BULLETIN 586
BUREAU OF MINES

HISTORICAL SUMMARY OF COAL-MINE EXPLOSIONS IN THE UNITED STATES, 1810–1958

BY H. B. HUMPHREY

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1960

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
Marling J. Ankeny, Director

This publication has been cataloged as follows:

Humphrey, Hiram Brown, 1895–
Historical summary of coal-mine explosions in the United States, 1910–1958. Washington, U.S. Govt. Print. Off., 1960.

viii, 280 p. illus., maps. 26 cm. (U.S. Bureau of Mines. Bulletin 586)
Bibliography: p. 279–280.

1. Mine explosions. 2. Coal mines and mining U.S. I. Title. (Series)

TN23.U4 no. 586 622.06173

U.S. Dept. of the Int. Library

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. Price $1.75

Foreword

The events described in this publication cover a much longer span of years than the life of any of the men who have had leading parts in them. Even the later period from 1910 to 1958 is longer than the active careers of those most closely identified with the seemingly never-ending battle to control and prevent mine-explosion disasters. Those most active from before 1910 to about 1930 have retired from the scene, and the oldest of those now concerned had their first experiences about 1915. In the accounts that follow there is acknowledgment of the endeavors and accomplishments of a few of the leaders in the early work of explosion prevention and their part in rescue, recovery, and investigation after explosions. Few, if any, of the many able leaders of later years are mentioned because of the number that would need to be included.

Among this number is John J. Forbes, former Director of the Bureau of Mines, who initiated preparation of this report to preserve and explain the record of a major accomplishment in coal-mine safety. His experience began in 1914 as a safety engineer, giving instruction to miners and recommending safeguards to operators. He had the task, many times repeated, of participating in rescue and recovery after mine explosions. In his career as a supervisor of the Bureau's safety program, he earnestly labored to bring realization of neglected hazards to both miners and officials and to remove the impediments that stood in the way of correcting dangerous conditions in the mines. Much of the progress in reducing the number of explosions and the loss of life from them was accomplished under his direction and by his devotion to this end. Through all the years that "Jack" Forbes was in the Bureau of Mines from first-aid miner to Director, he was a leader in this field.

Government research on the prevention of mine explosions began in the Technologic Branch of the Federal Geological Survey of the United States Department of the Interior in 1908, as a result of a succession of disastrous coal-mine explosions that caused the death of 1,148 miners in 8 mines in the United States in 1907. In 1910, this work was transferred to the newly created Bureau of Mines. Dr. Joseph H. Holmes, chief of the Technologic Branch of the Survey and first Director of the Bureau of Mines, was a vigorous organizer and tireless crusader for safety. He at once obtained the services of George S. Rice as his chief mining engineer; the latter already had become interested in the effect of rock dust in limiting the propagation of coal-dust explosions and had presented a paper before the Illinois Coal Mining Institute discussing his own and foreign observations that fewer explosions occurred in high-ash coal mines.

Rice, with headquarters at the Central Experiment Station of the Bureau of Mines at Pittsburgh, Pa., designed and constructed the first Experimental Coal Mine in the world at Bruceton, near Pittsburgh, for studying the mechanism of coal-dust explosions; and he demonstrated the efficacy of rock dusting in preventing propagation of explosions.

During the Bureau's formative years in Pittsburgh, Rice with the cooperation of James W. Paul and under the inspiring leadership of Director Holmes, assembled an enthusiastic group of young mining engineers to investigate mine explosions, develop rescue methods at disasters, and educate operators and miners in safer methods. Among these enthusiasts was John J. Forbes, who later headed those activities. These men developed into the leaders of safety and efficiency in mining as taught in our mining schools and as practiced in industry today.

Other pioneer safety men were George S. Deike, E. H. Denny, Charles Enzian, H. P. Greenwald, G. W. Grove, Daniel Harrington, C. A. Herbert,

D. J. Parker, D. J. Price, J. J. Rutledge, J. T. Ryan, Sr., H. I. Smith, R. Y. Williams, H. M. Wolflin, and many others who made notable contributions to the Bureau's pioneering work in preventing and reducing the toll from mine explosions.

Marling J. Ankeny, the present Director, became associated with the Bureau of Mines in 1928 and assisted in recovery work and investigation of many of the explosions that occurred during the period after 1928; he contributed technologic information, with appropriate recommendations to the industry for preventing mine fires and mine explosions.

Most of the material in this publication appeared originally as Bureau of Mines Information Circular 7900.

JAMES WESTFIELD,
Assistant Director, Health and Safety.

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HISTORICAL SUMMARY OF COAL-MINE EXPLOSIONS IN THE UNITED STATES—1810–1958[1]

by

H. B. Humphrey[2]

Summary

EXPLOSIONS of gas and dust in coal mines have caused death and injury to miners and destruction of workings in all countries where coal is mined underground. In the United States the first reported explosion was in 1810; explosions have continued to the present. The danger to men in a mine when an explosion occurs is not always measured by the violence created or by their nearness to the area through which flame and violence extend. As many, perhaps more, men have died from gases and lack of oxygen (known as "after-damp") than have been killed by the blast and heat. Mine explosions often are caused by a combination of factors, including concentration of methane in air, formation of clouds of dust, and the presence of a flame or spark. These explosion factors have varied with changes in mining methods and practices over the years, but the basic causes have always been the same. Understanding of the causes and acceptance of ways to guard against explosions and their effects have been slow to spread from investigators to officials and then to bosses and miners. To a considerable extent there has been a belief that explosions were a mining risk that might be put off but could not be prevented. Such belief is based on the human failure to maintain and observe necessary precautions. These failures, caused by inertia to change, carelessness, or reliance on continuance of past explosion-free years, are being reduced in number and effect by education of miners and supervisors and acceptance of higher prevention standards.

[1] Work on manuscript completed September 1959.

[2] Mining health and safety engineer, Bureau of Mines.

PURPOSE OF REVIEW

The purpose of this review is to relate the growth of explosion hazards to the increased number and size of the coal mines and the changes in mining methods. The causes of explosions during each period of years are discussed to show progress or its lack in controlling or eliminating different causes. The history of efforts by Government agencies and the coal-mining industry is connected as far as seems plausible to the rise and fall of the number of explosions and fatalities from them during certain periods.

Detailed descriptions and accounts of many explosions will explain the practice and failures that have been mainly responsible for these disasters, and to some degree a number of them indicate the success attained so far in controlling the spread of ignitions in certain mines. No illustrations can be given of explosion prevention; on that point the only evidence is a decrease in the recorded occurrences.

In all probability the prevention and control of coal-mine explosions in this country have been brought to a stage where a summation of their history, the existing hazards, and the effective means of prevention may assist in framing new programs of attack.

ACKNOWLEDGMENTS

The material upon which the author has drawn has been the product of the experience and thinking of the many able men in the Bureau of Mines and other organizations who have risked their lives in rescue and recovery work after fires and explosions and have investigated and searched painstakingly for the causes of hundreds of disasters. In addition, reports of research and experiments to find the factors and conditions causing explosions and those to develop and prove means for prevention have been used and quoted. Any attempt to single out individuals by name except by references to publications would be an impossible undertaking. Men of the Bureau of Mines are named as authors of explosion reports and as authors of reference publications. Some persons outside the Bureau are similarly recognized.

EARLY HISTORY, 1702–1890

THE VIRGINIA DISTRICT

Coal from the outcrops was used very seldom for fuel by the Indians and only rarely by early settlers in this country. Wood was plentiful and easy to get and to burn. Some was converted to charcoal for special purposes. However, in 1702 coal from the deposits on the James River in Virginia was used in blacksmith forges. Digging coal for local use continued there, but the first record of coal shipped on the river was in 1758.

Another mine was opened near Richmond in 1760 (*10, pp. 28–31*).[3] By 1810 or a few years earlier 3 of the numerous shafts then being worked were 300 feet deep. In those mines methane was encountered that often formed explosive mixtures in poorly ventilated workings. The first report of an explosion is found in a letter of 1818 describing the mines, then known as "Heath's pits." The statement is made that (*22, pp. 125–130*):

> Previous to the adoption of this (improved) method of ventilation, they experienced great inconvenience from carbonic acid gas; and some of the workmen had been killed by an explosion of carburetted hydrogen gas.

Mining flourished in the Richmond coalfield through 1840 and to a moderate extent during the Civil War. Operations were irregular and profits were uncertain because of inefficient methods and the competition of other fields for other than local markets. By 1890, active mining had nearly vanished, and although some revival was attempted about 1906, coal production ceased in a few years.

FIRST EXPLOSION HAZARDS IN VIRGINIA MINES

Explosions in the mines in the Richmond field began when depths were reached that required real ventilation and recurred until work was stopped and the mines filled with water. Most of the explosions originated from the ignition of gas, although a few are reported as dust explosions caused by blasting (*8, pp. 4–11*). Open lights were used throughout this period, and black powder and dynamite were employed to break coal and rock in the mines.

The flame safety lamp, invented in 1815 and introduced in British mines about 1818, made it possible to operate mines in that country that had been closed because the danger from gas had become too great with the methods of lighting and testing for gas previously used. The advent of the flame safety lamp did not change the alarming increase of explosion disasters in British mines, because safety lamps were as dangerous as miners' open lights when improperly used (*54, p. 26; 55, pp. 85–89*). Safety lamps were known and used in the Virginia mines as early as in England, because British or Scottish miners were brought over to direct and oversee the laborers (*22, pp. 125–130*). An advertisement for pit hands by the Mid-Lothian Mining Co. in the Richmond Enquirer, January 9, 1840, states that "all precautions are being observed under expert guidance of two mine foremen from England." A description of the Virginia mines by the president of the Mid-Lothian Mining Co., published in the American Journal of Science in 1841, shows clear understanding of the need for precautions against gas accumulations and careless use of lights.

> The ventilation of the mines is committed to the management of a Newcastle miner or gas man of much experience and skill, trained by Mr. Buddle, the distinguished English mining engineer. The ventilation is kept up by means by brattice work of boards, and aided by a furnace underground. The atmospheric air is taken down one side of the shaft, and courses the whole drift, passing outby the furnace in the opposite side of the shaft. On the upcast side the air is received some 30 feet from the bottom of the pit into the shaft. Large quantities of inflammable gas are thrown out from the coal in the mines constantly, and any interruption in the air coursing the mines with regularity, might and would be attended with disastrous consequences from an explosion of the gas. Sir Humphrey Davy's lamp is used at the mines more as a pioneer than otherwise; no mines are considered safe that require to be worked by safety lamps. They ought to be used only in going through the mines to see that all is right, before the miners are put to work; or to be used to free the mines in case they are overcharged with gas.

In a work on coal mining in the United States published in 1876, the author comments as follows on the use and dangers of the flame safety lamp and earlier ways of finding gas accumulations (*55, p. 87*):

> They are all covered by the wire-gauze cylinder. The great objection to every kind of safety lamp is the feeble light they give, which tempts the miners to

[3] Italicized figures in parentheses refer to items in the bibliography at the end of this report. Page references apply to the citations and not to this bulletin.

take off the top or gauze, and risk the consequences of an explosion.

Before the discovery of the safety lamp the presence of firedamp in coal mines was ascertained by the miner creeping cautiously forward along the mine, holding a lamp or candle in one hand and screening the flame with the two forefingers of the other, meantime keeping his eye intently fixed on the top of the light. As he reaches the explosive compound, the top of the flame begins to elongate and to assume a color of greyish blue. He stops at this juncture, and slowly raises his light towards the roof where the firedamp floats. The flame now elongates into a sharp spire, the top changing from greyish blue to a pure fine blue, and giving off minute luminous sparks. This is the extreme point of danger—a sudden movement of the body or a quick lowering of the lamp would cause an explosion. The miner lowers the lamp with great caution, and extinguishes the flame with his thumb and finger. This experiment, termed "trying the candle," was one of extreme peril, and was entrusted only to the more coolheaded of the miners. If the gas was not very copious, it was fired by means of "the firing line." A light was attached to the end of a cord, that passed over a wheel at the wall face; the light was then drawn into the fire-damp while the miner retreated to a safe distance. Sometimes the miner would wrap himself in a wet jacket, and stretching himself flat on the floor would raise his light and explode the gas over his head. In France, this person was sometimes called the penitent, as his head was covered by a mask resembling a monk's cowl, but he was more generally named the cannoneer of the mine.

BEGINNING OF COAL MINING AND FIRST MINE EXPLOSIONS IN THE STATES

Records of the early mining of coal in some of the States are definite and detailed; in others they are obscure and vague because of the irregular growth of the trade or a lack of means of transportation from the deposits to towns or works where coal might be introduced as a fuel. From sources such as Howard N. Eavenson's book, The First Century and a Quarter of American Coal Industry, Bureau of Mines publications (Bulletin 115, etc.), and other writings on coal mining in this country the data shown in table 1 were compiled. The distinction between "first mining" and "first production" is made to show when coal was first taken for local use and when commercial production was

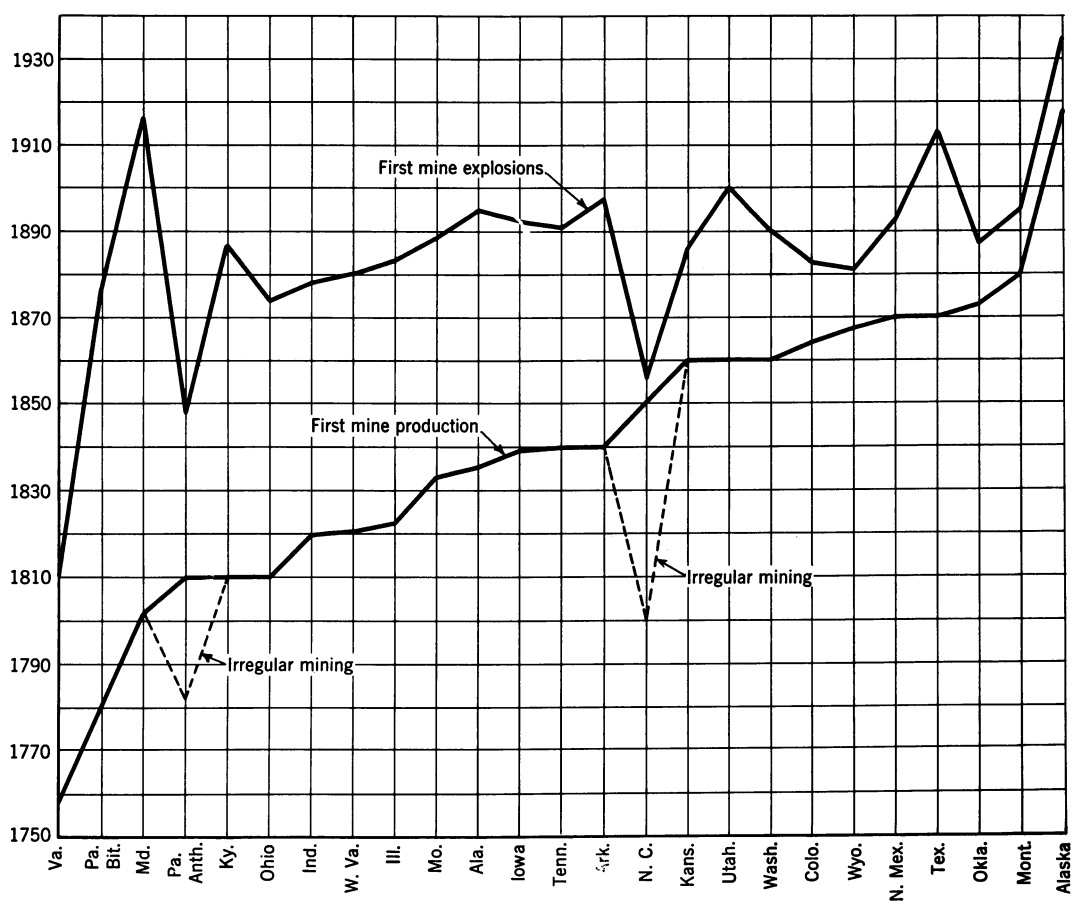

FIGURE 1.—Interval from first mining to first explosion, by States.

begun. In most States these dates are established by historical accounts, but in a few an approximate date has been chosen representing a period of small and irregular mining. In each State the first recorded fatal explosion and the first major explosion disaster are shown. In several States the first recorded explosion was a major disaster. The dates of the first mine production and of the first explosion in each State are plotted in figure 1, to show the average lapse of years before the explosion hazard became manifest. In States where mine production was begun before 1820 the average interval before an explosion oc-

TABLE 1.—*First coal mining and first explosions, by States*

State	First mining	First production	First explosion	Description		
				Mine	Number killed	Cause
Alabama	1830	1835	May 22, 1891	Pratt No. 1 shaft	11	Gas, open light.
Alaska	1855	1916	Oct. 26, 1937	Evan Jones	14	Gas and dust, smoking.
Arkansas	1830	1840	Mar. 4, 1897	Kansas & Texas No. 44.	14	Gas and dust, blown-out shot.
Colorado	1860	1864	Nov. 29, 1883	Crested Butte	1	Gas, open light.
			Jan. 24, 1884	Crested Butte	59	Do.
Georgia	1835	1860				
Illinois	1810	1822	Jan. 9, 1883	Coulterville	10	Gas and dust, blown-out shot.
Indiana	1810	1819	Nov. 21, 1878	Sullivan	8	Gas, open light.
Iowa	1835	1839	Nov. 8, 1892	Pekay	3	Dust, blown-out shot.
			Feb. 14, 1893	Chicago & Iowa	8	Do.
Kansas	1853	1860	Dec. 17, 1887	No. 3 Western C. & M. Co.	3	Do.
			Nov. 9, 1888	Frontenac shaft No. 2.	40	Do.
Kentucky	1790	1810	Oct. 7, 1887	Hopkins Co	3	Gas and dust, blown-out shot.
			Apr. 20, 1904	Stearns No. 5	5	Dust, blown-out shot.
Maryland	1775	1802	Feb. 29, 1916	Davis No. 42	16	Do.
Michigan	1835	1840				
Missouri	1817	1833	Mar. 29, 1888	Keith & Perry No. 6	24	Gas and dust, blown-out shot.
Montana	1867	1880	Jan. 25, 1895	Montan C. & C. Co	1	Gas, open light.
			Feb. 27, 1943	Smith	74	Gas and dust, open light.
New Mexico	1863	1870	1893		1	Do.
			Feb. 27, 1895	White Ash	24	Do.
North Carolina	1775	1850	1855	Egypt shaft	3	Gas, open light.
			Dec. 19, 1895	Cummock (Egypt)	39	Do.
North Dakota	1884	1884				
Ohio	1804	1810	Feb. 10, 1881	Robbins	6	Gas, open light.
Oklahoma	1872	1873	Apr. 5, 1887	Old Savannah No. 2	18	Do.
Pennsylvania A	1776	1810	Feb. 19, 1847	Spencer	7	Do.
Pennsylvania B	1760	1780	1877		(1)	Do.
			Dec. 29, 1879		3	Do.
South Dakota	1874	1883				
Tennessee	1834	1840	January 1891	Thistle	1	Do.
			Dec. 20, 1895	Nelson	28	Gas and dust, blown-out shot.
Texas	1850	1870	Aug. 28, 1914	Dolores	1	Gas, open light.
Utah	1851	1860	Mar. 22, 1900	Winter Quarters No. 1.	(1)	Dust, blown-out shot.
			May 1, 1900	Winter Quarters Nos. 1 and 4.	200	Do.
Virginia	1702	1758	1810	Heath's pits	Several	Gas, open light.
Washington	1854	1860	1889	Roslyn	1	Do.
			May 10, 1892	do	45	Do.
West Virginia	1800	1820	Mar. 27, 1880	Newburg	2	Do.
			Jan. 21, 1886	do	39	Gas and dust, open light.
Wyoming	1859	1867	Mar. 4, 1881	Almy	38	Do.

[1] No fatalities.

TABLE 2.—*Major explosions in United States coal mines to 1890*

Date	Name of mine	Location of mine	Killed
1839: March 18	Black Heath	Near Richmond, Va	53
1844	do	do	11
1847: February 19	Spencer [1]	Pottsville, Pa	7
1850	Cox's pit, Clover Hill	Winterpock, Va	7
1854: May 15	Chesterfield	Near Richmond, Va	20
1855: March 19	Midlothian	Coalfield, Va	55
1859: April 13	Bright Hope, Clover Hill	Winterpock, Va	9
1863	Raccoon, Clover Hill	do	17
1867: April 3	Bright Hope, Clover Hill	do	69
1871: August 14	Eagle Shaft [1]	Pittston, Pa	17
October 2	Otto Red Ash [1]	Branch Dale, Pa	5
1873: June 10	Henry Clay [1]	Shamokin, Pa	10
1876: May 20	Midlothian	Coalfield, Va	8
July 24	Black Diamond	Nortonville, Calif	6
1877: May 9	Wadesville [1]	Wadesville, Pa	7
1878: January 15	Potts [1]	Locust Dale, Pa	5
November 21	Sullivan	Sullivan, Ind	8
1879: May 6	Audenried [1]	Audenried, Pa	6
November 2	Mill Creek [1]	Mill Creek, Pa	5
1880: March 5	Nanticoke No. 2 [1]	Nanticoke, Pa	6
May 3	Lykens Valley [1]	Shamokin, Pa	5
1881: February 10	Robbins	Robbins, Ohio	6
March 4	Almy	Almy, Wyo	38
1882: February 3	Midlothian	Coalfield, Va	32
May 24	Kohinoor [1]	Shenandoah, Pa	5
1883: January 9	Coulterville	Coulterville, Ill	10
1884: January 24	Crested Butte	Crested Butte, Colo	59
February 20	West Leisenring	West Leisenring, Pa	19
March 13	Laurel	Pocahontas, Va	112
October 27	Youngstown	Uniontown, Pa	14
1885: October 21	Plymouth No. 2 [1]	Plymouth, Pa	6
1886: January 12	Almy, No. 4	Almy, Wyo	13
January 21	Newburg	Newburg, W. Va	39
March 8	Uniondale	Dunbar, Pa	6
August 30	Fair Lawn [1]	Scranton, Pa	6
November 26	Conyngham [1]	Wilkes-Barre, Pa	12
1887: April 4	Old Savanna No. 2	Savanna, Okla	18
1888: March 29	Keith & Perry No. 6	Rich Hill, Mo	24
November 3	Kettle Creek	Clinton County, Pa	17
November 9	Shaft No. 2	Frontenac, Kans	40
1890: February 1	Nottingham [1]	Plymouth, Pa	8
April 2	Susquehanna No. 4 [1]	Nanticoke, Pa	5
May 15	Jersey No. 8 [1]	Ashley, Pa	26

[1] Anthracite.

curred was about 75 years; where mining was begun between 1820 and 1850, the interval was almost 60 years; and where mining became a local industry after 1850, the average explosion-free period was about 20 years. The lessening interval reflects the more rapid development of the mines in later years as against the slow handwork of earlier days. As examples, commercial development of coal in Wyoming was begun in 1867 with a reported production of 5,000 tons and increased to over 100,000 tons by 1870; in Colorado the production in 1864 was 500 tons, increasing to 10,000 tons by 1869 and 100,000 tons by 1875. In 1833, when the first fatal explosion was recorded, the production was more than 1¼ million tons. The summations in figure 1 and table 1 indicate that the conditions under which explosions in coal mines began to occur were not at all haphazard and that explosions usually began when the mines were developed to a stage favorable to such conditions. The combinations of conditions that led to fatal mine explosions are given, where known, in the accounts of disasters related in this book.

EXPLOSIONS IN VIRGINIA MINES, 1810–90

The major explosions in United States coal mines listed in table 2 are those on which definite information has been found by the Bureau of Mines (*19*). Several other explosions in Virginia mines in the early years are mentioned in letters or articles relating to these

mines, but details have not been found. The references mentioned the following occurrences:

Date	Mine	Killed	Cause
1810 (approx.)	Heath's pits	Some	Gas-open light.[1]
1817 (approx.)	Will's pits	None	Do.[2]
1836	Chesterfield	Unknown	Do.[3]
1840	Will's pits	Some	Do.[4]
1851	English pit	Unknown	Do.[5]
1854 (May)	do	do	Do.[5]
1855 (March)	Midlothian pit	do	Do.[5]
1855 (November)	Black Heath	3	Do.[5]
1875	Raccoon Co [6]	3	Do.[7]

[1] Ref. *10, p. 73.* "Previous to the adoption of this method of ventilation, they experienced great inconvenience from carbonic acid gas; and some of the workmen were killed by an explosion of carburetted hydrogen gas."

[2] American Journal of Science, vol. 43 No. 1 April-June 1842, pp. 1-14. "These mines were opened about 25 years ago; during the first year's operation, when the miners were out at their dinner, about 1 o'clock in the day, and within an hour from the time they ascended, the pit fired and flames instantly rushed from the shaft to the height of 200 feet above the surface * * *."

[3] Ref. *10, p. 93.* "Last year, in one of the newly worked mines in Chesterfield, this (explosion of gas) occurred, to such effect, as to cause the work to be stopped, and the value of the property to be lost—at least for the present time."

[4] Ref. *10, p. 93.* "Several accidents by explosive gas occurred in these mines during the last year and preceding years, by which some lives were lost, and several men severely burnt. They are now wrought safely, under the management of Newcastle ventilators."

[5] Ref. *10, p. 129.*

[6] Originally Clover Hill, later Winterpock.

[7] Ref. *8, p. 5.*

The foregoing instances illustrate the unfortunate manner in which the dangers of explosions were demonstrated, heeded temporarily or ignored, and forgotten as new owners reopened the old mines or sank new shafts. The mining methods were of the same haphazard order, and but few mines were worked profitably or for extended periods. There were undoubtedly many other explosions, on some of which no record was made or on which reports no longer exist.

March 18, 1839; Black Heath Mine, Near Richmond, Va.; 53 Killed

(From Henry Howes, Virginia, Its History and Antiquities, published 1845 (10, p. 120))

Some years since, when ventilation was less understood than at present, an explosion took place—of the most fearful character. Of the fifty-four men in the mine, only two who happened to be in some crevices near the mouth of the shaft, escaped with life. Nearly all the internal works of the mine were blown to atoms. Such was the force of the explosion, that a basket then descending, containing three men was blown nearly one hundred feet into the air. Two fell out, and were crushed to death, and the third remained in, and with the basket, was thrown some seventy or eighty feet from the shaft, breaking both his legs and arms. He recovered. It is believed, from the number of bodies found grouped together in the higher parts of the mine, that many survived the explosion of the inflammable gas, and were destroyed by inhaling the carbonic acid gas which succeeds it.

The Norfolk and Western Railroad was completed from Radford to Pocahontas in May 1883, and in the following month the first shipments from the great Pocahontas coalfield were made. The first mine was in Virginia, but the other mines opened shortly afterward were across the line in West Virginia. Less than a year later one of the worst coal-mine explosion disasters in the country occurred at the Virginia mine.

March 13, 1884; Laurel Mine, Pocahontas, Va.; 112 Killed

(From Bureau of Mines Bulletin 20, pp. 20, 29)

The night shift was in the mine at 1 o'clock in the morning when the explosion shook the ground and dwellings for half a mile around the mine. None of those in the mine survived. The mine consisted of five openings from the outcrop in a ravine into the hillside. Cars, timbers, and debris were hurled from the openings with awful force. The fan, the mine buildings, and surroundings on the surface in front of the openings were demolished. Fire succeeded the explosion in the mine, and all that could be done was to seal the openings as the fire and smoke rapidly increased. After the sealing, steam was conveyed into the mine from five boilers. The mine was flooded, then opened, and the bodies were recovered in April. It was thought that dust, with possibly some gas, was fired by blasting. Gas could not be found in the mine after the explosion, although some claimed to have found it while working there before the disaster. The mine was considered nongassy, and no safety lamps were used. Ventilation was of a low order. Blasting was done at the end of each shift. Shooting was "off-the-solid," using excessive amounts of black blasting powder. The mine was very dry and dusty.

For months after this explosion, its causes and possible preventive measures were argued in newspapers and technical journals. This disaster, with those at Crested Butte, Colo., and West Leisenring, Pa., caught public attention; a mine-inspection bill was introduced in the Virginia Legislature but failed to come to a vote. Several committees investigated the circumstances, and the published conclusions stated that fine coal dust in mines was a serious explosion hazard when coupled with firing of heavy charges of black powder without first undercutting the coal. The question of whether coal dust might be ignited without any gas being present was not clearly answered, although experiments had indicated that it might occur (*48, pp. 28, 29*).

EXPLOSIONS IN PENNSYLVANIA MINES, 1847–90

ANTHRACITE MINES

Anthracite in the Wyoming Basin of Pennsylvania was used locally by blacksmiths in 1769 and as domestic fuel in 1808. The source of supply was outcrops and river banks, with no mining involved. Mining and shipments developed slowly to 1812 but more rapidly after that. Early mining along the outcrops gave

essentially no trouble from gas, but by 1870, when State inspection was established, explosions were frequent. Ventilation was crude, and accumulations of gas were generally "brushed" or burned out.

Records of explosions before 1870 are incomplete. The following instances are those of which accounts were found in addition to the major disasters shown in table 2 (*14, p. 23*). The tabulation below does not contain all occurrences of gas ignitions described in the reports of the State inspectors of mines first published in 1870. Instances of ignitions causing injury by burns, but no explosion or violence, were not included as explosions. The distinction is not clearly defined in all instances.

Date	Colliery	Killed	Injured	Cause	Notes
1866: Aug. 26	Schuylkill County	3		Open light	
Summer	Luzerne County	3		Furnace	3 in mine repairing shaft.
Autumn	do		9	Open light	10 in mine repairing shaft.
1870: Aug. 31	Nesquehoning County	2		Flame safety lamp	Miner removed gauze.
1871: June 2	Locust Run	3	3	Open light	Ventilation inadequate.
1872: Feb. 8	Henry shaft	4	1	do	Reopening.
1875: Dec. 28	Hutchinson	3	4	do	Broke into old workings.
1876: Feb. 12	Exeter	4	2	do	Repairs on idle day.
Apr. 12	Room Run	4	4	do	Change in ventilation.
1878: Oct. 8	Luzerne County	4	0	Fire	Rekindling of fire.
1879: Jan. 9	No. 4 shaft	1	1	Open light	Lit by fire boss.
Sept. 24	Sloan shaft	0	4	do	Fan being replaced.
1882: June 15	Stanton shaft	3	3	do	Sinking shaft.
1884: Dec. 8	Northumberland County	4	1	Flame safety lamp	Broken lamp.
1885: Feb. 17	Hillman Vein shaft	2	11	Open light	Fan broke down.
1887: Mar. 30	Von Storch	2	5	do	Gas moved over lights.
June 23	Slope No. 4	3	2	do	Entered uninspected workings.
1888: Jan. 17	Fairmont	1	3	do	Door left open.
1890: Sept. 20	Hollenback	4	0	do	Officials in idle mine.
Oct. 8	Gaylord	2	1	Blasting (dynamite)	Blasted in idle breast.

From 1870 to 1890, inclusive, reports of the State inspectors give the details of 200 gas ignitions and 368 resulting fatalities in the anthracite mines, additional to the more violent explosions listed above and in table 2. Before 1870, when the mining law went into effect and inspection was begun, the ventilation provided in the mines was often inadequate and irregular. In later years the inspectors commented feelingly on their difficulties in persuading some miners and officials to avoid the obvious dangers of gas explosions by keeping the air moving in workings open to the men, by examining the mines for the presence of gas, and by keeping men from taking open lights into places where gas had been found or where no examinations had been made. In the Reports of the Inspectors of Mines for 1879 (p. 123) the situation is well described.

> Some of these (explosions of gas) might, and should have been avoided, and unless we in mining should, in future, reach such perfection, different to anything known in other branches of business, and that our people become so constituted as to avoid all human errors, surely these or similar misfortunes, will be visited upon us occasionally. * * * Nearly each severe case we have had in this district, has been when repairing, making improvements, or when the mine was not producing coal, and mostly by the very persons whose duty it was to prevent others from going into said danger.

The mines were not so deep or pressures so heavy as to cause dangers of sudden release of large quantities of gas, so that very few large explosions were experienced. Many considered the frequent ignitions of methane incidental to the mining of coal—a hazard to be minimized but beyond tight control because of the natural and human factors that might be combined as causes. The lessons of these explosions were, however, recognized, and improvements in ventilation and inspection were adopted as the anthracite mines were deepened and extended. These improved practices were incorporated into revisions of the anthracite mining law, usually as an aftermath of disasters that roused public attention (*57, pp. 23–27*). Notable examples were:

February 19, 1847; Spencer Mine (Anthracite), Pottsville, Pa.; 7 Killed

(From letter of State mine inspector, 1950, to the Federal Bureau of Mines)

From the best information I can gather, the Spencer Coal Co. had a breaker and mine about 1 mile north of Minersville. The slope was driven on the Peach Mountain vein for a distance of 360 feet. Two levels were worked off this slope; on the first, the west gangway was advanced 4,000 feet; on the second, the east gangway was advanced 1,500 feet and the west, 1,950 feet. A tunnel was driven to the

Tracey vein, and gangways were driven off this tunnel. A second opening was shown on the Peach Mountain vein. The extent of this development in 1847 is uncertain.

All coal seams in this area are gaseous. Open lights were used and black powder and squibs were used for blasting. It is thought that the ventilation arrangements were poor and that tests for gas were made with open lights, resulting in a local explosion.

At the time of this disaster, there were no laws to provide for the health and safety of persons employed in the Anthracite industry.

May 7, 1860; Reppliers Colliery (Anthracite), Minersville, Pa.; 2 Killed

(From the Miners' Journal, Pottsville, Pa., May 12, 1860)

On Monday morning about 9 o'clock at Reppliers Colliery, Minersville, an explosion of firedamp took place, shockingly mutilating 2 miners and 2 boys. One miner and one of the boys died. The explosion was caused by the neglect of the miners in leaving their safety lamps in the breasts at night, and going in in the morning with naked lamps to get them.

August 13, 1860; Hoch Colliery (Anthracite), Forestville, Pa.; 2 Killed

(From the Miners' Journal, Pottsville, Pa., Aug. 25, 1860)

An explosion of firedamp at Forestville on Monday of last week resulted in the instant death of 1 man and a boy and the fearful crushing and maiming of 2 boys. The man was the fireboss at the colliery. One of the boys struck a match in the presence of gas.

August 14, 1871; Eagle Shaft (Anthracite), Pittston, Pa.; 17 Killed

(From the Miners' Journal, Pottsville, Pa., Aug. 19, 1871, and the Philadelphia Public Ledger, Aug. 16, 1871)

About 10 o'clock in the morning an explosion of firedamp in the Eagle shaft killed all the men in the inner workings of the pit. Men at the foot of the shaft heard the explosion and felt the shock and a harmless gust of air. They went into the gangway to see what might be done for those inside and found one body outside a fall of rock that blocked the passage. Hope was given up for the lives of the others. Rescuers dug through the fallen rock but could not get inside until they put out the fire in the furnace and turned water down the shaft. Some of the brattices that were destroyed were replaced to provide enough air to reach the bodies which were brought out by the night of August 15. It was thought that a fall forced gas out of worked places onto the open lights of the workers. The shaft was sunk in 1856 and the mine nearly worked out. Gas was very troublesome. One of the men killed had been the only survivor of an explosion that killed 5 men in this mine in 1860.

June 10, 1873; Henry Clay Colliery (Anthracite), Shamokin, Pa.; 10 Killed

(From report of State inspector of mines, 1873, p. 13)

This disaster resulted from the uncautious act of the mine boss, while exploring old works and igniting the firedamp, which killed himself and suffocated his men in the lower level by afterdamp, brought down by the downcast ventilation.

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November 26, 1886; Conyngham Colliery (Anthracite), Wilkes-Barre, Pa.; 12 Killed

(From report of State inspector of mines, 1886, p. 81)

The workmen descended the Conyngham shaft * * * before seven o'clock a. m., and because water in the sump threatened to cover the tracks, they waited there, * * *. About 5 minutes after 7 o'clock * * * 2 men went into the west airway to the sump carrying lamps * * * gas, which had accumulated in the sump above the water, exploded. The flame extending out to * * * the waiting workmen * * * burned the largest number more or less * * * those on the lower side most severely, but the largest number * * * only slightly burned, were at work again in about a week thereafter. * * * On Thanksgiving day (the 25th) the steam pipe on the boilers had to be repaired, and this caused the pump to stop for 6 hours * * * the pump after being started, failed to lower the water below the roof before the explosion occurred. * * * At about 4 o'clock the morning of the 26th, the fireboss * * * discovered the gas. He renewed a danger-mark * * * about 80 feet outside * * * the edge of the gas. * * * the two persons * * * went in over the boards with danger marks on, and then through the door, which was covered with danger marks * * * and on to the sump.

