FINAL REPORT, EXPLOSION, CARSWELL MINE, KOPPERS COAL COMPANY, KIMBALL, McDOWELL COUNTY, WEST VIRGINIA, JANUARY 22, 1941

By

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

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GENERAL INFORMATION

Location and Operating Officials

The Carswell mine is located on the King branch of the Norfolk & Western Railway, about 1 mile north of Kimball, McDowell County, West Virginia, and is owned and operated by the Koppers Coal Company. The mines in this section are known as the Houston Division.

The officials of the Koppers Coal Company, the Houston Division, and the Carswell mine are as follows:

President	J. P. Williams, Jr.	Pittsburgh, Pa.
Vice President	P. C. Thomas	Pittsburgh, Pa.
Assistant to Vice President	L. C. Campbell	Pittsburgh, Pa.
Division Superintendent	J. O. Davis	Keystone, W. Va.
Division Safety Engineer	F. J. Bailey	Kimball, W. Va.
Mine Superintendent	Frank Kerr	Kimball, W. Va.
Mine Foreman	William Ford	Kimball, W. Va.

Employees and Production

Approximately 600 men are employed underground and 100 men on the surface working two shifts, producing an average of about 3,000 tons of coal a day.

Openings

The Carswell mine operates the King and Tidewater leases, as indicated on the map which is shown in the appendix of this report. The mine is opened by five shafts - three located near Carswell surface plant, a slope and a shaft in the former King mine, and three drifts and a shaft opening in the former Tidewater mine. One shaft opening at Carswell is used for hoisting coal and rock and also for intake air. The second shaft opening at Carswell, which formerly opened the No. 4 Pocahontas coal bed, now abandoned, is used to lower and raise men and materials into and out of the mine. The third shaft serves as an upcast airway. The two slopes and shaft in the former King mine serve as escapeways and intake airways. The three drift openings of Tidewater serve as escapeways and intake airways and the shaft serves as an escapeway and upcast airway.

Nature of the Coal Bed

The mine is operating in the Pocahontas No. 3 coal bed, which averages about 60 inches in thickness and is overlain by from 1 to 14 inches of draw slate and 1 to several feet of black shale and sandstone. The Pocahontas No. 4 coal bed is located about 60 feet above the No. 3 bed. The floor of the No. 3 coal bed consists mainly of fireclay.

The coal is a low-volatile bituminous and is soft and friable. The principal impurity is a 4-inch band of "bony" near the center of the coal, which is characteristic of the Pocahontas No. 3 coal bed.

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INTRODUCTION

A gas and coal-dust explosion occurred in the Carswell mine of the Koppers Coal Company, Kimball, McDowell County, West Virginia, at about 4:30 a.m., January 22, 1941. Five men were killed as a result of this explosion, of which number four were killed outright by burns and violence and one died 2 days later from burns. Thirteen additional men in the affected area were burned and suffered from the effects of carbon monoxide poisoning. A total of 145 men were in the mine at the time of the explosion. One hundred twenty-seven men who were in other sections of the mine escaped some time after the explosion. These men were not aware that an explosion had occurred. They were notified by telephone by the dispatcher and left the mine without any difficulty. The explosion was local in character and was confined to an area of about 200-foot radius from the intersection of No. 36 room and 2 left entry. No appreciable property damage was sustained. The writers believe that rock-dusting within and outby the affected area localized the explosion.

From evidence found following the explosion and from statements of survivors it appears that the explosion had its origin at the mouth of room 36 when gas issuing from this room was ignited by an arc from the nips of a mining machine cable which were attached to the power cable at this point.

Water had been used to allay the coal dust at three different points in this conveyor section - at the elevator car loading station and at the unloading point of each room conveyor. The mine is rock-dusted throughout. Haulageways are rock-dusted weekly by a rock-dusting machine and in the advance workings each man is supposed to distribute by hand a bag of rock dust each shift.

The Bureau of Mines at Pittsburgh, Pa., was notified of the explosion by the Associated Press at about 8:00 a.m. Messrs. W. J. Fene and F. E. Griffith collected equipment and left the Bureau about 10:45 a.m., driving to Welch, W. Va., and arriving there at 11:30 p.m. Mr. J. S. Ferraro, who was at Raleigh, W. Va., was notified and arrived at the mine about 2:00 p.m. Mr. F. J. Furin, who was at Cannelton, W. Va., was also notified and arrived at the mine about 10:00 p.m. State Mine Inspectors Chatfield and Jones were notified and assisted in the recovery work following the explosion. The recovery work was completed and all the injured men and bodies were brought out of the mine before noon, January 22, 1941.

The roof in this mine is extremely tender, also being infested with pots, kettle bottoms, horsebacks, and fossil stumps, which make it treacherous, and the roof requires extensive as well as careful timbering. Five- by eight-inch crossbar timber sets on 3-foot centers are used over trackways, and posts with substantial cap pieces set on 4-foot centers are used on the side or gob area. Prepared cap pieces and wedges are provided. No timbers are recovered in pillar work.

Systematic timbering rules are posted and are strictly enforced.

Ventilation and Gases

The mine is ventilated by two 5- by 10-foot centrifugal-type fans, which are offset from the upcast shafts, are equipped with reversing doors, and are operated exhausting. One fan located at Carswell is driven by an electric motor and was moving at the time of the investigation 76,300 cubic feet of air per minute at a recording water-gage pressure reading of 3.5 inches; this fan is equipped with a steam-engine auxiliary drive.

The Tidewater fan located on the surface near the Tidewater shaft is electric motor-driven and was exhausting at the time of the investigation 219,396 cubic feet of air per minute at a recording water-gage pressure of 5.6 inches. An attendant is on duty 24 hours a day at this installation and reports hourly via telephone to the power-house engineer at the Carswell surface plant, who can cut all electric power from the mine in the event of fan failure.

The split system of ventilation is used and is controlled by overcasts, stoppings, and doors. Overcasts and permanent stoppings are constructed of brick and temporary stoppings are of canvas. Doors, with few exceptions (temporary), are installed in pairs, forming an air lock between them so that when one door is open the other, having the same effect upon the ventilating current, can remain closed, thus enabling trips to pass through them without interrupting the ventilating current. All doors are provided with latches. Door installations equipped with latches or other devices for holding them open "invite" interruption of the air current. It is suggested that latches or other means of holding doors open be discontinued and that bumper bars be provided on the doors so that they can be opened by the locomotive and held open by the sliding action of the bumper bar against cars or locomotive while passing through them in either direction, after which they will close automatically when the trip has passed. If bumper bars are not practical, some other method should be utilized. Break-throughs are driven at intervals of 80 feet or less.

With few exceptions, main and secondary haulage roads are on intake air. One of the notable exceptions to this rule was on second King mains, where the main haulageway passed through a system of doors into a return air current from active and pillared areas of the mine and was being conducted over this haulageway to the Tidewater upcast shaft. This creates an extremely unsafe condition in the mine and it is suggested that sufficient overcasts be erected to take this return air off the haulage road.

The following is an analysis of the Pocahontas No. 3 coal bed in the Carswell mine, from Bureau of Mines Technical Paper 405, Analyses of West Virginia Coals:

	Percent
Volatile matter	16.1
Fixed carbon	77.1
Moisture	1.8
Ash	5.0
Sulphur	0.6
Calories	8,122
B.t.u.	14,620

UNDERGROUND MINING METHODS, CONDITIONS, AND EQUIPMENT

Method of Mining

The newer workings of the mine are opened by six diagonal entries which intersect the King and Tidewater leases. The 45° angle on which these entries are driven permits a grade in favor of loaded cars. A system of four to six entries is turned at an angle of 45° from the diagonal entries which open up the Carswell, King, and Tidewater leases. From these entries pairs of room or butt entries are turned at intervals of 300 to 500 feet. Rooms ordinarily are not developed during advance work.

In the hand-loading parts of the mine room development is so systematized that when the 60-foot center rooms are driven through to the adjacent pair of butts, pillars are promptly recovered. A 45° angle pillar-extraction line is maintained.

In the conveyor sections and particularly in the more recent work no definite angle of extracting pillars is being followed.

Only development work is being done in the mobile-loading section of the mine.

The coal is undercut with permissible Jeffrey shortwall and arcwall cutting machines. Coal is drilled with hand augers in the hand-loading sections and by permissible Jeffrey electric coal drills in the conveyor and mobile-loading sections.

Permissible electric power-driven units are used on the Jeffrey "face" and "room" conveyors. The "mother" and "elevator" conveyor units are non-permissible.

A portable approved type of junction box is advanced with the working face in conveyor rooms for connecting the power cables from the permissible shortwall mining machines, the electric coal drill, and the face-conveyor unit.

Air samples were collected during the investigation, analyses of which are shown in table 1. It is believed that the results of analyses of samples taken in split returns are fairly representative of the average daily conditions, except that the methane content may be lower in some instances, due to the fact that some of the samples were collected while a portion or all of the mine was idle.

