROAD DUSTS,

FARMVILLE MINE, JUNE 1925.

Lab. No.	Material.	Location.
A 12447	Road dust	4 left turnout, 100 ft. inby main slope.
A 12448	Rib dust	4 left turnout 100 ft. inby main slope.
A 12449	Rib dust	4 right aircourse between slope and slope aircourse.
85592	Coal	Composite of 3 samples

Analyses, sizing, etc. (as received)

Lab.No.	A 12247	A12448	A12449	85592
Moisture	2.3	2.4	2.7	2.0
Volatile matter	28.0	23.1	27.8	32.4
Fixed carbon	52.9	54.7	53.5	58.1
Ash	16.8	19.8	16.0	7.5
Moisture plus ash	19.1	22.2	18.7	9.5
$\frac{V}{V.+F.C.}$	.346	.296	.342	.358
Coke	3 or 4%	4+ %	3 or 4%	
Percentage through				
20 mesh	100	100	100	
48 mesh	56.1	44.5	64.9	
100 mesh	36.5	22.6	42.5	
200 mesh	21.8	10.3	26.9	

Explosibility of the coal dust in the Farmville mine.

The dusts collected from the lower parts of the mine vary in their degree of fineness. The percentage that passes a 100 mesh screen ranges from 22.6 to 42.5 and that passing through a 200 mesh screen from 10.3 to 26.9. The rib samples contain the higher percentage of fine dusts which are the more dangerous as they are easily raised into a cloud and ignite more readily.

The ratio of volatile to total combustible in this coal varies from .296 to .346 in the dust samples and averages .358 in the face coal samples. From tests made on various coals at the Experimental mine, this ratio indicates a highly explosive coal dust, which would require the presence of at least 62 per cent inert material to prevent the dust from

igniting from a blown out shot, with coal dust, 20 per cent of which passes through a 200 mesh screen. For each per cent of gas present, 8 per cent inert material must be added to the above amount in order to render the dust non-explosive.

Experiments conducted by the Bureau of Mines at the Experimental mine, have proven the explosibility of bituminous coal dust which passes through a 20 mesh screen. The explosibility of coal dust increases with fineness, pulverized dust being most easily ignited. Coal dust with 30 or 40 per cent volatile matter is much more flammable than dust with only 15 or 20 per cent. The presence of even one per cent of fire-damp also greatly increases the explosibility of the coal dust. Details of testing at the Experimental mine are contained in Bulletin 167, U.S.Bureau of Mines.

The large quantities of dust present a distinct hazard and the roads should be cleaned, the gobbed material should be loaded out and the surfaces of entries and workings should be treated to render and maintain them in a safe condition. The application of rock dust will effectively fulfill this requirement and its immediate adoption is strongly urged.

Rock dusting

To effectively apply rock dust, it is necessary to thoroughly clean the entries and rooms of excess dust and pieces of coal or carbonaceous material. The black band and coal from the bottom bench now gobbed in the entries should be removed. Only incombustible material should be used to ballast the track.

In selecting a material for rock dusting, the following specifications should be adhered to:

(a) Size: All of the dust should pass through a 20 mesh screen and at least 50 per cent through a 200 mesh screen. The finer the dust the more easily it is raised into the air with the coal dust to prevent the propagation of flame.

(b) Composition: It is desirable to have less than 2 per cent combustible material and 10 per cent should be the maximum amount present. The free silica should be less than 25 per cent.

(c) Physical properties: The color should be as light as possible. Increased illumination decreases certain classes of accidents. The material should not readily absorb water, as this decreases the effectiveness of the rock dust.

In the initial application, a density of 4 or 5 pounds of dust per linear foot of entry should be obtained. Immediately after dusting an analysis should show at least 90 per cent of rock dust on the surfaces dusted, and when analysis shows the rock dust to be less than 70 per cent, redusting should be started. The rock dusted surfaces should be periodically sampled and analyzed.

Unsafe practices.

(a) Explosives:- Dillingham was reputed to have been in the habit of using excessive charges of explosives. The fact that a great deal of slack was found at working places, is evidence of this. Coal dust stemming was found in the hole directly below the blown out shot. Evidently sufficient ventilation was not maintained at the working faces in the 4 right section, which probably allowed accumulations of dangerous per cents of firedamp. These three practices - more than 1-1/2 pounds explosive, combustible stemming and the firedamp present - render the permissible explosive non-permissible and unsafe. Only incombustible

stemming, such as clay, should be used.

(b) Matches and smoking:- The coroner found matches on the fire-boss and 4 other men and a match was found in the jacket of one miner by the investigators. Sullivan, contractor on 4 left, was in the habit of going out on the main slope to smoke, according to information obtained. A rigid enforcement of the rule prohibiting carrying matches and smoking materials into the mine should be maintained at all times. Discharge of an offender should be the penalty of an infraction of this rule.