Twelve men died of burns, 20 recovered, 15 were uninjured.

February 1, 1890; Nottingham Mine (Anthracite), Plymouth, Pa.; 8 Killed

(From report of State inspector of mines, 1890, pp. 123–128)

About 9 o'clock a. m. * * * a fireboss * * * unexpectedly entered a body of firedamp with his naked light and caused a terrible explosion in which he was fatally burned, seven other persons were killed, and several others * * * injured. * * * All the workings west of the seat of the explosion were squeezing, and * * * men were at work timbering * * * The force of the explosion was such that every movable thing was blown from its place for hundreds of feet from the point where it occurred. * * * The fireboss had been employed in that part of the mine where no firedamp had been seen. He had been in * * * the Ross seam on this morning * * * and was evidently going to give directions regarding the timbering. No examination * * * between the squeeze and the points where the men were at work, was made. The (new) mine foreman had not become familiar with that part of the mine.

May 15, 1890; Jersey No. 8 Mine (Anthracite), Ashley, Pa.; 26 Killed

(From report of State inspector of mines, 1890, pp. 133–134)

About 9 o'clock a. m. * * * part of the workings of this colliery unexpectedly caved in, closing the escapeway of 28 persons * * * on the top split of the Baltimore seam. * * * One of the firebosses * * * with the party * * * through a thoughtless act, caused the death of all but 2, 25 of his companions and himself. * * * Finding that they were closed in * * * they went in through the faces to the fourth breast where they met a body of gas. He carried a flame safety lamp, and the others followed in the darkness. On returning * * * he struck a match to light his naked lamp, and the gas * * * having followed them, ignited and exploded.

BITUMINOUS-COAL MINES

Bituminous coal from beds outcropping in the river banks near Pittsburgh was used for fuel by troops and settlers in 1760; and as the settlements grew mines were opened in these and other outcrops in the region, with a combined yearly production of about 30,000 tons by 1790 (*10, p. 450*). The establishment of glass and iron plants and local domestic demands created a smoke cloud over the town, which was mentioned by travelers in 1800.

Not until 1860 were the mine openings so far underground that trouble was experienced from gas, although fires in the coal were reported, even as early as 1772. State inspection of bituminous-coal mines began in 1877 under a law that included provisions for improving ventilation and for preshift examinations and removal of gas accumulations before workmen were permitted to enter the mines. Earlier inspection bills, defeated in the legislature, contained the same provisions (*57, pp. 58–76*); the earliest bill was introduced in 1870, and investigating committees found wretched conditions for the miners' health and safety. Ventilation was generally neglected, being left to natural circulation or the movement of cars. The worst effects were on the health of men working in almost unbreathable air, but the occurrence of gas explosions is also mentioned. In 1874 a commission appointed by the Governor to study the safety conditions of the mines, "spoke about frequent explosions in the Monongahela River district, ascribing the cause to insufficient ventilation." A revision of the law in 1885 corrected some minor omissions in the provisions regarding ventilation and gas accumulations but did not require ventilation by fan or furnace in all mines, gassy or nongassy, as was recommended by the inspectors. Some of the inspectors believed that furnace ventilation should be prohibited altogether and that fans should be required at all bituminous-coal mines.

The major disasters through 1890 are listed in table 2. Others, in which fewer than 5 fatalities occurred, are given below. This tabulation contains only those in which the inspectors' reports indicated an explosion of some violence. Ignitions causing death or injury by burns without explosive force were not classed as explosions. Reports of the State inspectors for the years 1878 to 1890 inclusive, give accounts of 18 such ignitions, with 23 resulting fatalities (*14, p. 12, 13*).

Date	Mine	Killed	Injured	Cause	Notes
1879: Dec. 29	Westmoreland	3		Open light	Open door, no inspection.
1881: Oct. 27	Washington	1		do	Gas feeder, local.
1884: Apr. 14	Allegheny	2		do	Open door, no inspection.
1889: May 10	do	4		do	Mine idle, fan stopped.

The State inspectors, in their reports for 1888, recommended that the mining law be amended to "definitely direct the fireboss to examine every part of the mine when firedamp is known or supposed to exist", also—"to make a record—kept at the mine office * * *" also to specify the minimum distance from the face at which the air current should be circulating. Generally, reported conditions in the mines in 1888 were greatly improved over the descriptions given in the reports of the investigating commissions before enactment of the inspection acts. The explosions occurring during this period were predominantly instances of men with open lights entering uninspected workings where ventilation was inadequate or was not carefully maintained. Circumstances of notable major disasters were as follows:

February 20, 1884; West Leisenring Mine, West Leisenring, Pa.; 19 Killed

(From Adventures in the Mines, by T. T. O'Malley, 1891, p. 180)

Gas had accumulated in one of the entries during the night * * * men started to work in the morning without the mine having been examined * * * one went into an old room to look for rails * * * and lit the gas with his naked light, which exploded, burning and killing some of them, and the others were suffocated by the after damp. Several men * * * escaped by going around to another entry.

October 27, 1884; Youngstown Mine, Uniontown, Pa.; 14 Killed

(From Adventures in the Mines, by T. T. O'Malley, 1891, p. 181)

In one of the rooms * * * it was known that there was gas * * * examined about half past two in the morning * * * the explosion took place in the afternoon, just as the day turn were about to quit * * *.

The mine inspector * * * hurried to the mine * * * and got 5 or 6 men to follow him * * * they found men still living but overcome with the afterdamp; these were assisted to the outside * * * and recovered. * * * The door * * * was left open all day for the convenience of the driver. On the trip before the explosion * * * he had shut it, and * * * air * * * drove the (accumulated) gas into number seven, where the driver * * * with his naked light, exploded it. * * *

November 3, 1888; Kettle Creek Mine, Clinton County, Pa.; 17 Killed

(From State inspector's report, 1888, pp. 312–313)

Dynamite was being used to blast a ditch in the rock floor of a heading. The drill post gave way and fell on a supply of dynamite and caps that had just been brought in. The explosion was propagated by coal dust throughout most of the mine and up the airshaft. Despite popular belief that gas must be present to carry on explosion, the mine inspector concluded that coal dust was ignited. Five of the victims working in the vicinity of the dynamite explosion were killed by violence; the others died from suffocation and "afterdamp."

The inspector cited as examples of similar explosions, the Pocahontas, Va., disaster, that at Rich Hill, Mo., and the one at Frontenac, Kans.

The officials and mining men who investigated such explosions with an open mind recognized and accepted the fact that coal-dust explosions might be set off and spread through mine workings with no gas present in the mine air. This view was not generally accepted in spite of repeated disasters of that type, and a "blind spot" persisted in the industry in respect to the "disaster hazard" of coal-dust explosions initiated by blasting. Although the possibility of such occurrences was admitted in later years, the prevalence of conditions that might make such an explosion possible in comparison to the relatively infrequent disasters that resulted caused doubt of the seriousness of the hazard.

EXPLOSIONS IN OHIO MINES, 1874–90

Mining of coal began in Ohio probably in 1804 along the Ohio River near Wheeling. Other pits were opened at several locations in the next few years, the production amounting to approximately 1,000 tons by 1810 (*10, p. 265*). As in Pennsylvania, the workings did not extend far enough underground from the outcrops to encounter gas accumulations until about 1860. In 1870 Andrew Roy, urging passage of the coal-mine ventilation and inspection bill, stated:

So far there have been few explosions in Ohio mines, and none of great destructive force. This condition is due to the fact that our mines are level-free or comparatively shallow shafts (*54, p. 118*).

The ventilation provided in the mines was generally meager and in the great majority of mines over half of the current never reached the working faces. The bill passed, but the provisions for the inspection of mines were stricken out and the requirements of the law were disregarded. A revised law in 1874 provided for one inspector; Ohio was the first State to secure protection by State authority for bituminous-coal miners. Three years later Pennsylvania passed a similar law for bituminous-coal miners. Maryland followed, and in a few years other mining States enacted mining laws.

In 1860 a coal-cutting machine operated by compressed air was introduced in a mine in the Hocking Valley of Ohio. This machine, after a series of changes and improvements, became the Jeffrey, which was adopted by 1880 by mines in the other coal-mining States.

One explosion disaster causing the death of six Ohio miners is listed in table 2. This explosion occurred when the men entering the mine to work encountered a body of gas, which was ignited by their open lights. The fireboss examination had not been made, and the furnace ventilation was ineffective. Six men were killed and 5 injured. The mine inspectors' reports for 1874 through 1890 do not give enough details on the reported ignitions to show whether any violence resulted. Of the 25 ignitions, 4, other than the Robbins disaster of 1881, resulted in fatalities; these 4 were single fatalities. In addition to the 10 killed, 44 were injured in the 25 ignitions. All were caused by open lights, deficient ventilation, and negligent inspection.

EXPLOSIONS IN COLORADO MINES, 1883–90

Coal mining was begun in Colorado during the Civil War and developed rapidly, reaching an annual production of nearly 1 million tons by 1880. The first record of explosions found was in 1883, during the first year of coal-mine inspection (*35, p. 1*), regarding which the State coal-mine inspector said in his report:

True causes could be traced either to insufficient ventilation, carelessness, and lack of rigid discipline in carrying on energetic ventilation and other precautions needed to be enforced in a mine giving off explosive gases. * * * When any quantity of fine coal dust is observed in an entry, air course, or room it should be made damp and be removed from the mine, and thus keep every place as free from dust as possible. * * * A system of bratticing close up to the face of each and every place in the mine from crosscut last made (whether gas should just then show its presence or not) which should not be more than 50 or 75 feet.

As in all other coal-mining States, the practices did not follow the recommendations of the mine inspector, and explosions continued to occur.

The disasters in which five or more persons were killed are listed in table 2. Other ignitions involving force and violence are the following:

Date	Mine	Killed	Injured	Cause	Notes
1883: Nov. 29	Crested Butte	1	3	Open light	Open door.
1885: Jan. 12	Rockvale	1	4	do	Entered abandoned section.
1888: Jan. 14	Rockvale No. 1	1	4	do	Gas liberated by shot.
Nov. 5	Starkville	2		do	Gas, dust, and powder.
Dec. 3	New Castle	3	8	Blown-out shot	Dust.
Dec. 10	Coal Creek	2	9	Open light	Gas leaked sealed area.
1890: Jan. 1	Como	1	3	do	Brushing gas from face.

Six local ignitions reported by the State inspector for this period did not evidence violence but resulted in burning or other injury to eight miners. As noted, other small ignitions occurred but were not recorded.

January 24, 1884; Crested Butte Mine, Crested Butte, Colo.; 59 Killed

(From report of State inspector of coal mines, 1883–84, pp. 12–24

At about 8 o'clock, shortly after the fireboss finished examining the mine and reported to the miners that their working places were free from gas with exception of No. 18 room, No. 2 level, a violent explosion traversed the mine from that room to the surface. The fireboss had warned the miner that the brattice leading to the room face was broken near the entry and gas had accumulated. While the fireboss was on the surface gathering materials to repair the brattice, the miner went into the room and nailed up the loose boards. The men were not removed from the return side, and the gas was moved out to the entry where it was ignited by the open lights. The explosion was carried by dust, and many of the men were caught in the flame and force. Of the men in the mine, 59 were killed and 12 escaped before being overcome by afterdamp. The damaged fan was repaired, and ventilation was gradually restored; but the mine was not cleared for several days.

The men and officials at this mine were accustomed to move small bodies of gas with no precautions and were not aware of the hazards of larger accumulations. The next major disaster occurred in 1893; but there were 16 minor explosions in the intervening 9 years, caused either by ignitions of gas by open lights or of dust by black blasting powder. Although the State inspector recommended improved ventilation, gas testing, and sprinkling, the practices were not changed to any marked degree. Although the inspector energetically tried to get the mine workers and officials to recognize the explosion hazards, the danger was usually accepted or ignored.

EXPLOSIONS IN OTHER STATES BEFORE 1891

Other States in which coal-mine explosions were reported before 1891 are Illinois, Indiana, Kansas, Kentucky, Missouri, North Carolina, Oklahoma, Washington, West Virginia, and Wyoming. The major disasters occurring in these States are listed in table 2, and minor explosions are noted in table 1. The reports of these explosions show them to have happened much the same as those described in the States already covered (*9, 15, 32, 33, 38*). The following brief accounts, from State inspectors' reports, mining journals of the period, and other sources, show how similar the problems were in most of the coal-mining States.

March 27, 1880; Gaston Mine, Marion County, W. Va.; 2 Killed

(From State inspector's report, 1883, pp. 40–41)

The explosion occurred in the head of an entry being driven to the rise of the seam; and, there being an insufficient air current to expel the gas, it accumulated in such quantity, in the head of the entry, that when the naked lights of the miners came in contact with it an explosion resulted, killing the two miners. A boy was sent into the same place afterward for something when the gas flashed again and burned him badly but not fatally. The ventilation was natural.

The inspector, who entered on his duties in 1883, recommended a stack and steam jets at the mouth of an old main entry, which did produce a satisfactory air current to clear the mine in 1884.

March 4, 1881; Almy Mine, Almy, Wyo.; 38 Killed

(From the Cheyenne Weekly Leader, Mar. 10, 1881)

A terrific explosion occurred last night between 9 and 10 o'clock in the Central Pacific mine, killing 35 Chinamen and 3 white men. The mine was opened in 1869 and is nearly worked out. It is mine No. 3, Nos. 1 and 2 having been worked out. About 200 men worked in the mine by day and as many as 75

at night. Nearly the whole force was Chinamen. A fire had been raging in the mine for 5 years, but it had been hemmed in by stone walls. The supposition is that gas accumulated and in some way communicated with the fire. The explosion burned the surface works, and the mine slope was set on fire. Fifteen men were rescued alive from the fourth level, and 1 was badly injured from the north air course.

September 18, 1885; Benwood Mine, Ohio County, W. Va.; 3 Killed

(From State inspector's report, 1885, p. 31)

Mine idle, door left open, gas in heading, men went in to bail water. Open lights lit gas. Local explosion.

January 12, 1886; Almy No. 4 Mine, Almy, Wyo.; 13 Killed

(From the Deseret Evening News, Salt Lake City, Utah, Jan. 14, 15, 19, 1886)

The night of January 12 about 25 minutes to 12, the people of the vicinity were startled by a loud report as of thunder, and for a few seconds the sky was illuminated for miles like a bright-yellow sunset. The noise and light, proceeding from the No. 4 mine, was caused by an explosion of gas, the force of which was so terrific as to blow all of the buildings aboveground into kindling wood, sending great timbers and rocks three-quarters of a mile. Miners' houses were struck and pierced, but the people in them were not seriously injured. Two miners riding down the slope in a trip of empty cars had got down to the 3d level, when the explosion broke the cars into fragments and shot them out as from a cannon. The two bodies were blown to pieces and were found a considerable distance from the portal. Eleven men and two boys were said to have been in the mine, and all were killed. Rescue crews forced their way into the mine and placed temporary brattices to permit recovery of the bodies. The last was brought out January 15. The explosion was thought to have originated in the 13th level on the south side of the mine, when gas was ignited by a miner's open light. Although the mine had been troubled with gas the fireboss had reported it clear at 6 a. m. on the day of the explosion.

January 21, 1886; Mountain Brook Shaft, Newburg, W. Va.; 39 Killed

(From Adventures in the Mines, by T. T. O'Malley, 1891, p. 246)

Following the sound of the explosion, flame rose far above the mouth of the shaft. * * * Firedamp accumulated in one of the rooms and was accidentally ignited by a miner's lamp. * * * The force of the explosion * * * blocked the aircourse. When the work of exploration began it was found that the whole force of the mine, 39 men and boys, were stark and cold in death.

The State inspector's report stated that, at 2:45 p. m., the explosion tore out doors, stoppings, and brattices and knocked out timbers. All men in the mine were killed. A crew digging a drainage ditch tore down a door that had been nailed shut across a room mouth, allowing the air current to bypass the section of the mine inside that room. The gas accumulated in about 2 hours and was ignited by the open lights. The mine was known to be gassy and was wet. Ventilation and gas testing were lax.

April 4, 1887; Old Savanna No. 2 Mine, Savanna, Okla.; 18 Killed

(From Adventures in the Mines, by T. T. O'Malley, 1891, pp. 251–253)

The explosion killed 6 miners, and 12 of their comrades lost their lives in attempting to rescue the bodies through chokedamp. The torrent of flames forced from the mouth of the slope was over 100 feet in length. * * * It was followed by a fearful concussion. The engine house, over a 100 feet long and 2 stories high, was blown into splinters and in a few minutes it was enveloped in flames . . .

(From other records and accounts gathered by R. D. Bradford, Bureau of Mines, McAlester, Okla.)

The No. 2 mine, Savanna Coal Mining & Trading Company, Savanna, Indian Territory, was a slope mine producing an average of 200 tons of coal per day, with 80 men employed. The dust explosion, caused by a blown-out shot of black powder, damaged the mine to the extent that it never operated again. Four shot firers and two sprinklers were in the mine and were killed by the explosion about 10 o'clock at night. Twelve rescuers suffocated trying to get through from No. 1 mine into No. 2. Three parties of rescuers went in before ventilation was restored, and all who approached the connecting door between the mines lost their lives.

October 7, 1887; Reinicke Mine, Madisonville, Ky.; 3 Killed

(From State inspector's report, 1887, pp. 17–18)

On that evening at quitting time, when the workers were at the shaft bottom, the shot firer loaded two holes in a breakthrough not quite connected. He lit one and retreated. The shot blew out, and the flame swept back through the mine to the shaft. A mixture of methane and coal dust in the air was given as the cause. Ventilation was poor, and the mine was dusty. Sprinkling was adopted after the explosion.

March 29, 1888; Keith and Perry No. 6 Mine, Rich Hill, Mo.; 24 Killed

(From Adventures in the Mines, by T. T. O'Malley, 1891, pp. 251–253)

At noon when a large force of men were in the mine * * * an explosion wrecked the mine * * * and trapped nearly 100 miners. * * * The bodies removed from the pit * * * showed the terrific force of the explosion. * * * Coal dust was blown in the flesh and some * * * were frightfully mutilated. The explosion was attributed to gas accumulation and careless inspection. Open lights were used.

November 9, 1888; Shaft No. 2, Frontenac, Kans.; 40 Killed

(From coroner's inquest report, November 11–15, 1888)

The explosion originated in the 4th North entry off the east side of shaft No. 2 * * * and was caused by the igniting of powder, the same coming in contact with other explosive properties * * * powder and gas being the main factors, * * * the dry and dusty condition of the mine contributed to the violence. * * * If the company had kept the entries well sprinkled, and paid more attention to the gas, the explosion would not have been so great. * * *

(A) I was preparing my shot before going home. Heard several shots fired, one a little stronger than usual. Coming to entry found door blown off, also

another door off. Going toward main entry found men returning * * *, was drove back by afterdamp, tried it at another point, was drove back. Tried west entry and got out. Was followed by 8 or 10 men. Coming out found men down, some injured; overcast was blown to pieces. About 150 feet from shaft there was a heavy fall. Came up air shaft. The mine was well ventilated, a very dry mine. * * * There was 2 or 3 shots fired until the large explosion came.

(B) I was not in the mine at the time. * * * I quit the mine on account of daily explosions between 3 and 4 weeks ago * * * when an explosion * * * burned 3 or 4 men. That explosion was caused by gunning shots, by men that did not understand mining. Have seen the fire shoot back from 100 to 200 feet and have been singed by it * * * Have never seen gas in the mine except when cutting horsebacks or slips.

(Supt.) It was caused by a keg of powder exploding and firing others. It was not a tight or blown out shot. (Mine inspector agrees.)

CAUSES AND CONTROL OF EXPLOSIONS TO 1890

CAUSES AND FATALITIES

In all of the coal-mining States, as the mines were extended deeper from the surface, explosions occurred more often and caused more deaths and injuries. By 1890 the States then mining coal commercially in which explosions had not been recorded were Alabama, Arkansas, Iowa, Maryland, Montana, New Mexico, Tennessee, and Utah. Several of these States experienced explosions in the next few years, and some may have had unrecorded fatal ignitions earlier. Almost all the explosions of gas, dust, or both were ignited by open lights or blown-out shots of black blasting powder. The few exceptions were caused by explosions of dynamite, opening flame safety lamps, ventilation furnaces, and fires. As open lights were used (except in a few mines, where work was attempted with flame safety lamps), smoking or matches do not figure as a cause.

Records of fatalities from coal-mine explosions compiled by the Federal Bureau of Mines show that the number of fatalities was increasing from 1870 to 1890 and that explosions in bituminous-coal mines caused about half of such deaths between 1880 and 1890 (*11, pp. 27–58*).

SAFETY LAWS AND INSPECTION

Mine safety laws were passed by most of the coal-mining States before 1890, and mine inspectors were given varying powers for obtaining compliance. The earliest law was adopted in 1869 for the anthracite region of Pennsylvania, providing for one mine inspector for Schuylkill County, the other counties being omitted. Following the Avondale mine fire, with the loss of 109 lives, the same year, the law was strengthened, and inspectors were provided for all the districts. The first bitumi-

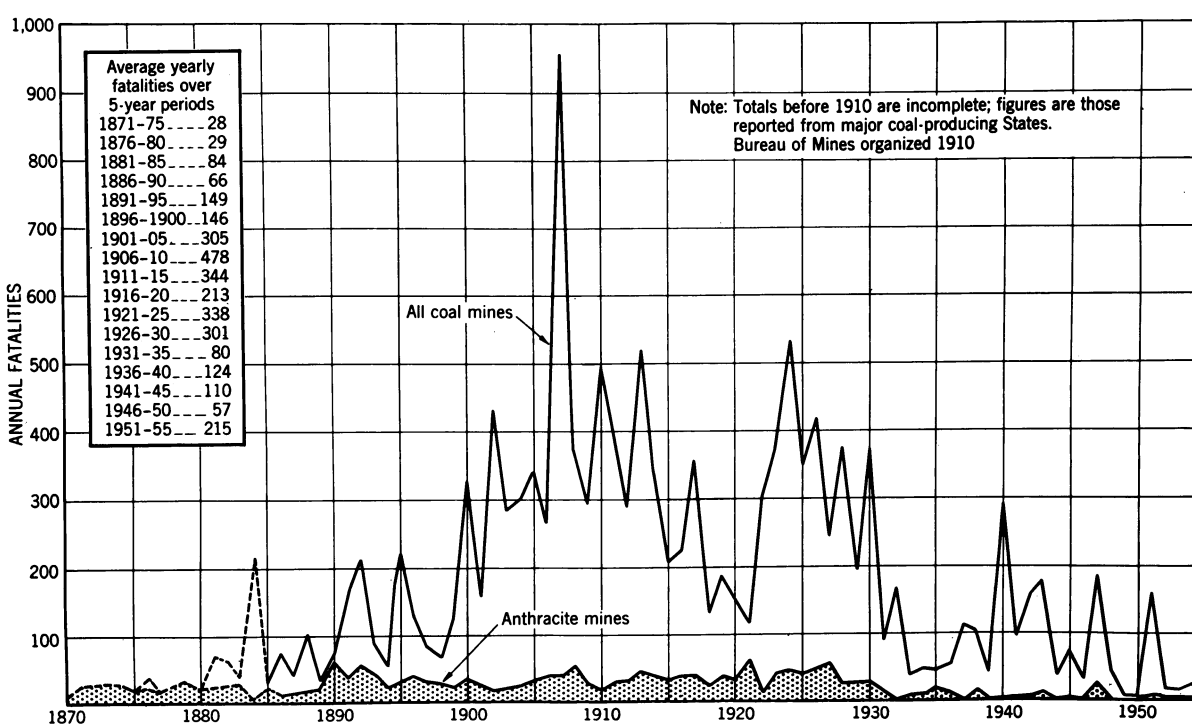

FIGURE 2.—Fatalities from gas and coal-dust explosions in all coal mines, 1870–1955.

nous-coal-mine safety law to be enacted was in Illinois in 1872, making the county surveyors ex officio inspectors of mines. A bill passed in Ohio in 1873 established safety regulations for coal mines but did not provide for inspection; a revised law providing for one inspector was enacted in 1874. Other States followed with mine-inspection acts in the following order (*11, pp. 133–354*):

Pennsylvania anthracite	1869	Washington	1883
Illinois	1872	Kentucky	1884
Iowa	1873	Wyoming	1886
Ohio	1874	Montana	1889
Maryland	1876	Alabama	1891
Pennsylvania bituminous	1877	New Mexico	1891
Indiana	1879	Oklahoma	1891
West Virginia	1879	Utah	1891
Tennessee	1881	Arkansas	1893
Missouri	1881	Michigan	1899
Colorado	1883	North Dakota	1907
Kansas	1883	Texas	1907
		Virginia	1912
		Alaska	1917

QUALIFICATIONS OF INSPECTORS

The need for requiring mine inspectors and mine foremen and superintendents to know something of gases, ventilation, and other subjects, as well as to have a minimum length of practical experience, was apparent long before State mining laws were enacted. Examining boards to certify candidates for these positions were set up in most States. In a handbook published in 1885, Andrew Roy, a pioneer in coal-mine safety and first Ohio mine inspector, advocated (*56, pp. 158–159*):

> To successfully cope with the ever-increasing problems of the mine, a higher standard of intelligence than now obtained, and such as every nation of the world exacts of its mining captains, should be prescribed by law. All mining bosses, previous to assuming charge of mines, should be required to appear before a board of examiners and receive a certificate of competency, as is done in the case of schoolteachers.
>
> Examining boards, composed of practical miners, mining engineers, and colliery owners, might be formed in different mining districts of the State, before whom all the mining bosses would be examined on the subjects relating to the practical working and ventilation of mines. It would not be necessary, in the present state of mining knowledge, to require of the candidates for certificates of competency any greater knowledge of the science of chemistry and physics than relate to the natural laws governing the art of mining. It might also be proper to have two grades of certificates * * * one for mining bosses, and one for superintendents or mining engineers.

Questions on gases and ventilation included in mine-inspector applicants' examinations in Illinois and Colorado in 1883 were (*6, pp. 173–177*):

> Name and describe the methods by which artificial ventilation can be successfully produced in mines.
>
> What are the methods for splitting the air-currents in mines, and what are the advantages to be derived from the same?
>
> Describe the kind of furnace you would use to ventilate mines where explosive gases are generated in large quantities; and in what part of the mine would you locate the same?
>
> What instruments should an inspector have to enable him to discharge his duties under the "Mining Act," and describe the particular use of each?
>
> Where are these gases generally found in the mines, and how can their presence be detected, previous to any serious results?
>
> What has been your experience and observation in mines where dangerous gases are evolved?
>
> What kind of a safety lamp would you recommend, and why?

REVISION AND ENFORCEMENT OF LAWS AND REGULATIONS

The extent to which these laws and the various inspection authorities prevented or curtailed explosions in the mines can only be guessed, since there is no way of knowing what explosions would have occurred without these controls. Their defects were pointed out by the inspectors in urging revisions by State legislatures. The restraints and neglects of the inspectors in carrying out the provisions of the laws were protested by miners' committees and investigators following explosion disasters. Usually each disaster was followed by some tightening of the State regulations or local compliance with those considered to be in effect.

The theories and practices applied to mine ventilation changed slowly. Andrew Roy, in his handbook published in 1885, commented (*56, pp. 136–187*):

> As underground excavations become more extensive, the natural forces, even during seasons most favorable to their operation, become wholly inadequate as a ventilating power, owing to the resistance which the top, bottom, and sides of the air-way offer to the moving current of air, and artificial ventilation has to be applied to produce the circulation required to sweep away the gases and render them harmless. Furnaces and fans are the powers applied to produce artificial ventilation. Frequently exhaust steam from the steam-pump at the bottom of the upcast or pumping shaft is applied; but, while this is a valuable auxiliary, it is too weak a ventilating force in a large and extensive mine to be used alone.
>
> The furnace has long been the favorite method of producing ventilation among practical men, but of late years exhaust fans of the Guibal, Schiele, Waddle, and other patterns have been introduced, and worked so successfully as to supplant the furnace nearly altogether over large and important mining districts in England and the other continental States of Europe. The furnace in its first cost is cheaper than the fan, and in deep mines is capable of doing equally effective work, while in shallow mines the fan is both cheaper and more effective as a ventilating power. The furnace is likely, however, to continue a ventilator as long as coal mining is followed.

The Ohio mine law of 1874 included provisions for eliminating hazards from gases that might have been model standards for years to

come but must have been irregularly observed, judging by the explosions that continued to occur. These sections read:

SEC. 9. The owner or agent of every coal mine, whether shaft, slope or drift, shall provide and maintain, within six months after the passage of this Act, for every such mine, an amount of ventilation of not less than one hundred cubic feet per person employed in such mine, and as much more as the inspector may direct, which shall be circulated to the face of each and every working place throughout the mine; and all mines generating fire-damp shall be kept free of standing gas; and, in all mines where fire-damp is generated, every working place shall be carefully examined every morning, with a safety lamp, by a competent person, before any of the workmen are allowed to enter.

SEC. 12. All the safety lamps used for examining coal mines, or which may be used in working any mine, shall be the property of the owner of the mine, and shall be under the charge of the agent of such mine; and in all mines generating explosive gas, the doors used in assisting or directing the ventilation of the mine shall be so hung and adjusted that they will shut of their own accord, and cannot stand open; and in all such mines the mining boss shall keep a careful watch over the ventilating apparatus and the airways, and he shall measure the ventilation at least once a week at the inlet and outlet, and also at or near the face of all the entries; and all such measurements shall be reported once a month to the inspector.

SEC. 15. Any miner, workman, or other person who shall knowingly injure or interfere with any safety lamp, air-course, or brattice, or obstruct or throw open doors, under his charge or control, every such person shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding fifty dollars, or imprisonment in the county jail not exceeding thirty days, or both, at the discretion of the court.

Observance of these well-considered safeguards fell short in Ohio, as well as in other States where the laws, if any, were less thorough. In addition to the presence of gas and open lights, dust hazards were not well understood, and open lights and black blasting powder were used almost everywhere.

CONTROL OF OPEN LIGHTS, GAS, AND DUST

In those mines and States where there was reasonable compliance with safety laws, many explosions were avoided, and hundreds of lives were saved by eliminating some of the conditions that permitted men with open lights to enter unventilated, uninspected mines or workings. A majority of the explosions in the early years were traceable to these causes; and similar lapses persisted, even where prohibited by law. Practices and conditions known to be dangerous did not always result in explosions, and the tendency of miners and officials to regard them as harmless in their own mines because an explosion had not yet occurred has long been notorious.

During this period the explosive properties of fine coal dust were shown by several explosions that were carefully investigated by competent mine officials, engineers, and professors of mining engineering. These investigations were supplemented by experiments by individuals and by official commissions in England, France, and other countries. The conclusions that coal dust was explosive without any admixture of gas were published and were accepted by those best informed on mine explosions and their causes. The mining journals and the published reports of State coal-mine inspectors for the period 1870–90 abound in discussions of this point. However, this view was not generally accepted by the industry; and some prominent mine inspectors and other officials even disputed it, claiming that some methane must be present before any explosion could be initiated. Sprinkling of dusty workings was recommended and adopted as a safety measure in some mines as the dangers of dust became known. An example of the recognition of this hazard, based on experience in the mines without experimental tests, is the following extract from the report of an Oklahoma mine inspector in 1886:

November 18th, 1886, an explosion occurred in the Cherokee Coal & Mining Cos. mine * * * resulting in the burning of * * * two men. My investigation showed * * * that something had occurred of unexpected nature. Fortunately those injured were the only men occupying that portion of the mine * * *. Where the explosion originated * * *, a current of air of about 4,000 cubic feet per minute was passing in the entry, yet none * * * reached the face of the room * * *. Gas is generated though not to an explosive or inflammable degree, * * * as evidence * * * the miner worked in the room, just preceding the explosion, with a naked light, charging a hole with powder, preparing to blast. After lighting the match or fuse he went out * * * following the entry * * * the distance of two rooms. * * * He and the other man seated themselves waiting * * * for the blast * * *, which went off in a few seconds * * *, resulting instantly in the explosion, wherein they were burned and bruised, hurling them and large stones twice their weight all along the entry, blowing open the trap door near the bottom of the shaft, knocking down the cager, and making appearance at the mouth of the shaft, one hundred and fifty feet above with * * * a terrific blast. The explosion * * * could not have been caused by gas * * * or from the amount of powder in the charge, * * * about 1 pound and a half * * *. No blower of gas was tapped. * * * I attribute the cause to * * * another agency which previous to this explosion was little thought of in this coalfield, namely *coal dust*, stirred up from the blast of a blown-out shot, as it was in this instance, with the liberation of a little gas from the newly mined coal to assist the flame from the powder in igniting the dust in the room which came in contact with a * * * current of air in the entry, which encouraged the combination, so that the further it went the more dust it received and the more violent it grew, until it found relief at the mouth of the shaft.

Such an occurrance was repeated hundreds of times in mines in many coal-mining States.

1891–1900

HAZARDS AND OCCURRENCE OF EXPLOSIONS

Between 1890 and 1900 annual coal production in the United States increased from about 160 million tons to nearly 270 million; employment rose from 326 thousand men to 448 thousand. The proportion of machine-mined coal increased from 5 to 25 percent of the total as electric chain-mining machines succeeded the earlier compressed-air punchers. Electric trolley locomotives came into use during these years (*11, pp. 84, 104, 105, 290, 291*). Mines became deeper, with more abandoned rooms and old workings where gas and dust could easily accumulate. To offset this, ventilation methods and equipment were improved, and in some mines better inspection procedures became customary.

During these years several important coal-mining States experienced their first major explosion disasters; these included Alabama, Arkansas, Iowa, New Mexico, Tennessee, Utah, and Washington (see tables 1 and 3). The number of fatalities from gas and dust explosions almost doubled that in the preceding 10 years. In 1890 the greater part of these deaths were from explosions in anthracite mines, but by 1900 the majority were in bituminous-coal mines.

Major explosions during 1891 to 1900 are shown in table 3—a total of 38 explosions, with 1,006 fatalities. In addition to these disasters, Bureau of Mines publications list over 250 minor explosions; each resulted in 1 to 4 deaths, with a total of 426. Three-fourths of these fatal minor explosions and fatalities occurred in anthracite mines. These records include only the States on which reviews have been compiled (*5, 8, 9, 11, 14, 15, 32, 34, 37, 38, 43, 44*). The reported explosion fatalities in all of the States for these 10 years totaled 1,473 (*11, pp. 14, 15*).

TABLE 3.—*Major explosions in United States coal mines, 1891–1900*

Date	Name of mine	Location of mine	Killed
1891: January 27	Mammouth	Mount Pleasant, Pa	109
May 22	Pratt No. 1	Pratt City, Ala	11
November 8	Susquehanna No. 1 [1]	Nanticoke, Pa	12
1892: January 7	No. 11	Krebs, Okla	100
May 10	Roslyn	Roslyn, Wash	45
July 23	York Farm [1]	Pottsville, Pa	15
1893: January 10	Como	King, Colo	24
February 14	Chicago and Iowa	Albia, Iowa	8
March 13	Choctow	Alderson, Okla	9
June 22	Susquehanna No. 1 [1]	Nanticoke, Pa	5
September 21	Lance No. 11 [1]	Plymouth, Pa	6
1894: November 20	Blanche	Standard, W. Va	8
1895: January 22	Tate	Sturgis, Ky	5
February 18	West Bear Ridge [1]	Mahanoy Plane, Pa	5
February 27	White Ash	Cerrillos, N. Mex	24
March 20	Red Canyon	Red Canyon, Wyo	62
April 8	Blue Canyon	Lake Whatcom, Wash	23
October 7	Dorrance [1]	Wilkes-Barre, Pa	7
December 19	Cumnock	Cumnock, N. C	39
December 20	Nelson	Dayton, Tenn	28
1896: February 18	Vulcan	New Castle, Colo	49
March 23	Berwind	Dubois, Pa	13
October 29	Shaft No. 3 [1]	South Wilkes-Barre, Pa	6
December 26	Oswald	Princeton, Ind	7
1897: January 4	No. 1	Alderson, Okla	5
March 4	Kansas & Texas No. 44	Huntington, Ark	14
September 3	Sunshine	Sunshine, Colo	12
1898: March 19	No. 2 Slope	Alabama	6
September 23	Umpire	Brownsville, Pa	8
1899: February 21	Blocton, No. 2	Blocton, Ala	5
April 21	Cook & White	Madrid, N. Mex	5
July 24	Grindstone	Grindstone, Pa	5
December 9	Carbon Hill No. 7	Carbonado, Wash	31
December 23	Sumner	Sumner, Pa	19
1900: March 6	Red Ash	Red Ash, W. Va	46
May 1	Winter Quarters 1 & 4	Scofield, Utah	200
May 23	Cumnock	Cumnock, N. C	23
November 9	Buck Mountain [1]	Mahanoy City, Pa	7

[1] Anthracite.