It will be observed that a sample, No. 245, collected 150 feet inby room 36 off 2 left the day following the explosion contained 0.84 percent methane and another sample, No. 246, collected near the mouth of the room contained 0.23 percent methane. Samples No. 898 and 244, containing 0.47 percent methane with 29,346 cubic feet of air per minute and 0.21 percent methane with 189,950 cubic feet of air per minute, respectively, represent the volume of air entering the Tidewater upcast shaft. Samples 872 and 882 with 20,500 and 55,800 cubic feet of air per minute, containing 0.44 and 0.48 percent methane, respectively, represent the volume of air returning through the Carswell upcast shaft. From the analyses of these samples, of 295,596 cubic feet of air per minute in the total returns, it is indicated that about 1,288,600 cubic feet of methane is being liberated from the mine each 24 hours. Considering the large amount of methane being liberated in this mine (1,288,600 cubic feet per 24 hours), it is apparent that extreme caution must be exercised to prevent a disruption in ventilation that would permit the gas to accumulate.

Preshift examinations for gas are made by fire bosses and systematic sampling of return air is done weekly by the ventilation inspector. The safety and ventilation inspectors are also equipped with M.S.A. methane indicating detectors for making other gas surveys.

Haulage

All underground haulage is by electric trolley locomotives. Cars are of steel end-gate construction, with hinge-link and pin couplings, and are of about 4-ton capacity. Clearance generally is adequate in entries and rooms to provide safe passage of persons by trips; however, it was observed that clearance was not adequate at several points along haulageways. Shelter holes are provided at regular intervals, but at several points where grading has been done they are not maintained at track level. Trolley wires are guarded at junctions and man-trip loading and unloading stations by a rubberized-flap guard attached to the trolley-wire hangers. A telephone dispatcher and a block signal system is used to regulate all underground haulage traffic.

Blocking cars is accomplished by a pin-clevis device at working faces and by a fixed heavy chain and hook device along haulage entries. From information obtained it was learned that more than 200 of these devices were installed during the year 1940. This fixed heavy chain-hook car or trip block is positive in action and is easily attached or detached from a car or trip.

The system of ventilation used in the two conveyor sections depends entirely on circulating the full volume of air used to ventilate this portion of the mine over the worked-out area. Sudden or slow subsidence of these pillared or worked-out areas may completely stop or reduce the volume of air circulated and cause the ventilation of the working places to be inadequate.

It is suggested that the system of ventilation now used be changed to assure an adequate volume of air circulating through the open and active workings and return through open air courses to the fan rather than through worked-out areas, and at the same time be so regulated as to maintain an air pressure differential over the pillared or worked-out areas with open "bleeder" entries extending into the main returns.

It was observed during the investigation that large abandoned sections, including developed, partially pillared, and pillared sections of the mine, were being ventilated, or at least attempts were being made to ventilate them. It is believed that these sections should be effectively and securely sealed and provisions made to relieve excess pressure through a water seal, and any gas thus released should be directed into the main returns of the mine. Such sealing would (1) greatly enhance the safe operation of the mine by creating within the sealed-off sections a condition that would not permit formation of explosive mixtures of methane and air, (2) improve the ventilating efficiency by a reduction in mine resistance, and (3) permit a larger volume of air to be circulated through the active workings of the mine. The savings effected by this measure should more than offset the cost of sealing.

In the past the question of advisability, from a safety standpoint, of sealing abandoned or unused places in coal mines has been much discussed. Some have considered that it was highly dangerous to enclose areas in a mine that might fill with gas. The Bureau agrees with this point of view, unless the stoppings are strong and fireproof. On the other hand, it has been found that in large room-and-pillar mines, in which the pillars may or may not have been extracted, the old areas generally are not well ventilated and often cannot be properly inspected. Furthermore, these regions act as places for accumulating dangerous coal dust in addition to gas.

It was observed that unusual dependence was being placed on canvas stoppings, canvas check curtains, and long lengths of line brattice in directing and controlling the air in the mobile-loading and conveyor sections of the mine. The ventilation in the explosion area was dependent upon canvas, as also is the ventilation in the D-2 conveyor section. So many things can happen to canvas stoppings and line brattice to render them ineffective that the use of excessive amounts of this material is inadvisable.

As development proceeds in the mobile-loading sections, the necessity for extensive use of canvas for directing the ventilation will be reduced. On the other hand, if the same method of ventilation and method of mining are continued in the conveyor sections, maintenance of adequate ventilation will become increasingly difficult. It is believed, if rooms were developed in pairs from only one side of butt entries, that more positive control of ventilation could be obtained.

The mine is classed as gassy by the West Virginia Department of Mines and fire bosses are employed to examine the mine before the shift enters and while the men are at work.

TABLE 1. - Analysis of samples of air collected in Carswell mine, Koppers Coal Company, January 24-25-27, 1941

Sample No.	Location in mine	Carbon dioxide	Oxygen	Methane	Nitrogen	Quantity of air, cu. ft. per min.	Methane liberated in 24 hrs., cu. ft.
244	Return, right side, Tidewater shaft	0.09	20.82	0.21	78.88	189,950	574,409
898	Return, left side, Tidewater shaft	0.29	20.44	0.47	78.80	29,346	198,614
872	Return from old workings near Carswell shaft	0.17	20.60	0.44	78.79	20,500	129,888
882	Return at Carswell shaft	0.16	20.66	0.48	78.70	55,800	385,689
243	Return from 3rd King mains (Goodman section)	0.07	20.76	0.48	78.69	20,916	144,571
245	In room 36, 2nd right off King mains (top fall)	0.07	20.70	0.84	78.39	-	
246	do.	0.08	20.83	0.23	78.86	-	
248	Return from 1st King main (at overcast)	0.07	20.70	0.65	78.58	11,475	107,406
249	Return at No. 6 overcast	0.08	20.78	0.38	78.76	49,608	271,455
371	Return at No. 10 overcast	0.10	20.79	0.18	78.93	39,200	101,606
881	Return from No. 4 Tidewater pillar section	0.24	20.38	0.69	78.69	26,240	260,721
891	Return at No. 3 overcast	0.19	20.56	0.48	78.77	70,720	488,817
899	Return from No. 8 Tidewater pillar section at No. 4 Tidewater overcast	0.15	20.58	1.12	78.15	23,560	379,976
900	Return from 1st right main at overcast	0.07	20.62	0.46	78.85	12,960	85,847
372	Return from 2nd right main section	0.07	20.78	0.52	78.63	16,569	124,069

Lighting

Fixed incandescent lights mounted in weatherproof sockets are installed at track switches, intersections, and various other places along the haulage system; these lights are not guarded. Permissible Wolf and Koehler flame safety lamps are carried by all foremen, safety and ventilation inspectors, fire bosses, pumpers, machinemen, and the mobile-loading crew for use in testing for gas. Mobile-loader operators and machinemen are supposed to test for gas before moving their machine beyond the last open crosscuts and frequently while the machine is in operation at the face. It was observed that this requirement was being adhered to. Edison portable electric cap lamps are used by miners and all other employees for illumination. The use of open lights and smoking are prohibited. Periodic search is made for matches and smokers' articles.

Machinery Underground

All machinery underground is operated electrically by 275 volts direct current. This machinery includes locomotives, pumps, permissible coal-cutting machines, permissible coal drills, permissible and nonpermissible-type conveyor power units, and a permissible Goodman mobile-loading machine.

Transmission lines are taken into the mine at several points through shafts and boreholes. Feeder cables are well installed on insulated hangers along haulageways. The transmission lines are sectionalized by means of hand switches. No transformer, rectifier, or converter stations are located underground. A considerable amount of trailing cable is used in connection with mechanical loading operations, and it was observed that much of this cable was in bad condition, having numerous and improperly made temporary splices. No vulcanized splices were observed. However, the company is fully aware of the many hazards and the inefficiency of improperly installed and maintained trailing cables, and has recently purchased cable-splicing equipment and has prepared cables in 100-foot lengths for use in connection with mechanical mining. This equipment was not ready for use at the time of the explosion, but has probably now been installed.

It is believed by the investigators that this system will eliminate many of the hazards that are now encountered with trailing cables, by permitting sections of the cables, when in need of repair, to be taken out and replaced by a section of new or repaired cable. This experiment is noteworthy and commendable.

Explosives and Blasting Practices

Permissible explosives, duPont Lumpcoal C in 1-1/4- by 6-inch cartridges, are used for blasting coal and rock. All shots are fired electrically with small recessed terminal Burgess dry-cell batteries and duPont No. 6 electric detonators. Explosives and detonators are obtained by the miner from an attendant at the distributing magazine on the surface. One day's supply of explosives is placed in a rubberized explosives bag. Electric detonators are placed in a screw-top cylindrical wooden container and are carried by the miner to the man-trip loading station near the bottom of the shaft, where

they are loaded into separate compartments of an insulated explosives car. The insulated explosives cars are hauled to the various sections of the mine by a trolley locomotive, which precedes the man-trip by about 10 minutes. Tool cars are also handled on the same trip.