(c) Electrical machinery:- The motors on the electric hoists, pumps and booster fan are not of permissible type and being operated on the return air, they are dangerous. The use of the mining machine under these conditions presents a hazard.

(d) Mining:- The coal is shot off the solid, excepting for 2 places. The mining machine should be used for undercutting all places. Shooting off the solid should be abolished.

(e) Shot-firing:- All shots should be loaded, tamped and fired by competent shot-firers, and the firing should be done when all men are out of the mine, except those authorized to fire the shots. Shotfiring from outside the mine when everyone is out of the mine would be an even safer practice.

(f) Safety lamps:- The machine man should carry a magnetic lock flame safety lamp of an approved type, and he required to test for gas before entering a working place. All shotfirers or those performing this duty should also test for gas before firing any shots.

(g) Fire boss:- After making an inspection the fire boss should be required to make a written report in a book supplied for this purpose only,

His report should state where he had made his tests and, if gas were found, where and how treated. No attempt should be made to remove gas while the shift of men are in the mine.

Conclusions.

1. The explosion was caused by the ignition of firedamp and coal dust.

2. The cause of the explosion was a blown out shot.

3. The propagation of the explosion was by coal dust, aided by the presence of firedamp in the air.

4. The second explosion was probably caused by the ignition and detonation of explosives.

5. The propagation was through the ignition of coal dust, probably aided by the presence of firedamp.

6. The violence of the explosion was limited, principally to heavy roof falls in third right, and on the main slope between third and fourth left. In the remainder of the mine little physical damage was done.

7. The explosion extended throughout most of the mine, due to the dustiness existing everywhere.

8. This explosion demonstrates the danger of shooting coal off the solid.

9. The explosive was not used under permissible conditions, since coal dust stemming was used, probably in the presence of a dangerous percentage of firedamp.

10. The first explosion was of little violence, yet probably all the men below second right were either burned to death or were suffocated by the afterdamp.

11. Under the present system of continuous ventilation, and with the large quantities of firedamp being liberated, it is dangerous to use the electric hoists and mining machines. The hoist motor at second right, located on the main return is especially dangerous.

12. The practice of men carrying matches into the mine presents a distinct hazard.

Recommendations.

To prevent the recurrence of explosions within this mine the following recommendations are offered:

(a) The haulage roads should be on the intake roadways which will require that a separate split be maintained in each pair of lateral entries. This may be accomplished by erecting overcasts. The electric hoists should be placed on the intake entry. It will be necessary also to place the pump motors on a fresh air split. The left slope aircourse should be connected and carried forward simultaneously with the slope and right aircourse. The ventilating fan should be enclosed in a fire proof building and moved from its present location to 30 feet to either side of the return and be equipped with suitable explosion doors.

(b) The requirements of permissibility should be enforced in using explosives. The maximum charge should not be exceeded, namely, 1 1/2 lbs per hole; only clay stemming should be employed, and this should be preferably brought into the mine by the company; detonators should be kept in a separate container and at a safe distance from the explosives. Detonators should be carried into mine in non-electrical conducting container, similar to the Du Pont safety cap boxes; also explosives should be carried into mine in non-conducting fibre containers.

(c) Men entering the mine should be searched for matches and smoking materials.

(d) The fireboss should make a written, signed report of his examinations.

(e) Shooting off the solid should be abolished and undercutting with approved types of mining machines extended to include all working faces. Pending general use of mining machines coal faces should be snubbed with pick and the depth of drill holes in coal not extended beyond base of snubbing.

(f) All safety lamps should be under the direct supervision of a competent attendant, who must keep them in a clean and safe condition. Mine foreman, fireboss, machine men and shotfirers should all carry and make use of magnetic, flame safety lamps of an approved permissible type.

(g) Shotfiring should be performed by competent men employed only for this purpose, who will fire shots when the shift of men is out of the mine. Shooting should be done with electric detonators and approved type blasting machines.

(h) There is a great coal dust hazard in this mine. It is recommended that excess dust and combustible gobbed material be loaded out of the mine and rock dusting be adopted to render the dust non-explosive.

(i) In order to prevent the formation of dust at its principal source, the face of workings, it would be a progressive step to equip mining machines with water on the cutter bar to lay the dust while coal is being undercut.

(j) All mining machine replacements should be of an approved type. The squirrel cage type of electric motor is not an approved class and is not safe unless it has met the specifications for permissibility recommended by the Bureau of Mines.

(k) The face of workings should be examined for gas before and after blasting, by the fire boss.

(l) Before a mining machine is taken into a place, a test should be made for gas by a person competent to detect its presence, and during the time of cutting frequent tests should be made for gas, and if gas is detected the machine should be shut down until the gas has been removed by a current of air.

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Respectfully submitted,

J. J. Forbes,

C.W. Owings.

Approved:

Chief of Coal Mining Investigations.

BUREAU OF MINES PITTSBURGH, PA.