The sources of ignition were open lights, black blasting powder, and dynamite and in the anthracite mines the inefficient and unsafe flame safety lamps. The conditions responsible for the mounting toll of these explosions are brought out in the following accounts of the disasters that caused the greatest loss of life.

DESCRIPTION OF DISASTERS

January 27, 1891; Mammouth No. 1 Mine, Mount Pleasant, Pa.; 109 Killed

(From report of State inspector, 1891, pp. 316–322)

* * * The mine was reported in good condition and free from fire-damp on the day before the explosion * * *. The fireboss made an examination of the mine before anyone was permitted to enter.. * * * Jan. 27, and found * * * the mine perfectly safe. The primary cause * * * was fire-damp * * * mostly if not all generated by the fall * * * off No. 3 flat * * * intensified by fine coal dust * * *. Fully 75 percent of the persons killed were smothered by afterdamp. * * * The quantity of gas fired was not large. * * * The rescuing parties * * * discovered fires smoldering in several places * * * but * * * with tubs of water the fires were soon extinguished.

Another account by T. T. O'Malley, 1891, states that only active workings were inspected by the fireboss and that the mine was considered nongassy, being worked with open lights.

The same State inspector in 1892 instituted legal proceedings against a fireboss of a nearby mine for failure to examine half of the working places before sending the men in. The miners at that mine protested this action against the fireboss.

May 22, 1891; Pratt No. 1 Shaft, Pratt City, Ala.; 11 Killed

(From chief mine inspector's letter to Dr. Joseph A. Holmes, Director, Bureau of Mines, 1912

The explosion occurred during the early part of the day shift in shaft No. 6 side of the mine. Eleven men were killed, 10 of whom were convicts and the other a free man who was the fireboss. He had found gas in a place, dangered the place off and reported it. One of the convicts was in the mine for the first time in his life. He crossed the danger board and went into the place in an attempt to see what the gas looked like. The ignition occurred from his open lamp, and as far as known dust did not enter into the explosion.

January 7, 1892; Mine No. 11, Krebs, Okla.; 100 Killed

(From the Colliery Engineer, February 1892, pp. 160–162)

The mine has always given off a moderate amount of gas * * *. The miners work with naked lights, and the mine is carefully inspected for gas before the miners go to work * * *. Shot firers go into the mine after the miners are out, between 6 p. m. and midnight. The entry men are the only miners allowed to fire their own shots, and * * * they are not to commence firing until 5 : 30 p. m. * * *. At 5 o'clock hoisting of the men began * * *. Five cages had been raised and 30 men landed at the surface, * * * when a cloud of smoke and dust burst from the shaft. * * * As the fan was undisturbed the engine was given more steam to increase the speed. * * * Rescuers were lowered * * * in a basket. * * * Many men, uninjured or slightly burned walked through the return airways, and escaped * * * by No. 7 shaft. * * * As no inspector was appointed for Indian Territory, a committee was appointed who * * * determined that * * * the explosion came from 1 or 2 shots in entry 0 * * * fired at 5 : 04. * * * The shots were badly located and blew out * * * firing the dust. * * * The roadway was sprinkled but much fine dust * * * on the ribs and elsewhere carried the explosion to the shaft.

May 10, 1892; Rosyln Mine, Roslyn, Wash.; 45 Killed

(From State mine inspector's report, 1892, pp. 13–15)

On Tuesday afternoon * * * a disastrous explosion killed forty-five men. * * * Airways had to be repaired to be able to go down into lower levels. * * * By Wednesday morning a large force of men was at work, and by 10 o'clock Thursday night the last body was brought outside. * * * A hole drilled in a crosscut being driven from the airway to the slope was drilled through. * * * Gas entered the slope from an accumulation in the crosscut on the airway side and was ignited by the naked lamps of the men on the slope side. The man working in the airway had a safety lamp; the others had naked lamps. * * * Dust was an important factor in the explosion.

January 10, 1893; Como Mine, King, Colo.; 24 Killed

(From Engineering and Mining Journal, Jan. 14, 1893, p. 37)

A frightful explosion occurred * * * at the mine * * * by which 24 workmen lost their lives. The accident was caused * * * by a "windy shot." * * * Explosion of the dust set free and circulated blackdamp and the almost instant death of the men followed. * * * The portion of the mine in which the accident occurred was promptly sealed up by the proper authorities to await the arrival of the State inspector of coal mines.

February 27, 1895; White Ash Mine, Cerrillos, N. Mex.; 24 Killed

(From State inspector's report, 1895, pp. 15 and 23)

An explosion occurred at 11 a. m. * * * Entrance was prevented * * * by chokedamp in the slope. * * * Ventilation by canvas was forced direct * * * to the entry in which the explosion occurred. * * * The work of exploring that level was completed about 11 p. m., and the last of the * * * bodies taken to the surface. * * * About 125 men were at work * * * and every precaution and means were used for prompt rescue and revival * * * of all survivors. * * * The explosion was caused by two men sent into a room * * * to take up track * * * and who ignited a body of standing gas. * * * The fireboss had found a small body of gas at the face and had put up a danger signal, 100 feet from the face.

(The explosion, propagated by dust, traversed the entire mine.)

March 20, 1895; No. 5 Mine, Red Canyon, Wyo.; 62 Killed

(From Engineering and Mining Journal, Mar. 23, 1895 (p. 280), Apr. 6 (p. 327), May 11 (p. 447), and from accounts given to Bureau of Mines by rescue workers)

Sixty-two men perished in a terrific explosion which occurred about 5:45 p. m. in mine No. 5, at Red Canyon, Wyo. * * * About 150 men were employed in the mine, but many of them had come out before the disaster occurred. Just before the explosion a number of men had reached the surface, and those who started at once for their homes escaped injury in the flying debris resulting from the wreck of the hoisting works. * * * The shock of the explosion was felt for miles around and * * * was heard 7 miles away. * * * The explosion blew out or loosened all the timbering and supports and cracked and shattered the walls and roof, so that the search for the dead was attended with great peril. * * * and grows more difficult as the working parties advance toward the 7th level where * * * 38 men were. * * * The State mine inspector * * * testified that * * * in his opinion the explosion was caused by a blown-out shot which ignited coal dust. * * * Other witnesses gave testimony that the explosion was caused by an overabundance of gas in the mine, and that due precaution had not been exercised. Coal was blasted from the solid. Black blasting powder was used to charge the holes, and blasting barrels and squibs were used to fire the shots at any time during the shift. All of the 58 men in the mine were killed and also 4 others who were in line with the opening on the surface. The mine was gassy, and gas watchmen made rounds from 4 a. m. until noon when they left. The mine was reopened in May 1896.

April 18, 1895; Blue Canyon Mine, Lake Whatcom, Wash.; 23 Killed

(From State mine inspector's report, 1895, pp. 10–12)

Between 2 and 3 o'clock in the afternoon an explosion killed 23 of the 25 men in the mine. * * * A hole drilled in the bottom rock had been charged with giant powder and fired. * * * The hole was poorly directed and did not break * * *, but the blast ignited gas and dust. * * * The explosion was not widespread, and the men died mainly from asphyxiation. * * * Gas was evident in quantity and under pressure in the strata. Most of the men descended to the gangway and were overcome there.

December 19, 1895; Cumnock Mine, Cumnock, N. C.; 39 Killed

(From an account given to the Bureau of Mines by Maj. H. A. London in 1912)

At 8:20 a. m., an hour after the day shift of 66 men had gone into the mine, an explosion in slope No. 1 killed all 37 in that section and 2 in slope No. 2 section. Survivors were brought out in cages from the 465-foot shafts. Gas was ignited by open lights. The fireboss had made his inspection and said it was all right.

(From Engineering and Mining Journal, Jan. 18, 1896, pp. 57–58)

The mines will be more familiar under their old names of the Egypt mines. The main shaft 550 feet deep was opened during the Civil War. It was allowed to fill with water and was not opened until 1887. * * * The coal is fiery, and this is the third fatal explosion that has happened since the mine was first opened. * * * Against a fresh face * * * little jets of gas exuded from the seam. * * * The men used only the ordinary uncovered miner's lamp, no provision being made for safety lamps. * * * The refusal of the coroner to hold an inquest * * * is credited to the expense to the county * * * being too great. * * * There is no mine inspector in North Carolina and no mining laws. * * *

December 20, 1895; Nelson Mine, Dayton, Tenn.; 28 Killed

(From State mine inspector's report, 1895, pp. 160–208)

The State inspector's report shows that the fireboss found gas in three places and "marked them out." He came out, and the men went in. It was expected that the men would "brush out" the gas from their working places. The explosion, at about 7:15 a. m., was set off by a man going into one of the "marked-out" rooms or near it. All men used open lights except firebosses and men working in places where gas was suspected. There was standing gas in pillar sections. Of the 113 men and 20 mules in the mine, 28 men and 16 mules were killed. The explosion was spread by gas and dust. The officials said it was due to a miner's carelessness. The mine inspector said legislation was needed to regulate the operation of gaseous mines.

February 18, 1896; Vulcan Mine, New Castle, Colo.; 49 Killed

(From State mine inspector's report, 1896, pp. 47–66)

On Tuesday morning, an explosion * * * resulted in the death of 49 men. * * * The mine was ventilated by 2 fans * * * so arranged that if 1 fan was disabled the other would ventilate the whole mine. The mode of ventilation * * * was well conducted. The management recognized the danger incident to the presence of coal dust and took * * * precautions. * * * Tanks are connected with * * * pipes running into the rooms, * * * and hose * * * by which every section of the mine can be reached. * * * The explosion originated in the west entry near one of the chutes. Explosive placed on a lump of coal blocking the chute and covered with a small quantity of dust and slack * * * set off gas, and an explosion resulted. * * * The ingredients were dust and gas. * * * The effect of the explosion was so violent that every man in the mine died instantly. * * * The fans located on the surface were blown to pieces, and the three openings were nearly closed * * * by the timbers being blown out and the dirt caving in. Every wooden stopping and door in the mine was broken except one. * * * In regard to the use of explosives I recommend * * * no shots to be fired or powder detonated anywhere in the mine except at a specified time; and all men to be out of the mine except those actually required for the purpose of firing.

December 9, 1899; Carbon Hill No. 7 Mine, Carbonado, Wash.; 31 Killed

(From State mine inspector's report, 1898–1901, pp. 11–16)

The disaster * * * occurred about 11 a. m. * * * This mine throws off CH_4 gas in considerable quantity, but is one of the best ventilated mines. * * * An open

safety lamp was found in 4th crosscut at 69 chute, together with pipe and tobacco. * * * The brattice conveying the air to the face of this chute had been displaced, permitting gas to accumulate. * * * The explosion occurred by the ignition of a small quantity of gas, the force due to this raising the dust, * * * the principal factor in this explosion. * * *

March 6, 1900; Red Ash Mine, Red Ash, W. Va.; 46 Killed

(From State mine inspector's report, 1900, pp. 303–335)

This mine was known to generate * * * gas, and a fireboss was employed. * * * Gas was * * * generated at the face of all headings beyond 8th right, and * * * it was the custom of miners to wait on the main heading * * * between the 6th and 7th headings * * * until the fireboss reported to the men before they advanced. On the morning of March 6, 1900, the men did not wait but proceeded to their working places. * * * At 7:16 a. m. the explosion occurred. The fireboss had not entered earlier that 6:35 o'clock, and * * * he was near the face of 8th right heading where he made the first test. * * * Gas was found there by the fireboss, for he had opened a valve on the compressed-air line near the face to dilute and drive out the gas. * * * This explosion was * * * due to a positive violation of the mining law, that says * * * "no workman shall enter or be permitted to enter any mine or part of a mine generating firedamp, until it has been examined by the fireboss and reported by him to be safe." * * *

The open lights carried by the men found on the 7th left heading were responsible for the ignition of the gas. The cause of the accumulation of gas is that a machine runner * * * last to leave the mine at midnight on the 5th of March, opened the door on 7th left heading and did not look to see that it closed. * * * Here was another violation of the law. * * * The fan was shut down from midnight to 5:30 a. m. * * * A new and dangerous condition has arisen in the mines in this State in recent years—an excessive amount of dust as the result of mining machinery. Large quantities of dust had accumulated in the mine and this dust was the principal agent of extending the explosion. * * * The force of the explosion was violent. * * *

May 1, 1900; Winter Quarters 1 and 4 Mines, Scofield, Utah; 200 Killed

(From State mine inspector's report, 1900, pp. 64–102)

At 10:25 in the morning an explosion originating in No. 4 mine cost 200 men their lives and injured 7. Two men came out of No. 4 mine uninjured, and 103 came out of the connecting No. 1 mine uninjured. * * * The explosion occurred at the head of the "Pikes Peak" section. It was caused by an accidental explosion of black powder or a windy or blown-out shot. * * * The amount of powder taken in the mine was very large; * * * 30 kegs were exploded in all throughout the mine, adding to the force of the explosion. * * * Part of the blast shot out to the surface through No. 4 tunnel and airshaft, and part went through No. 1 mine; * * * this part soon lost its force, and heat * * * as the dust in No. 1 mine was damp. * * * There were 60 men smothered by the afterdamp; * * * and were not burned. * * * At no time has there been known to exist in the * * * mines, any explosive gases, before or since the explosion. * * * No mine is safe without a sufficient amount of moisture to keep the dust damp. * * * I have suggested to the companies that they put a watering system in all the mines, so that every place can be sprinkled. * * * This company has complied.

May 23, 1900; Cumnock Mine, Cumnock, N. C.; 23 Killed

(From the News and Observer, Raleigh, N. C., May 23, 24, 26, 1900)

At 4:30 in the afternoon an explosion in the east heading of the mine cost the lives of 22 miners and the superintendent. The explosion is thought to have been caused by a broken gauze in a safety lamp. Between 40 and 50 men were in the mine at the time. Five were brought out alive from the east heading, while none of the men in the other parts of the mine were injured. All of the bodies were horribly burned, and they were recovered during the night as the mine was not damaged very much. A survivor, brought up from the east heading and resuscitated, said he heard a report like a dynamite shot and the next instant the firedamp exploded. The superintendent, who came from Pennsylvania 2 years before, was in the east heading and was killed. Twenty men were killed outright, and 3 others died after being rescued. It was thought that the gas accumulated and that one of the flame safety lamps with which the men worked became overheated or was hit, breaking the glass and gauze. Coal was mined by pick and blasted by battery. Dynamite was used because it will not explode gas. Pennsylvania men own the property; extensive improvements were made since the explosion in December 1895, and the mines had been thought safe.

The mine was not operated afterward.

METHODS AND PROGRESS IN CONTROLLING AND PREVENTING EXPLOSIONS

Explosions in bituminous-coal mines from 1891 to 1900 were more frequent and caused greater loss of life than in earlier periods. Although understanding and regulation of the dangers were better in the older coal-producing States, the hazards were increased by deeper mining, mechanical cutting, and a prevalent belief that gas and dust were dangerous only in large quantities. Many mine officials and mine inspectors knew the facts and recommended suitable precautions, but the reports of conditions in mines where the explosions occurred show that the usual safeguards of testing for gas, removal before men entered, and sprinkling to allay dust were often omitted.

Although electric cutting machines and locomotives were brought into use, no explosions of electrical origin are recorded. Numerous explosions set off by blasting led to development of safer types of explosives, and by 1899 such "safety explosives" were advertised and were used in some progressive mines.

George S. Rice, a pioneer investigator of the causes and prevention of mine explosions and later organizer of this work in the Bureau of

Mines, recognized the mechanism of dust explosions and published his conclusions in 1893 (*48, pp. 29–31*). His observations on the remedies adopted are quoted from Bureau of Mines Bulletin 20, The Explosibility of Coal Dust.

As it was noted that the explosions were usually more severe on the intake airway, it was proposed and in some States carried out * * * that the fan should be slowed up or stopped at the shot-firing time. This was on the theory that fresh air and pressure increased the chance of ignition. To a small extent, sprinkling or wetting the floors of the roads * * * was practiced.

An important change was then made in many of the States west of the Mississippi by the passage of laws requiring the shot firing to be done by shot firers, the miner still drilling and charging the drill holes. The immediate results were not at all favorable as the miners, relieved of personal risk, transferred it to the shot firers. There was an increasing tendency to do less and less cutting to relieve the shot, and to increase the already large charges of black powder. The effect was to cause more accidents from blown-out and overcharged shots, although the number of killed and injured men was decreased owing to the fewer number of men exposed to the hazard. Further legislation * * * in some States, compelling the inspection of holes by the shot firer before they were loaded * * *, improved the situation.

East of the Mississippi River (in Illinois and Indiana) * * * the number killed from mine explosions was relatively small until a change came in the method of paying the miners * * *. After 1897 they were paid on the basis of run-of-mine coal produced. This took away from the miner the incentive for cutting the coal and for using small charges of powder, and put a premium upon shooting down the coal in the easiest and cheapest manner. "Shooting off the solid" * * * became very general, and with it a large increase in the amount of black powder used in the shots. * * * This produced an immediate increase in the number of explosions and fatalities therefrom. Fortunately, the explosions were usually of limited character because the natural conditions were unfavorable to widespread explosions. Nevertheless, the accidents were so frequent that legislation followed in Illinois requiring the employment of shot firers, and inspection by them of the drill holes, and limiting the charge of black powder. In Indiana the conditions have been somewhat similar * * *, except that employment of shot firers has not been compulsory * * *. In Pennsylvania * * * and in Ohio, the method of paying the miner on the screened-coal basis has prevailed * * *, and in these States and in parts of West Virginia the system of undercutting before shooting has generally been adhered to * * *

1901–10

HAZARDS AND OCCURRENCE OF EXPLOSIONS

Again, as in the preceding 10 years, the number killed in mine explosions doubled that in the 10 years just before. In fact, as is shown in figure 2 (p. 14), the average number of fatalities from explosions per year for 1901–10 was 391, whereas the average for 1891–1900 was 147. The number of explosions, also, as indicated by the record of major disasters (table 4) and by other Bureau of Mines published records (*5, 8, 9, 11, 14, 15, 32–34, 36–38, 43, 44*), was at least doubled. Table 4 lists 111 major explosion disasters, with a total of 3,316 fatalities. The total number of deaths from gas and dust explosions for these years is given as 3,912 (*11, pp. 46–55*). During the same 10 years production of coal in the United States increased from about 270 million to 500 million tons, and the men employed from 448 thousand to 725 thousand. The percentage of machine-cut coal increased from 25 percent in 1900 to 45 percent in 1910.

Thus the number of explosions and resulting fatalities more than doubled in 1901–10 over those in 1891–1900, while the number of mines, the production of coal, and the men employed reached a total less than twice as large. During this period the hazards multiplied far past control by the practices and methods of earlier years, although most of the failure to exercise necessary safeguards was due to the disregard by both officials and miners of precautions that were known and used rather than to the sudden appearance of new or unforseeable conditions leading to explosions. The causes and conditions leading to these appalling catastrophes are clearly depicted in the accounts that follow, and any preliminary or theorizing discussion would be useless.

Tables 1 and 4 show that the first major explosion disaster in Kentucky occurred during these years. States or Territories that had no major explosions until after 1910 were Alaska (1937), Maryland (1916), and Montana (1943). No explosions are reported for Georgia, Michigan, North Dakota, or South Dakota, but coal production in these States is small.

In the mounting disasters of these years the same contributing causes and sources of ignition were repeated many times, with only minor variations. The reports of these explosions give, as the most frequent contributing causes, poorly maintained or inadequate ventilation, neglect to test for gas, use of open lights in gassy mines, failure to remove dust accumulations and not keeping the dust wet down, use of black powder, and shooting overburdened and overloaded holes. The sources of ignitions were open lights (about 50 percent), blasting (about 44 percent), fires (about 5 percent), and electric arcs (about 1 percent).

Major explosions during these years were too numerous to permit including all of them;

TABLE 4.—*Major explosions in United States coal mines, 1901–10*

Date	Name of mine	Location of mine	Killed
1901: April 29	McAlester No. 5	Alderson, Okla	6
May 15	Chatham	Farmington, W. Va	10
May 27	Richland	Dayton, Tenn	20
June 10	Port Royal No. 2	Port Royal, Pa	19
September 16	Spring Gulch	Spring Gulch, Colo	6
October 25	Buttonwood [1]	Plymouth, Pa	6
October 26	Diamondville	Diamondville, Wyo	22
1902: January 24	Lost Creek No. 2	Oskaloosa, Iowa	20
March 6	Catsburg	Monongahela, Pa	5
March 31	Nelson	Dayton, Tenn	16
May 19	Fraterville	Coal Creek, Tenn	184
July 10	Rolling Mill	Johnstown, Pa	112
August 7	Bowen	Bowen, Colo	13
September 15	Algoma No. 7	Algoma, W. Va	17
September 22	Stafford	Stafford, W. Va	6
October 1	Lawson	Black Diamond, Wash	11
November 29	Luke Fidler [1]	Shamokin, Pa	7
1903: March 15	Cardiff	Cardiff, Ill	5
March 23	Athens No. 2	Athens, Ill	6
March 31	Sandoval	Sandoval, Ill	8
April 12	Central Slope 77	Carbon, Okla	6
June 19	Blossburg No. 3	Blossburg, N. Mex	5
June 30	Hanna No. 1	Hanna, Wyo	169
November 20	Bonanza No. 20	Bonanza, Ark	11
November 21	Ferguson	Connellsville, Pa	17
1904: January 25	Harwick	Cheswick, Pa	179
April 20	Stearns No. 5	Stearns, Ky	5
May 11	Big Muddy	Herrin, Ill	10
October 28	Tercio	Tercio, Colo	19
December 7	No. 5	Burnett, Wash	17
1905: February 20	Virginia City	Virginia City, Ala	112
February 26	Grapevine	Wilcoe, W. Va	6
March 18	Rush Run and Red Ash	Red Ash, W. Va	24
March 19			
March 22	Oswald	Princeton, Ind	9
April 3	Zeigler	Zeigler, Ill	49
April 20	Cabin Creek	Kayford, W. Va	6
April 27	Eleanora	Dubois, Pa	13
April 30	No. 19	Wilburton, Okla	13
July 5	Tidewater	Vivian, W. Va	[2] 5
July 6	Fuller	Searight, Pa	6
October 29	Hazel Kirk No. 2	Monongahela, Pa	5
November 4	Tidewater	Vivian. W. Va	7
November 15	Braznell	Bentleyville, Pa	7
December 2	Diamondville No. 1	Diamondville, Wyo	18
1906: January 4	Coaldale	Coaldale, W. Va	22
January 18	Detroit	Detroit, W. Va	18
January 24	Poteau No. 6	Witteville, Okla	14
February 8	Parral	Parral, W. Va	23
February 19	Maitland	Walsenburg, Colo	14
February 27	Little Cahaba	Piper, Ala	12
March 22	Century No. 1	Century, W. Va	23
April 22	Cuatro	Tercio, Colo	18
August 6	Susquehanna No. 7 [1]	Nanticoke, Pa	6
October 3	Pocahontas	Pocahontas, Va	36
October 5	Dutchman	Blossburg, N. Mex	10
October 24	Rolling Mill	Johnstown, Pa	7
1907: January 14	Deering No. 7	Clinton, Ind	7
January 23	Primero	Primero, Colo	24
January 26	Lorentz	Penco, W. Va	12
January 29	Stuart	Stuart, W. Va	84
February 4	Thomas No. 25	Thomas, W. Va	25
March 2	Holden [1]	Taylor, Pa	7
March 16	Bond and Bruce (Greeno)	Tacoma, Va	11
April 26	Morgan	Black Diamond, Wash	7
May 1	Whipple	Scarboro, W. Va	16
June 18	Johnson No. 1 [1]	Priceburg, Pa	7
December 1	Naomi	Fayette City, Pa	34
December 6	Monongah Nos. 6 and 8	Monongah, W. Va	362

[1] Anthracite.
[2] 3 miners and 2 visitors killed. Not charged as a coal-mine disaster.

TABLE 4.—*Major explosions in United States coal mines, 1901–10*—Continued

Date	Name of mine	Location of mine	Killed
1907: December 16	Yolande	Yolande, Ala	57
December 19	Darr	Jacobs Creek, Pa	239
December 31	Bernal	Carthage, N. Mex	11
1908: January 30	Backman	Hawks Nest, W. Va	9
February 10	Moody	South Carrolton, Ky	9
March 28	Hanna No. 1	Hanna, Wyo	59
May 12	Mount Lookout [1]	Wyoming, Pa	12
July 15	Williamstown [1]	Williamstown, Pa	6
November 28	Rachel and Agnes	Marianna, Pa	154
December 29	Lick Branch	Switchback, W. Va	50
1909: January 10	Zeigler	Zeigler, Ill	26
January	Carbon Hill	Gayton, Va	6
January 12	Lick Branch	Switchback, W. Va	67
January 19	Stone Canyon	Chancellor, Calif	6
January 25	Orenda No. 2	Boswell, Pa	5
February 2	Short Creek	Short Creek, Ala	18
March 2	No. 14 [1]	Pittston, Pa	8
March 31	Echo	Buery, W. Va	6
March 20	Sunnyside	Evansville, Ind	6
April 9	Eureka No. 37	Wimber, Pa	7
June 23	Lackawanna No. 4	Wehrun, Pa	21
July 6	Toller	Tollerville, Colo	9
October 3	Northwestern	Roslyn, Wash	10
October 21	Rock Island No. 8	Hartshorne, Okla	10
October 31	Franklin, No. 2	Johnstown, Pa	13
December 11	Baker No. 5	Clay, Ky	7
December 23	Mine A	Herrin, Ill	8
1910: January 11	Nottingham [1]	Plymouth, Pa	7
January 31	Primero	Primero, Colo	75
February 1	Browder	Browder, Ky	34
February 5	Ernest No. 2	Ernest, Pa	12
February 8	Barthell No. 1	Stearns, Ky	6
March 12	South Wilkes-Barre No. 5 [1]	Wilkes Barre, Pa	7
March 31	Great Western No. 2	Wilburton, Okla	6
April 20	Mulga	Mulga, Ala	40
April 21	Amsterdam	Amsterdam, Ohio	15
May 5	Palos No. 3	Palos, Ala	84
October 8	Starkville	Starkville, Colo	56
November 3	Yolande No. 1	Yolande, Ala	5
November 6	Lawson	Black Diamond, Wash	16
November 8	Victor American No. 3	Delagua, Colo	79
November 11	Shoal Creek No. 1	Panama, Ill	6
November 25	Providence No. 3	Providence, Ky	10
December 14	Greeno	Tacoma, Va	8

[1] Anthracite.

the following accounts cover those in which there was great loss of life or that were significant because of the conditions found or because they were effective in securing better protection in the future against this hazard.

DESCRIPTION OF DISASTERS

May 27, 1901; Richland Mine, Dayton, Tenn.; 20 Killed

(*From report by Commissioner of Labor, 1901*)

The mine, opened in 1898, had not worked continuously. The single entry was in 1,400 feet, and the mine employed 30 men. At shooting time, 4:30 p. m., nearly all the men had reached the main entry when 2 explosions occurred in rapid succession. Flame covered most of the mine, scorching leaves at the adit entrance. The origin was a blown-out shot at the head of a cross entry, followed by the explosion of a keg of powder on the main entry causing a second coal-dust explosion. All shots were on the solid, black powder was used, and overcharges, windy and blown-out shots were frequent. The entries were very dusty. Of the men, 20 were killed and 8 injured.

October 26, 1901; Diamondville Mine, Diamondville, Wyo.; 22 Killed

(*From accounts obtained from men who helped in recovery work*)

Gas was ignited while fighting a fire. Efforts were made to rescue the men trapped in the mine, but they failed. The mine was then sealed underground and on the surface. The bodies were recovered later when the seals were removed.

January 24, 1902; Lost Creek No. 2 Mine, Oskaloosa, Iowa; 20 Killed

(From State inspector's report, 1903, pp. 47–50)

The explosion * * * occurred * * * about noon. * * * Air had been well conducted * * * and * * * it had been the practice to slow down the fan just before * * * and until completion of the firing. The explosion started in room No. 10 on the 2d north * * *, which had been driven only 50 feet and so had no breakthroughs connecting with adjacent rooms. * * * The miner had charged 2 holes; 1 hole only was fired. The shot blew through into an old drill hole, * * * flaming gases were ejected into the room. * * * The dust stirred up in this room by the firing of the shot and ignited by the flaming gases increased the initial force of the explosion considerable. There were * * * 20 dead and 14 injured. * * *

May 19, 1902; Fraterville Mine, Coal Creek, Tenn.; 184 Killed

(From report of Commissioner of Labor, 1902 (Bureau of Mines files))

The mine opened in 1870 was one of the oldest in the State and had been in almost continuous operation; 200 men and boys were employed. The furnace was not fired from Saturday night until Monday morning, and ventilation was stagnated. The mine was considered to be nongassy although gas was known to be present in that section of the old and abandoned Knoxville Iron Company mine into which openings had recently been made. The miners had not been in the mine more than an hour when at 7:20 a. m. thick smoke and dust were seen coming from the ventilating shaft and from the mouth of the mine. Rescuing parties were organized and penetrated about 200 feet where they came upon the body of a victim of the afterdamp. They could go no farther and returned to await dispersal of the deadly gas. At 4 o'clock a rescue corps again entered. Brattices had been destroyed, and along the main entry the force of the explosion was terrific, timbers and cogs placed to hold a squeeze were blown out, mine cars, wheels, and doors were shattered, and bodies were dismembered. In other parts of the mine no heat or violence was shown, and suffocation had brought death to those whose bodies were found there.

A barricade had been placed across 15 right entry near the heading to protect the miners there from the deadly afterdamp. The 26 men found there must have lived for several hours, as notes were written as late as 2 p. m. At first it was thought that the gas had come from the old mine, but later inspectors indicated that the gas was liberated from overhanging strata by the "creep" that had begun with unusual violence shortly before the explosion. The gas accumulated because of inadequate ventilation and was ignited by the open lights. Dust was thick in the mine and was blown up and burned in the explosion. No sprinkling was done. Recommendations by the mine inspector that had not been carried out were for cleaning and enlarging airways, rebuilding brattices and doors, increasing the furnace capacity, tests for gas, and removing dust.

Testimony given before the commissioner on June 6, 1902, was emphatic in condemning the laxity of the officials, as:

The mine foreman was not competent, and the company had not installed a fan as the State inspector had recommended.

July 10, 1902; Rolling Mill Mine, Johnstown, Pa.; 112 Killed

(From State inspector's report, 1902, pp. 52–72, 612–616)

At 11:30 a. m. the explosion in the Klondike section killed 112 persons, 7 by force or burns and the rest from suffocation by afterdamp. * * * Twenty-one others were rescued alive. * * * The destruction from the force of the detonation was * * * small, attesting to its feebleness. * * * No. 2 room had been cut through to the rib fall on No. 5 entry where gas was known to exist. * * * The gas * * * was ignited by coming in contact with one or both of the miners' open lamps, found at the face of the room. * * * Under the law none but locked safety lamps should have been used in that part of the mine. * * * All the men employed in the vicinity of the gas which exploded * * * were selected on account of their knowledge of safety lamps and the method of using them to examine for gas, for which they were ordered to look always before firing shots, but * * * were permitted to take their naked lights into the danger marks made by the firebosses. * * * It gave the man a better light for traveling to work, but it also afforded an opportunity for * * * using his naked lamp for the sake of getting a better light. * * *

I am expected to make suggestions which may aid in the prevention of such catastrophes, but I despair of offering anything that would avail under the circumstances. What can we do when * * * a miner recklessly disregards safety * * * and violates all laws and rules in the mine, * * * where detection is no easy matter? * * * No one in a gaseous district should use any except a locked safety lamp. Until a safety lamp is put upon the market which will give something near as good illumination as the ordinary naked light, the men will continue their aversion to the common safety lamp. * * * The miner of today * * * all too frequently in order to get a better light than it affords, throws caution to the winds and endangers himself and others.

June 30, 1903; Hanna No. 1 Mine, Hanna, Wyo.; 169 Killed

(From Cheyenne Daily Leader, June 30–July 6, 1903)

At 10:30 a. m. the mine was rent by an explosion of gas when 215 men were in the pit. Flames burst forth with great fury, and the mouth of the mine was filled with debris. The explosion was thought to have originated at the end of the slope, 1½ miles underground. The blast tore timbers from the slope and hurled them far outside. Entrance was made through the manway, and bodies of men and mules were found throughout the mine. A fire was burning, and gas accumulated in the workings. Forty-six men were rescued alive. A survivor related that 2 explosions occurred about 2 seconds apart. One was from blasting, the other from the ignition of gas and dust. Attempts to control the fire and open the lower levels failed, and the mine was sealed at the 14th level. The mine was reopened in November, but some parts were left sealed and 1 body was not recovered.

January 25, 1904; Harwick Mine, Cheswick, Pa.; 179 Killed

(From State inspector's report, 1904, pp. xiii, xiv)

* * * I had not thought it possible that a catastrophe so awful in proportions could occur in a mine like the Harwick, which was new and reported to be relatively safe. * * * The explosion was * * * of terrific force, the tipple, built of iron, was wrecked,

and a mule was blown out and over the tipple from the bottom of the shaft. * * *

The coal is mined by compressed-air machines of the Puncher type, * * * blasted down by dynamite. The shots were prepared and charged by the men who loaded the coal, and the shots were fired by shot firers. Each shot firer carried a Davy lamp; * * * to fire, he inserted a wire through the gauze of the lamp * * * until it was the proper temperature and * * * would then apply it to * * * the fuse. * * * The shots near the roof * * * required an extremely heavy charge. * * * Nearly all advanced workings were very dry and dusty. * * * Locked safety lamps were used exclusively in all working places * * * except at the bottom of the shaft. * * * The cause of this explosion at about 8:15 a. m., was a blown-out shot * * * in a part of the mine not ventilated as required by law. * * * Sprinkling and laying of the dust * * * had been neglected; * * * firedamp existed in a large portion of the advanced workings. * * * The explosion could be transmitted * * * by the coal dust suspended in the atmosphere by the concussion from the initial explosion * * * the flame exploding the accumulations of firedamp and dust along the path of the explosion, carrying death and destruction into every region of the workings. * * * The fireboss did examine part of * * * the mine; * * * his last report was made January 23. * * * Insufficiency of ventilation was partly due to accumulation of ice at the airshaft. * * *

February 20, 1905; Virginia City Mine, Virginia City, Ala.; 112 Killed

(From Engineering and Mining Journal, Mar. 23, 1905, p. 597; Mar. 30, p. 625; Apr. 13, p. 741)

The State Mine Inspector has submitted his report to the Governor * * *. Every man who was at work at the time of the explosion lost his life. The chief inspector expresses the belief that a windy shot was made by one of the miners in the 5th entry left, in which too much dynamite or powder was used. This shot caused a dust explosion. * * * The damage to the mine was not serious. * * *

The State Mine Inspector and his two assistants are making a close examination of all mines in the State, especially in regard to coal dust. * * * In the Flat Top mines * * *, where 154 State convicts are worked, besides a large number of county convicts, they found that short fuses were being used and mining rules not strictly carried out. Coal dust was reported, and the operators were instructed to sprinkle the mine and take out an accumulation of dust. * * * The mining laws of Alabama are to be enforced to the letter, and all indications point to some radical amendments.