Shot holes are charged, stemmed with rock dust, and fired by the miners in the hand-loading sections, by the assistant foreman in the conveyor sections, and by a member of the mobile-loading crew who is designated as shot firer. No regular shot firers are employed. Blasting is done at any time during the working shift.

The coal is generally undercut to a depth of 6 and 9 feet and boreholes are drilled to a depth of 5-1/2 and 8-1/2 feet. One exception to this was observed in the immediate explosion area; four holes ranging in depth from 24 to 60 inches were found drilled on the solid, two of which had been fired and had blown out 1 or 2 hours before the explosion. Another instance of solid shooting was observed in the partially developed break-through in the left room on the D-2 conveyor section; here, too, there was indication that a borehole drilled on the solid had blown out. This is an extremely dangerous practice and indicates lack of supervision on the part of underground officials.

In the interest of safety, permissible explosives fired electrically should be used exclusively. While this is being done in this mine, the conditions of permissibility of explosives for use in coal mines should be studied carefully by the officials at this mine and rigidly followed. They are: (1) not more than 1-1/2 pounds shall be used in any one shot; (2) the explosive shall be fired only by use of electric detonators of standard make and proper strength; (3) shots shall not be fired on the solid; (4) only permissible shot-firing units should be used; and (5) only incombustible stemming material tightly tamped to the collar of the hole should be used.

In addition to the above, competent shot firers should be employed to fire all shots, and they should be required to make tests for gas with permissible flame safety lamps before and after firing a shot.

Drainage

Considerable water is "made" in the mine and many sections of the mine are damp to wet. Fifteen electric pumps are used to gather and discharge the water to the outside.

Coal Dust

Considerable coal dust is made during the operations of undercutting, drilling, blasting, and loading. An excessive amount of coal dust was observed along the conveyor lines in the conveyor sections and in the advance working of the mobile-loading section, but haulage roads and hand-loading places are kept fairly clean. The excessive accumulations of coal and coal dust observed in the conveyor sections are due to failure to clean up thoroughly as the face conveyors are advanced. This condition is probably due to lack of supervision by crew foremen and to haste in completing the cycle of operation. Such accumulations of dust should be cleaned up as the conveyors are advanced, as they constitute an additional dust-explosion hazard.

Water was being used to allay coal dust at three points along the "mother" conveyor in the explosion area and on the undercutting machine in the mobile-loading section. Water is supplied by means of tank cars with hose connections to the points of distribution.

Excessive amounts of suspended dust were observed in the D-2 conveyor section during the operation of the face conveyor. The finely divided dust suspended in the air became so dense in one of these rooms after 5 minutes of hand-loading face conveyor operation that visibility was reduced to practically zero. It is suggested that some measure to allay this dusty atmospheric condition be adopted immediately.

To lessen the coal-dust explosion and health hazards and to decrease the amount of rock dust needed to afford full protection against the propagation of a dust explosion, the following measures are recommended: (1) All mining machines should be provided with water sprays to wet the fine coal as cutting is being done; (2) the face regions should be wetted before and after blasting; (3) water sprays should be installed on face conveyor units and loading and unloading points along room and "mother" conveyor units; (4) the coal face and the working place approximately 40 feet therefrom should be kept free of coal dust by use of water; (5) the coal should be loaded on conveyor lines so it will not fall off, and any accumulations of coal and dust along the lines should be loaded out promptly; (6) the coal should be so loaded that it will not be shaken off the cars while in transit and the empty cars and loads should be so sprayed as to prevent dust from being distributed along the haulageways.

The above practices are aimed at wetting the dust at the point of its formation in the working places and elsewhere, thus preventing it from rising into the air and being distributed widely by the air current. The use of water at the working face can best be effected by having water lines extend to near each face so mining machines may be connected to the water line and the face region may be properly sprinkled. The installation of sprinklers along haulageways will prevent the blowing of dust from the top of fast-moving trips, which is largely responsible for the wide distribution of coal dust. Moreover, coal dust in the air materially decreases visibility and this increases the hazard to the mine worker through not being able to see clearly a threatening fall of roof or coal or possibly some dangers from machines. Also atmospheric dustiness endangers the health of the employees and appreciably reduces their efficiency.

Rock Dust

The mine is rock-dusted throughout by a rock-dusting machine and by hand. Employees engaged in work at the face are required to distribute one bag of rock dust per man per shift. Company records disclose that 5.2 pounds of rock dust were distributed throughout this mine per ton of coal mined during the year 1940. This is a decidedly commendable record.

Fifty-one samples of dust were collected in the mine during the investigation, the analyses of which are shown in table 2.

A study of the analyses of these dust samples shows:

1. The incombustible content of the rib- and roof-dust samples, Nos. 3, 5, 7, 9, and 11, collected in the explosion area, ranges from 14.3 to 95.0 percent, with an average of 64.78 percent. The road-dust samples, Nos. 4, 6, 8, 10, and 12, range from 21.7 to 64.8 percent, with an average of 45.06 percent incombustible.

The analyses of samples Nos. 3, 4, 5, 6, 8, and 10 indicate that additional rock-dusting is necessary to increase the incombustible content of the dust in these areas to 65 percent, the amount necessary to prevent propagation of the flame.

2. From table 2 it will also be noted that analyses of samples Nos. 14, 16, 18, 21, 22, 24, 26, 30, 32, 34, 35, 36, 37, 38, 39, 41, 43, 44, 46, and 54, collected in various parts of the mine, indicate that additional rock-dusting is necessary to increase the incombustible content of dusts in these areas to 65 percent. It is believed, however, that the incombustible content of the dust, even though inadequate in some places, definitely arrested the flame in the affected area and prevented propagation of the explosion to other parts of the mine.

It is indicated that dust of the Pocahontas No. 3 coal bed requires a minimum of 65 percent incombustible to prevent propagation of an explosion where no gas is present. Where gas is present in the air current, the incombustible content should be increased 1 percent for each 0.1 percent of gas present.

Based on the percentage of gas found in return air sample No. 882 (table 1), the dust on this split should contain in excess of 69 percent of incombustible matter to insure against propagation of an explosion. Likewise, the incombustible content of the dust in return airways in other sections of the mine should be increased where gas is shown in the return air.

GENERAL SAFETY CONDITIONS

First Aid and Mine Rescue

All employees at this mine have completed instruction in Bureau of Mines first-aid methods.

The West Virginia Department of Mines maintains a mine rescue station at this operation, which is equipped with six self-contained oxygen breathing apparatus, six All-Service gas masks, and other accessory equipment. Five mine rescue crews consisting of 6 men to the crew or 30 men from this mine are trained monthly in the use and care of the mine rescue apparatus. All underground employees are equipped with self-rescuers.

Safety Organization

A safety inspector is employed at the mine to examine the mine daily and he reports unsafe practices and conditions to the superintendent or mine foreman. A division safety engineer is employed to examine the mines within the division at regular intervals who reports to the division superintendent. A full-time ventilation inspector is employed at this mine who measures air, collects return air samples from the various splits, and reports his findings to the superintendent.

TABLE 2. - Analysis of dust samples collected in Carswell mine, Koppers Coal Company, Kimball, West Virginia, January 24-25-27, 1941

Sample No.	Location in mine	Kind of sample	Percent			Cumulative 100-percent through 20-mesh Percent through			Remarks
			Combustible, V. + F.C.	Incombustible, moisture plus ash	Through 20-mesh	48-mesh	100-mesh	200-mesh	
3	150 ft. inby room 36 off 2nd left air course off King main	Rib & Roof	85.7	14.3	66.2	-	-	-	In explosion area
4	do.	Floor	78.3	21.7	73.1	64.0	41.9	29.6	do.
5	2nd left air course inby curtain near room 36	Rib & Roof	49.3	50.7	83.8	90.3	81.9	72.5	do.
6	do.	Floor	53.2	46.8	79.1	94.4	62.8	51.4	do.
7	2nd left air course, 100 ft. outby room 36	Rib & Roof	14.6	85.4	89.7	95.6	85.7	71.2	do.
8	do.	Floor	50.1	49.9	81.8	77.6	57.8	43.3	do.
9	2nd left, 30 ft. inby room 44	Rib & Roof	21.5	78.5	78.9	86.8	74.2	60.9	Rock-dusted
10	do.	Floor	57.9	42.1	74.3	71.5	52.0	38.8	do.
11	2nd left, 150 ft. inby room 41	Rib & Roof	5.0	95.0	93.5	96.9	89.5	72.4	do.
12	do.	Floor	35.2	64.8	79.7	93.5	62.8	50.1	do.
13	In room 41 off 2nd left	Rib & Roof	25.0	75.0	87.0	89.2	78.8	64.2	do.
14	do.	Floor	70.0	30.0	73.9	67.4	44.3	30.6	do.