DATE: 7-7-25

DETAILS OF MINE EXPLOSION IN FARMVILLE MINE, CAROLINA COAL CO. COAL GLEN, N.C. MAY 27, 1925

SCALE AS SHOWN

DRAWN BY: E.N.H.

CHECKED BY:

APPROVED: C.W. Owings

ASSISTANT ENGINEER

C-741

Origin

Blowout Shot

Gas

Heavy coke on roof

Car thrown no violence

"Hot Shot" battery - cable

Box of 25 sticks Monobel

keg and about 75 caps

Burned magazine sheet

Car blowing outward from

Dip 10°-12°

Heavy coke, outby

Mule Barn

12448

Stable

Coke inby

12447+8

Gas

Heavy explosive

Coke

Matches in clothing

3 cars disrupted

Undercut

Heavy coke, inby and outby

35 H.P. hoist

Cranny inby

3 RIGHT

Coke outby

Curtain blown outby

Telephone, 15' outby

Heavy coke outby

Wires and debris outby

Cross bars thrown inby

Side track loaded cars intact

3 empty cars wrecked, heaviest coke outby ends of cars

Booster fan

Gas

Coke inby exposures from all directions

Coke inby side of prop

Gas feeders

Gas

Coal-dust staining

Coke on roof and floor

Cart wrecked

Coke inby

Hoisting engineer

Telephone

Hoist

42336

Door

2 RIGHT

1 RIGHT

Air lines

Undercast

Pipe 3"-4"-6"

Door

Bore hole

1 LEFT

Sump

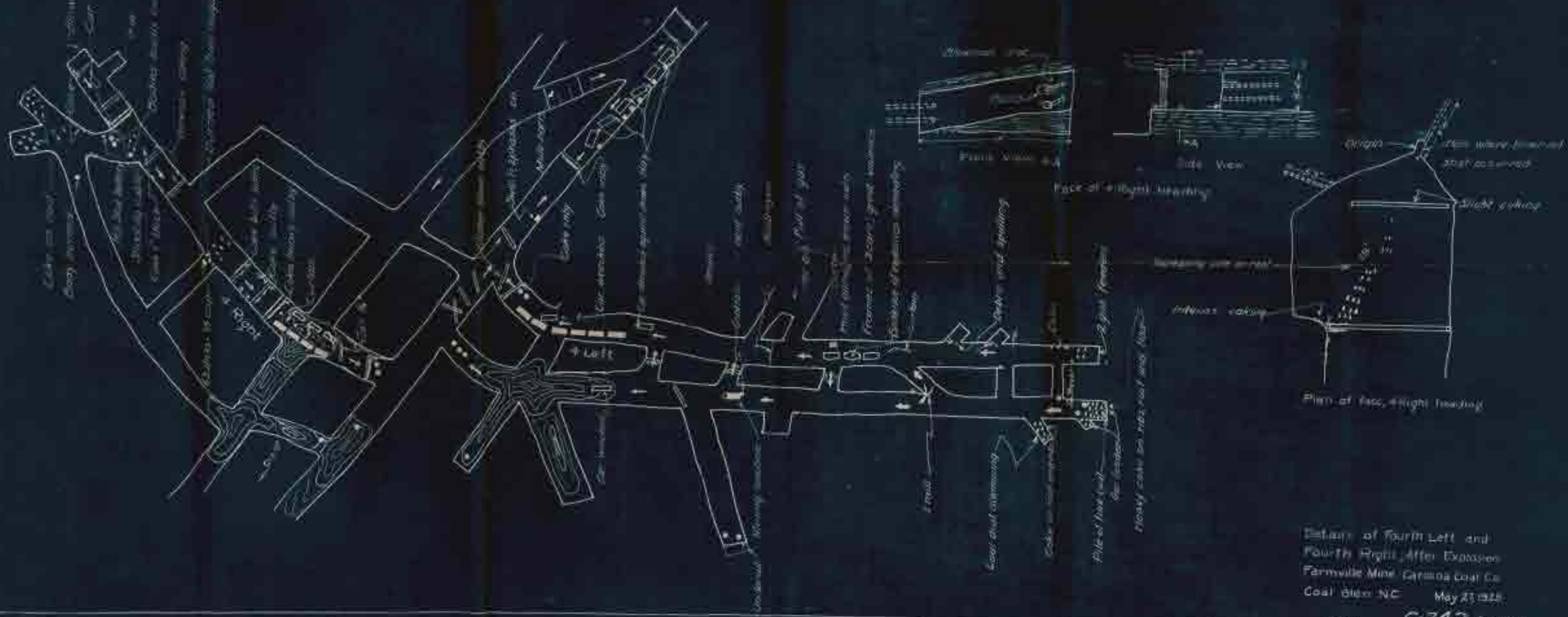
2 LEFT

42361 — Fan

LEGEND

- Air sample
- Dust sample
- Body
- Direction of force

Scale



Detail of Fourth Left and
Fourth Right Aften Extension
Farmville Mine Carolina Coal Co.
Coal Glen N.C. May 23 1928

C 742