The coroner's jury has returned a verdict * * * that the explosion was caused by a windy shot and that certain warnings had been given previously. A number of damage suits have been filed. * * *

March 18, 19, 1905; Rush Run and Red Ash Mines, Red Ash, W. Va.; 24 Killed

(From State inspector's report, 1905, pp. 265–266)

These * * * drift mines * * * are in the Fire Creek seam, * * * from 3½ to 7 feet in thickness. * * * Explosive gas has been generated * * * ever since they were opened; * * * in addition, mining has been done by machinery which created more fine dust than * * * in mines where picks are employed. * * * On Mar. 6, 1900, 46 lives were lost in the Red Ash mine. At that date these two mines were separate; * * * since then they have been connected * * *. On March 18, 1905, 5 hours after the mine had ceased operation for the day, an explosion occurred in the Rush Run mine by which 8 men lost their lives; the explosion extended into the Red Ash mine, where 5 more men lost their lives. * * * To rescue these men, 11 men entered the Rush Run mine * * * and * * * were lost in a second explosion. * * * The first explosion resulted from blasting or from loose explosives on the track run over by a car, causing a widespread dust explosion. The second occurred when gas accumulated by derangement of the ventilation was ignited by open lights of the rescue party. * * * These mines were regularly inspected and found apparently safe under all ordinary conditions. Every requirement of the Mining Laws was being observed. * * * There are hundreds of our miners and bosses * * * who cannot be induced to believe that explosions * * * can be brought about by dust. * * * Any method by which this danger could be demonstrated on a small scale at a public exhibition among our mining people, would undoubtedly be * * * most effective education. * * *

The chief mine inspector, James W. Paul (later employed by the Federal Bureau of Mines), an able engineer with keen powers of observation and analysis, included a number of sound conclusions and recommendations on explosion hazards in his published report for the year ended June 30, 1905. The investigations and experiences of his department with mine explosions in West Virginia showed that the mining laws and even nominally good safety practices of that day did not serve to prevent mine explosions under conditions often occurring in the mines. Among the causes and remedies discussed were:

The changing conditions at the mines * * * have revolutionized the character of labor employed * * * by reason of the introduction of machinery to supplant * * * manual labor and animals. * * * Inexperienced men are employed who know practically nothing about the dangers within a mine and * * * are unable to exercise the care essential to their own safety. * * * Any safeguard will have to operate through those having immediate supervision of the employee.

A remedy presents itself in requiring all mine bosses and firebosses to have a State license. * * * Where inspectors find the boss * * * permitting any dangerous practices, his license should be revoked. All powder carried into the mines shall be in cans, not to exceed 5 pounds.

Where breakthroughs in the rooms are not closed as additional breakthroughs are made, place "checks" across the entry to divert the current of air into the rooms and if ventilation is not sufficient place brattices in the breakthroughs.

Remove dust from the mine, and make the dry parts wet by spraying systematically and regularly.

All coal operators should have on hand a safety lamp, kept in good order.

April 3, 1905; Zeigler Mine, Zeigler, Ill.; 49 Killed

(From State inspector's report, 1905, pp. 3–12)

The mine was developed in the No. 6 seam, averaging 12 feet in thickness under a cover of 417 feet. Gas was generated in quantity. * * * The mine had not been examined since March 23. * * * The fan was stopped at 11:30 p. m. March 31. * * * Three compressors with a total of about 3,000 cubic feet per minute were operated and expected to ventilate the mine. * * * After working in this fashion * * * Saturday and Sunday night and Monday morning, * * * explosive gas was ignited in the third east cross-

cut * * * by a miner's lamp at 7:10 a. m. as 17 men went there to work. All of these men had naked lamps. * * * A large quantity of powder in kegs was in the mine, and this was ignited producing a second and smaller explosion. * * * The first explosion was the most violent, it went up the airshaft; the second went up the hoisting shaft. * * * The timbers in the mine were nearly all blown down, * * * except at the magazine on the main haulway. * * * In other parts of the mine * * * the trolley wires were twisted * * * and pit cars piled up on each other. * * * The mine was not examined before men entered as required by the State Mining Law. * * * In violation of the Mining Law crosscuts were not made * * * 60 feet apart * * *, rooms being driven 250 to 350 feet from the last crosscut. * * * Having powder and explosives stored in the mines is a violation of the Mining Law.

The district mine inspector and two others were killed by afterdamp during rescue operations, and a construction worker on the surface was killed by the explosion. A State inspector reported that he put on 1 of 2 company-owned Vajen-Bader head protectors and entered the poisoned atmosphere of No. 1 entry and succeeded in taking down a brattice that interfered with coursing fresh air to Nos. 1 and 2 entries. This is one of the first references found to the use of oxygen breathing apparatus in recovery work after a mine explosion in this country.

December 2, 1905; Diamondville No. 1 Mine, Diamondville, Wyo.; 18 Killed

(From Cheyenne Daily Leader, Dec. 3, 6, 7, 1905, and the Kemmerer Camera, Dec. 3, 1905)

Every man in the workings met death when a dust explosion, caused by a blown-out shot, wrecked the mine. The shock of the explosion was felt over the town, rocking buildings violently. The explosion at 11:25 last night occurred over 3,000 feet from the shaft and wrecked the brattices and blocked the entrance to lower levels of the mine. The night force was small, their work being to break down coal for the day shift. The first body was brought up by noon of December 2, the last on December 6. The main force of the explosion at the 12th level made matchwood of 8-by-8 timbers, and the stone and cement stoppings 18 to 24 inches thick were destroyed so that no trace remained. The door at the first level was blown to splinters. Rescuers were seriously affected by afterdamp, but heroic attempts were made to reach possible survivors. The mine resumed operation in about 4 months.

January 4, 1906; Coaldale Mine, Coaldale, W. Va.; 22 Killed

(From State inspector's report, 1906, pp. 195–199)

At 11:30 on the forenoon * * * an explosion in the Smoky Hollow section resulted in the death of 22 persons. * * * The force of the explosion was * * * disastrous. Heavy timbers were blown out and some were blown across the valley, * * * mine cars were broken and distorted. * * * No * * * explosive gas has been reported. * * * The explosion was the result of a keg of powder exploding and inflaming the dust. * * * Powder in 25-pound cans had been * * * taken into the mine in violation of instructions from the inspection department. * * * The testimony was presented to the grand jury, but no indictment was returned. * * *

February 8, 1906; Parral Mine, Parral, W. Va.; 23 Killed

(From State inspector's report, 1906, pp. 203–206)

The mine had * * * only 1 opening, a shaft 685 feet deep, which was partitioned and used as * * * an inlet and outlet for the ventilating current. * * * At the time of the explosion there were in the mine * * * 35 persons, of which number 23 were killed, the remaining 12 not being injured. * * * The mine produced small quantities of gas. * * * Open lights were used. * * * The explosion of a body of gas being ignited * * * inflamed the dust in the east part of the mine. The force upon reaching the shaft, went up the shaft, doing no damage to the west side. There was considerable water near the shaft. * * * A heavy fall of roof in an intake aircourse liberated gas which * * * * was ignited by the open light of a driver * * * near the first right heading. Gas was liberated for several days after the explosion. * * * The coroner's jury declared the explosion to be an unavoidable accident. * * *

March 22, 1906; Century No. 1 Mine, Century, W. Va.; 23 Killed

(From State inspector's report, 1906, pp. 206–209)

At 4:30 p. m. * * * an explosion in the No. 1 Shaft mine * * * resulted in the death of 23 persons. * * * The workings and ventilation have been carefully, planned * * * for a gaseous mine. * * * Some parts of the mine were dry, and dust accumulated. A sprinkling car was used to dampen the entries and rooms. * * * The explosion was caused by a blown-out shot, which produced a typical dust explosion. The hole had been drilled 6 feet 2 inches deep, square on the solid * * * in robbing out a pillar. * * * Eleven men were killed by the force of the explosion, * * * 12 others by * * * the after gases.

October 3, 1906; Pocahontas Mine, Pocahontas, Va.; 36 Killed

(From memoirs of W. A. Bishop, former chief inspector, Pocahontas Fuel Co., and Richmond Times Dispatch, Oct. 4, 6, 7, 1906)

An explosion in the St. Paul entry of the west mine of the Pocahontas Collieries at 5 o'clock in the evening entombed 60 to 100 men. A few escaped from the Tug River side of the mine, most of them drivers and engineers, the engineers drawing fire from their engines before making for the outside. The force of the explosion was barely noticeable at the mine mouth, 2½ miles from the entry in which it occurred. A number of men in the south mine were almost suffocated before being rescued. Rescue work was slowed by an immense amount of debris in the workings. Thirty-four bodies of victims were removed by October 6, and 2 rescue workers died from exposure to afterdamp. A blown-out shot of black blasting powder, fired on the solid at the time the shifts were changing, ignited gas and dust.

January 23, 1907; Primero Mine, Primero, Colo.; 24 Killed

(From State inspector's report, 1907, pp. 80–89)

The explosion * * * at 4 a. m. * * * shook the camp and * * * disorganized the fan casing. * * * After 3½ hours the fan was placed in working order * * * and a

third attempt made to enter. * * * They succeeded * * * and the effort to rescue continued until the last body was found on February 2d. * * * All the men in the mine were killed. * * * The fireboss was the only one in the district where the explosion seemed to have started. * * * His safety lamp was open, but not the least damaged. * * * Evidence of conflicting forces makes it difficult * * * to come to any absolute conviction as to the origin. * * * Different theories may account for such an explosion but * * * never will be able to determine with certainty its initiatory point. * * * In spite of the wet condition of roadways, dust took an important part in augmenting the explosion. * * * Its transmission from the starting point to the other remote districts was wholly due to this agency. * * * Sprinkling of roadbeds only is not an absolute preventative against the exploding of dust and * * * roof and sides should be sprinkled as well. * * * The mine was adequately equipped to force air into all working places. The detail of continuously conducting the air to faces of all the places must * * * be left to the operators.

January 29, 1907; Stuart Mine, Stuart, W. Va.; 84 Killed

(*From State inspector's report, 1907, pp. 484–491*)

The opening to the mine consists of a 4-compartment shaft 585 feet deep; to secure a second opening to meet the requirements of the State Law, the * * * intention was to connect the underground workings of the Parral mine * * * the connection needing * * * 1,000 feet of entry. The development of the mine was principally the driving of entries, but some rooms were being driven. * * * There were about 100 persons employed within the mine, but just prior to the explosion 2 cageloads were taken out, leaving about 84 * * *, all of whom were killed. * * * Such a number being within the mine was in violation of the law. For a similar violation the officers of the company were at the time under indictment. * * * Prior to the explosion * * * a wreck in the shaft and repair of shaft timbers * * * required about * * * 3 hours. The loaders were dismissed for the day * * * and repaired to the bottom of the shaft, and were followed by the contractors, drivers, and trapper boys. * * * Few * * * were at their regular working places. * * * The body of a man * * * was found badly burned within the entrance to his room, * * * 24 feet long. * * * The effects observed lead to the belief that * * * entering his room with an open light he had ignited a body of gas, * * *. Propagation * * * was aided by coal dust.

February 4, 1907; Thomas No. 25 Mine, Thomas, W. Va.; 25 Killed

(*From State inspector's report, 1907, pp. 492–495*)

On Monday morning about 6:30 o'clock an explosion * * * killed 24 persons. * * * The superintendent * * * lost his life after the explosion by advancing too far into the afterdamp. * * * About 18 hours previous to the explosion, the fan was stopped by reason of an accident to the * * * electric motor. * * * The fireboss did not make an examination of the mine on that morning, although he was at the mine. * * * Gas had collected on the 3d left, and as two workmen entered 3d left their open lights ignited the gas. * * *

December 1, 1907; Naomi Mine, Fayette City, Pa.; 34 Killed

(*From State inspector's report, 1907, pp. xvi–xviii, 38–39*)

About 7:45 p. m. Sunday, an explosion of firedamp augmented by coal dust * * * resulted in the death of 34 persons, all that were in the mine. * * * A large quantity of gas must have been ignited. * * * The gas was not detected before anyone was allowed to enter the mine. * * * For some time previous to the explosion, only the working places were being examined before the mine was allowed to be entered. * * * The cause of the gas being present was an open door. * * * The explosion was caused by an open light or an electric spark from the * * * wires. The system of ventilation * * * was faulty, having too many doors. * * * They commenced to sink a shaft, * * * but very little progress had been made. It was evident that the fireboss had been trying to get the men together preparatory to leaving the mine. * * *

December 6, 1907; Monongah Nos. 6 and 8 Mines, Monongah, W. Va.; 362 Killed

(*From report by Frank Haas, 1908, unpublished—copy in Bureau of Mines files; also notes of Federal Geological Survey engineers (22, p. 6)*)

The No. 6 and No. 8 mines were slope openings about 1¼ miles apart. The mines were ventilated separately but were connected so that each mine could be ventilated from either opening in case of necessity. The workings were wired for electricity, and the coal was undercut by electric cutting machines. Black powder was used for blasting; the tamping composed largely of coal dust. No shot firers were employed. Open lights were used by all workmen. Traces of gas were found in the advanced workings, and firebosses made daily examinations before the men entered. The mines were dusty, and haulways were dampened by water cars. On that Friday morning, 367 men were in the mines, and work progressed as usual until 10:28 a. m., when the explosion killed nearly all the men, wrecked the ventilating system, smashed motors and cars, and destroyed the No. 8 openings, together with the boilerhouse and fan, but did little damage to No. 6 slope. (Figure 3 is a view of the openings taken a day or so later.) Four men escaped through an outcrop opening, and 1 man was rescued. Rescue crews restored ventilation by building brattices to conduct the air from No. 6 fan. Three fires were found and extinguished with water. All props and timbers were blown down, causing heavy falls of roof, except in one entry. By December 12th all workings had been ventilated and searched and 337 bodies recovered. In the next week 17 others were found, and 8 more were taken out in the work of removing the fallen rock and restoring the workings. One of the dead was an insurance agent who had entered the mine to do business with the men. About the time of the explosion a trip of loaded cars had reached the knuckle of No. 6 slope, when part of the trip broke away and ran to the bottom of the slope, piling up and blocking the entry. It is thought that the dust cloud resulting in the intake air current was ignited by an arc from electric wires torn down by the wreck or by open lights of men in the vicinity. This opinion was accepted by some of the most expert of the investigators. Separate investigations were made by parties of mine inspectors from West Virginia, Pennsylvania, and Ohio, repre-

FIGURE 3.—Mine entrance after explosion, Monongah, W. Va., December 6, 1907.

sentatives of the Fairmont Coal Company and of the Federal Geological Survey, and by a commission of European mine investigators who were in the United States at the request of Dr. Joseph A. Holmes to study the problem of coal-mine explosions. The evidence of the origin of this explosion was much confused, and some of the investigators attributed the explosion to blown-out shots, others to gas ignited by open lights, or to dust clouds ignited by electric arcs or open lights.

December 16, 1907; Yolande No. 1 Mine, Yolande, Ala.; 57 Killed

(*From State inspector's report, 1908, unpublished*)

The slope was driven about 1,400 feet on * * * the Big Seam * * * which pitches about 15° to 18°. The mine has a return airway on each side of the slope, one used as a manway, and either could be used as an escapeway. * * * Each entry had a separate ventilating * * * split. * * * In the explosion at 10:25 a. m. 57 men lost their lives; 30 escaped from the mine after the explosion. * * * The fan was damaged very little, but owing to the brattices and overcasts being destroyed the air was short circuited and the men left alive in the mine died before they could be reached except one on the slope. * * * Very few men among the rescuers were overcome by afterdamp. * * * Sprinkling had not been done that day although waterlines and hose were installed. * * * The fireboss had quit on the morning of the explosion, and it was doubted whether the mine was inspected. * * * Gas at the face of a place was ignited by an open lamp, dust causing the explosion to extend to the other workings.

December 19, 1907; Darr Mine, Jacobs Creek, Pa.; 239 Killed

(*From State inspector's report, 1907, pp. xviii–xxvii, 869–870*)

At 11:30 in the morning * * * an awful rumbling followed by a loud report and a concussion that shook the nearby buildings was felt within a radius of several miles. The Darr mine was never deemed a very dangerous mine as it generated only a small percentage of gas and was worked with open lights. The explosion had * * * terrific force * * *. Progress by rescuers (fig. 4) was very slow owing to the fact that all the stoppings were blown out. * * * Only one man escaped * * *; he was on his way to the engine room for oil. * * * The cause may have been the projection of flame into a gaseous and dusty atmosphere * * * by an open light or a blown-out shot. * * * The system of workings * * * does not provide for efficient ventilation * * *. We recommend * * * the development on a four-entry system, * * * that ventilation be controlled by overcasts instead of doors, * * * that flameless explosives be used for all blasting, * * * that competent shot firers * * * prepare, charge, and fire the shots after workmen are out of the mine, * * * that all stemming be with clay or other incombustible material, * * * that a water system be installed for wetting and laying the dust, * * * that all accumulations of dust be loaded out, * * * that the mine be worked exclusively with locked safety lamps, * * * that enough firebosses should be employed to make careful examinations of the mine * * *, and that the mine foreman devote the whole of his time to his duties as described by law and maintain rigid discipline. * * *

FIGURE 4.—Rescue workers, Darr-mine explosion, Jacobs Creek, Pa., December 19, 1907.

March 28, 1908; Hanna No. 1 Mine, Hanna, Wyo.; 59 Killed

(From Cheyenne Daily Leader, Mar. 29, 1908 and accounts given by men)

The first explosion at 2:59 in the afternoon is known to have killed 18 men. The second explosion at 10:30 that night entombed rescuers led by the State mine inspector. At 1 o'clock in the morning a passage had been forced through the debris at the east slope and rescue parties had brought out two of the entombed rescuers. The second explosion was more terrific than the first, rocking the ground violently and causing the already ruined entrances to crumble still further. Ordinarily there would have been 300 men working in the mine, but on March 22 fire broke out on the 10th level, and the force was reduced. The flames were walled off but broke out anew, and only 18 experienced fire fighters went into the workings. After the second explosion it was found impossible to penetrate the workings because of the fire that spread beyond control. The mine was sealed after 32 bodies were recovered, leaving 27 inside. It was never reopened.

November 28, 1908; Rachel and Agnes Mine, Marianna, Pa.; 154 Killed

(From State inspector's report, 1908, pp. 5–19, 130–132)

The disaster occurred about 10:45 on Monday morning. * * * All the employees in the mine were killed but one. * * * As the fan casing was destroyed and the top of the outlet shaft and headframe badly wrecked, it was several hours before ventilation could be partly restored. * * * By Wednesday morning all the bodies had been removed * * * except those covered by the debris and * * * water. * * * The mine was badly wrecked, stoppings destroyed, * * * timbers dislodged and roof fallen. * * * Ventilation was more than ample * * * all stoppings and overcasts were of brick or concrete * * * and the workings were ventilated by six separate air splits with brattice cloth used to conduct air from the last crosscut to the faces. * * * Explosive gas is generated in the mine which is worked generally with open lights. * * * Much fine dust was produced in cutting, blasting, and hauling. * * * A water system was used but was ineffective to thoroughly wet the dust. * * * A blown-out shot in the face of No. 3 Blanche entry * * * was the initial point of the explosion, * * * igniting dust and gas. * * * A secondary explosion occurred in the main dip entries where an accumulation of gas had been found and the men removed shortly before the disaster.

A committee of experienced mining engineers made an investigation and report at the request of the chief mining inspector. Their findings agreed with those of the investigating group of State mine inspectors and included some conclusions and recommendations regarding con-

trol of explosion hazards that were repeated hundreds of times in the next 30 or more years.

We feel that it should be recognized that mines liberating gas and producing dust have to face the danger of ignition from three principal causes: Open lights, blown-out shots, and electric sparks. To reduce these dangers to a minimum, without forcing conditions that would sacrifice the value of property, should be the aim of our future laws. We feel that the danger of open lights can be more easily eliminated than the other two, and we do not believe it is a hardship to enforce the use of improved safety lamps in any or all mines that have given off or are apt to give off explosive gas.

It is a recognized necessity that in mining the Pittsburgh coal, other means than hand-pick mining must be employed. It can be blasted under proper regulations with a minimum amount of danger. To do this we feel that it is necessary that competent shot firers be employed who shall have charge of, and be responsible not only for the firing of the shot, but for the quantity and the quality of the explosive used; that all holes be tamped with clay; that the shot firers use only permissible explosives as furnished by the company; that all shots be fired by an electric battery; and that blasting for the complete safety of the miners be done only between shifts; when the men are out of the mine.

We recognize at the present time that one of the most dangerous conditions of any mine is the accumulation of dust. To prepare and take care of it is a serious problem, and we cannot but recommend that the same care as used in the Marianna mine for distributing water for saturating the dust be employed in every mine under like conditions. We also feel that it is not simply a question of the sprinkling of the dust, but that it should be a saturation; that unless the coal dust is saturated, the sprinkling does not accomplish the purpose. We also feel that in all mines where machines are used for undercutting the coal, the accumulations of fine coal and dust should be loaded and taken out of the mine before shooting.

We recognize the present estimated commercial value of the use of electricity in mines, but we can only recommend its use of intake air currents, believing there is sufficient power otherwise obtainable to do the necessary work as economically; and in eliminating electricity from all gaseous parts of the mine we remove as great a danger as the open light.

The miner should realize his importance as a factor in not only safeguarding his own life, but those of his fellow-employees by faithfully following rules and regulations prescribed, and his education should be first on these lines: That the employer and employee working together for mutual protection under intelligent guidance will reduce liability to accident by explosion by removing the causes.

We realize that to follow out on the lines of our recommendations may mean increased costs of operating expenses, and hardships might result between competitive fields unless similar laws are enforced in all such fields.

The chief mine inspector gave thought to the recognized fact that disastrous explosions were occurring with alarming frequency in mines that were deemed to be models of safe planning and management. His conclusions approached but did not stress the fact that both State and company officials neglected to train and supervise the practices of miners and coal loaders. His summary declared:

It is to be regretted that explosions of this kind cannot be entirely prevented, but while that is impossible they could be greatly reduced in number if all the persons concerned in mining would cooperate intelligently in their work. Personal responsibility enters largely into this matter, for it is known and has often been demonstrated that the oversight, neglect, or carelessness of one person in a mine may cause the death of hundreds of others. This uncertainty is always present, and often when we think a mine, such as the Marianna, is safe, some one becomes heedless of the rules and regardless of consequences, and as a result an explosion occurs. Nor is it always the ignorant foreigner who is the culprit; frequently the most intelligent miner, overconfident regarding the safety of the mine, is the one to bring on disaster. It is very evident, however, that it is the plain duty of the Commonwealth of Pennsylvania to teach the foreign miners the language of the country and how to mine coal with safety to themselves and to others.

December 29, 1908; Lick Branch Mine, Switchback, W. Va.; 50 Killed

(From State inspector's report, 1909, pp. 615–628)

The mine * * * opened by drifts is in * * * coal having a thickness of 8½ feet * * * in addition a most excellent roof, practically no props or timber * * * used. * * * The mine is free of gas * * * and is worked with open lights. * * * The miners * * * had been shooting coal from the solid * * * a strict violation of rules. * * * This explosion was due to the excessive use of black powder and the improper placing of the hole and the violation of the law. The miners * * * in this district are chiefly Negroes, and ignorant unskilled foreigners, who have no conception of their own danger * * * arising from the excessive charging of holes. * * * The explosion was propagated by dust. * * * I recommend that safety explosives shall be used, * * * that solid shooting be prohibited * * * that shot firers be employed, * * * that all holes be tamped with clay, * * * that shooting be done after employees have retired from the mine, and that all dusty sections be kept thoroughly watered. * * *

January 10, 1909; Zeigler Mine, Zeigler, Ill.; 26 Killed

(From report by R. Y. Williams, Federal Geological Survey)

A fire on November 8, 1908, was caused by crossed electric wires and when attempts to fight it were unsuccessful the mine shafts were sealed. Thirty-one men were killed during the time the fire was fought. Sulfur gas and finally steam was forced into the workings through a borehole. On January 9, 1909, the seals were removed and the fan started. A crew of men entered the mine to restore ventilation and clean up the mine. At 12:15 a. m. on January 10, gas that filled the upper end of the West C south entries was carried over the region where the fire had previously raged and an explosion occurred which killed 26 men and again wrecked the mine. Forty hours later black smoke issued from the airshaft and immediately both shafts were sealed.

On February 9, 1909, the fan was started and the seals opened. A crew entered to restore ventilation. At 11:15, February 10, three men near 1st West C south saw fire ignite a body of gas ahead of them, causing an explosion that killed three men at the shaft bottom. Eleven men, including the three that saw the ignition start, escaped. The shafts were again sealed and left closed for 15 months.

January 12, 1909; Lick Branch Mine, Switchback, W. Va.; 67 Killed

(From State inspector's report, 1909, pp. 628–646)

The second explosion * * * occurred at 8:40 a. m. in the section east of the new main entry and extended all over the mine * * * An overcharged shot ignited the coal dust. The hole was improperly placed, heavily loaded with black powder and stemmed with coal dust. Coal dust in the mine was not kept moist.

June 23, 1909; Lackawanna No. 4 Mine, Wehrum, Pa.; 21 Killed

(From Federal Geological Survey report, by J. W. Paul, 1909)

The explosion occurred about 7:40 a. m. * * * resulting in the death of 21 men and the injury of 12 others. Seven died from burns or injuries and 14 * * * from afterdamp. The explosion area was limited due to the wet conditions in other sections * * *. All bodies were recovered by 7:30 p. m. * * * On the previous night a charge of powder in the bottom coal at the face of an air course blew out. The following morning the miner put two sticks of dynamite in the same hole and fired them without using any tamping. The shot ignited the coal dust in the working place. The miner who fired the shot survived the explosion.

January 31, 1910; Primero Mine, Primero, Colo.; 75 Killed

(From Federal Geological Survey report, by G. S. Rice, 1910)

The mine has a slope driven 5,000 feet with seven pairs of entries turned left and five * * * right. * * * The mine is gaseous and dry. * * * Locked safety lamps were used, and holes were charged with permissible explosives by shotfirers and fired after the men were out of the mine. * * * About 110 men were in the mine on day shift * * *, and at 4:30 about 35 * * * had come out * * * when the explosion shot out of the slope mouth. Black smoke, flame, and dust caught 4 men at the mouth of the slope and hurled them against a moving trip of cars, killing 3 and burning the other. * * * The mine was badly wrecked. * * * Rescue workers reestablished ventilation with great difficulty. One man was recovered alive. * * * The last of the bodies were found May 19. The source of the ignition was not determined but may have been the detonation of detonators and explosives by a fall of roof, igniting dust and carried through the mine by gas and dust. * * *

February 1, 1910; Browder Mine, Browder, Ky.; 34 Killed

(From Federal Geological Survey report, by J. J. Rutledge, 1910)

The mine is gaseous but the coal is hard and makes little dust. * * * The 200-foot shaft connects with No. 9 and No. 11 seams. The explosion occurred at noon in No. 11 seam, resulting in the death of 34 men and the serious injury of 2 boys. * * * Gas accumulated in unventilated idle rooms. It was ignited by open lights and the explosion was spread by coal dust and kegs of black powder. * * * No great damage was done to the mine workings. * * *

April 20, 1910; Mulga Mine, Mulga, Ala.; 40 Killed

(From Federal Geological Survey Notes, by J. J. Rutledge)

A comparatively new mine with few working rooms, numerous headings, a high velocity in the air currents, single doors, and no splitting of air currents. * * * Methane issued all around the faces, but open lights were used. * * * Permissible explosives were used; but some dynamite was found, and all coal was not cut before blasting. Water was not used to wet the dust. A fall in a pillar section forced gas out on the naked lights. The explosion was propagated by dust. The mine foreman who was outside the mine was the only man on the mine crew who escaped alive. Figure 5 shows the company rescue car at the scene.

May 5, 1910; Palos No. 3 Mine, Palos, Ala.; 84 Killed

(From Federal Geological Survey investigator's notes)

The explosion resulted in the loss of 83 men inside and 1 man on the outside of the mine and did much damage to the underground equipment. * * * The coal is mined by pick and is blasted with permissible explosives but dynamite is used for brushing the roof and for breaking the "middleman." The mine liberates methane, and where ventilation is not properly conducted there are accumulations of the gas. The ventilating current is continuous throughout the mine. Fine dry coal dust was much in evidence all through the mine. Miners used open-flame lamps, and the only flame safety lamps were those carried by the firebosses. The explosion originated in the 6th right entry through the ignition of a body of gas by an open-flame lamp, and dry coal dust propagated the explosion throughout the mine and out the mouth of the slope.

October 8, 1910; Starkville Mine, Starkville, Colo.; 56 Killed

(From State inspector's report, 1910, pp. 149–153)

About 10 p. m. an explosion * * * started about 800 feet from the portal on the main haulage road, caused by the derailment of loaded cars displacing timbers and setting in motion a shower of fine dust that had accumulated upon the timbers. * * * The trolley wire * * * came into contact with the iron bar of the cars, creating an arc * * * which ignited the dust. * * * The force traveled inward along the haulage road to C–1 fan, wrecking it, and stopped at C–1 parting in a wet section, * * * turned right to the new main haulage road, and passed through the Stine fan; wrecking it * * *, and continued into the H-entries. * * * Ventilation was restored by installing a new fan at the entrance to the air course. Work of recovering the bodies was slow and hazardous. * * * Sprinkling of the road beds did not suffice to avoid this explosion in which gas did not enter. * * *

November 8, 1910; Victor American No. 3 Mine, Delagua, Colo.; 79 Killed

(From Federal Geological Survey report, by J. C. Roberts, 1910, and State inspector's report, 1910, pp. 154–160)

At about 1 p. m. a fire occurred on the inby side of a door in a crosscut between a main entry and aircourse. At 2 p. m. when the fire was discovered all the officials went into the mine to fight the fire and a motor was sent outside to get hose. At 2:30 p. m. before it could get back an explosion occurred. About 121 men were in the mine; of these 28 came out through the connecting No. 2 mine, 4 were rescued alive from behind a canvas barricade by helmet men, and 14 men who also had bratticed themselves off came out the following day. Three men on the outside at the pit mouth were killed by flying rocks and timbers. A member of the rescue crew who gave his breathing apparatus to one of the four men found behind the barricade stayed behind to wait for the party's re-

FIGURE 5.—Company car at Mulga-mine explosion, Mulga, Ala., April 20, 1910.

turn. He was later found overcome in another part of the mine and died the next morning. The area where the fire occurred was dry and dusty, and it was thought that collapse of the burning door and supports stirred up a cloud of dust, aided by the dust raised by the motor going out. The fire ignited the dust cloud, and the explosion was propagated to the mouth of the slope with great violence. The explosion spread through several entries but was limited by wet areas. The fire was probably started by a discarded wick from the open lights. The crosscut was used as a lunch and waiting room. Gas had not been reported in the mine.

METHODS AND PROGRESS IN CONTROLLING AND PREVENTING EXPLOSIONS

BASIC CAUSES AND ATTITUDE OF MINERS AND OFFICIALS

As terrific disasters overshadowed the almost unreported but frequent lesser explosions in which only a few mine workers were killed or injured, the causes were studied and remedies proposed. Correction was difficult to bring about, because of the settled practices and deep-rooted habits in which both mine officials and mine workers persisted. The truth that untrained, and for the most part poorly educated, men could not safely carry on the work in most of the mines without close supervision by well-trained and alert foremen after all hazardous conditions were carefully controlled was recognized by many. Only a small number of inspectors and other officials and engineers believed that correction was possible. By far the greatest danger was refusal of the great majority of officials and workers to admit that explosions in their mines were more than a remote possibility.

The managing officials of companies operating well-conducted mines were amazed to find their mines not immune. Figures 6 and 7 are views of average working places in 1910. Figures 8 and 9 are typical of these years and of years before and after. Following the occurrence of explosions in these supposedly safe mines, the officials of a few notable companies made careful search for the flaws in their methods of protection and put into practice whatever safeguards they could devise to correct these latent hazards. Such earnest effort was unusual; the published reports of State mining departments show that the companies ordinarily claimed that all provisions of the mining laws were being complied with and that disasters were wholly due to illegal or care-

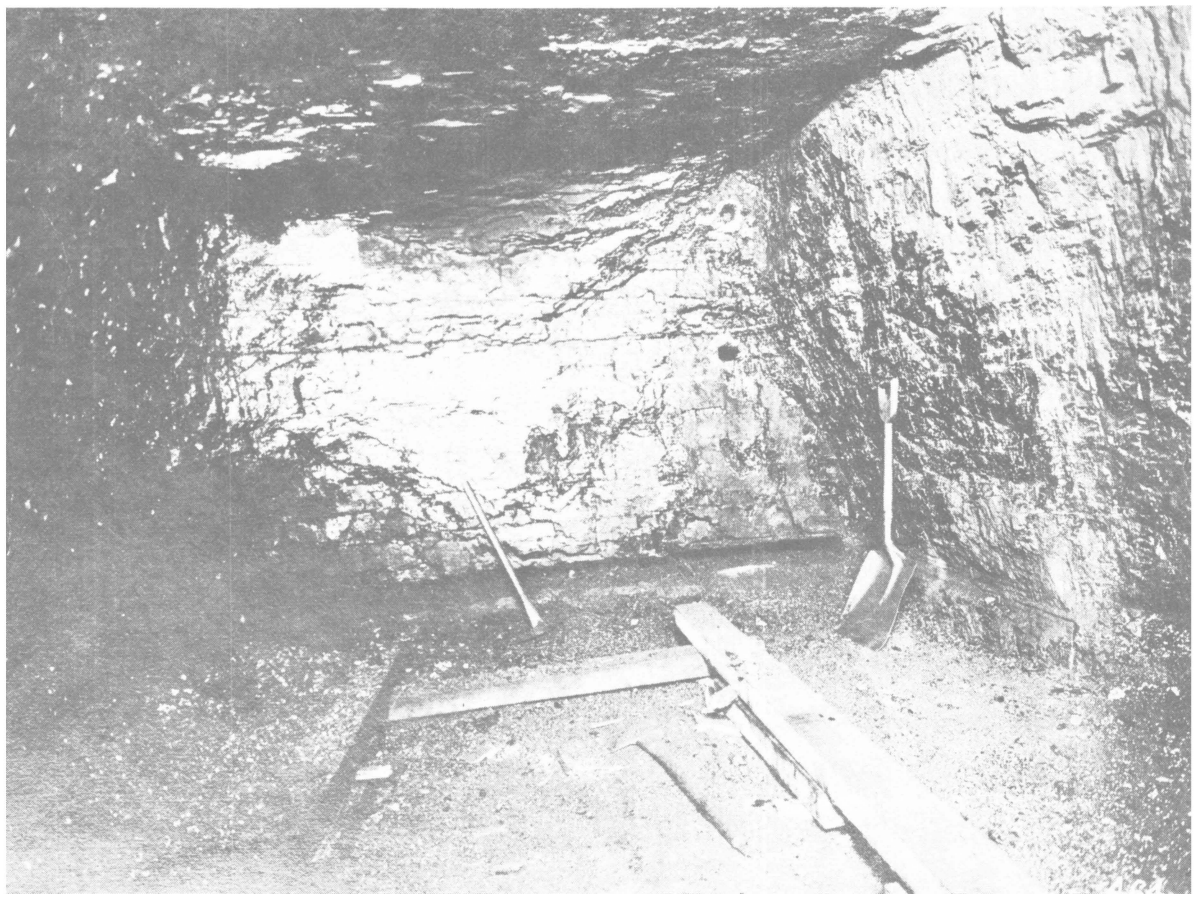

FIGURE 6.—Wooden track, face of heading, 1910.

less acts of workers, for which the company was not responsible. Coroners' juries ordinarily brought in a verdict that no blame could be attached to anyone for the explosion. State mining inspectors usually reported that their investigations showed that violations of mining laws had not been evident during inspections before the explosions. In many instances omissions in the laws, whereby existing hazards were not covered, were pointed out, and revisions in the laws were proposed in the chief inspectors' annual reports to the Governors. Court action against offenders provided under the provisions of mining laws in several States did not deter individuals, officials, or companies from evasions that often were directly responsible for explosions.