TABLE 2. - Analysis of dust samples collected in Carswell mine, Koppers Coal Company, Kimball, West Virginia, January 24-25-27, 1941 (contd.)

Sample No.	Location in mine	Kind of sample	Percent			Cumulative			Remarks
			Combustible, V. + F.C.	Incombustible, moisture plus ash	Through 20-mesh	100 percent through 20-mesh; Percent through 48-mesh	100 percent through 20-mesh; Percent through 100-mesh	100 percent through 20-mesh; Percent through 200-mesh	
15	No. 1 airway off 1st King haulway	Rib & Roof	3.1	96.9	99.0	98.7	89.5	75.1	Rock-dusted
16	do.	Floor	42.6	57.4	76.0	76.9	58.1	44.4	do.
17	No. 2 King airway off King haulway	Rib & Roof	18.0	82.0	88.5	91.2	83.3	70.2	do.
18	do.	Floor	64.1	35.9	69.1	68.2	44.5	27.5	do.
19	Main King haulway on No. 3 airway	Rib & Roof	2.1	97.9	99.8	99.9	87.7	69.3	do.
20	do.	Floor	34.4	65.6	75.7	71.0	52.3	38.5	do.
21	No. 4 airway off King haulway	Rib & Roof	67.7	32.3	68.4	-	-	-	Not rock-dusted
22	do.	Floor	83.2	16.8	58.5	62.2	40.6	29.8	do.
23	No. 5 airway right off King haulway	Rib & Roof	20.1	79.9	87.8	90.0	78.9	65.4	Rock-dusted
24	do.	Floor	63.5	36.5	70.3	60.2	37.0	24.6	do.
25	No. 6 airway right off King haulway	Rib & Roof	9.4	90.6	94.7	95.2	85.6	71.5	do.
26	do.	Floor	63.6	36.4	76.3	82.1	48.5	33.6	do.
27	Between 1st and 2nd left on 44 haulway	Rib & Roof	7.4	92.6	94.9	95.6	79.9	61.4	do.
28	do.	Floor	37.5	62.5	73.3	70.5	53.1	41.3	do.

TABLE 2. - Analysis of dust samples collected in Carswell mine, Koppers Coal Company, Kimball, West Virginia, January 24-25-27, 1941 (contd.)

Sample No.	Location in mine	Kind of sample	Percent			Cumulative			Remarks
			Combustible, V. + F.C.	Incombustible, moisture plus ash	Through 20-mesh	100 percent through 20-mesh			
						Percent through			
						48-mesh	100-mesh	200-mesh	
30	Between 1st and 2nd left, on 43 haulway	Floor	82.5	17.5	57.8	58.1	37.5	28.4	Not rock-dusted
31	On 1st left between 34 and 41 haulway	Rib & Roof	6.4	93.6	93.4	97.8	90.4	73.4	Rock-dusted
32	do.	Floor	41.9	58.1	74.6	75.3	55.8	42.9	do.
33	On 1st left air course between 34 and 41 haulway	Rib & Roof	8.2	91.8	98.9	99.4	89.5	72.0	do.
34	do.	Floor	56.5	43.5	70.1	71.4	50.8	36.8	do.
35	On 33 haulway, 60 ft. from 1st entry	Floor	91.8	8.2	51.7	50.6	28.7	19.0	Not rock-dusted
36	D-2 conveyor section, in left room 30 ft. from entry	Floor	41.0	59.0	73.8	78.2	59.5	45.1	Rock-dusted
37	D-2 conveyor section, in right room 40 ft. from entry	Floor	84.9	15.1	58.9	60.9	41.0	28.6	do.
38	D-2 conveyor section, along mother conveyor 100 ft. from loading elevator	Floor	58.2	41.8	64.2	70.6	52.6	41.7	do.
39	On 25 haulway, between 1st left and King haulway	Floor	55.9	44.1	80.9	90.5	44.6	31.4	do.
40	do.	Rib & Roof	10.1	89.9	98.9	99.0	87.2	74.1	do.
41	150 ft. from face No. 1, 3rd King mains	Floor	80.0	20.0	57.5	47.4	19.6	12.7	do.
42	do.	Rib & Roof	23.0	77.0	83.8	86.5	72.6	56.1	do.

TABLE 2. - Analysis of dust samples collected in Carswell mine, Koppers Coal Company, Kimball, West Virginia, January 24-25-27, 1941 (contd.)

Sample No.	Location in mine	Kind of sample	Percent			Cumulative			Remarks
			Combustible, V. + F.C.	Incombustible, moisture plus ash	Through 20-mesh	100 percent through 20-mesh			
						Percent through			
						48-mesh	100-mesh	200-mesh	
43	150 ft. from face No. 2, 3rd King mains	Rib & Roof	60.1	39.9	77.8	-	-	-	Rock-dusted
44	do.	Floor	75.4	24.6	69.4	61.8	37.8	20.9	do.
45	150 ft. from face 3rd heading off 3rd King mains	Rib & Roof	17.6	82.4	84.2	-	-	-	do.
46	do.	Floor	43.1	56.9	76.0	77.3	58.2	43.7	do.
47	150 ft. from face 4th heading off 3rd King mains	Rib & Roof	11.4	88.6	93.9	98.0	83.2	65.5	do.
48	do.	Floor	36.1	63.9	76.3	80.3	57.7	41.3	do.
49	On 12 haulway off 3rd King mains, 25 ft. outby station 6522	Rib & Roof	31.1	68.9	78.4	82.9	68.4	56.6	do.
50	do.	Floor	37.8	62.2	76.2	80.4	61.8	47.1	do.
51	On 13 haulway off 3rd King mains, opposite station 6522	Rib & Roof	27.2	72.8	93.3	80.6	63.7	47.3	do.
52	do.	Floor	25.0	75.0	76.9	75.4	55.3	37.1	do.
53	On 3rd King haulway off 3rd King mains, 50 ft. outby 13 haulway	Rib & Roof	8.1	91.9	92.0	98.3	89.2	77.1	do.
54	do.	Floor	52.8	47.2	69.5	68.6	46.1	31.0	do.

A safety committee composed of the mine superintendent, the mine foreman, the safety inspector, two miners, two day men, and one outside man has been organized at the mine. The employee members of this committee are appointed by the management, each member attending three meetings, after which he is replaced by a newly appointed member. The appointment of committee members is staggered so each committee meeting has some new member. The committee holds regular monthly meetings with the mine superintendent presiding. The duty of the committee is to investigate all serious and fatal accidents and to make recommendations for preventing recurrence; reports are also made on all unsafe conditions observed and methods to eliminate the hazards are recommended.

Weekly safety meetings are held for all foremen and a general safety meeting is held once a month to which all employees are invited.

The mine also participates in an intercompany safety record competition. The competition consists of the awarding of a trophy to the mine having the best accident frequency record for the preceding month.

Commendable Safety Practices and Safety Record

Many commendable safety practices are in effect at the Carswell mine, some of which are as follows:

1. The use of permissible electrical equipment at working faces.
2. The use of permissible explosives.
3. The use of permissible electric cap lamps.
4. The use of safety shoes, hats, and goggles by all employees.
5. Rock-dusting.
6. Use of water to allay coal dust.
7. A safety organization.
8. Systematic check on ventilation.
9. All underground employees equipped with self-rescuers.

These and other safety practices and features have served to bring about a steady reduction in accidents at this mine during the past several years and to establish a low accident record for 1940. The following shows the accident record at the Carswell mine since 1930:

Year	Accident frequency
1930	129.1
1931	86.0
1932	62.7
1933	65.8
1934	91.2
1935	93.5
1936	58.6
1937	33.6
1938	14.9
1939	25.8
1940	19.0

Supervision and Discipline

The maximum number of men who are under a foreman in the conveyor sections is 9 to 10, in the mobile-loading section 15, and the maximum number in the hand-loading sections is 35; this should permit close supervision with two or more visits to each working place during the shift.

From observation and from other information, it is the opinion of the investigators that the supervision at this mine is not as efficient as it should be for a mine having as many unfavorable natural conditions. In the first place, many of the foremen do not have certificates of competency issued by the Department of Mines. Moreover, foremen in charge of mechanical-loading units are required to perform work other than of a supervisory nature; it is believed that foremen should confine their activities to supervisory work and to looking after the safety of their men.

Fire-Fighting

No fire-fighting organization, other than the training of men in the use and care of respiratory apparatus, is maintained.

PREVIOUS EXPLOSIONS IN THIS OR NEARBY MINES

Mine	Year	Fatalities
King	1916	6
Carswell	1919	6
King	1925	2
Keystone No. 2	1928	8

MINE CONDITIONS IMMEDIATELY PRIOR TO EXPLOSION

The mine was operating normally and no unusual conditions had been observed during the day or preceding the day of the explosion. The weather was clear and no sudden drop in barometric pressure had occurred prior to the explosion.