TECHNOLOGIC BRANCH, FEDERAL GEOLOGICAL SURVEY

Public attention, aroused by the increasing frequency of mine explosions and the resulting great loss of life, brought about action through Federal agencies to find means to control a menace that was plainly out-of-hand. This approach was through the Geological Survey, the existing agency of the Federal Government connected with mining. In his First Annual Report as Director of the Bureau of Mines, Dr. Joseph A. Holmes told of the work of the Technologic Branch of the Geological Survey and the beginning of the Bureau of Mines.

> A series of disastrous coal-mine explosions late in 1907 having caused widespread discussion as to the loss of life in mines, Congress * * * authorized an investigation as to the causes of mine explosions with a view to increasing safety in mining. * * * Immediately after the passage of the act of May 22, 1908, the Mine-Accidents Division of the Technologic Branch was organized. Investigation having shown that one of the chief causes of coal-mine explosions in the country was the use of unsafe explosives, the necessary steps for the establishment of a suitable station for the testing of explosives were taken. * * * Explosives that * * * passed certain tests were designated as permissible explosives * * *, and their names were published. The first list of such explosives was published in 1909. In addition to investigations at this Pittsburgh Station of explosives, mine gases, and dusts, and investigations of electrical equipment and other possible causes of mine explosions, investigations were also made in mines within which explosions had

FIGURE 7.—Coal shot down in heading, 1910.

occurred. In an endeavor to reduce loss of life in rescue operations after mine disasters * * *, an investigation was undertaken of various types of mine rescue apparatus and of mine rescue work in general.

In addition to the main station at Pittsburgh, branch stations with rescue apparatus were established in various coalfields, the first * * * in cooperation with the State geological survey, at Urbana, Ill., in 1908, the second at Knoxville, Tenn., and the third at Seattle, Wash., in 1909.

ESTABLISHMENT AND WORK OF THE BUREAU OF MINES

The Bureau of Mines was established by an act of Congress (36 Stat. 369), effective July 1, 1910. The demand for special recognition and aid from the Federal Government for the mining industry had been increasing for a number of years * * *. At the time of the passage of the act, * * * the factors that were most effective in calling attention to the advisability of action by the Government were disasters in coal mines and a growing realization of the waste of both life and resources in the varied mining and metallurgical industries of the country.

In regard to safety in mining the act stated: That it shall be the province and duty of said Bureau * * * to make diligent investigation of the methods of mining, especially in relation to the safety of miners and the appliances best adapted to prevent accidents, the possible improvement of conditions under which mining operations are carried on, * * * the use of explosives and electricity, the prevention of accidents and * * * to make such public reports * * * as the Secretary * * * may direct, with the recommendations of such Bureau.

Provision was made for the transfer to the Bureau of Mines of the duties of the Technologic Branch of the Federal Geological Survey.

In his report on the work of the first year of the Bureau, Director Dr. Joseph A. Holmes listed investigations and tests on explosion-proof motors and electric blasting, on new permissible explosives (88 of which had been approved by July 1, 1911), and on the explosi-

FIGURE 8.—Boy and haulage mule.

bility of mixtures of coal dust and air and noted the opening of the Experimental Mine at Bruceton, Pa., for the conduct of experiments to determine, under the conditions of actual mining, the behavior of different types of explosives, the conditions that determine the ignition of gas or dust, and the factors involved in the spread of the resulting explosions. The main purpose of these investigations was to discover the most efficient methods of preventing such explosions. Field stations and mine-safety cars were distributed in coal-mining States to assist in rescue work, to train mine crews, and to investigate fires and explosions.

In charge of the section of the Bureau devoted to mine rescue work and training, and investigation of mine explosions and fires, was J. W. Paul, a mining engineer with exceptional experience in these fields. After serving as chief of the West Virginia Department of Mines, he joined the Technologic Branch of the Geological Survey in 1908 and came with that group into the Bureau of Mines. He was a leader in developing the mine-safety work of the Bureau and the inventor of the Paul oxygen breathing apparatus. Later he was in charge of the Experimental Mine and then the head of the staff set up to study roof falls. Although modest, his knowledge and powers of analysis, as well as his fine character, made him respected and admired by mining men.

Other mining engineers who participated in rescue and recovery work and investigation of mine disasters with the Technologic Branch of the Survey and in the first year with the Bureau were: George S. Rice, Chas. Enzian, R. Y. Williams, J. J. Rutledge, J. C. Roberts, H. I. Smith, J. T. Ryan, Geo. Deike, and D. J. Price. Many other well-known men joined the staff in the next few years.

RECOMMENDATIONS OF SURVEY GROUP IN 1908

The conditions responsible for mine explosions and recommendations for their correction were published in the report of three mining experts, who, with engineers of the Technologic Branch of the Survey, visited mines in the larger coalfields in 1908 (*64, pp. 3–12*). That report, which Director Holmes had reprinted as a Bureau paper in 1912, recommending renewed attention, contained several interesting passages:

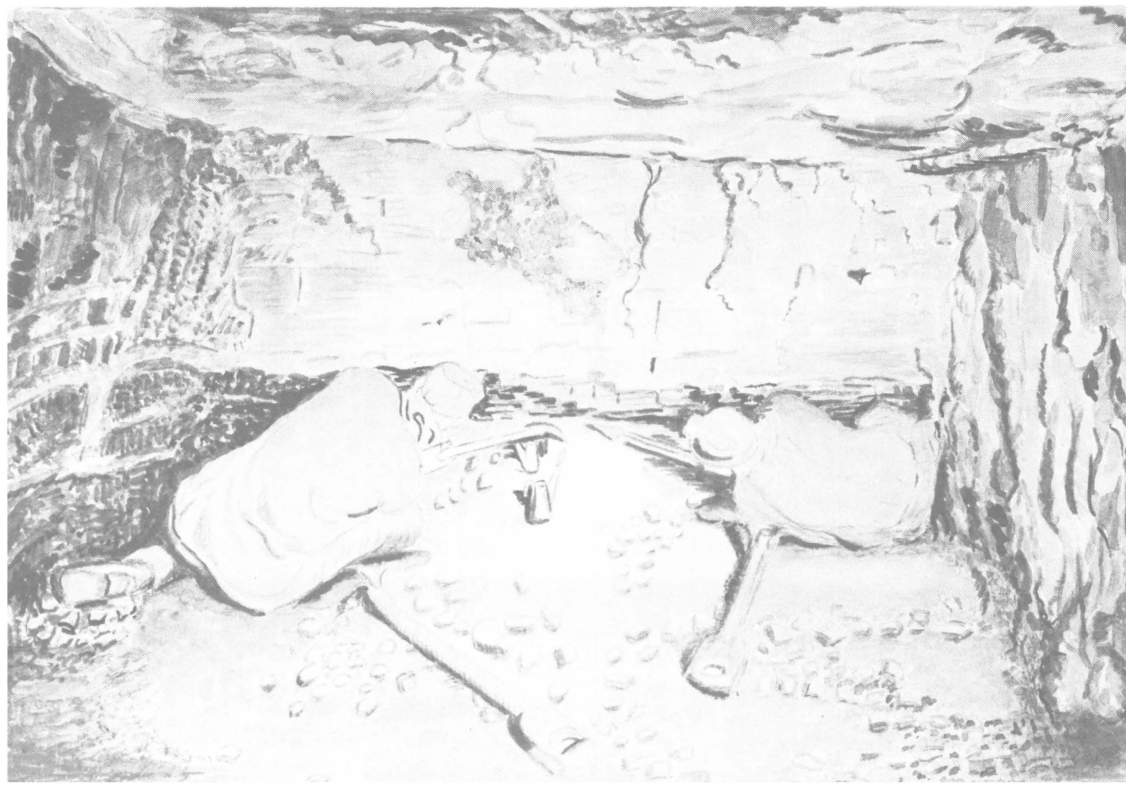

FIGURE 9.—Miners undercutting coal face with picks.

In America * * * the industry has developed so rapidly that thorough organization has not yet been possible; a large percentage of the men entering the mine are unfamiliar either with mining methods or the English language * * *. We recommend * * * the use only of "permissible explosives;" * * * investigations to determine the amount of charge of such explosives * * * to reduce danger to a minimum; * * * shooting off the solid should not be practiced; * * * shots should never be tamped with fine coal or material containing coal; * * * mines should be kept free as possible * * * from coal * * * dust, * * *; the dust should be kept continually wet, * * * in mines where 2 percent of methane can be detected by a suitable method, only locked safety lamps should be used; * * * no live electric wire should be permitted in any entry or heading of a coal mine in which the air current contains 1 percent of methane; * * * the responsibility for safety in the mine should primarily rest with some person, manager or superintendent, clothed with full authority; * * * the employment of a sufficient number of foremen, and also of one or more inspectors to see that the regulations are strictly enforced; * * *. The positions of State inspectors should be made independent of all considerations other than that of efficiency, their continuation in service should be coexistent with good behavior and proper discharge of duty; * * * the establishment in the mining regions of schools for the training of firebosses, mine foremen, and superintendents, and inspectors. The instruction should be practical rather than theoretical.

These observations support the general conclusion that the greatest difficulty in preventing mine explosions has been in gaining acceptance of known precautions.

1911–40

HAZARDS AND OCCURRENCE OF EXPLOSIONS

The halting progress of the struggle to control and prevent coal-mine explosions for 30 years after the beginning of organized efforts can be seen by the chart and tabulations in figure 2 (p. 14). The seesaw record of these years has been discussed in reviews and reports published by the Bureau of Mines. The repeated alternation of low and high fatality totals has been laid mainly to relation of efforts in years following one with a relatively good explosion-fatality record and additional precautions taken in years following those with bad records (*24, p. 13*). The comparative

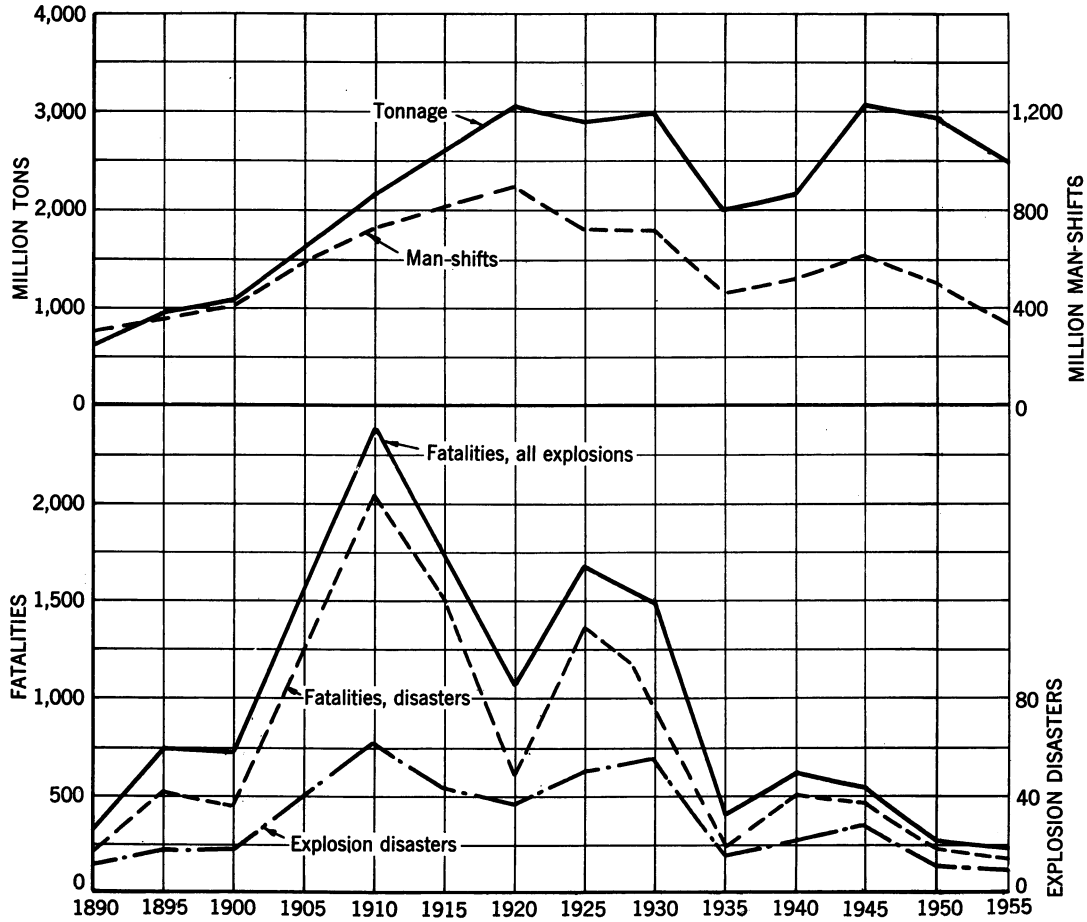

FIGURE 10.—Tonnage, man-shifts, explosions, and resulting fatalities in coal mines of the United States, by 5-year periods, 1890–1955.

progress of these 3 decades is also charted in figure 10, from the 5-year totals of table 5.

TABLE 5.—*Tonnage, man-shifts, explosions, and resulting fatalities, by 5-year periods, 1886–1955, United States coal mines*

5-year period	Million tons	Million man-shifts	Fatalities		Number of disasters
			Disasters	All explosions	
1886–90	692	305	214	328	12
1891–95	894	360	527	743	18
1896–1900	1,136	402	461	730	18
1901–05	1,697	585	1,212	1,524	43
1906–10	2,273	727	2,104	2,388	68
1911–15	2,646	812	1,533	1,722	44
1916–20	3,132	900	618	1,066	37
1921–25	2,795	726	1,322	1,690	50
1926–30	2,977	728	1,195	1,504	55
1931–35	2,026	473	247	398	16
1936–40	2,346	521	505	620	21
1941–45	3,180	615	458	549	28
1946–50	2,964	512	238	285	11
1951–55 [1]	2,488	331	184	215	8

[1] 1 surface fatality in 1952 and 4 in 1954 caused by dust explosions in surface preparation plants are not included. Figures for 1955 and 1956 are preliminary. In 1956 there were no major explosion disasters and only 11 fatalities from minor explosions, including 2 boys who were visiting in a small mine.

The number of disasters and of fatalities reached a peak in the 1906–10 period with lesser peaks between 1925 and 1930 and again in 1941–45. The tonnage and employment totals continued to climb until 1920. The production held fairly high until the depression years in the 1930–35 period, then rose sharply during World War II. Since 1920, mechanization has caused a rapid decline in the number of men employed, with a very low point in the man-shifts during the depression years and a rise during the war years. The downward trend in the record of explosions and fatalities since 1910 is possibly the most significant feature of the chart. The sharp reduction in these totals between 1910 and 1920 certainly was due to the combined efforts of the Bureau of Mines, State inspectors, and mine officials to curb the causes then existing. The resurgence of explosions between 1920 and 1930 is not easy to attribute to specific circumstances; the progress of explosion-prevention measures during this period is described farther along. The second sharp decline in

disasters and explosion deaths appears in 1931–35, at the low point of production and employment. During these years many mines were shut down all or part of the time.

The total yearly fatalities for 1911–20 averaged 279, almost a third less than in 1901–10. The average number of fatalities for the next 10 years (1921–30) was higher—320, and for the next two 10-year periods the averages were lowered to 102 and 86. Table 6 lists 223 major explosion disasters between 1911 and 1940, while table 4 and lists of earlier disasters show only 161 for the 30 years from 1881 to 1910. The total fatalities from explosions during these two 30-year periods, as shown by table 5 and figure 2, were 7,000 and 6,133.

TABLE 6.—*Major explosions in United States coal mines, 1911–40*

Date	Name of mine	Location of mine	Killed
1911: January 20	Carbon Hill	Carbon Hill, Va	7
February 9	Cokedale	Trinidad, Colo	17
March 18	No. 16	Mineral, Kans	5
April 8	Banner	Littleton, Ala	128
April 24	Ott No. 20	Elk Garden, W. Va	23
May 27	Cameron [1]	Shamokin, Pa	5
July 15	Sykesville	Sykesville, Pa	21
August 1	Standard	Welch, W. Va	6
October 23	O'Gara No. 9	Harrisburg, Ill	8
November 9	Adrian	Punxsutawney, Pa	8
November 18	Bottom Creek	Vivian, W. Va	18
December 9	Cross Mountain	Briceville, Tenn	84
1912: January 9	Parrish [1]	Plymouth, Pa	6
January 16	Carbon Hill	Carbon Hill, Va	5
January 19	Central	Central City, Ky	5
January 20	Kemmerer No. 4	Kemmerer, Wyo	6
March 20	San Bois No. 2	McCurtain, Okla	73
March 26	Jed	Jed, W. Va	81
April 21	Coil	Madisonville, Ky	5
June 18	Hastings	Hastings, Colo	12
July 11	Panama	Moundsville, W. Va	8
July 16	Carbon Hill	Gayton, Va	8
August 13	Abernant	Abernant, Ala	18
1913: February 19	Seagraves	Eldorado, Ill	5
April 23	Cincinnati	Finleyville, Pa	98
May 17	Noble	Belle Valley, Ohio	15
August 2	East Brookside [1]	Tower City, Pa	20
October 22	Stag Canon No. 2	Dawson, N. Mex	263
November 18	Acton No. 2	Acton, Ala	24
December 16	Vulcan	New Castle, Colo	37
1914: January 10	Rock Castle	Rock Castle, Ala	12
April 28	Eccles Nos. 5 and 6	Eccles, W. Va	181
September 16	Lehigh No. 4 [1]	Lansford, Pa	7
October 5	Mulga	Mulga, Ala	16
October 27	North or No. 1	Royalton, Ill	52
1915: February 6	Carlisle	Carlisle, W. Va	21
February 17	Prospect [1]	Wilkes-Barre, Pa	13
February 18	New Home No. 2	Rich Hill, Mo	5
March 2	Layland No. 3	Layland, W. Va	115
April 5	Shoal Creek	Panama, Ill	11
May 24	Smokeless Valley No. 1	Johnstown, Pa	9
July 27	United Coal No. 1	Christopher, Ill	9
August 31	Orenda	Boswell, Pa	19
November 16	Northwestern	Ravensdale, Wash	31
November 30	Boomer No. 2	Boomer, W. Va	23
1916: February 8	Lance [1]	Plymouth, Pa	7
February 11	Ernest No. 2	Ernest, Pa	27
February 29	Davis No. 42	Kempton, Md	16
March 9	Hollenback [1]	Wilkes-Barre, Pa	6
March 28	King	Kimball, W. Va	10
March 30	Robindale	Seward, Pa	8
August 8	Woodward [1]	Wilkes-Barre, Pa	6
October 19	Jamison No. 7	Barrackville, W. Va	11
October 22	Roden	Marvel, Ala	18
November 4	Bessie	Palos, Ala	30
December 13	Fidelity No. 9	Stone City, Kans	20
1917: March 13	Henderson No. 1	Hendersonville, Pa	14

See footnotes at end of table.

TABLE 6.—*Major explosions in United States coal mines, 1911–40*—Continued

Date	Name of mine	Location of mine	Killed
1917: April 27	Hastings	Hastings, Colo	121
June 2	Rend No. 2	Herrin, Ill	9
June 13	Banner	Banner, Ala	6
August 4	West Kentucky No. 7	Clay, Ky	62
November 29	Old Ben No. 11	Christopher, Ill	18
December 15	Yukon No. 1	Bluefield, W. Va	18
December 20	No. 3	Catoosa, Tenn	11
1918: August 7	Harmar	Harmarville, Pa	8
August 28	Burnett	Burnett, Wash	12
September 28	North	Royalton, Ill	21
1919: March 31	Empire	Aguilar, Colo	13
April 29	Majestic	Majestic, Ala	22
June 30	Alderson No. 5	Alderson, Okla	15
July 8	Lansford colliery [1]	Lansford, Pa	8
July 18	Carswell	Kimball, W. Va	6
August 6	Weirwood	Weirwood, W. Va	7
August 18	Oakdale	LaVeta, Colo	18
December 3	No. 3	Jacksonville, Ind	6
1920: April 14	Stag Canon Nos. 1 and 6	Dawson, N. Mex	5
May 3	Submarine	Clinton, Ind	5
June 2	Ontario	Cokeburg, Pa	6
July 19	Renton No. 3	Renton, Pa	9
August 21	No. 19	Degnan, Okla	10
November 23	Parrish	Parrish, Ala	12
1921: February 12	Moffat Nos. 1 and 2	Oak Hill, Colo	5
March 9	Rahn No. 11 [1]	Seek, Pa	5
August 31	Harco	Harrisburg, Ill	12
1922: January 30	Layman	Hulen, Ky	6
February 2	Belle Ellen No. 2	Belle Ellen, Ala	9
February 2	Gates No. 2	Gates, Pa	25
February 7	Marietta	Pinson Fork, Ky	9
March 20	Dilltown No. 1	Dilltown, Pa	5
March 24	Sopris No. 2	Sopris, Colo	17
May 25	Acmar No. 3	Acmar, Ala	11
September 29	Lake Creek	Johnston City, Ill	5
October 11	No. 11, Progressive	McCurtain, Okla	8
November 6	Reilly No. 1	Spangler, Pa	79
November 22	Dolomite No. 3	Dolomite, Ala	90
November 25	No. 4	Cerillos, N. Mex	12
1923: January 10	Dolomite No. 1	Dolomite, Ala	5
February 8	Stag Canon No. 1	Dawson, N. Mex	120
February 21	Alliance [1]	Kaska, Pa	5
March 2	Arista	Arista, W. Va	10
May 5	Southwestern	Aguilar, Colo	10
June 26	Richards Colliery [1]	Mount Carmel, Pa	5
August 14	Frontier No. 1	Kemmerer, Wyo	99
October 7	Midwest	Palisades, Colo	6
November 6	Glen Rogers	Beckley, W. Va	27
December 7	Black Hawk	Happy, Perry Co., Ky	9
1924: January 25	McClintock	Johnston City, Ill	33
January 26	Lancashire No. 18	Shanktown, Pa	36
March 8	No. 2	Castle Gate, Utah	172
March 28	Yukon No. 2	Yukon, W. Va	26
April 28	Benwood	Benwood, W. Va	119
June 6	Loomis colleries [1]	Nanticoke, Pa	14
July 25	Gates No. 1	Brownsville, Pa	10
September 16	Sublet No. 5	Sublet, Wyo	39
September 21	Rains	Rains, Utah	5
December 17	Burnett	Burnett, Wash	7
1925: January 15	Diamond No. 1	Providence, Ky	6
February 20	City	Sullivan, Ind	52
March 17	Barrackville	Barrackville, W. Va	33
April 26	New Slope	Sewickley, Pa	5
Do	Hutchison	Millgrove, Pa	5
May 22	Woodward [1]	Edwardsville, Pa	7
May 27	Carolina	Farmville, N. C	53
May 31	No. 2	Piper, Ala	6
June 8	No. 9	Sturgis, Ky	17
July 23	Rockwood	Rockwood, Tenn	10

See footnotes at end of table.

TABLE 6.—*Major explosions in United States coal mines, 1911–40*—Continued

Date	Name of mine	Location of mine	Killed
1925: August 3	Dorrance [1]	Wilkes-Barre, Pa	10
November 13	Finley	Madisonville, Ky	5
December 10	Overton, No. 2	Irondale, Ala	53
December 14	Wilkeson	Tacoma, Wash	5
1926: January 13	No. 21	Wilburton, Okla	91
January 14	Jamison No. 8	Farmington, W. Va	19
January 29	New Orient No. 2	West Frankfort, Ill	5
Do	Mossboro No. 1	Helena, Ala	27
February 3	Horning No. 4	Horning, Pa	20
February 16	Nelson	Nelson, Ky	8
March 8	Eccles No. 5	Eccles, W. Va	19
May 6	Randolph collery [1]	Port Carbon, Pa	5
July 3	Pettebone collery No. 6 [1]	Kingston, Pa	7
July 21	Dixie	Moffat, Ala	9
August 26	Clymer No. 1	Clymer, Pa	44
September 3	Tahona	Tahona, Okla	16
October 4	Rockwood	Rockwood, Tenn	27
October 30	Colliery No. 7 [1]	Nanticoke, Pa	9
November 15	Mound	Moundsville, W. Va	5
December 9	Francisco No. 2	Francisco, Ind	37
1927: March 30	Saline No. 2	Ledford, Ill	8
April 2	No. 53	Cokeburg, Pa	6
April 30	Federal No. 3	Everettville, W. Va	97
May 13	Shanon Branch No. 3	Capels, W. Va	8
May 26	Woodward No. 3 [1]	Edwardsville, Pa	7
May 27	Delagua	Delagua, Colo	7
August 3	West Kentucky No. 7	Clay, Ky	15
December 20	Franco No. 1	Johnston City, Ill	7
1928: January 9	No. 18	West Frankfort, Ill	21
February 20	Kinloch	Parnassus, Pa	12
February 24	Mama No. 3	Jenny Lind, Ark	13
April 2	Keystone No. 2	Keystone, W. Va	8
May 19	Mather No. 1	Mather, Pa	195
May 22	No. 30	Kenvir, Ky	8
May 22	No. 1	Yukon, W. Va	17
May 25	Baltimore No. 5 [1]	Parsons, Pa	10
June 20	No. 1	National, W. Va	6
August 9	Hillside	Johnstown, Pa	5
August 15	Irvons No. 3	Coalport, Pa	13
October 22	McAlpin	McAlpin, W. Va	6
November 30	Princess Poca	Roderfield, W. Va	6
December 18	No. 2	Drakesboro, Ky	6
1929: January 26	Kingston No. 5	Kingston, W. Va	[2] 14
March 21	Kinloch	Parnassus, Pa	46
May 27	Connellsville	Yolande, Ala	10
September 27	Covington	Tahona, Okla	8
December 1	Old Ben No. 8	West Frankfort, Ill	7
December 17	Old Town	McAlester, Okla	61
1930: January 13	Peerless	Straven, Ala	7
January 19	No. 1	Lillybrook, W. Va	8
February 6	Standard	Standardville, Utah	[3] 23
March 8	New Peerless	Lynn, Utah	5
March 26	Yukon	Arnettsville, W. Va	12
March 30	Pioneer	Kettle Island, Ky	16
April 12	Carbonado	Carbonado, Wash	17
October 27	Wheatley No. 4	McAlester, Okla	30
November 5	No. 6	Millfield, Ohio	[4] 82
November 29	Lutie No. 5	Lutie, Okla	15
December 6	Lamb	Madrid, N. Mex	5
1931: January 3	Midvale No. 4	Midvale, Ohio	5
January 6	No. 2	Glen Rogers, W. Va	8
January 28	Little Betty	Dugger, Ind	28
May 29	Richards Colliery [1]	Mount Carmel, Pa	5
November 3	No. 20	Holden, W. Va	5
December 28	Overton No. 1	Irondale, Ala	5
1932: January 18	Parrott	Parrott, Va	6
February 27	Boissevain	Boissevain, Va	38
June 13	Splashdam No. 6	Splashdam, Va	10

See footnotes at end of table.

TABLE 6.—*Major explosions in United States coal mines, 1911–40*—Continued

Date	Name of mine	Location of mine	Killed
1932: December 7	Morgan-Jones	Madrid, N. Mex	14
December 9	Zero	Yancey, Ky	23
December 24	Moweaqua	Moweaqua, Ill	54
1933: September 11	Oakmont	Barking, Pa	7
1934: August 6	Derby No. 3	Big Stone Gap, Va	17
1935: January 21	Gilberton [1]	Gilberton, Pa	13
July 17	No. 155	Van Lear, Ky	9
1936: January 20	Monarch No. 2	Broomfield, Colo	8
August 24	Clear Spring [1]	West Pittston, Pa	5
September 2	Macbeth	Macbeth, W. Va	10
November 19	Bates	Bates, Ark	5
1937: March 11	Macbeth	Macbeth, W. Va	18
March 28	Kramer	DuBois, Pa	9
July 15	Baker	Sullivan, Ind	20
October 15	Mulga	Mulga, Ala	34
October 26	Jonesville	Jonesville, Alaska	14
1938: January 12	Harwick	Harwick, Pa	10
February 11	Vail (Star Valley)	Afton, Wyo	5
April 22	Keen Mountain	Hangar, Va	45
April 27	No. 1 Slope [1]	Pottsville, Pa	8
June 2	Butler Slope	Pittston, Pa	10
1939: July 14	Duvin	Providence, Ky	28
1940: January 10	Pond Creek No. 1	Bartley, W. Va	91
March 16	Willow Grove No. 10	St. Clairsville, Ohio	72
July 15	Sonman	Portage, Pa	63
August 27	No. 2	Bates, Ark	10
November 29	Nelms	Cadiz, Ohio	31
December 17	No. 4	Raleigh, W. Va	9

[1] Anthracite mine.
[2] Includes 1 on surface.
[3] Includes 3 killed by fall of slate about 28 hours later.
[4] Includes 3 visitors.

Deaths from explosions, 1911–56

10-year period:	*Fatalities*
1911–20	2,788
1921–30	3,194
1931–40	1,018
1941–50	859
1951–56	215

Sources of ignitions, 1851–1956

Period	Open lights and smoking	Blasting and explosives	Flame safety lamps	Fires	Electric arc	Friction sparks	Total
1851–60	9	1					10
1861–70	7	1	1	1			10
1871–80	78	6	19	10			113
1881–90	124	29	20	2			175
1891–1900	198	64	50	10			332
1901–10	300	270	10	20	6		606
1911–20	405	120	17	7	34		583
1921–30	263	112	10	5	94		484
1931–40	114	43	8	2	95		262
1941–50	114	60	14	2	59		249
1951–56	34	37	5	3	71	16	166

CAUSES AND SOURCES OF IGNITION

The contributing causes and the sources of ignition of the explosions occurring from 1911 to 1940 were much the same as those causing the explosions in the years from 1901 to 1910. The neglect of ventilation, omission of testing for gas, use of open lights in gassy mines, tolerance of smoking, use of black powder and overloading shots, and failure to remove coal dust or to use water and rock dust were factors often reported. Use of open-type electric equipment in face regions was also a commonly observed hazard. The sources of ignition listed in reports were, in order: Open lights or smoking, explosives and blasting, electric arcs, flame safety lamps, and mine fires.

the smaller occurrences in coal-mining States where no reports were published, would be larger but probably would show approximately the same relative proportions of sources of ignition and of explosions and ignitions in the periods of years. The percentage of occurrences from each ignition source during the 10-year periods is shown in table 7. These percentages are approximate, because complete and accurate reports of all explosions and ignitions were not made.

The spectacular rise in the number of explosions to the peak in 1901–10 is evident on the chart. The acceleration of the reduction in the number of explosions from then to the 1931–40 period is also clearly shown. The great preponderance of ignitions from open lights and

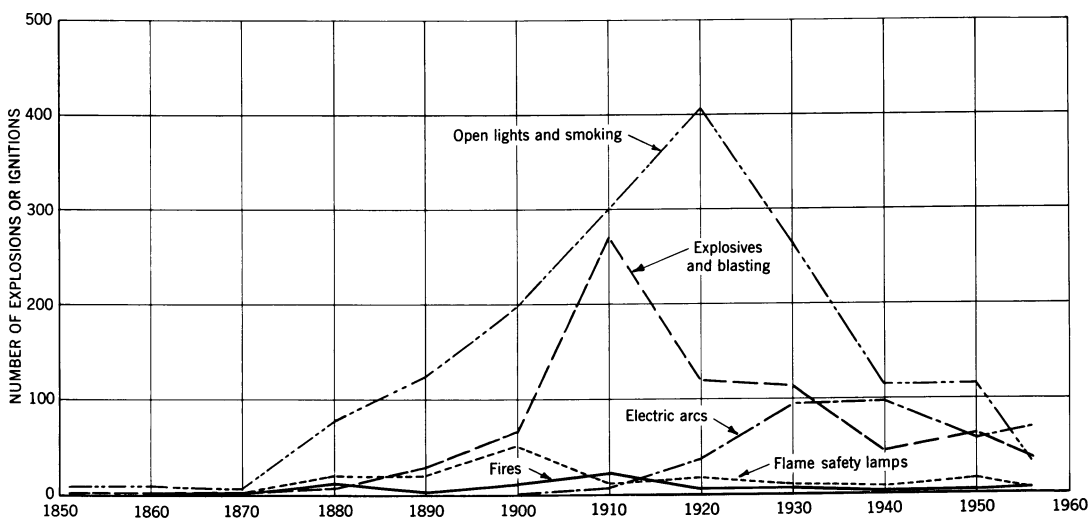

FIGURE 11.—Sources of coal-mine explosions and ignitions, by 10-year totals, 1851–1950.

Explosions from these sources of ignition for each 10-year period from 1851 to 1950 are shown in figure 11. In making this chart the recorded explosions and ignitions during each 10-year period were classed under the ignition sources. The total number of occurrences shown in any period is not complete, because accurate and complete records were not kept. The definition of an ignition is not uniform, because gas was lit thousands of times without resulting injury or violence. Many times and in many places such lighting of small gas accumulations was intentional as an accepted means of getting rid of gas that prevented work with open lights. The records used in compiling the totals in figure 10 (p. 37) include many small fatal and nonfatal ignitions recorded in State mine inspectors' reports. An overall total, including

smoking for 30 years is as would be expected. The rapid increase in the number of ignitions from explosives up to the 1901–10 total was due to the use of black blasting powder and high explosives; the gradual decline was due to a slowly won acceptance of permissible explosives. The number of explosions due to electric arcs reached serious proportions between 1920 and 1940. This hazard was greater than is indicated by the chart, as most of these ignitions resulted in fatalities and more than half were major disasters. Ignitions from unsafe use of flame safety lamps have been a minor cause of explosions since before 1870; most of them were in anthracite mines until after 1920. Ignitions from active mine fires were reported from 1870 to 1930 but were few in number at any time.

TABLE 7.—*Sources of ignition, coal-mine explosions, for 10-year periods, 1851–1956, percent*

10-year period	Source of ignition					
	Open lights and smoking	Blasting and explosives	Electric arcs	Flame safety lamps	Fires	Friction sparks
1851–1860	90	10				
1861–1870	70	10		10	10	
1871–1880	70	5		16	9	
1881–1890	70	17		12	1	
1891–1900	61	20		16	3	
1901–1910	50	44	1	2	3	
1911–1920	69	21	6	3	1	
1921–1930	55	23	19	2	1	
1931–1940	44	16	36	3	1	
1941–1950	46	24	24	5	1	
1951–1956	20	22	43	3	2	10

OPEN LIGHTS AND ELECTRIC CAP LAMPS

During the 30 years from 1911–40 the hazard of explosions and ignitions from open lights carried in the mines was reduced by providing better ventilation, by more inspections for gas, and by gradual adoption of closed lights to replace open-flame cap lamps. The decreased number and percentage of explosions from open lights and smoking are shown in figure 10 and table 7. The number of explosions from these causes dropped from 405 during 1911–20 to 114 during 1931–40. The percentage of all explosions dropped from 90 to 44. The changes in ventilating practices or in testing for gas cannot be put down on tables, charts, or figures, but the replacement of open lights by electric cap lamps is shown by figure 12. From 1910, when only open lights were used by miners working underground, the use of closed lights was extended to more mines each year. In 1940 approximately 53 percent of the men working underground in coal mines used permissible electric cap lamps. Open lights were displaced chiefly in gassy mines, at least in the first half of the period; this was particularly notable from 1920–25. Although the hazard of open lights was reduced by half, smoking continued, rules and laws to the contrary.

KINDS OF EXPLOSIVES USED

The growth of mechanical mining was as shown in this tabulation:

Year:	*Machine-mined, percent*
1910	45
1920	60
1930	75
1940	88
1950	92

After a steady increase to about 1940, the percentage of underground bituminous coal cut by machine had reached a virtual saturation point by 1948. The change afterward amounted to about 1 percent a year. In 1955 about 80 percent of the underground bituminous-coal production was mechanically loaded. Shooting off the solid was gradually reduced along with the use of black blasting powder. In 1910, black blasting powder composed 80 to 90 percent of the explosives used in mining coal; in 1920, it was 72.7 percent; in 1930, 51.6 percent; and in 1940, 38.7 percent. In the next 10 years the percentage of black blasting powder dropped to 6.3 percent and by 1955 to 1.6 percent.

The percentages of black blasting powder, nonpermissible high explosives, and permissible explosives that were used in the coal mines from 1901 to 1955 are shown in table 8 and by the graphs in figure 13. The increasing percentage of permissibles accompanied gradual abandonment of the use of black blasting powder up to 1943. Owing to the increasing proportion of strip coal produced, beginning 1946, and to the heavier overburden to be moved, the poundage of high explosives other than permissibles was greater than the quantity of permissibles used to mine coal. This relation of explosives consumption for coal mining had not been observed since 1915.

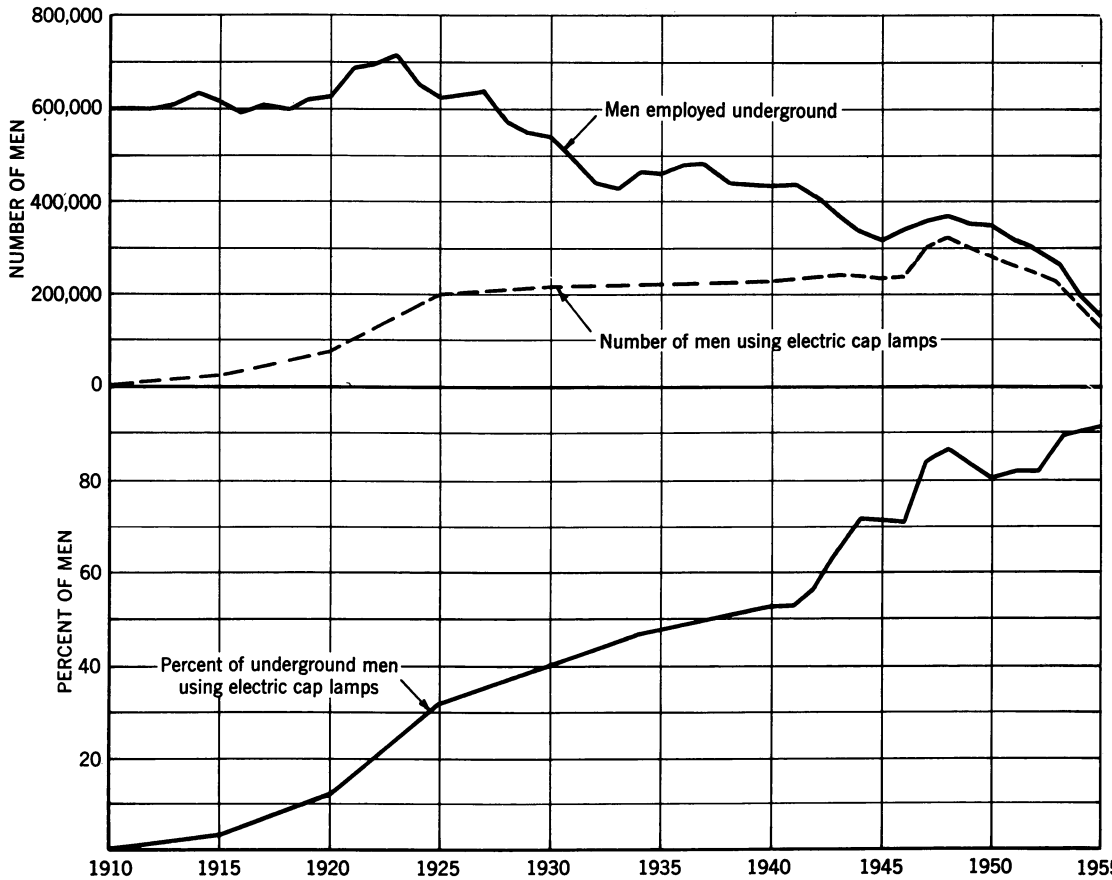

FIGURE 12.—Use of electric cap lamps in coal mines in the United States, 1910–55.

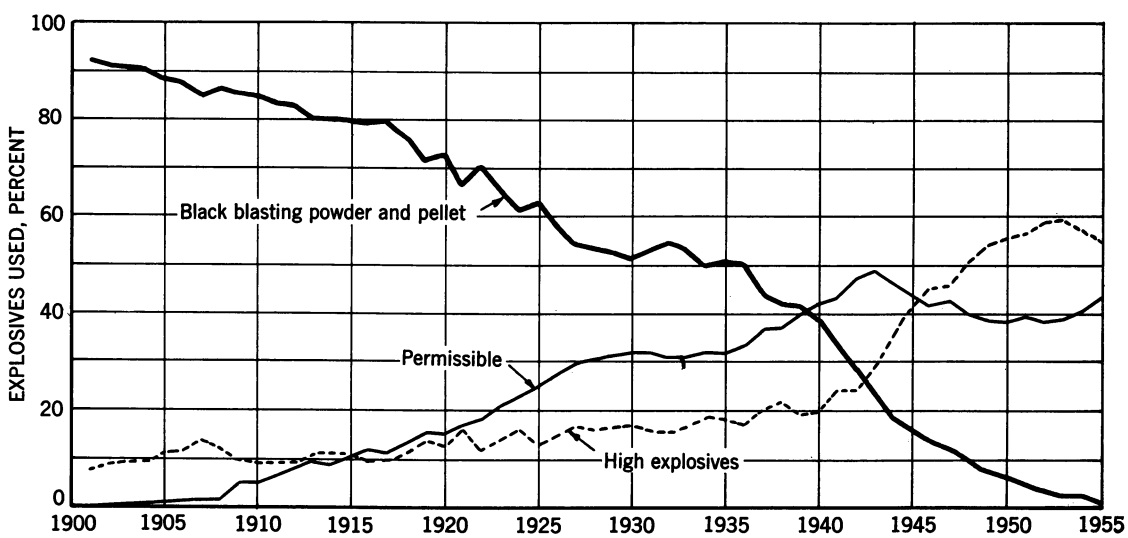

FIGURE 13.—Kinds of explosives used in coal mines in the United States, 1901-55, percent.

States coal mines, 1901–55, percent

Year	Black blasting powder and pellet [1]	Dynamite, etc.	Safety and permissible
1901	92.1	7.9	
1902	91.3	8.7	0.01
1903	90.6	9.2	.2
1904	90.4	9.2	.4
1905	88.4	10.9	.7
1906	87.7	11.4	.9
1907	85.2	13.7	1.1
1908	86.7	12.1	1.2
1909	85.3	9.7	5.0
1910	85.0	9.1	5.9
1911	83.3	9.2	6.5
1912	82.8	9.2	8.0
1913	80.1	10.5	9.4
1914	80.1	11.0	8.9
1915	79.1	10.6	10.3
1916	78.9	9.3	11.8
1917	79.4	9.5	11.1
1918	75.9	11.0	13.1
1919	71.1	13.7	15.2
1920	72.7	12.3	15.0
1921	66.0	16.1	17.9
1922	70.2	11.6	18.2
1923	65.0	14.0	21.0
1924	61.3	16.0	22.7
1925	62.6	12.7	24.7
1926	57.6	14.9	27.5
1927	54.2	16.5	29.3
1928	53.5	16.0	30.5
1929	52.7	16.3	31.0
1930	51.6	16.8	31.6
1931	52.9	15.5	31.6
1932	54.3	15.3	30.4
1933	53.0	16.2	30.8
1934	49.8	18.3	31.9
1935	50.4	18.0	31.6
1936	50.0	16.9	33.1
1937	43.8	19.9	36.3
1938	41.5	21.3	37.2
1939	41.2	19.0	39.8
1940	38.7	19.4	41.9
1941	33.0	23.8	43.2
1942	28.8	23.9	47.3
1943	23.0	28.5	48.5
1944	18.2	35.4	46.4
1945	15.6	41.0	43.4
1946	13.6	45.0	41.4
1947	11.9	45.7	42.5
1948	9.7	50.6	39.7
1949	7.5	53.9	31.6
1950	6.3	55.4	38.3
1951	4.3	56.2	39.5
1952	3.1	58.7	38.2
1953	2.1	59.0	38.9
1954	2.3	57.7	40.0
1955	1.6	56.2	42.2

[1] Percentages of black blasting powder and pellet and of high explosives for 1901–11 are approximate. As complete records were not kept, these percentages are calculated from production and explosives consumption reported by leading coal-producing States. Percentages of safety and permissible explosives, 1901–55, and of other types, 1912–55, are from Bureau of Mines Bulletin 115 (ref. *19*) and annual Bureau reports on explosives production and use. Liquid-oxygen explosive used in open-pit mines is omitted from the above percentages.

DESCRIPTION OF MAJOR DISASTERS

The explosion disasters causing the death of five or more persons are briefly described in the following accounts.

January 20, 1911; Carbon Hill Mine, Carbon Hill, Va.; 7 Killed

(*From Richmond, Va., Times Despatch, Jan. 21, 1911, and Bureau of Mines Information Circular 6766*)

At 7:15 a. m. a party of men walked into a chamber that had become filled with gas due to a broken air pipe. The gas was ignited by their open lights. Five were killed and 8 injured; 2 died later.

TABLE 8.—*Kinds of explosives used in United*

February 9, 1911; Cokedale Mine, Trinidad, Colo.; 17 Killed

(*From Bureau of Mines report, by J. C. Roberts*)

At about 9 p. m. the explosion forced dense volumes of flame, smoke, and dust out of the main slope and fan shaft with frightful violence. Cars and timbers were hurled out of the slope, and the shock was felt in Trinidad, 9 miles away. The explosion doors at the top of the fan shaft worked perfectly, and the fan did not stop. Damage to the mine was moderate. The explosion was caused by a blown-out shot in a room, accentuated by the detonation of a sack of dynamite left near the face of the room, and propagated by coal dust (fig. 14).

The explosive used was 40 percent nitroglycerin dynamite. Coal was supposed to be undercut by hand, but some places were shot on the solid. Clay was used for stemming. All holes were loaded and fired by shot firers after the shift had checked out. A complete electric blasting system had been installed but had been abandoned because of the men cutting the wires. Sprinkling was done but not in rooms. The mine was dusty. A chief shot firer and 8 assistants were in the mine with 8 entry men; 2 of the shot firers escaped, but the others were killed. Two mine officials attempted rescue with helmets; one collapsed and died. Another man without apparatus was suffocated while trying to reach him. The only trained men were the shot firers. Helmet crews from other mines arrived later and recovered the bodies (*23, pp. 3, 4*).

March 18, 1911; No. 16 Mine, Mineral, Kans.; 5 Killed

(*From Bureau of Mines report, by H. I. Smith*)

Saturday evening between 5:30 and 6:45 4 gas explosions occurred, 1 from a blast of powder and 3 from open lights, resulting in the death of 5 men and injuring 2 others. Three of the dead and the 2 injured were in a rescue party. One of the 3 men in the mine at the time of the first explosion escaped. No rescue apparatus was used. Coal was blasted from the solid with black powder; dynamite was used for brushing roof. Carbide lights and lard-oil torches were used for lights. No flame safety lamps were used. The mine was wet, muddy, and dirty as bottom was taken up. Firedamp came through breaks in the coal from an old mine with which connection was expected on that night. The other explosions were caused by rescuers entering with open lights (fig. 15). A flame safety lamp was brought from another mine and on March 21, Bureau of Mines Draeger (1910) rescue apparatus, Hobble electric lamps, and Wolf flame safety lamps were brought.

April 8, 1911; Banner Mine, Littleton, Ala.; 128 Killed

(*From Bureau of Mines report, by J. J. Rutledge*)

About 6:00 a. m. the convicts (about 90 percent Negroes) entered the slope as they entered and left earlier than usual on Saturday than any other day. About 6:20 a. m. the mine foreman and his assistant, standing near the slope mouth, heard a sound like a distant shot and at once observed smoke and a shower of gravel coming out the mouth of the slope. Investigation found a group of men working undisturbed in 3d left and others emerged from 4th and 5th left an hour or so later; about 30 men escaped. Rescue crews and apparatus arrived later and removed the bodies.

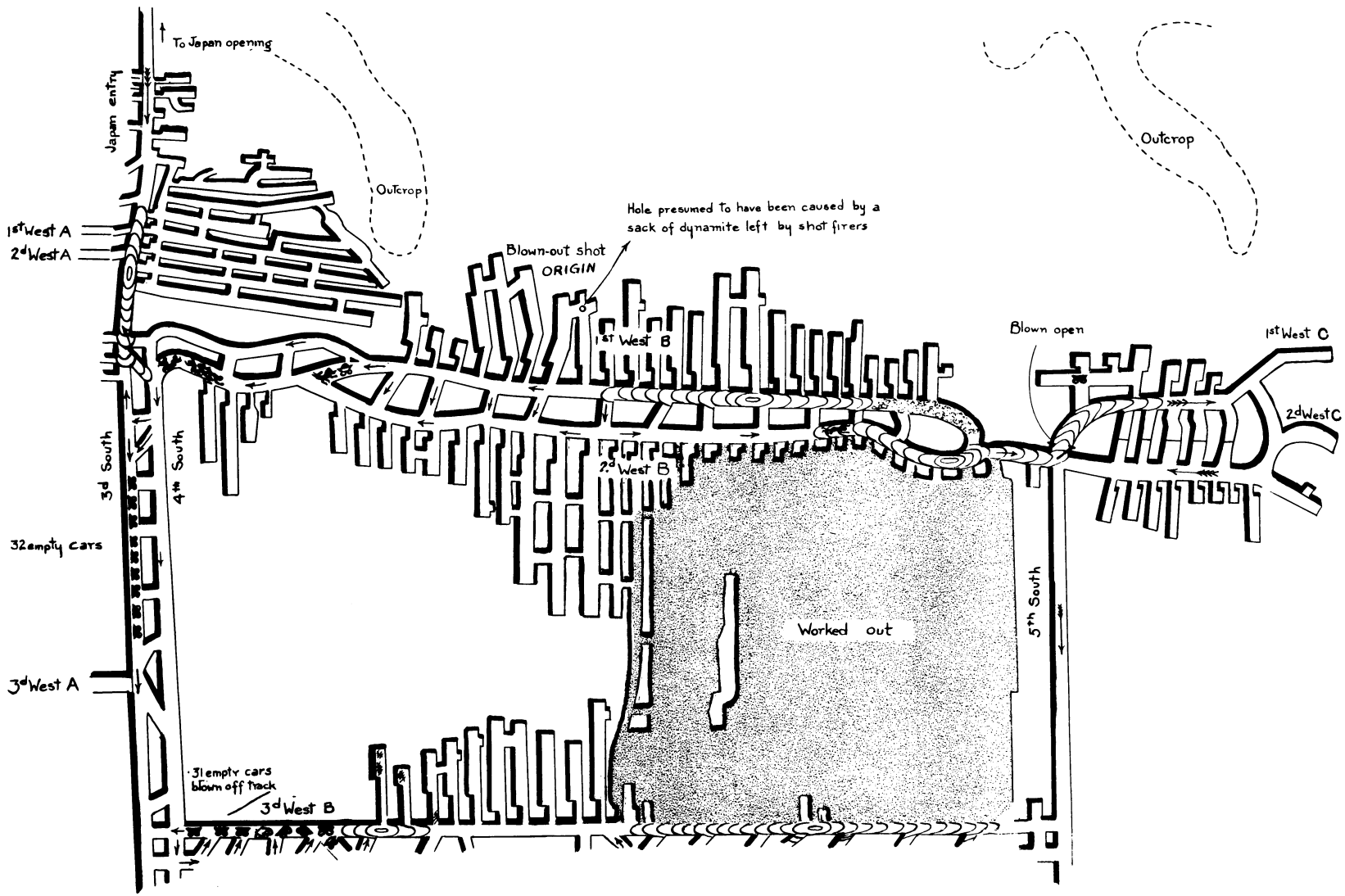

FIGURE 14.—Map of explosion area, Cokedale mine, Trinidad, Colo., February 9, 1911.

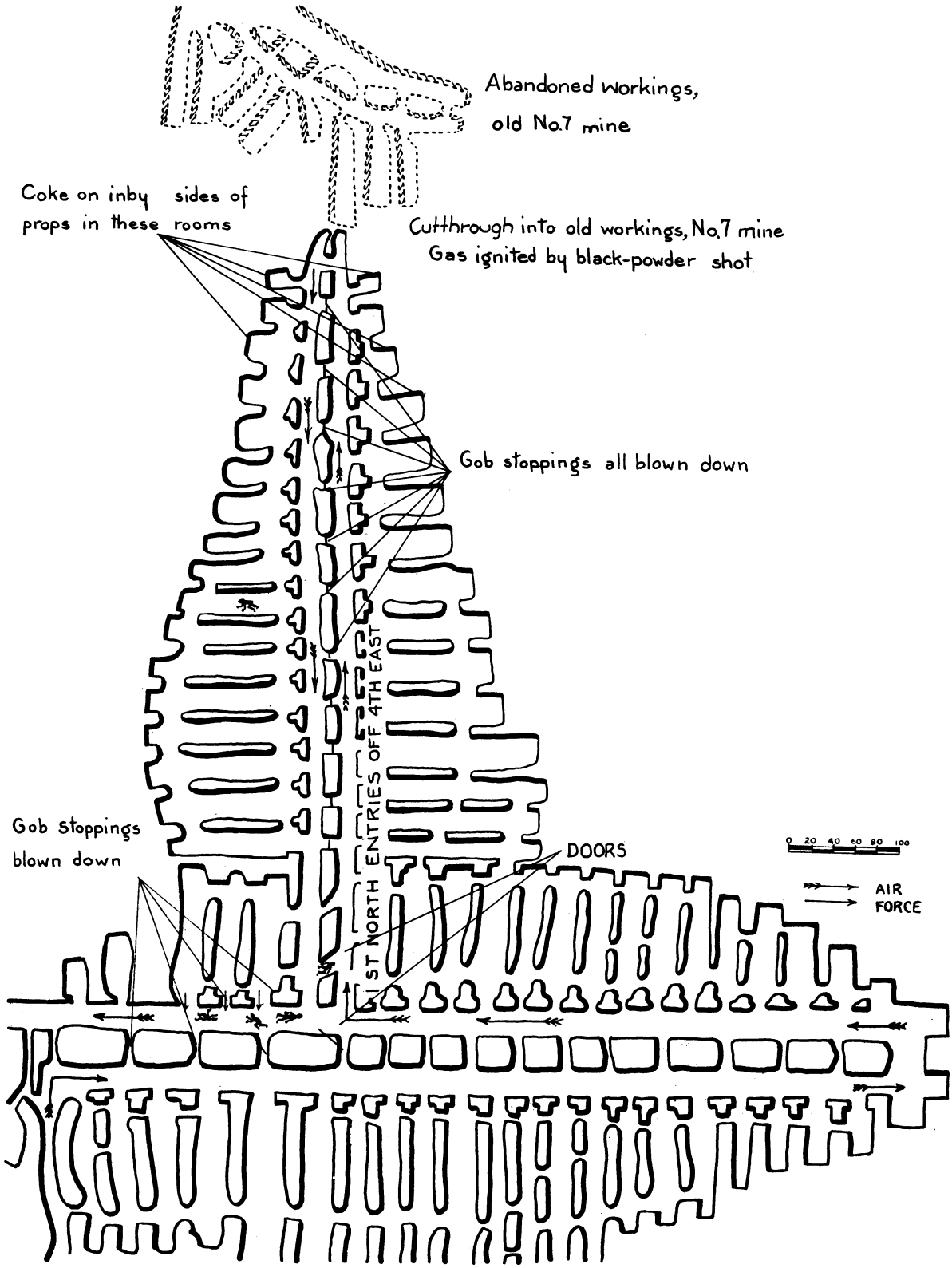

FIGURE 15.—Map of explosion area, mine No. 16, Mineral, Kans., March 1911.

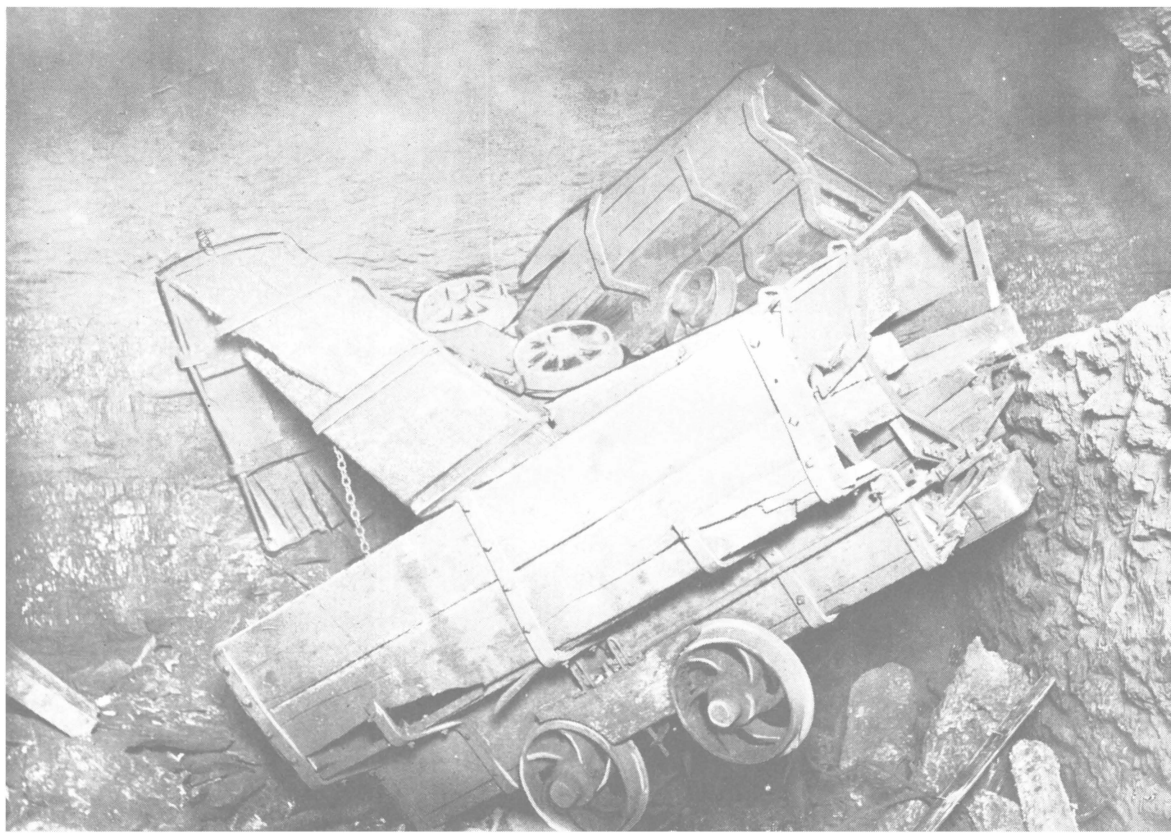

FIGURE 16.—Wrecked pit cars in Banner mine, Littleton, Ala., explosion of April 8, 1911.

FIGURE 17.—Coking on roof and ribs of entry, Banner-mine explosion, April 8, 1911.

Gas had been found in several places by firebosses that morning; it was concluded that an unreported accumulation in an idle room was ignited by the open light of a miner. The explosion was propagated by gas and coal dust.

Figures 16 and 17 are scenes in the mine, and figure 18 is a sketch of conditions found by the investigators.

April 24, 1911; Ott No. 20 Mine, Elk Garden, W. Va.; 23 Killed

(*From State mine inspector's report, 1911, pp. 21–22*)

Immediately after the explosion at 8:30 a. m. work was begun to repair the mine and reach the men inside. Five men in a section near the outcrop escaped. A shot fired in the face of an aircourse had blown out, igniting dust already stirred up by previous shots. The force of the explosion was carried over the whole working part of the mine by dust and gas. Some black blasting powder was used although only permissible explosives were permitted by rule of the district mine inspector and the company.

The workings were not sufficiently watered. Following this disaster the chief of the State department of mines ordered that all shooting in dry and dusty mines be done by shot firers after all men but shot firers had left the mine.

May 27, 1911; Cameron Mine (Anthracite), Shamokin, Pa.; 5 Killed

(*From State inspector's report, 1911, p. 515*)

The men were fatally burned by an explosion of gas in a tunnel; they were driving from No. 4 seam to No. 2 seam. During the night they cut the seam which was making gas. The fireboss came in at 6 o'clock and found them waiting in the gangway. He went into the tunnel with a flame safety lamp to make an examination, and they followed him with naked lights and ignited the gas.

July 15, 1911; Sykesville Mine, Sykesville, Pa.; 21 Killed

(*From Bureau of Mines report, by H. I. Smith and J. T. Ryan*)

At 3:30 p. m. the night shift of 27 men and the fireboss and the pumpman entered the mine. Six of these men worked on the north side and the other 21 in the south workings. At about 8:05 p. m. an explosion killed those in the south workings. Most of the men came to their death by suffocation; only one showed signs of violence and several were more or less burned. Recovery was begun at once and all bodies had been removed by the following morning. The explosion originated at an entry face by ignition of gas and dust by the flame of a shot or by an open light (fig. 19). Permissible explosives and black powder were used with coal dust for stemming, fired from a dry battery. Ventilation was not carried to that face and only haulageways were sprinkled.

August 1, 1911; Standard Pocahontas Shaft, Welch, W. Va.; 6 Killed

(*From Bureau of Mines report, by J. T. Ryan*)

At 11:19 p. m. an explosion occurred while 9 men were in the mine. One was found dead from violence and burns, the others were brought out alive but seriously burned; 5 died later. The mine was being developed and no coal had been shipped. Two shafts, 364 feet deep, were to be connected by an entry that was being driven from each shaft. After shooting 3 holes in the face of 1 entry the foreman and another man reconnected the electric light wires used for illumination. One bulb did not light and when it was screwed in the glass broke causing an arc that ignited gas present from audible feeders. Ventilation was by temporary cloth brattices down the shaft and up the entry to the face; a steam jet at the shaft bottom induced circulation.

Figure 20 shows the conditions and evidence reported by the investigators.

October 23, 1911; O'Gara No. 9 Mine, Harrisburg, Ill.; 8 Killed

(*From Bureau of Mines report, by H. I. Smith*)

At 8:10 a. m., about 40 minutes after 16 men had gone in to work, the explosion occurred near the door between mines No. 4 and No. 9, breaking through into No. 4 and carrying irrespirable gases over the men at work. The explosion was not violent in No. 9 mine but blew out stoppings and doors in one section of No. 4. About 20 minutes after the explosion occurred rescue parties partly restored ventilation, rescued men in the affected area and recovered the bodies of the dead. Gas accumulated after the door between the mines was left open by a man sent to drain water from the entry and was ignited by his open light. The explosion was propagated by the ignition of 3 kegs of powder and by coal dust.

November 9, 1911; Adrian Mine, Punxsutawney, Pa.; 8 Killed

(*From Bureau of Mines report, by J. J. Rutledge and J. T. Ryan*)

The explosion occurred about 6:10 a. m. as the men were entering the mine. Two of the 17 men who had reached the face areas were killed by violence, and 6 others in a section of the mine about 3,000 feet from the seat of the explosion died from inhalation of afterdamp. Four others in the same section escaped. Another man was overcome but was revived and gotten out alive about 2 hours after the explosion. After attempts were made to recover the bodies without the use of breathing apparatus it was found necessary to restore ventilation. Two bodies were not found until November 11. The crew of Bureau of Mines Rescue Car No. 6 assisted by exploring the mine ahead of the bratticing crews. The explosion appeared to have originated over 2,500 feet from the nearest bodies, which were badly mangled, and was evidently due to arcing of a trolley wire caused by a fall on an entry. Gas and dust were ignited (fig. 21).

November 18, 1911; Bottom Creek Mine, Vivian, W. Va.; 18 Killed

(*From Bureau of Mines report, by J. T. Ryan and H. I. Smith*)

At 11:00 a. m. an explosion resulted in the death of 18 men; 7 other men were rescued, 4 badly burned and 3 uninjured. A body of gas was ignited by the open lights of a survey party entering an abandoned room. Although the mine was gassy, lard-oil lamps were used by the miners. No mine official accompanied the land company's surveyors. The abandoned section was not inspected or ventilated.

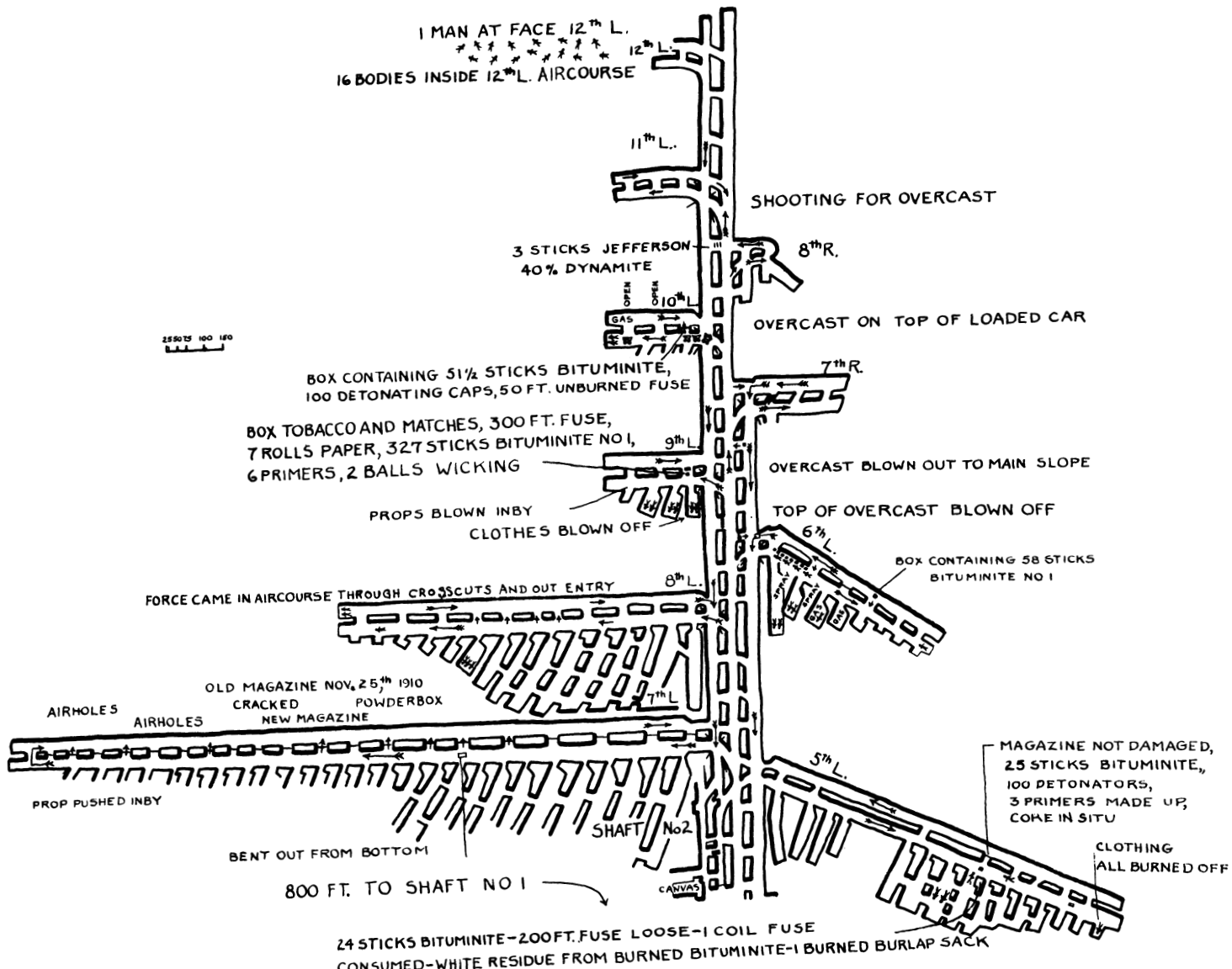

FIGURE 18.—Map of explosion area, Banner mine, Littleton, Ala., April 8, 1911.

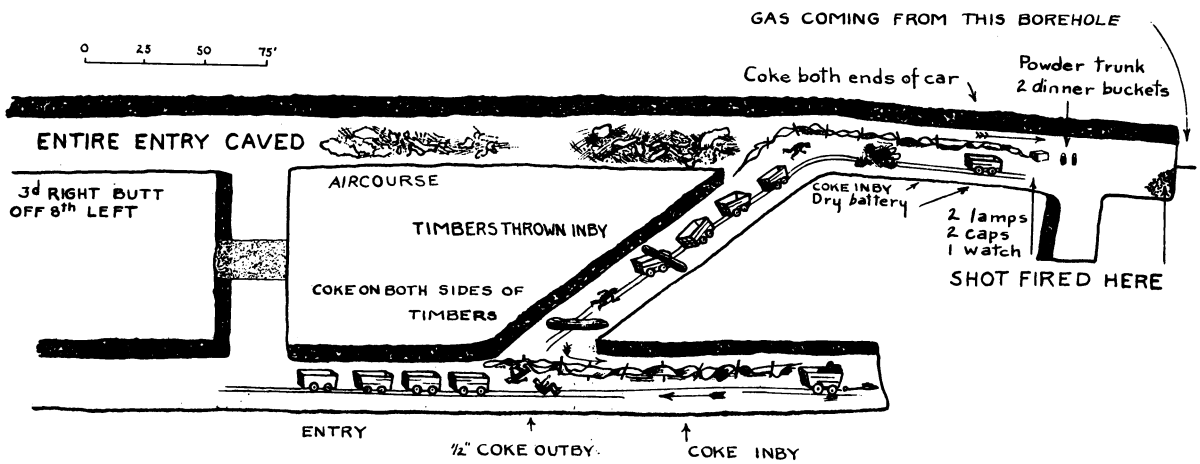

FIGURE 19.—Sketch of 3d right entry after explosion, Sykesville mine, Sykesville, Pa., July 15, 1911.

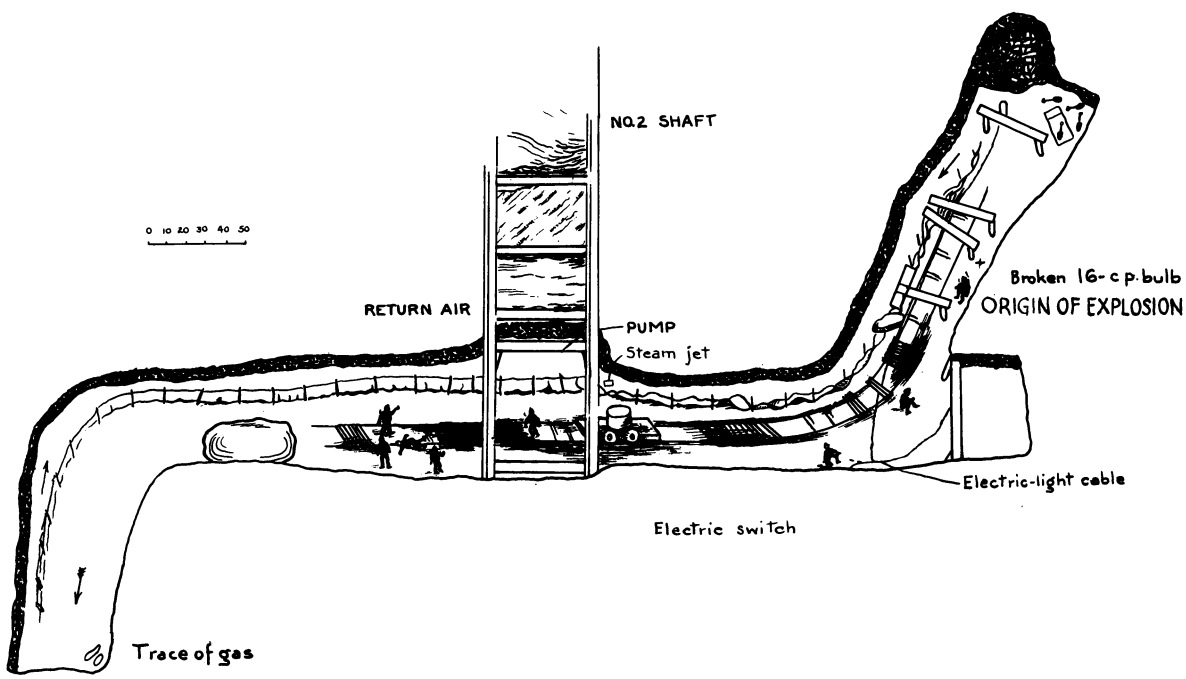

FIGURE 20.—Sketch of explosion area, Standard Pocahontas shaft, Welch, W. Va., August 1, 1911.