Some changes in the ventilation had been effected on the preceding day, and some 3 to 4 days previously three canvas stoppings had been erected at a point along 1st left entry where the No. 36 room off 2 left air course intersected it. These ventilation adjustments in all probability had a definite bearing on the accumulation of gas in 36 room, and slight leakage through these canvas stoppings gradually forced the gas-air mixture out of 36 room to 2 left entry air course.

Other circumstances that undoubtedly had a bearing on this gas-air mixture and igniting source are:

1. The room conveyor unit operating off 2 left entry had been moved out of the room and the loading head and several pan sections had been reinstalled in a new room set-up off 2nd left air course outby 36 room. In this moving operation the system of ventilating the rooms to right and left off 2 left air course was interrupted, thus short-circuiting the air away from No. 36 room on the right.

2. The trailing cable used for the face-conveyor unit, electric coal drill, and coal-cutting machine working in the newly started 37 room was temporarily coiled up along 2nd left air course outby No. 36 room.

3. From information obtained from the machineman who was cutting the face of No. 37 room neck immediately prior to the explosion it was learned that additional trailing cable was necessary to complete the undercutting of the place. He instructed his helper to pull some slack in the cable and, while this work was done, an arc was formed at the nips of the cable and the explosion followed. It was also learned that on several previous occasions arcs were formed at the nip connection and that the cable insulation was ignited causing a small fire.

STORY OF EXPLOSION AND RECOVERY OPERATIONS

Shortly after the explosion occurred one of the survivors telephoned the dispatcher informing him that an explosion had occurred. The dispatcher telephoned the outside and the mine officials were notified immediately. The dispatcher also telephoned and directed the removal of men working in the unaffected sections of the mine. Within a half hour a rescue party, including one doctor, entered the mine and proceeded to the scene of the explosion. A rescue team with breathing apparatus followed this party shortly thereafter. Other foremen and fire bosses who were in the mine at the time were notified and assembled at the scene of the explosion.

The foreman from the left room conveyor section on 2 left (the affected area), while painfully burned, directed and assisted 10 other frightened and some seriously burned men out of the smoke and afterdamp to the 1st King mains haulage entry by the time the first rescue party arrived. These men, suffering from exposure and burns, received medical and first-aid care at this time.

A party of six officials, dividing into groups of two men each, began an exploration trip in the affected area. Two men proceeded inby 44 room, two inby 41 room, and two inby 25 room off 1st King mains. The officials who had proceeded inby 44 room encountered a seriously burned man at the intersection of 2nd left air course. The two officials who started in 41 room proceeded to 2nd left, then inby 2nd left air course to 36 room, where they found two dead men near the intersection of 36 room with 2nd left air course and one semi-conscious man in the break-through between 2nd left air course and entry. They immediately rescued the injured man and brought him to the intersection of 44 room with 2nd left air course, where he was given first-aid care by the doctor and first-aid men.

All six officials who started the exploration trip, together with two State Mine inspectors and others, assembled and explored the affected area more carefully and found the bodies of the remaining two unaccounted-for men a short distance inby 36 room off 2 left entry.

The bodies of the four men were recovered by the mine rescue team, who made the recovery without respiratory protection, and were brought out of the mine about 10:00 a.m. One of the bodies had been completely cut into two parts.

PROPERTY DAMAGE

The explosion was confined to the 2nd left conveyor section. A canvas check curtain and a post had been set afire on 2 left entry 160 feet inby 41 room. This fire was extinguished by the party making the first exploration of the section. Relatively little property damage was done with the exception of disrupted and torn-down cables, damaged electric junction box, conveyor pans moved about, and a cave at the intersection of 36 room with 2 left air course.

FORCES

Forces of the explosion are indicated on the maps contained in the appendix of this report. Evidence indicates that the forces traveled outby to 41 room and inby to the gob area of 35 and 36 rooms off 2 left air course, to the gob area of 35 and 36 rooms off 2 left entry, and to the gob area on 2 left entry and air course.

FACTORS THAT PROBABLY PREVENTED SPREAD OF EXPLOSION

That the explosion did not extend over a greater area is due to several factors: (1) It is believed that the incombustible content of the dust was high enough to prevent the spread of the explosion; (2) the open area permitted expansion of the explosive gases at the intersection of 3 left air course with 36 room, which minimized the violence; and (3) because of the probability of a relatively small volume of gas-air mixture with a low concentration of methane, the temperature and pressure developed were not sufficient to continue propagation of flame through the coal dust.

INVESTIGATION OF CAUSE OF EXPLOSION

An investigation to attempt to determine the cause of the explosion was conducted on January 23, 24, 25, and 26 by the West Virginia Department of Mines, represented by N. P. Rhinehart, Chief, and Inspectors E. L. Chatfield, W. W. Jones, and J. W. Hall; the Koppers Coal Company, represented by J. O. Davis, Frank Kerr, William Ford, John Lindley, and F. J. Bailey; and the Federal Bureau of Mines, represented by W. J. Fene, F. E. Griffith, J. S. Ferraro, and F. J. Furin.

A joint coroner's inquest and hearing by the coroner of McDowell County and the West Virginia Department of Mines will be held.

SUMMARY OF EVIDENCE AS TO CAUSE, ORIGIN, AND PROPAGATION

The explosion is believed to have been initiated and for the most part propagated by gas; however, that coal dust aided to some extent in the propagation was evidenced by small deposits of coke on some of the timbers in the affected area. That the gas was ignited by an electric arc at the nips connection of the mining machine cable and the main power cable was substantiated by statements from survivors. That the cause of the accumulation of methane in No. 36 room was due to a short circuit in ventilation was brought out by statements from employees working on a previous shift, to

the effect that a canvas check curtain and a canvas regulator had been partially or completely torn down on the preceding shift. The fact that analyses of air samples collected in the explosion area the day after the explosion did not show an explosive mixture is no criterion that an explosive mixture did not exist during part of the preceding day. It is known that recent sudden outbursts of gas have occurred in this section of the mine, and such a sudden outburst of gas may have occurred just prior to the explosion.

The inspectors of the West Virginia Department of Mines who investigated the explosion and the Bureau of Mines investigators were in agreement that the cause of the explosion was the ignition of gas by an electric arc at the intersection of 36 room with 2 left air course.

LESSONS LEARNED FROM THE CONDITIONS AS THEY RELATE TO THIS EXPLOSION

In the opinion of the writers, there are three outstanding lessons learned from this explosion, as follows:

1. That where mechanical loading and conveying of coal are done, all working places (rooms, break-throughs, and entries) should be positively ventilated to the working face; and in at least some cases this should be effected by a properly constructed line brattice.

2. That foremen should not be permitted to do other than inspection, instructional, and supervisory work.

3. This explosion again clearly demonstrates the fire and gas-ignition hazard of improperly installed and maintained cables for transmission of electric power. It demonstrates, too, a need for better qualified and specifically trained men to install and maintain electrical equipment in a safe and workmanlike manner.

RECOMMENDATIONS

The following recommendations are made with the belief that their adoption will materially lessen the chances of occurrence of an explosion in this mine in the future.

Ventilation

1. The system of ventilating sections of the mine such as is used where conveyor loading is done should be changed so a definite volume of air will pass through the active workings and be directed into the return through open airways instead of through gob areas to the upcast shaft.

2. Ventilation should be conducted to the face behind substantially constructed line brattices in all mechanical- or conveyor-loading places regardless of whether gas is being liberated in detectable amounts.

3. Doors should be used instead of check curtains or "flies" in advance workings where it is not practical to erect permanent structures for controlling the ventilation.

4. Latches should not be installed on doors to hold them open, and doors should be hung in such manner as to insure positive self-closing. Permanent doors should be eliminated so far as possible by the use of overcasts.

5. Canvas stoppings should not be used where their expected service is for a period longer than 2 weeks; for periods longer than this stoppings should be constructed of incombustible material.

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

Allaying Coal Dust

1. Water should be used on all mining machines, on loading machines, before and after blasting, and on loaded and empty cars.

2. All working places should be kept thoroughly wetted in the face regions for at least 40 feet back from the face.

Rock-Dusting

1. Accumulations of coal and coal dust should be promptly cleaned up and loaded out.

2. Rock dust should be applied to the surface of all openings, airways, entries, haulageways, rooms, and crosscuts to within at least 40 feet of the working faces in sufficient amount so the incombustible content will be at least 65 percent. If the face region is not kept wet, the rock-dusting should be extended to the face.

3. If methane is present in the air current, the incombustible content should be increased about 1 percent for every 0.1 percent of gas present.

4. Samples of rock dust should be collected frequently in various places throughout the mine and, when analyses of such samples disclose that there is less than 65 percent incombustible present in any portion of the mine, redusting should be done immediately so the required amount or more of incombustible will be present at all times.

Explosives

1. The use of permissible explosives should be continued, but they should be charged and fired in a permissible manner.

A review of the conditions of use of such explosives to comply with permissibility is as follows:

(a) That not more than 1-1/2 pounds be used in any one borehole.

(b) That electric detonators of not less than No. 6 strength be used.