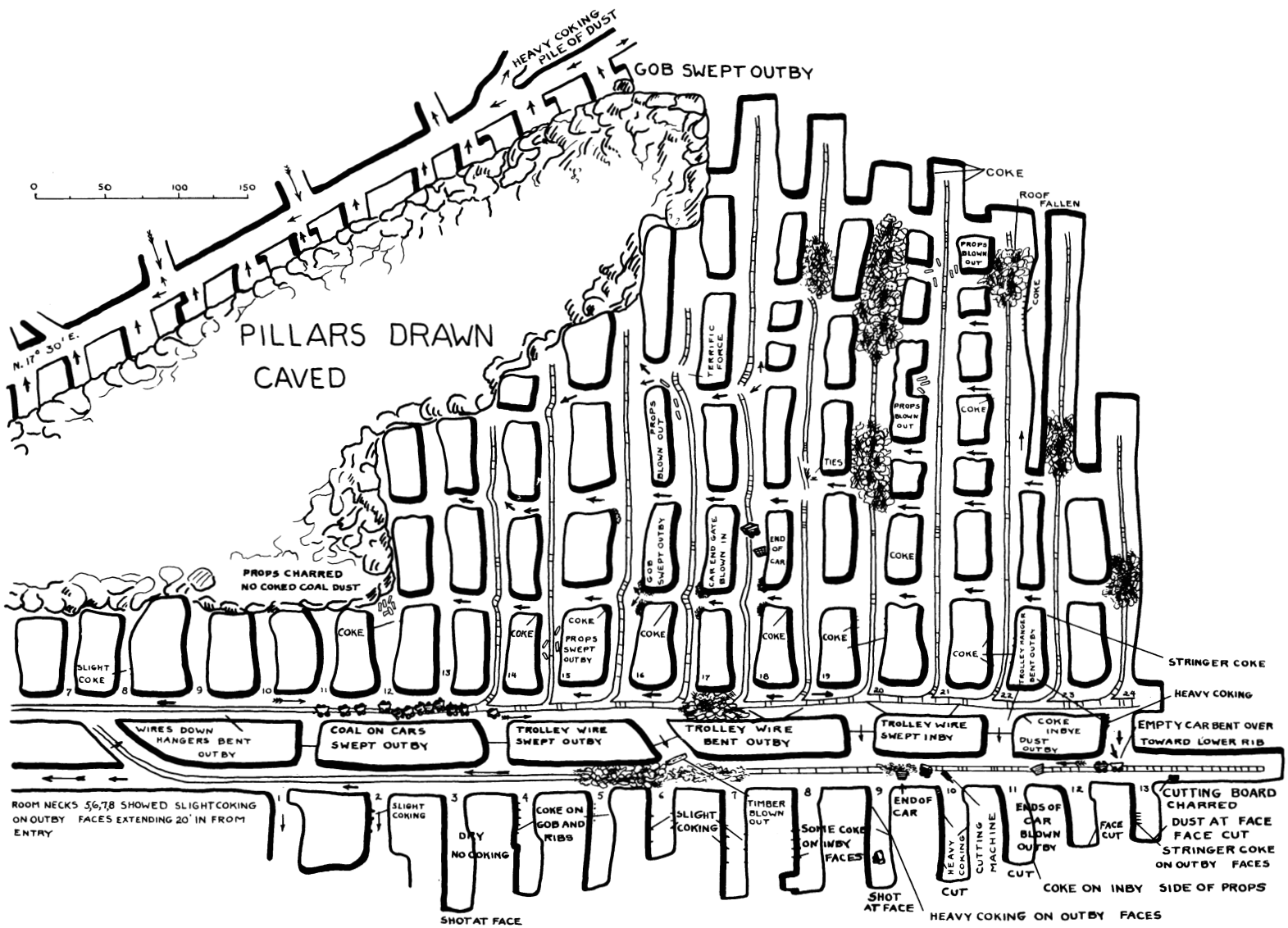

FIGURE 21.—Map of explosion area, Adrian No. 1 mine, Adrian, Pa., November 9, 1911.

December 9, 1911; Cross Mountain Mine, Briceville, Tenn.; 84 Killed

(From Bureau of Mines report, by J. J. Rutledge, and State inspector's report)

On that morning part of the force of 125 men remained on the surface waiting the arrival of more railroad cars in which to load the day's output. At 7:20 a. m., when the explosion occurred, 89 men were in the mine; 5 survived the explosion and the resulting afterdamp by barricading themselves (*24, p. 49*) (figs. 22–25).

The mine workings from the 17th right and 17th left entries to the face of the main entry were affected by the explosion with greatest violence in the 23d to 26th left entries. Rescue crews immediately started restoring ventilation and were joined by apparatus crews under direction of Director Holmes and engineers of the Bureau of Mines. Apparatus crews explored and worked in advance of the men erecting brattices and recovering bodies. Apparatus crews rescued the men from the barricade and extinguished several fires. The consensus of opinion among the men wearing the breathing apparatus was that the mouth-breathing type was much preferable to the helmet, especially under the conditions of low roof in this mine. The ignition was thought to have been caused by an open light, although there was also evidence that a blown-out shot of black powder may have ignited gas and dust. Ventilation was weak, and fireboss inspections were incomplete. Workings were dry and dusty, although some sprinkling was done in main haulways.

January 9, 1912; Parrish Mine (Anthracite), Plymouth, Pa.; 6 Killed

(From Bureau of Mines report, by Chas. Enzian)

The explosion in No. 5 tunnel, West Dip Road of No. 9 slope in the Five-Foot Seam, killed 6 men and injured 2 others as they were at lunch. The explosion of black powder and dynamite in miners' boxes on the haulway and of gas was caused by ignition of gas or black powder by an open light, resulting in two or three explosions set off one after the other. The rest of the men working in the vicinity ran through the dust and smoke to safety and then returned to bring out the victims.

January 16, 1912; Carbon Hill Mine, Carbon Hill, Va.; 5 Killed

(From Bureau of Mines report, by H. I. Smith)

Some men were putting in the cut holes for a round of shots in the No. 4 tunnel. Six holes were drilled partly in coal and partly in the rock, and each hole was loaded with 8 sticks of dynamite, without using any tamping. The battery to fire the shots was on a box of dynamite, 160 feet from the face. Seven men were near the box. When the shots were fired the flame extended back to the box, igniting the explosives, probably detonators and dynamite, resulting in the death of 5 of the men and injury of the 2 others. Dust and possibly gas were involved in spreading the flame.

January 19, 1912; Central Mine, Central City, Ky.; 5 Killed

(From Bureau of Mines report, by C. S. Stevenson)

At 5:30 p. m. all of the 5 men in the mine were killed by an explosion caused by a blown-out shot of black powder. Three of the men were shot firers and 2 were day men who stayed in the mine to bond track. The explosion was local but was propagated by gas and dust and the ignition of 4 cans of black powder. The coal was partly undercut by pick mining in some places, but most of the shooting was on the solid. A rescue party led by the State mine inspector and using 2 sets of Draeger (1910) apparatus and a pulmotor entered the mine soon after the explosion. They were able to restore the ventilation without use of the breathing apparatus until the air current was unexpectedly shut off and the party was overcome. One man was able to reach the apparatus where it had been left on the main entry and revive himself and direct a second rescue partly to the unconscious men, who were saved by the use of the helmets and oxygen from the extra cylinders. It was found that the air current had been cut off by one of the shot firers who had escaped the explosion but was trapped by the afterdamp. He put up a curtain across the 1st S. entry to try to hold back the afterdamp but fell and died after traveling 600 feet toward the main south. He was found next morning when rescue efforts were resumed.

January 20, 1912; Kemmerer No. 4 Mine, Kemmerer, Wyo.; 6 Killed

(From Bureau of Mines report, by J. C. Roberts)

At about 4 p. m. a coal-dust explosion caused by a blown-out shot of black powder resulted in the death of 6 men and injury to 20 others. The mine foreman on the surface heard a rumble and saw smoke issuing from the mouth of the slope. He ordered the fan speed increased and notified the company office and the Bureau of Mines car No. 4. He went into the mine and was overcome but revived and crawled up the slope. The rescue car arrived at 4:45 p. m. and rescue crews with breathing apparatus recovered the bodies and the injured in a short while. The explosion had little force and did not damage the mine. All coal was shot off the solid. Haulageways were watered once a week.

March 20, 1912; San Bois No. 2 Mine, McCurtain, Okla.; 73 Killed

(From Bureau of Mines report, by J. J. Rutledge, C. S. Stevenson, W. T. Burgess, and R. Y. Williams)

At 9:05 a. m. the seventh explosion since the mine was opened in 1902 killed 73 of the 97 men in the mine. Dust issued from the slope mouth, and in a few minutes 6 men came out the escapeway and 2 men from the main slope and reported the explosion. Fourteen men saved themselves by closing off a pump chamber and breaking the compressed-air line at the pump. They were released by a rescue party about 23 hours later (*24, p. 13*). One died while being carried out. Three others were brought out alive by rescue parties. Rescue parties with open lights started to restore ventilation and brought out three live men. Later Bureau of Mines breathing apparatus and flame safety lamps arrived and were used by the rescue crews. The mine was dry and dusty, although sprinkling was attempted. Standing gas in three places had been reported that morning. While the fireboss was moving this gas, it was ignited by the open lights of men waiting in the entry under direct charge of the foreman. Dust and gas spread the explosion. Sending the men into the mine before the gas accumulations were removed was in violation of the State law, as was reported by the State inspector.

March 26, 1912; Jed Mine, Jed, W. Va.; 81 Killed

(From Bureau of Mines report, by G. S. Rice and J. W. Paul)

The explosion occurred at 7:25 a. m. when 91 men were in the mine; 11 men, at the shaft bottom and in

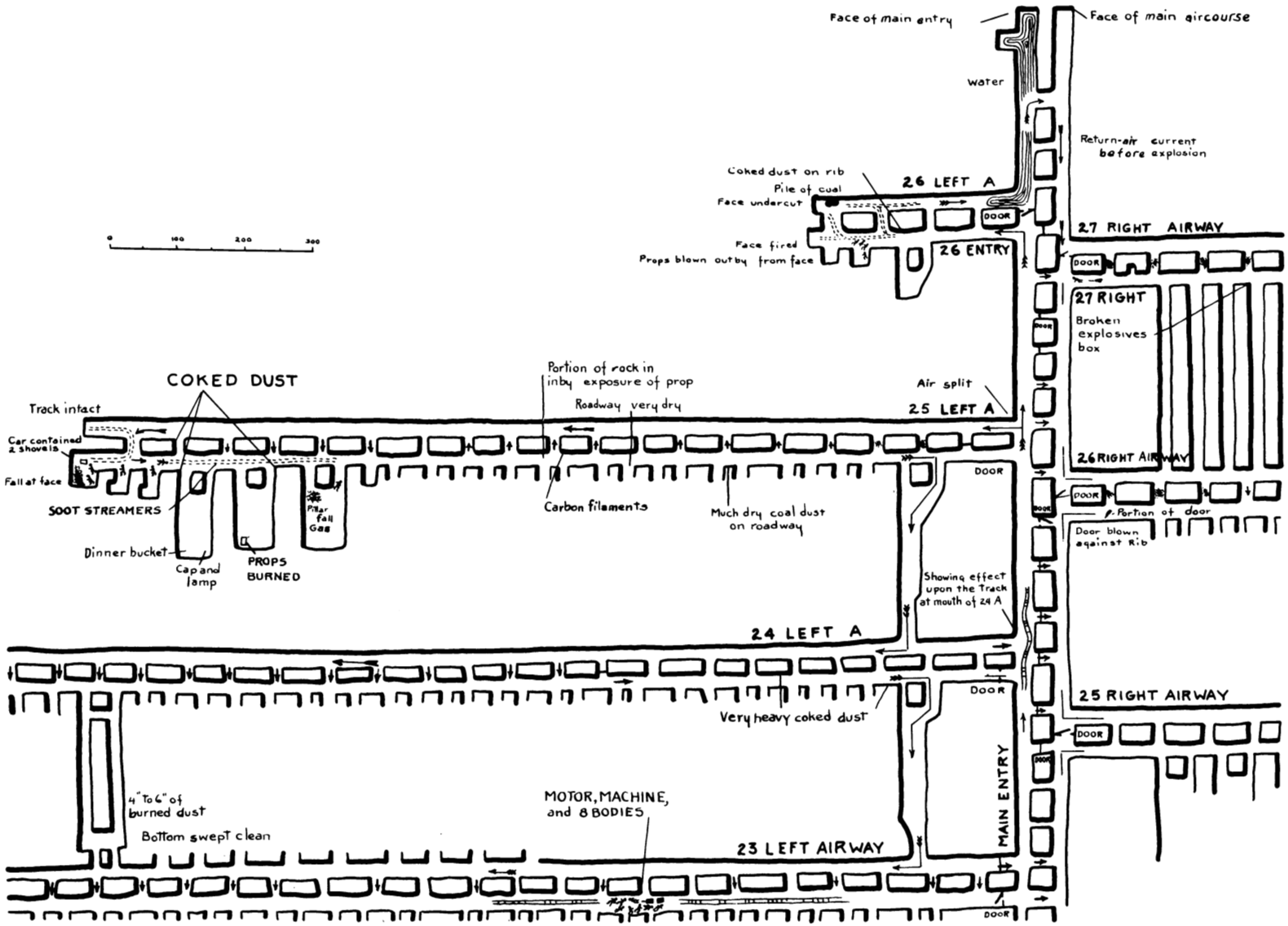

FIGURE 22.—Map of explosion area, Cross Mountain No. 1 mine, Briceville, Tenn., December 9, 1911.

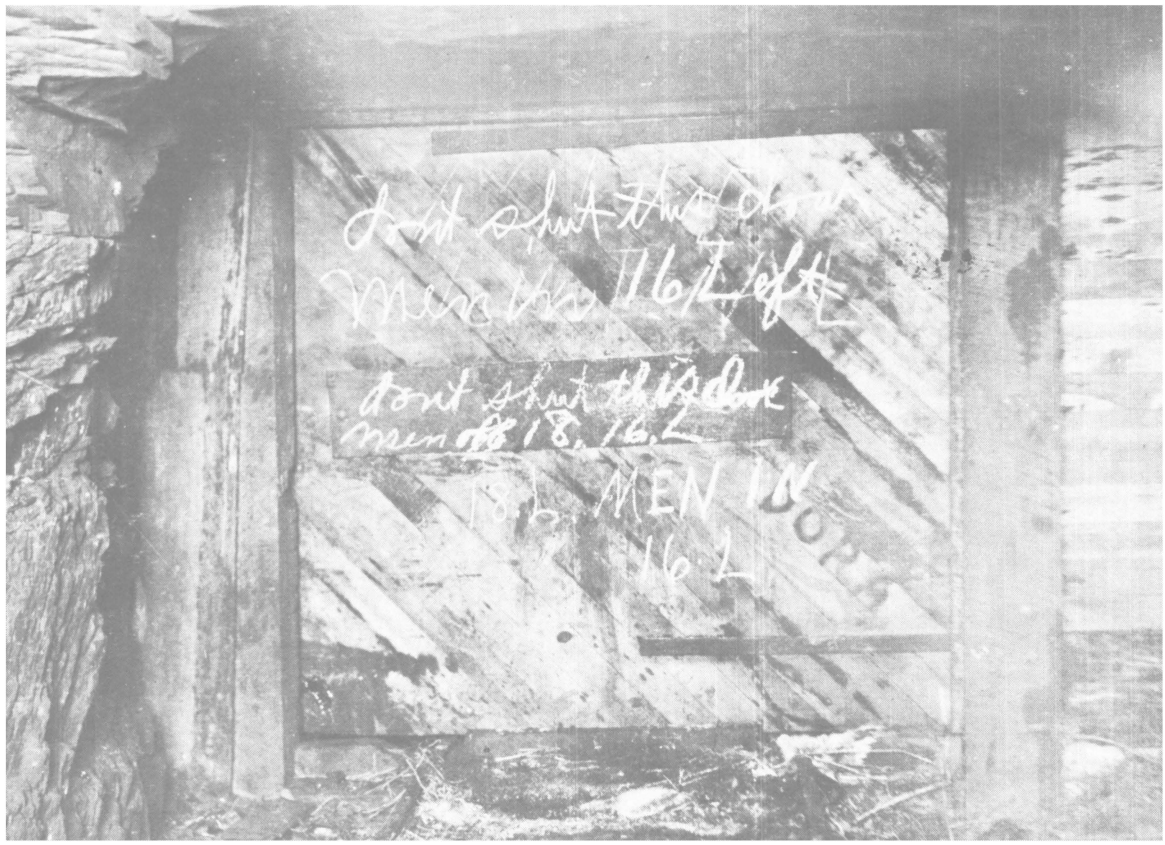

FIGURE 23.—Notice left on door by barricaded men, Cross Mountain No. 1 mine, Briceville, Tenn., December 9, 1911.

2 entries not reached by the explosion, escaped, but 1, a door boy, died after being brought to the surface. The damp condition and wideness of the entries leading to the shaft allowed the explosion to die away and prevented wrecking of the hoisting and air shafts. The mine was gassy, and ventilation did not keep the gas below the danger point. Rooms were turned in advance of the last crosscut, and open doors caused short circuiting of the air. Gas in a butt entry was ignited by a miner's open light. The explosion fed by dust and gas traveled toward the shaft but died out on damp ground. Indication on the surface was a rush of air and smoke from the mine openings. In half an hour men with flame safety lamps began erecting temporary stoppings. Rescue crews and rescue cars with breathing apparatus arrived quickly, and the work of restoring ventilation was carried on in a systematic manner. By the following day the entire mine had been explored and many bodies recovered. Others located under falls were not removed for several days. Where explosive gas concentrations could not be easily removed electric hand lamps were used for illumination.

April 21, 1912; Coil Mine, Madisonville, Ky.; 5 Killed

(*From Bureau of Mines report, by E. B. Sutton*)

The mine was opened by 2 shafts 290 feet deep, and because it was a new mine the workings were no more than 600 feet from the main shaft. The mine was gassy and the fan at the bottom of the airshaft was shut down when no one was in the mine. No work was done on that day but about 6:50 p. m. 5 men were lowered to load the coal that had been shot the night before. At 7:05 p. m. the explosion severely damaged the mine and the shafts and killed the men. One was blown out of the mine. The foreman had started the fan but did not wait for the air to clear before starting to inspect the workings with an open light.

June 18, 1912; Hastings Mine, Hastings, Colo.; 12 Killed

(*From Bureau of Mines report, by J. C. Roberts*)

The explosion occurred at about 9:30 p. m. in the workings of the "B" seam and did not spread to those of the overlying "A" seam. Besides the 12 men killed, 1 man was seriously burned; damage to the mine was small. The first-aid crew practicing in the emergency hospital noticed smoke coming out of the main slope and manway. Helmet and work crews were organized, and as the fan was not damaged progress in restoring ventilation was rapid. One man was rescued alive by a crew wearing breathing apparatus. All bodies were brought out within 30 hours. The night fireboss was clearing gas from the face of a cross entry, where it had been found that morning. The explosion started there and the fireboss' safety lamp found after the explosion was tested and found defective. Miners used electric cap lamps. Propagation was by coal dust and gas.

FIGURE 24.—Messages left by barricaded men, Cross Mountain No. 1 mine, Briceville, Tenn., December 9, 1911.

FIGURE 25.—Barricade opened by rescuers 58 hours after explosion, Cross Mountain No. 1 mine, Briceville, Tenn., December 9, 1911.

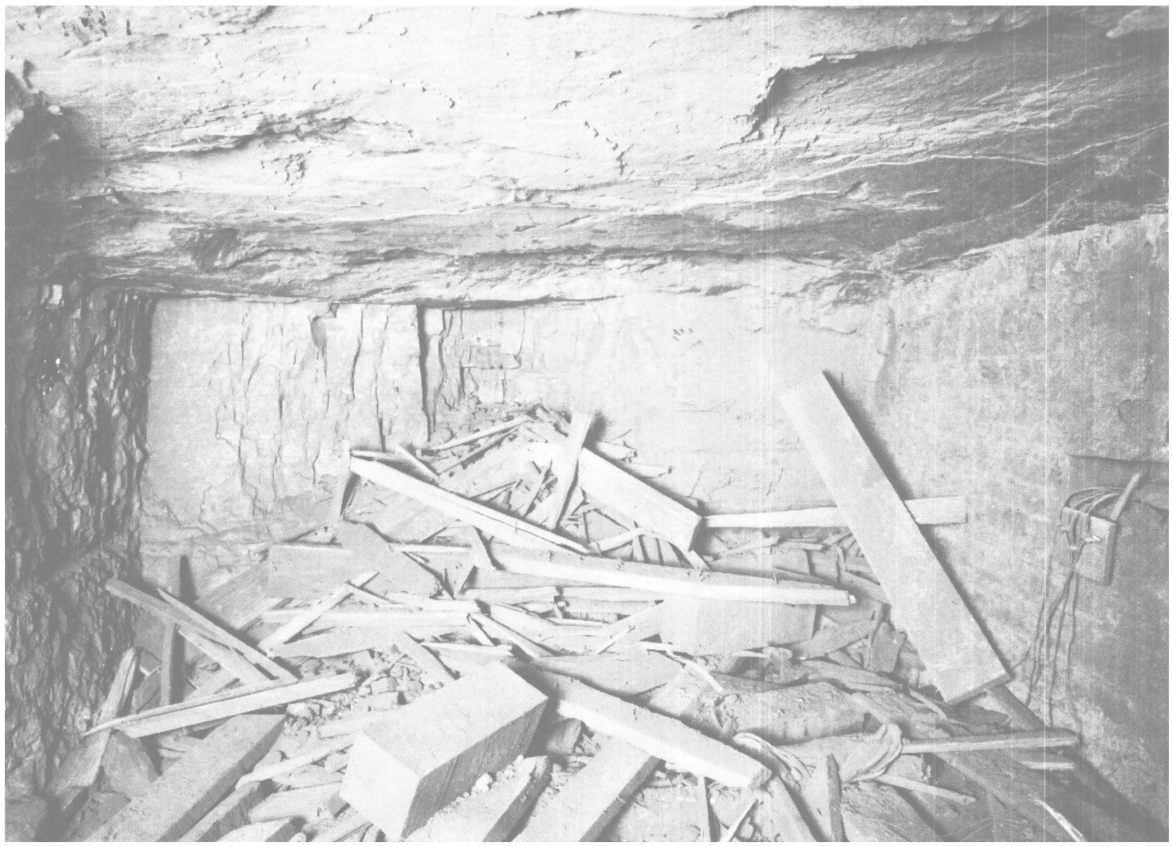

FIGURE 26.—Debris carried into entry face by suction wave of test explosion, Bureau of Mines Experimental Mine, Bruceton, Pa., September 20, 1912.

The company had been investigating the possibility of increasing safety through the use of "stone dust" as advocated in Great Britain and by Bureau engineers.

Bureau of Mines engineers used the knowledge gained by actual test explosions on the Bureau's Experimental Mine in determining the course and source of explosions they investigated. Figures 26 and 27 show the movement of debris and the formation of soot and carbon deposits after test explosions.

July 11, 1912; Panama Mine, Moundsville, W. Va.; 8 Killed

(From Bureau of Mines report, by G. H. Deike and J. T. Ryan)

The mine had been shut down and work on a limited tonnage had been started July 10. A fireboss and 9 men went down to load coal. Some men went to get their tools from their former working places, taking the safety lamp. The fireboss had not examined that section, and an open door short-circuited the air in two entries. Gas was ignited by the open lights, resulting in the death of eight men from burns and suffocation. Seven died almost instantly; 2 others, badly burned, made their way to the shaft and were hoisted to the surface; 1 died the next day. The 10th man was found by a rescue party and brought out alive 21 hours after the explosion.

538522 O–60—5

July 16, 1912; Carbon Hill (Old Dominion No. 1) Mine, Gayton, Va.; 8 Killed

(From Bureau of Mines report, by H. I. Smith)

The shot firer went to the face of 2d left gangway and found an accumulation of gas, then went back and told some men that he was going to take a chance in firing shots in that face with fuse instead of using a battery. He lit his pipe and went back to the face and charged the holes. He lit one fuse with his pipe but failing to light the second fuse from the first one, he struck a match, which ignited the gas, resulting in an explosion which killed eight men and injured another. The explosion was confined to six rooms along the gangway. Two rescue parties put up a canvas brattice line and recovered the bodies. Some of the rescue men were overcome but revived by use of compressed air. The mine was gassy, ventilation was weak, and open lights were used on the slope and main gangway; safety lamps were supposed to be used in all other parts of the mine. The coal dust present did not propagate the explosion. From January 1909 to June 1912, 6 explosions in this mine resulted in the death of 28 men and injury to 32 others.

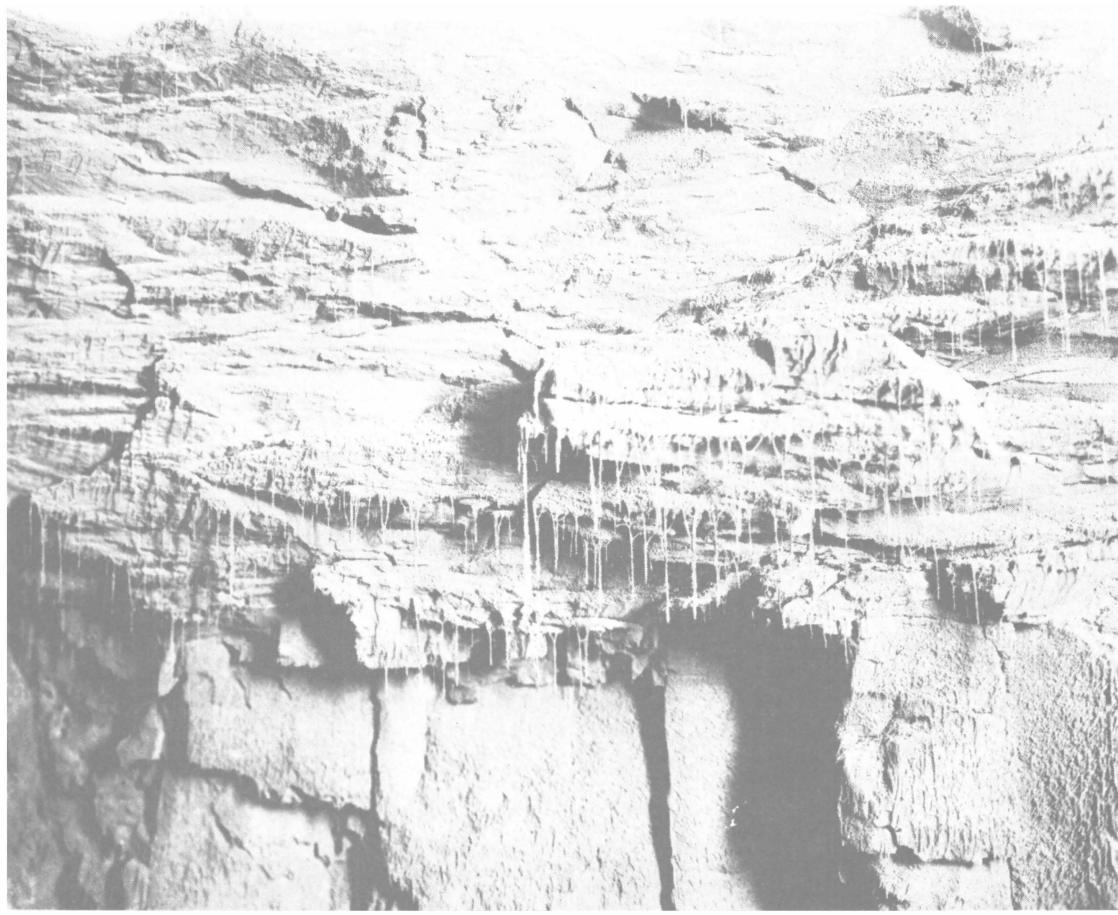

FIGURE 27.—Carbon filaments and coked dust near shot hole, test 2, Bureau of Mines Experimental Mine, October 30, 1911.

August 13, 1912; Abernant Mine, Abernant, Ala.; 18 Killed

(From Bureau of Mines report, by E. B. Sutton)

The explosion, at about 10:30 a. m., resulted in the death of 18 men, all Negroes. Six of these men were badly burned; the others were suffocated. One man, after repeated efforts to penetrate the afterdamp, took refuge at the face of 14th right aircourse and came out unassisted at about 1 p. m. Immediately after the explosion rescue and recovery work was begun. Seventeen bodies were removed during the afternoon. On August 14 an exploring party found a man in the 14th right aircourse, still alive, but in such a condition that he never regained consciousness. The explosion was caused by the open light of a laborer from room No. 8 on the 15th right entry when he went into the abandoned room No. 11. That room had been driven 195 feet and had only 1 crosscut into room No. 10. The mine made dangerous quantities of gas, but the continuous air current was not taken to working faces. All but heading men used open lights. Abandoned workings were not ventilated or inspected. The explosion was propagated by gas and dust over the workings inby the 14th right entry. Permissible explosives were fired by shot firers after the men were out of the mine. Sprinkling was provided for but seldom done..

February 19, 1913; Seagraves Mine, Eldorado, Ill.; 5 Killed

(From Bureau of Mines report, by R. Y. Williams and H. D. Mason, Jr.)

At 7:20 a. m. as the day shift of 225 men was entering the mine an explosion in the 3d and 4th west stub entry killed 4 men. The explosion of gas did not propagate because the coal dust was mixed with inert dust from the floor and roof. The ignition was caused by open lights, and the explosion was not violent. Gas accumulated because of an open door, and the fireboss had not visited these places that morning. The rest of the men left on hearing the explosion except three who were found by rescue crews and removed to the surface where they were revived. One died later.

April 23, 1913; Cincinnati Mine, Finleyville, Pa.; 98 Killed

(From Bureau of Mines report, by G. H. Deike and H. I. Smith)

At about noon the explosion killed 97 men, 20 or more by suffocation the others by force and burns. Of the 167 men in the mine 67 escaped uninjured through old workings, 1 was rescued alive by the first rescue parties and 2 by apparatus crews about 60 hours later. Five mules were taken out alive 4 days

after the explosion. One member of a rescue party lost his life while wearing breathing apparatus that was afterward found to have a broken connection (*23, p. 6*). Rescue and recovery work was started without delay. The explosion doors at the fan, which had been blown open, were closed, and the fan was repaired and started 8 minutes afterward. Breathing-apparatus crews from two coal companies and from the Bureau of Mines were brought in. The origin of the explosion was at the face of 12th butt off No. 14 face entry (fig. 28).

A miner had fired a shot that had broken into a clay vein, liberating a gas blower. After eating lunch he returned pushing an empty car and ignited the gas as he reached the face. The gas explosion stirred up the coal dust and traversed the live workings for a distance of 3,000 feet. Locked flame safety lamps were used in parts of the mine considered dangerously gassy, open lights elsewhere; many haulageways were lighted with incandescent electric lamps. Haulageways were sprinkled, and crushed rock salt was used to moisten dust in rooms. Permissible explosives were used tamped with clay and fired by shot firers where safety lamps were used.

Use of safety lamps and better control of dust by wetting and rock dust were recommended. Figure 29 (p. 61) is a sketch at the mine entrance during recovery of the victims.

May 17, 1913; Noble Mine, Belle Valley, Ohio; 15 Killed

(*From Bureau of Mines report, by H. D. Mason and G. W. Salisbury*)

A night crew of 20 men was engaged in the construction of a new motor road with the superintendent in charge. A few minutes before 7 o'clock the explosion occurred at a sidetrack about 5,800 feet from the shaft bottom, where 14 of the men were working, all being killed instantly. Six other men escaped, 2 badly burned. When some of these men brought word of the explosion to the outside, miners responded at once and a party was lowered, traveling the intake airway to where 1 of the 6 survivors lay injured. He was rescued, but one of the rescuers who made several trips alone into the unventilated explosion area collapsed and died on the way out. Open lights were used, the only safety lamps being a Davy and a Clanny lamp belonging to the foreman and the fireboss. Six Wolfe lamps were procured and used in subsequent rescue work, and more rescue equipment arrived later, including Draeger helmets that were not used. In building the new door on the motor road between 7th and 8th East entries the opening was open for 2 hours allowing an accumulation of gas in this section. When the new door was closed the gas was moved out upon the naked lights of the workmen. The explosion was limited and did not propagate along the haulageway (fig. 30, p. 62).

August 2, 1913; East Brookside Mine (Anthracite), Tower City, Pa.; 20 Killed

(*From Bureau of Mines report, by Chas. Enzian*)

The section of the mine in which the accident occurred was idle, except for 7 men mucking in a tunnel face. Two assistant foremen, a foreman, the district superintendent, and a bottom man were also in the mine. At 11:20 a. m. a rush of coal from pillars killed the two assistant foremen and released gas with explosive force. A rumbling was heard, and dust came out through the upcast fan stack. A rescue party of nine men went into the mine and reached the tunnel when a gas explosion occurred. The seven men from the mucking crew were coming out, and 1 of them ignited the gas generated by the crushing coal with his open light. The district superintendent and the foreman had also reached the danger area and were involved. A second rescue party then entered the slope and heroically recovered 3 living victims, 2 of whom died before reaching the surface, the other a few days later. Trained crews and rescue equipment soon reached the colliery, and apparatus crews were formed to assist in the work. The superintendent was found alive and removed by a rescue party not wearing apparatus, but he died a few hours later. The caved area extended 284 feet along the gangway. It was recommended that locked flame safety lamps or approved miners' electric lamps should be used.

October 22, 1913; Stag Canon No. 2 Mine, Dawson, N. Mex.; 263 Killed

(*From Bureau of Mines report, by G. S. Rice*)

The mine, opened by drifts, employed about 300 men. Coal was undercut, mostly by machine but some by hand-pick mining. Permissible explosives were used, fired electrically from outside. The mine was dry, and sprays were placed at intervals to wet the dust; they were not effective beyond 6 feet. The mine was usually free from firedamp except for occasional pockets, coming from the roof. Open lights were used. At about 3:00 p. m. blasts carrying smoke and dust burst out of the main openings. The explosion doors and one side of the fanhouse were blown out but were repaired in less than 2 hours. Of the 284 men in the mine, 14 from an unaffected section came out safely, and nine others, unconscious near the bottom of the airshaft, were rescued by an apparatus crew about 8 p. m. They were revived by the use of pulmotors. Two helmet men were lost that night when they overtaxed the oxygen supply by overexertion and going in farther than instructed. The oxygen was supplied at a fixed rate and when they tried to remove the oxygen bottles to breathe from them, they were overcome by afterdamp (*23, p. 7*). The explosion originated in a dusty pillar section where an overcharged shot had been fired. The explosion was propagated by coal dust along the haulageroads and into most of the workings, except where water and inert dust in the roads caused it to die away. The violence was not great, but cars were wrecked in some places and most of the stoppings blown out (fig. 31). Dynamite was used in blasting rock and may have been used in the pillar shot. The use of permissible explosives for all blasting, blasting only after the shift, and use of rock dust with the watering system were recommended.

November 18, 1913; Acton No. 2 Mine, Acton, Ala.; 24 Killed

(*From Bureau of Mines report, by E. B. Sutton*)

The explosion occurred at about 3:20 p. m., with 29 men in the mine, 24 of whom lost their lives, 13 received fatal injuries, and 11 were asphyxiated. At about 6:00 p. m., 3 men escaped unassisted, and about 9:00 p. m. a man was found overcome and was taken to the surface; another man regained consciousness after being overcome and made his way to the slope where he was found by rescuers. The explosion originated from overcharged and blown-out shots of black powder in the dry and dusty workings of the 8th left entry. Inexperienced foreign workers were placed there without safe instruction. Shooting was off the solid. No water was used.

Figures 32 and 33 (pp. 64 and 65) show the conditions found in the investigation.