(c) That holes shall not be drilled on the solid or the shot have a burden so great that it is likely to blow out.

(d) That the explosive be tamped with incombustible stemming to the colar of the hole.

(e) That the shots be fired with a permissible battery or other permissible firing device.

(f) That not more than one shot be fired at a time and that no shot be fired in the presence of a dangerous percentage of explosive gas.

2. Competent shot firers should be employed to do all shooting of coal and rock, and they should make tests for gas before and after firing each shot.

3. No more explosives should be taken into the mine or stored underground than is necessary for one day's operation.

Electricity

1. All electrical equipment used at or near the face of workings should be of the permissible type and should be maintained in a permissible manner.

2. Trolley or cable-reel locomotives should be operated only in 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 break-through.

3. The guarding of bare trolley and other bare electrical transmission lines should be continued wherever they are less than 6-1/2 feet above the rail and these should be maintained in good condition.

4. The splicing of cables underground should be prohibited and standby trailing cables should be provided for immediate replacement of worn or damaged cables. All trailing cable splicing should be done on the surface where they can be vulcanized efficiently.

General

1. Room development in conveyor mining should be done in pairs from one entry only.

2. Self-rescuers should be tested at least monthly by submersion in hot water and if air bubbles appear they should be discarded.

3. Only competent certified foremen should be employed.

4. Foremen's activities should be confined to supervision and to safety inspection work.

ACKNOWLEDGMENT

The writers wish to acknowledge the courtesies extended and the helpful assistance given by the officials of the Koppers Coal Company, particularly L. C. Campbell, assistant to vice president; J. O. Davis, division superintendent; F. J. Bailey, division safety engineer; Frank Kerr, superintendent; and William Ford, mine foreman. All information requested from these company officials in connection with this investigation was given without reservation. The cooperation of the West Virginia Department of Mines is also gratefully acknowledged.

Respectfully submitted

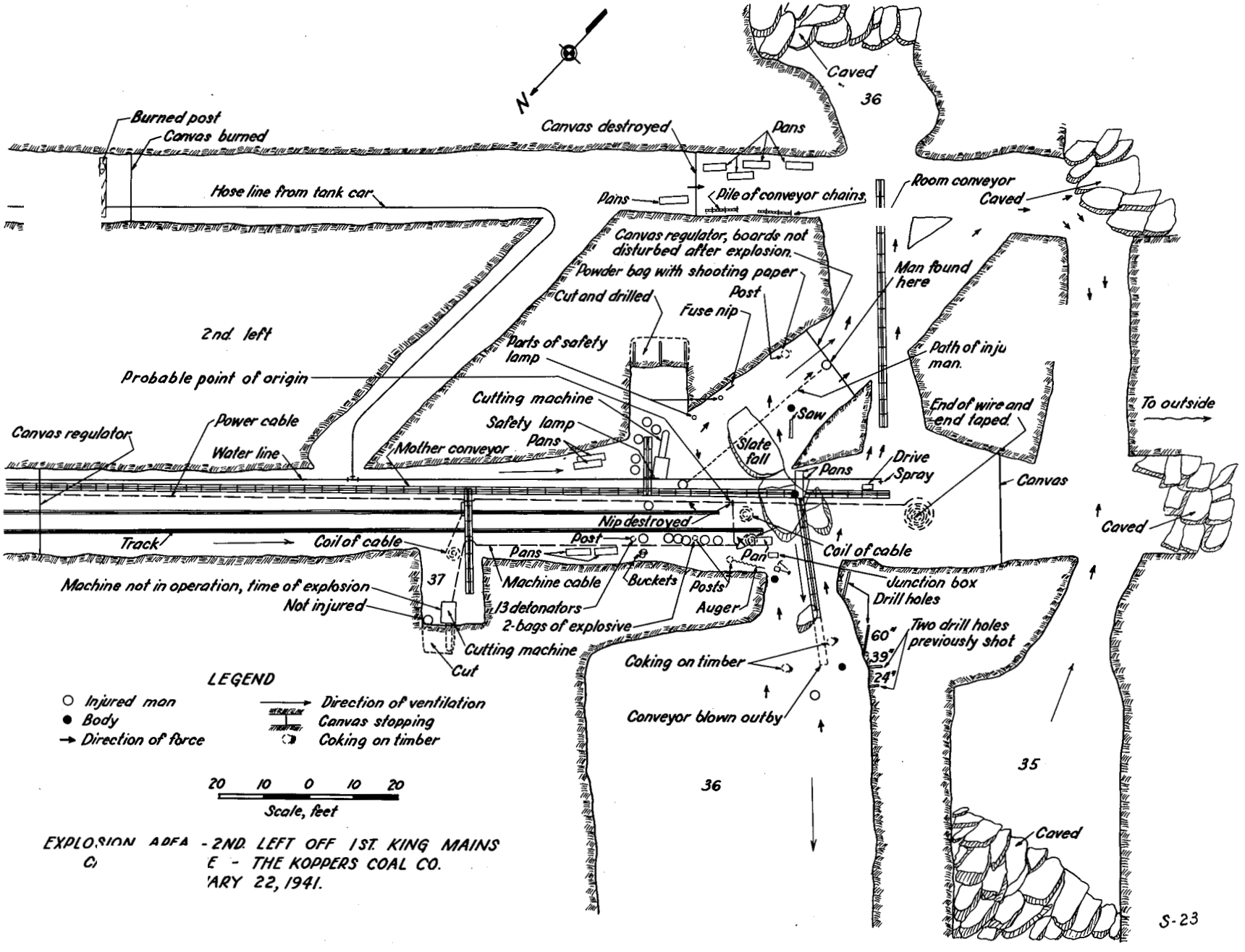
W. J. FENE
Mining Engineer

Approved:

D. HARRINGTON
Chief, Health and Safety Branch

F. E. GRIFFITH
Assistant Mining Engineer

A P P E N D I X



EXPLOSION ADEA - 2ND. LEFT OFF 1ST. KING MAINS
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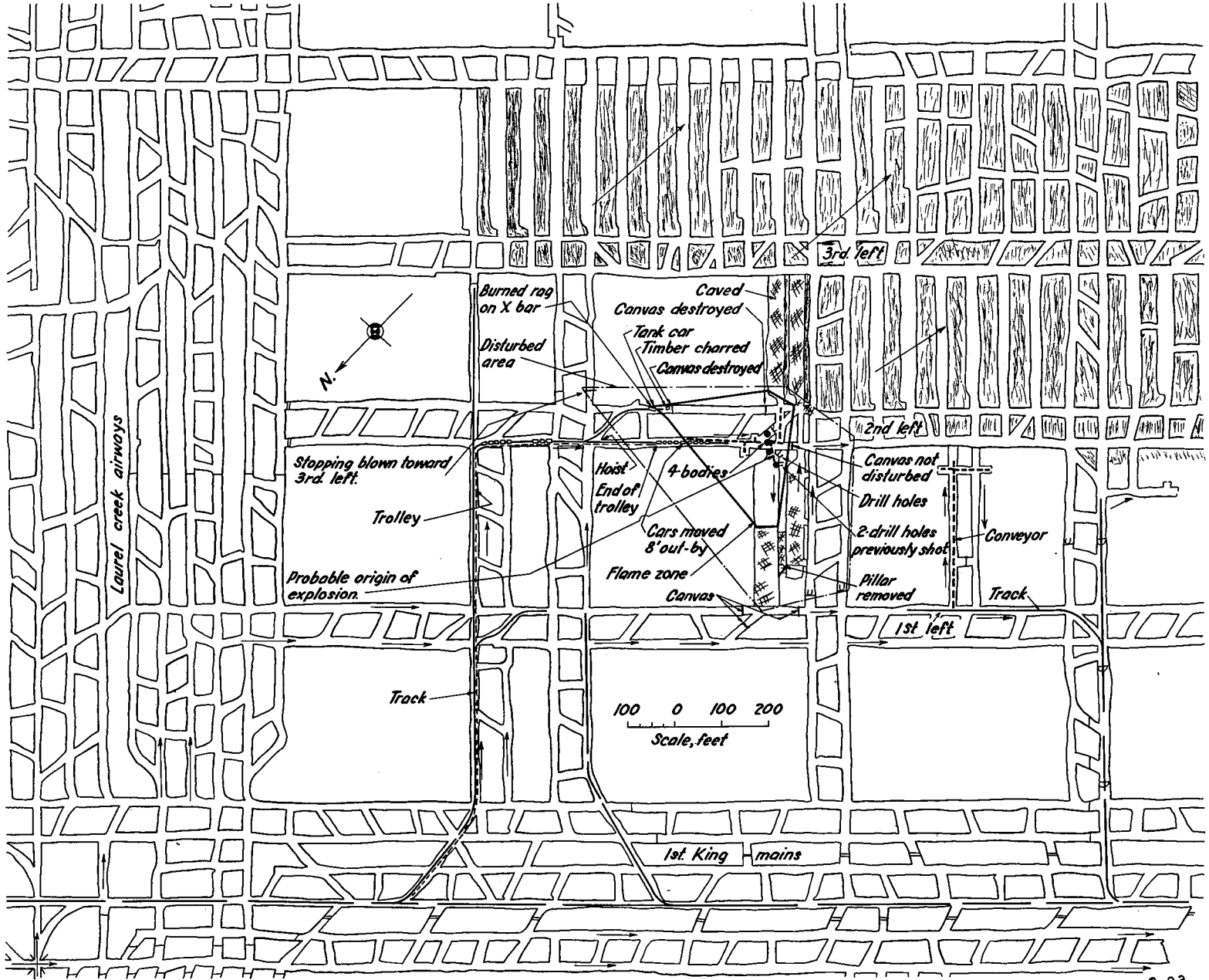

EXPLOSION AREA AND WORKINGS IN 2ND. LEFT OFF 1ST. KING MAINS - CARSWELL MINE - KOPPERS COAL CO. JAN. 22, 1941.

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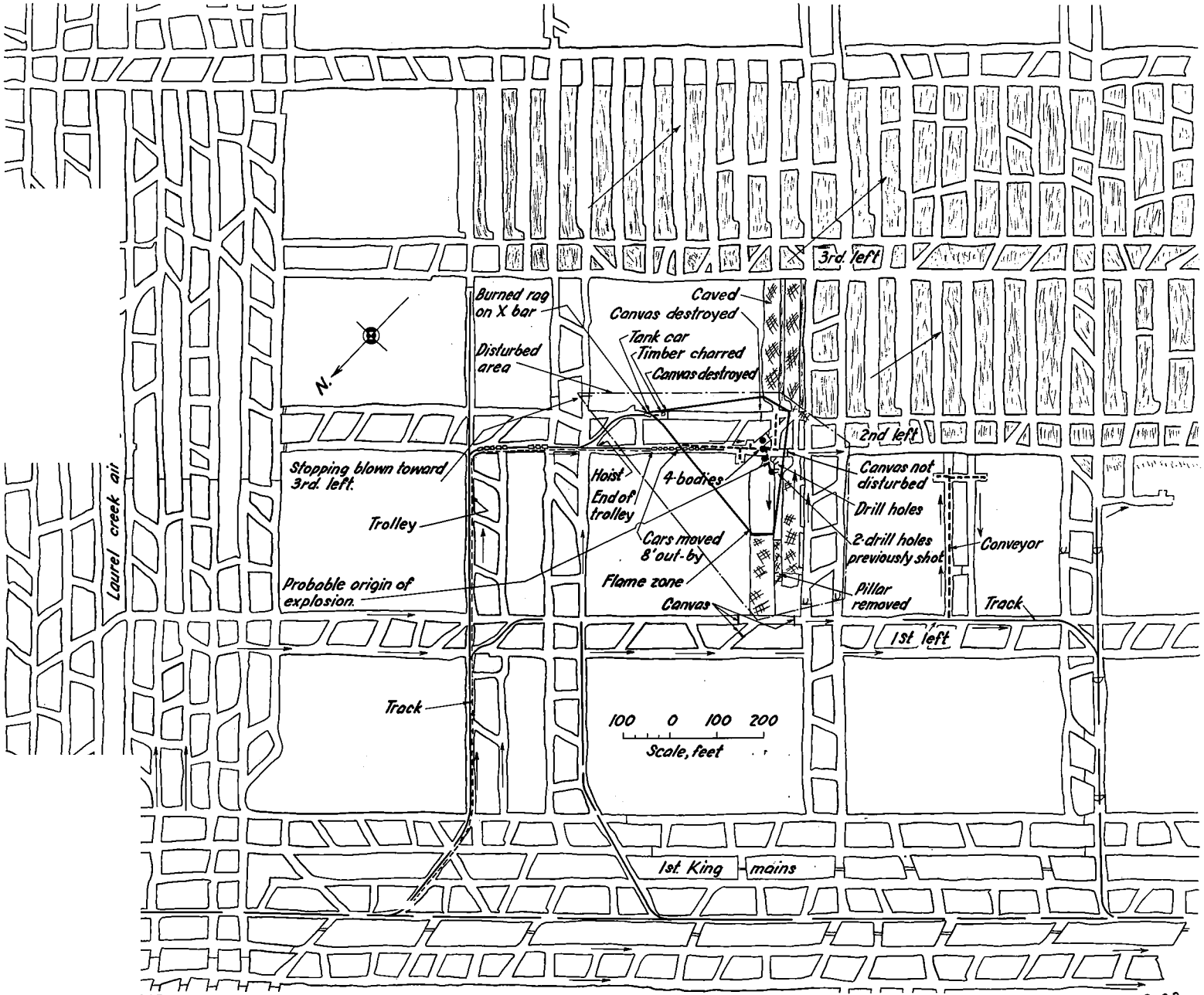

REA AND WORKINGS IN 2ND. LEFT OFF 1ST. KING MAINS - CARSWELL MINE - KOPPERS COAL CO. JAN. 22, 1941.

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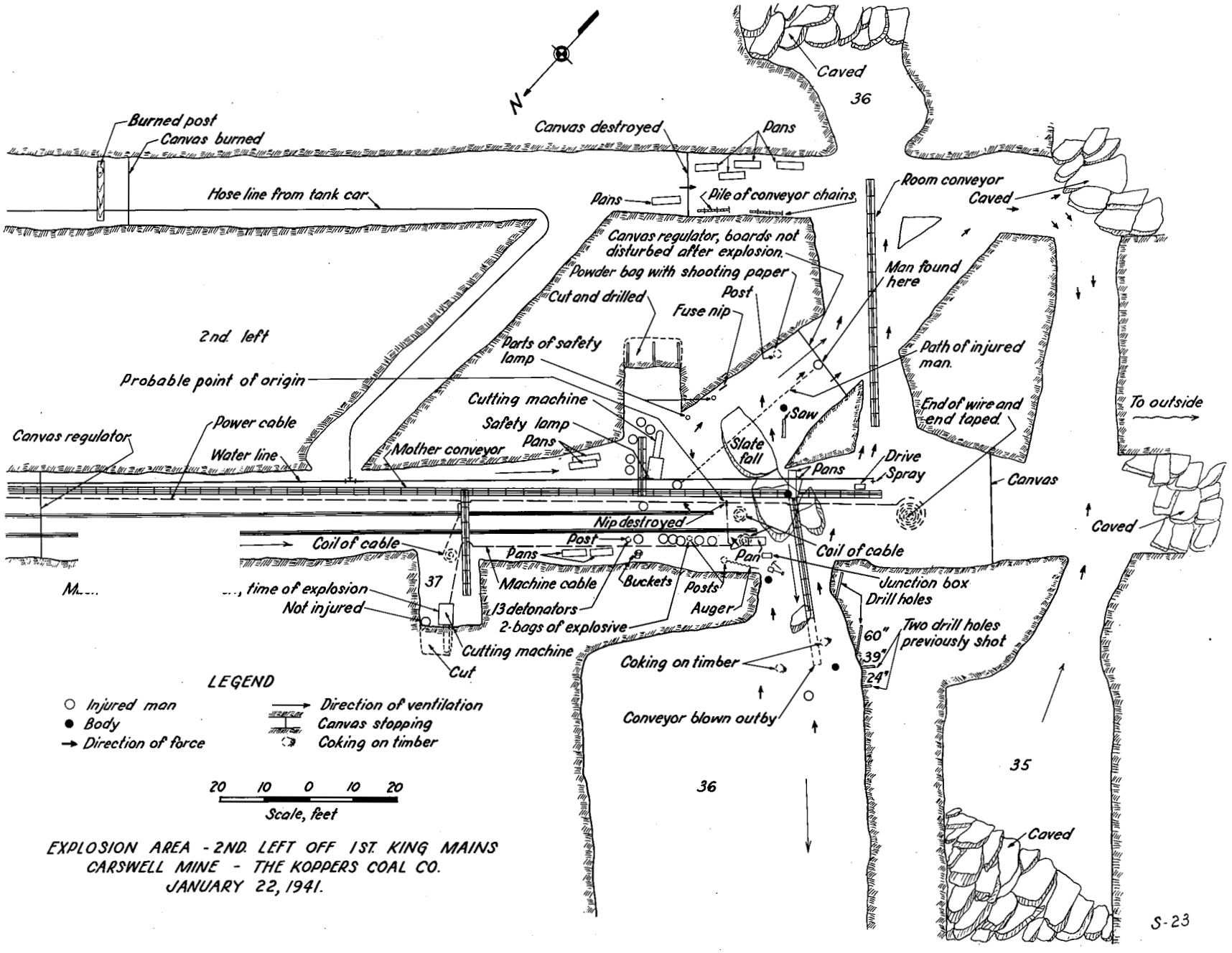

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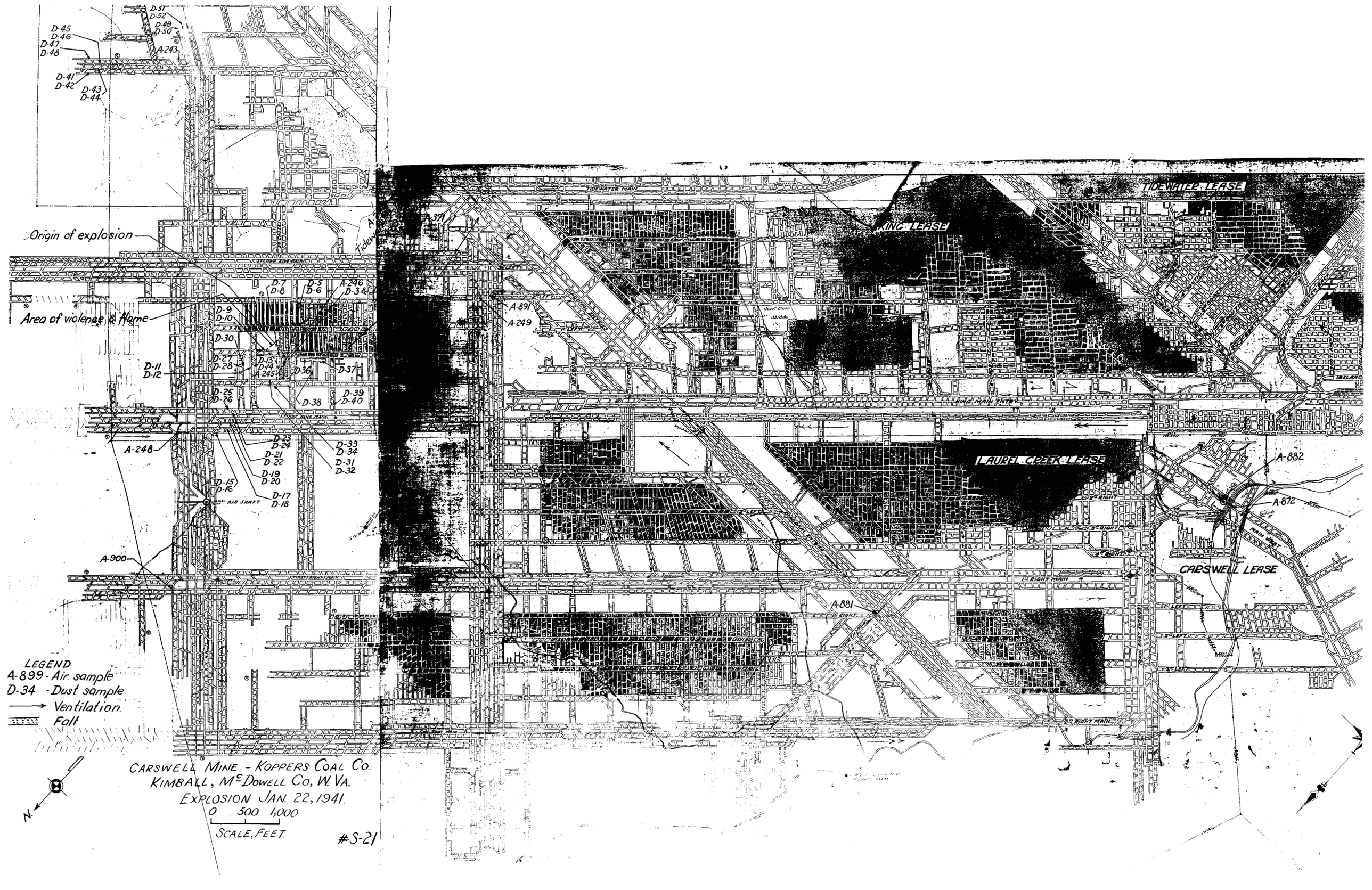
CARSWELL MINE - THE KOPPERS COAL CO.
JANUARY 22, 1941.


Origin of explosion
Area of violence & flame
TIDEWATER LEASE
KING LEASE
LAUREL CREEK LEASE
CARSWELL LEASE
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KING MAIN ENTRY
MAIN HEAT
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A-248
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A-872
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D-18
LEGEND
A-899 - Air sample
D-34 - Dust sample
Ventilation
Fall
N.
CARSWELL MINE - KOPPERS COAL CO.
KIMBALL, McDOWELL CO, W. VA.
EXPLOSION JAN. 22, 1941.
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SCALE, FEET.
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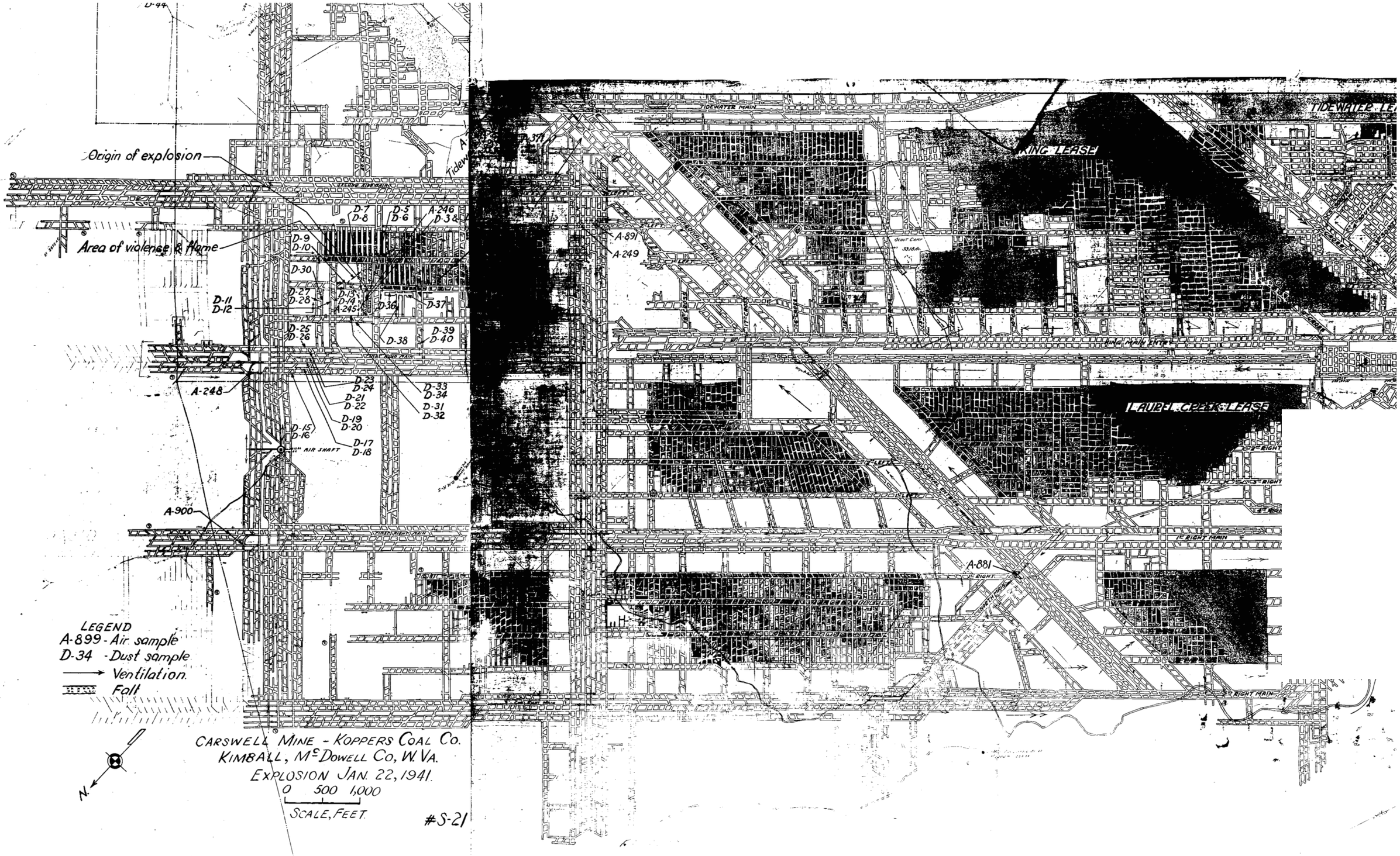
Origin of explosion
Area of violence & flame
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D-8
D-5
D-6
A-246
D-3&
D-9
D-10
D-30
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AIR SHAFT
A-900
A-899
D-34
A-891
A-249
A-881
TIDEWATER MAIN
KING LEASE
LAUREL CREEK LEASE
NORTH MAIN
RIGHT MAIN
LEGEND
A-899 - Air sample
D-34 - Dust sample
Ventilation
Fall
N.
CARSWELL MINE - KOPPERS COAL CO.
KIMBALL, Mc DOWELL CO, W. VA.
EXPLOSION JAN. 22, 1941.
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SCALE, FEET.
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