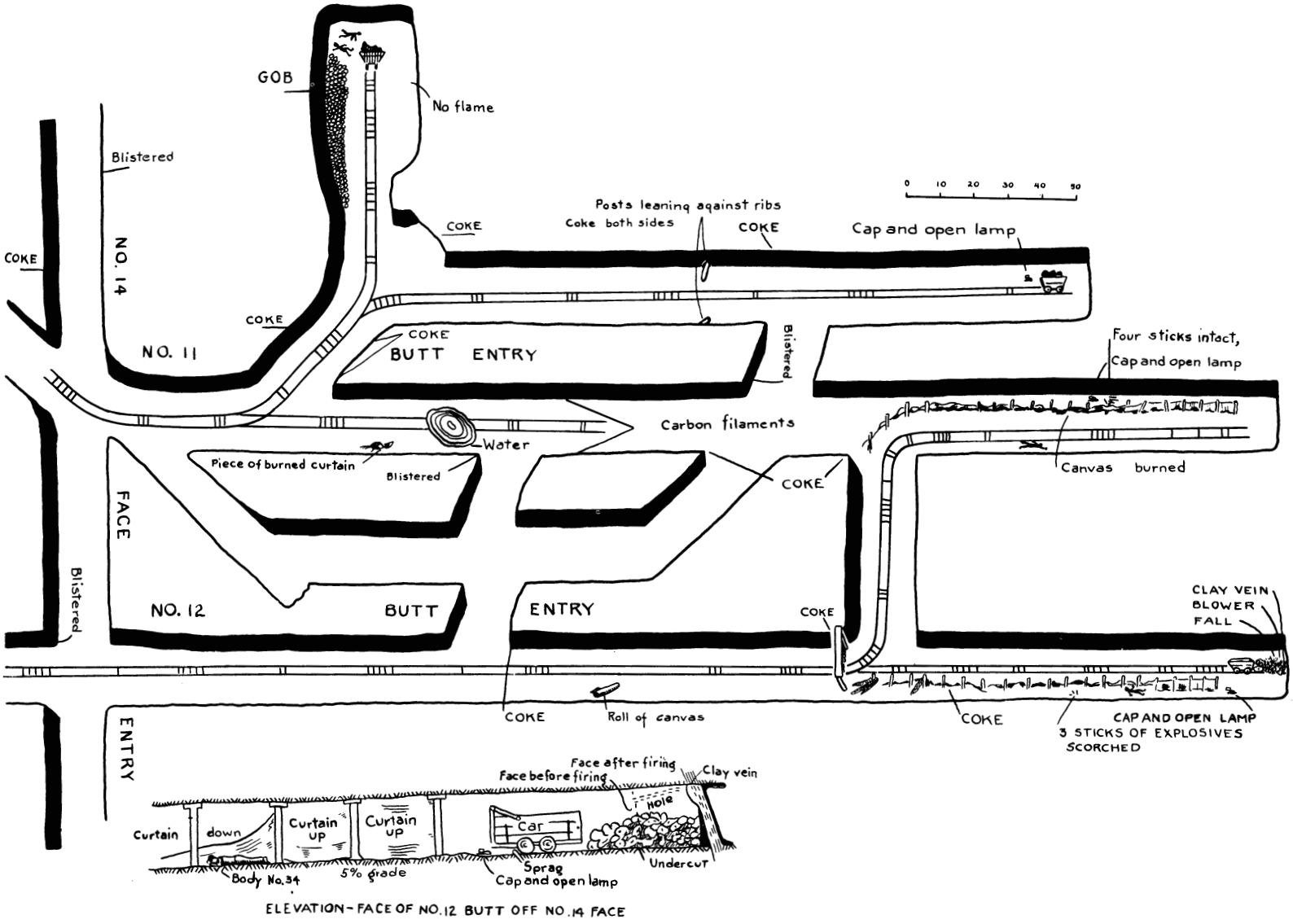

FIGURE 28.—Sketch of area at origin of explosion, Cincinnati mine, Courtney, Pa., April 23, 1913.

FIGURE 29.—Miners' families at mine entrance, Cincinnati mine explosion, April 23, 1913.

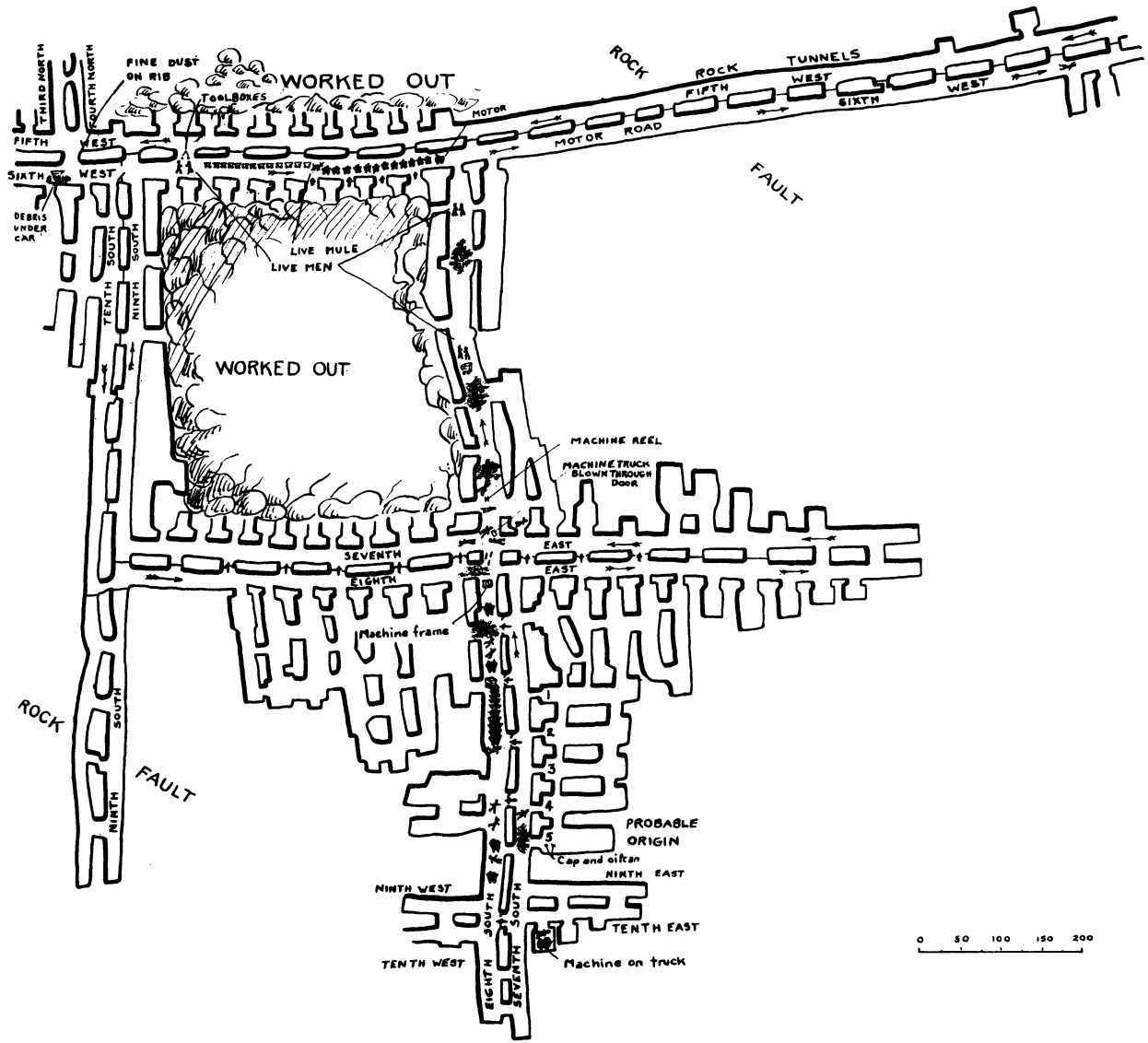

FIGURE 30.—Map of explosion area, Noble mine, Belle Valley, Ohio, May 17, 1913.

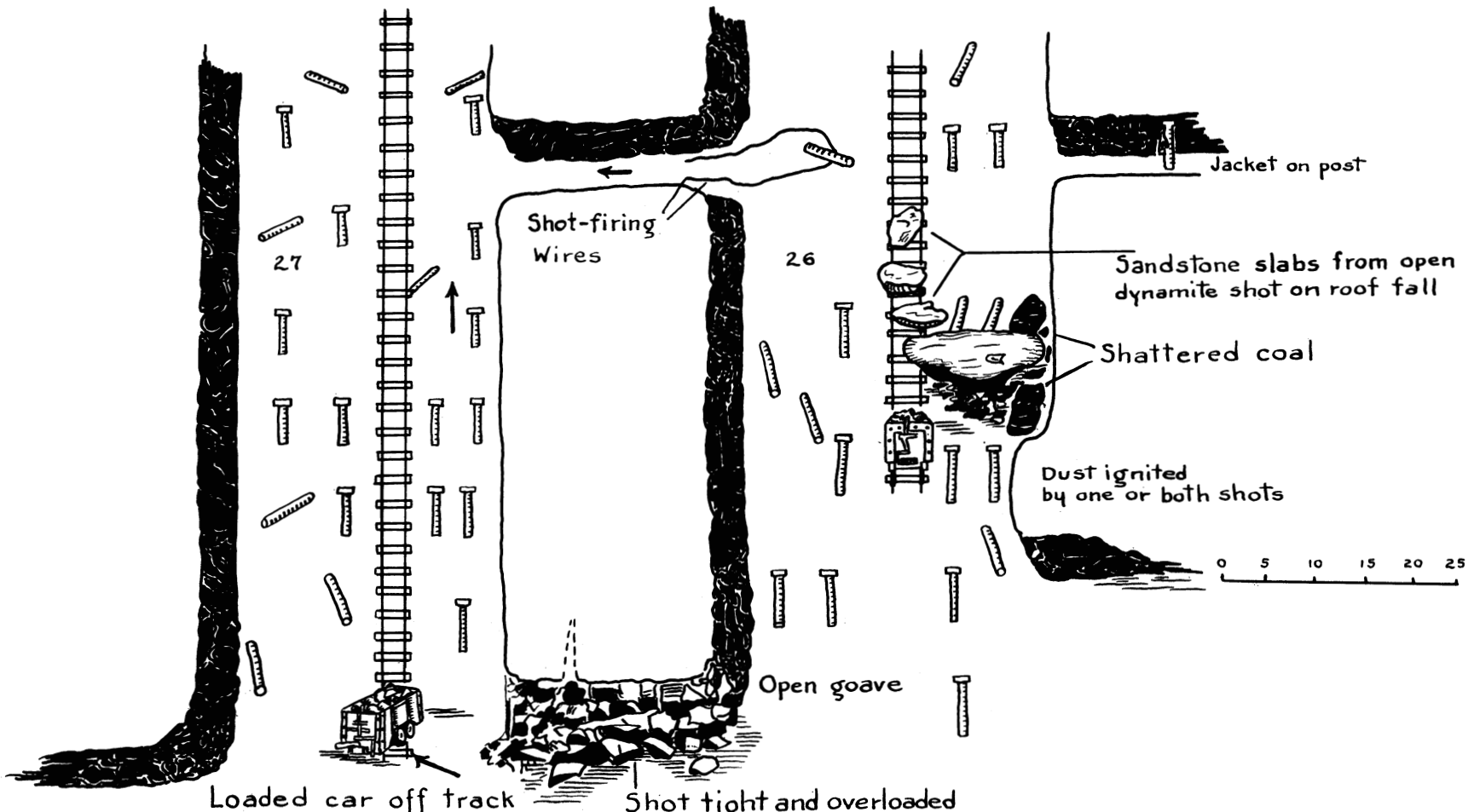

FIGURE 31.—Sketch at origin of explosion, Stag Canon No. 2 mine, Dawson, N. Mex., October 22, 1913.

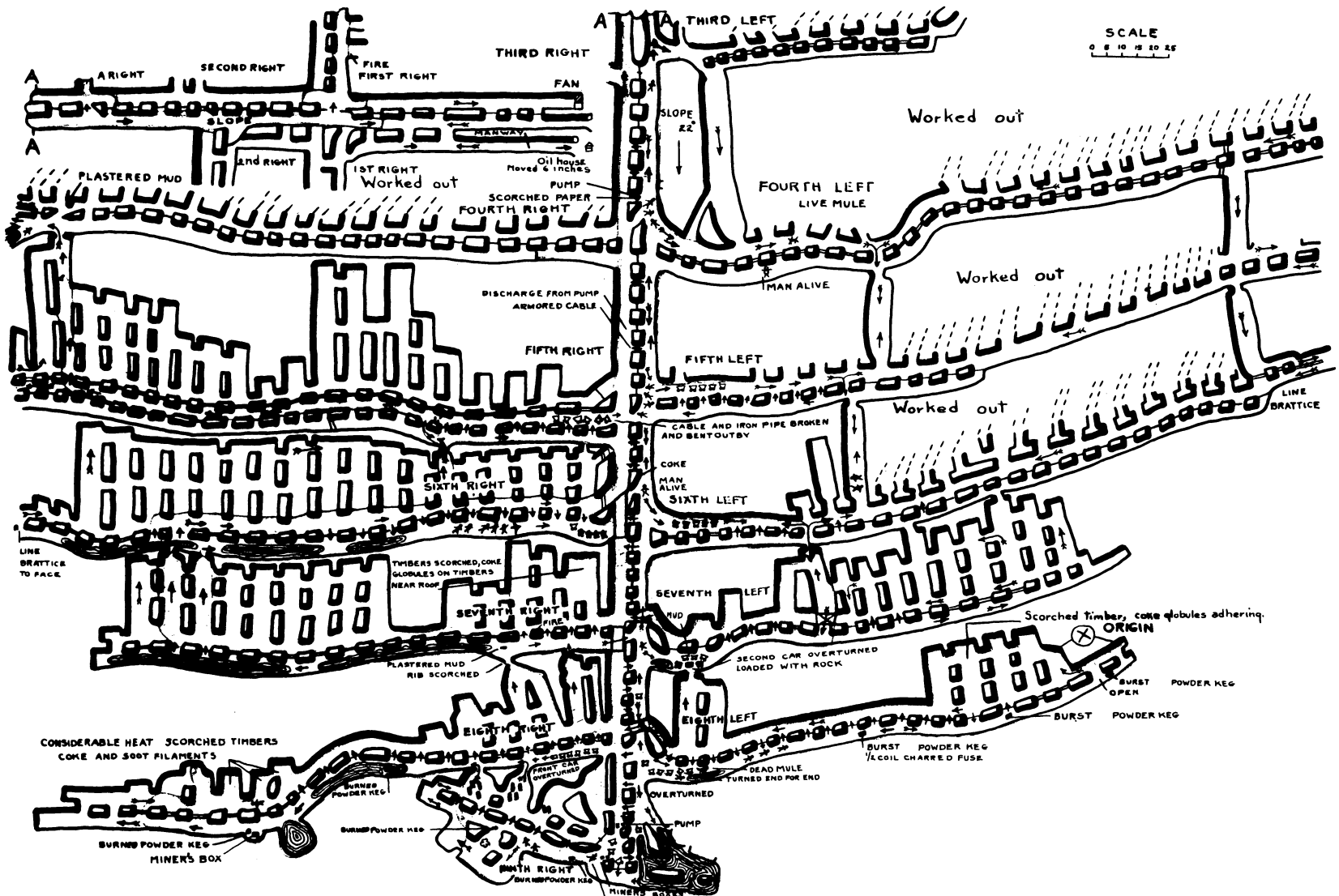

FIGURE 32.—Map of explosion area, Acton No. 2 mine, Acton, Ala., November 18, 1913.

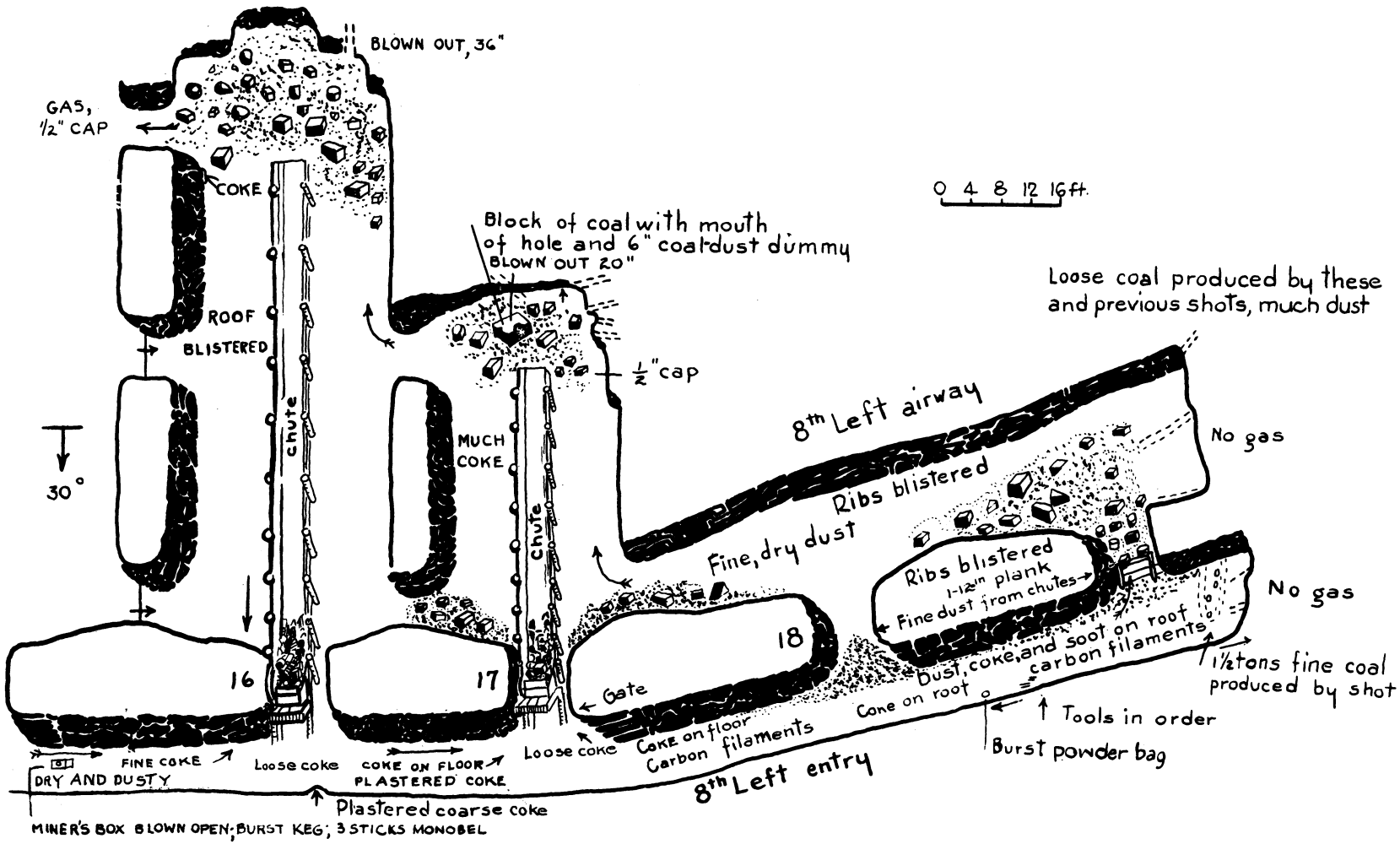

FIGURE 33.—Sketch at origin of explosion, Acton No. 2 mine, Acton, Ala., November 18, 1913.

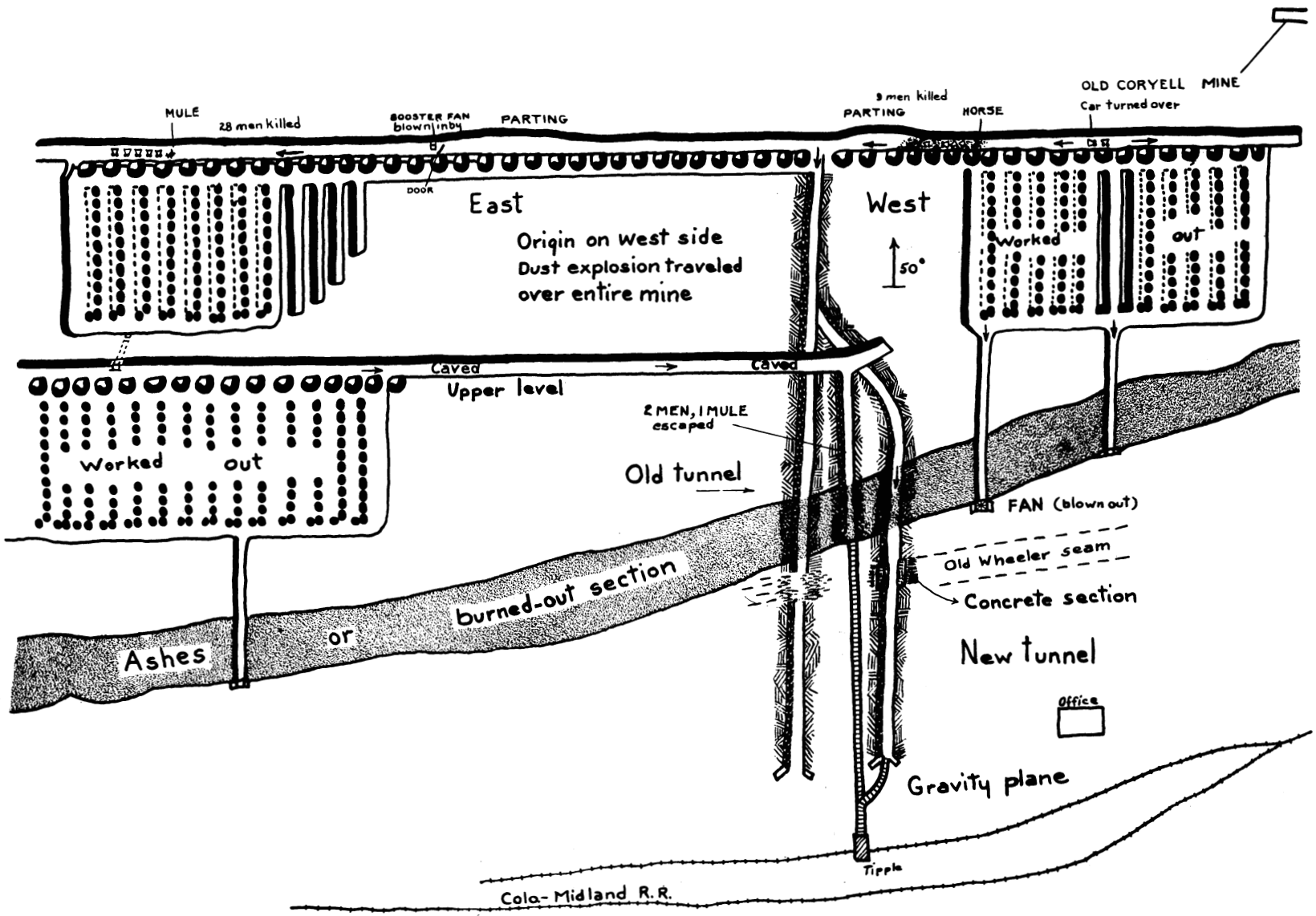

FIGURE 34.—Map of explosion area, Vulcan mine, New Castle, Colo., December 16, 1913.

FIGURE 35.—Blown-out shot, dummies filled with coal dust, Fort Branch mine, Indiana, February 1914.

December 16, 1913; Vulcan Mine, New Castle, Colo.; 37 Killed

(From Bureau of Mines report, by A. J. Strane)

The explosion at about 10 a. m. on Tuesday swept practically the entire working section of the mine, heavy falls were produced, much damage was done to the interior of the mine, and the fan on the surface was completely wrecked. All of the 37 men and 1 mule and 1 horse in the main workings were killed, 35 by violence. Two men and a mule in an old entry above were not affected. The seam pitches at 50° and is reached by rock tunnels from the footwall side. Safety lamps were supposed to be used in the section where the explosion originated, but one driver used an open light and shots were fired with caps and fuse. It was thought that gas was not involved but that dust was stirred up and ignited by an open shot in a chute or that dust from a fall in a chute was ignited by the open light. There was some suspicion of an intentional explosion because of labor troubles throughout the State, and threats had been made against this mine. Natural ventilation quickly cleared the mine of gases, and oxygen breathing apparatus was not needed for recovery of the bodies, although it was used by the superintendent on an exploration trip on the east entry.

A sketch of the mine is shown as figure 34.

January 10, 1914; Rock Castle Mine, Rock Castle, Ala.; 12 Killed

(From Bureau of Mines report, E. B. Sutton)

At 8:43 a. m. an explosion in the 17th right entry caused the death of 12 men from burns and suffocation. The fireboss had reported gas in 3 rooms that morning but had not examined 1 room in which gas had been found previously and had been cleared the day before. Miners were allowed to work in their rooms inby the rooms where the gas was standing. The mine foreman and the brattice man attempted to move the gas and either brushed it out onto the entry where it was ignited by one of the open lights or attempted to relight an opened flame safety lamp in an explosive body of gas. The explosion was spread by the fine dust but stopped at a wet section of the entry, as no great violence was developed. About 75 men in other parts of the mine were not affected. Four men with breathing apparatus helped to explore the 17 right section the next day to recover some of the bodies after ventilation was partly restored. The ventilation system permitted accumulation of pockets of gas and the occasional sprinkling of haulage roads from water cars was not effective. Rock dusting of rooms and watering of entries by hose were recommended.

Few pictures exist of the destruction in underground mine workings resulting from violent gas and dust explosions. Similarly there are very few photographs of the evident origins of such explosion. Figure 35 shows a blown-out shot found to have been the origin of a minor explosion in a mine in Indiana in 1914. Figures 36 and 37 were photographed in a mine in Illinois following a minor explosion where the forces were relatively moderate. Another picture of wreckage in a minor explosion is figure 38, taken in an Indiana mine in 1917.

April 28, 1914; Eccles Nos. 5 and 6 Mines, Eccles, W. Va.; 181 Killed

(From Bureau of Mines report, by H. D. Mason, G. S. Rice, and J. W. Paul)

At 2:10 p. m. an explosion in No. 5 mine killed every man in the mine, 172; and in No. 6 mine, working

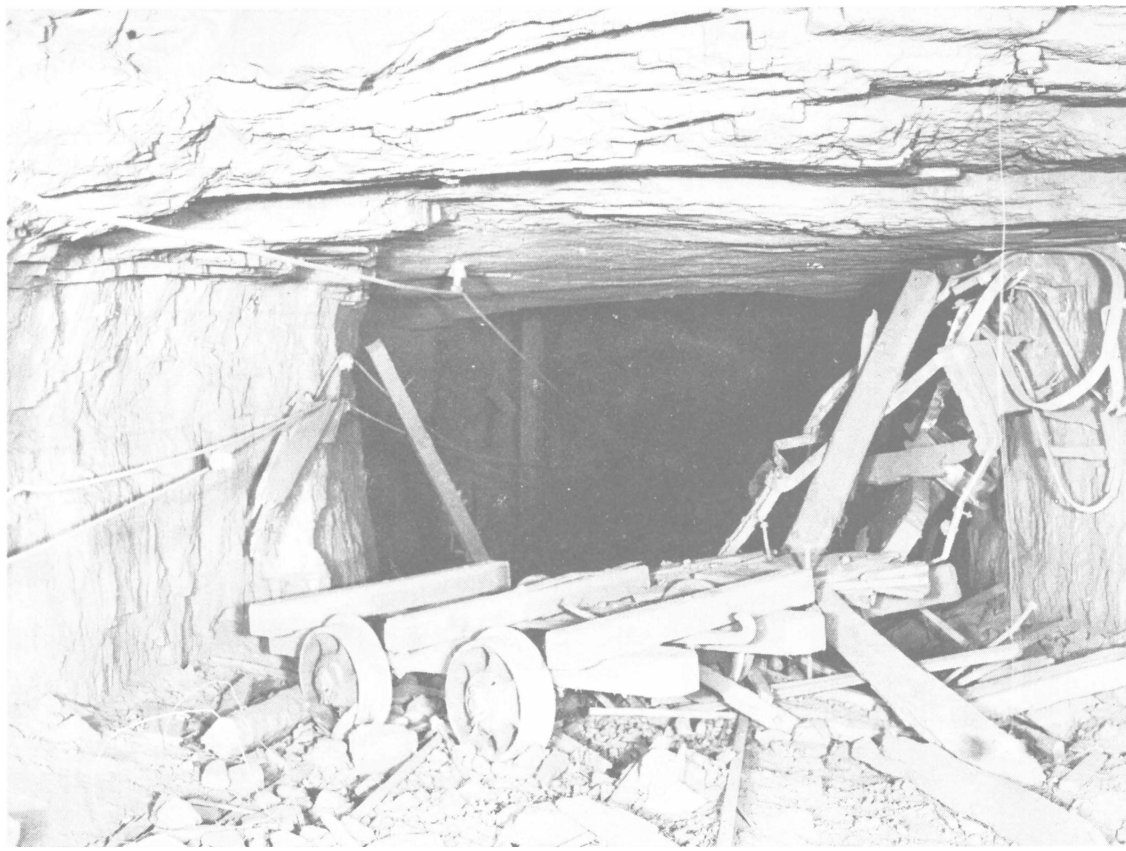

FIGURE 36.—Wreckage underground after explosion, Majestic mine, DuQuoin, Ill., 1914.

FIGURE 37.—Wrecked overcast, Majestic mine, DuQuoin, Ill., 1914.

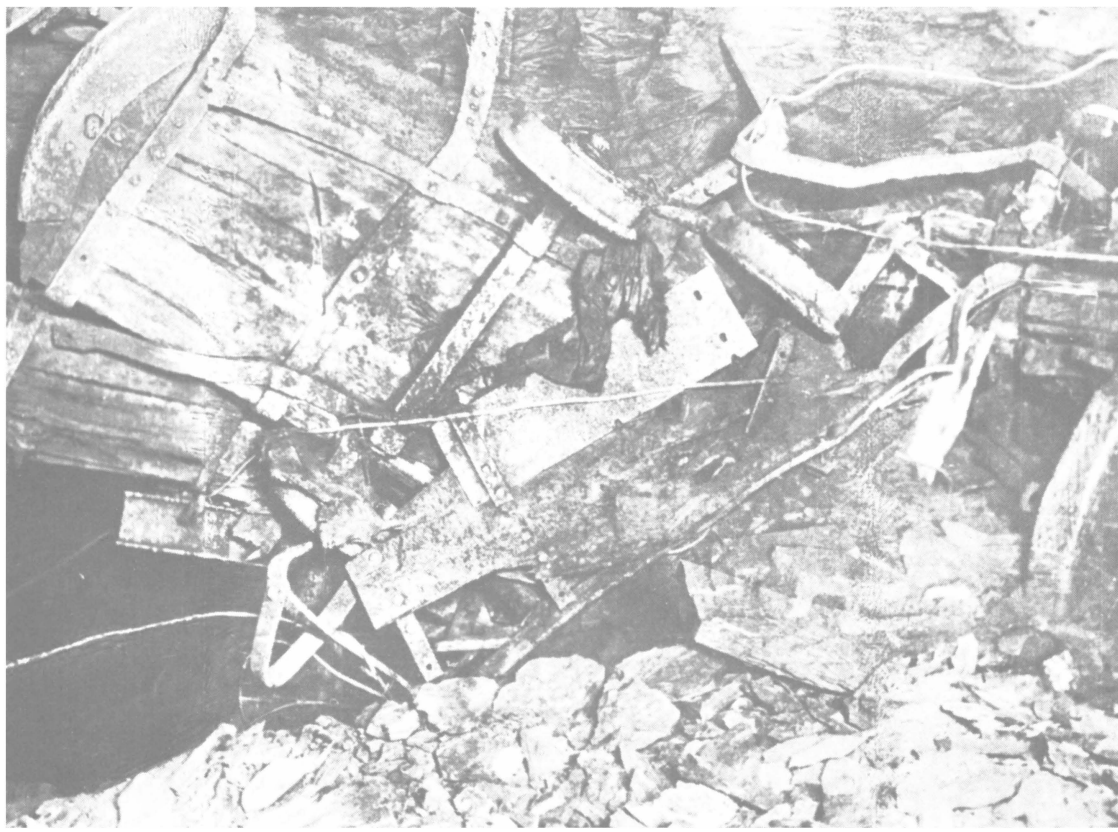

FIGURE 38.—Cars wrecked by explosion, Oliphant-Johnson mine, Indiana, February 1917.

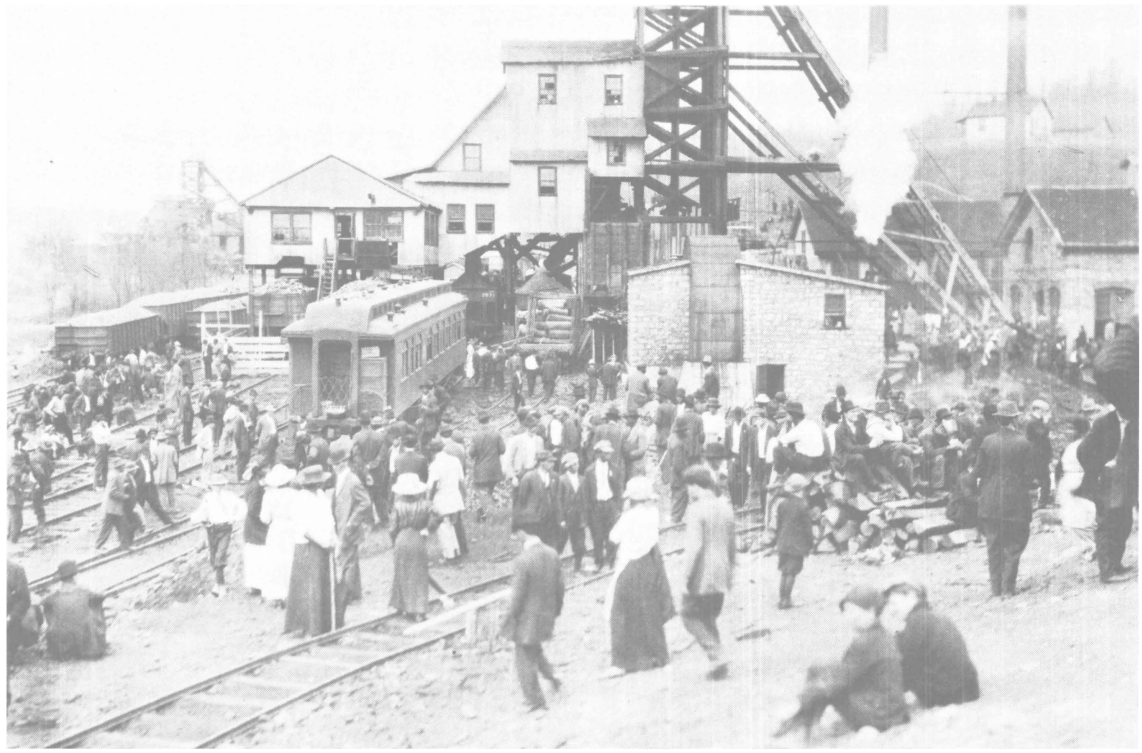

FIGURE 39.—Surface scenes after explosion, mines 5 and 6, Eccles, W. Va., April 25, 1914.

the seam above, 8 men were killed by afterdamp and 66 escaped, but 1 of these died later from injuries sustained while getting on the cage. The explosion originated in No. 5 mine, and there the heat and violence were so great that few of the 172 men in those workings could have lived any considerable time after the explosion. About 10 minutes after the first explosion, a second but less violent explosion occurred, carrying debris out of No. 5 shaft. The first and more violent explosion, accompanied by flame, carried timbers and quantities of mud up both shafts and blew off the explosion doors of the fanhouse at No. 5 shaft, but did not damage the fan. The explosion wave in No. 5 mine traveling toward No. 6 shaft blew a large quantity of water from a depression near the shaft up the shaft. This quenched the flame and prevented it from entering No. 6 mine. Rescue workers entered through No. 6 shaft (fig. 39).

Crews from other mines and Bureau of Mines men used apparatus in exploring and in restoring ventilation. A contractor had blasted out a coal barrier 4 feet thick between 2 mine sections, causing the air to be short-circuited in 1 section. Gas accumulated and was ignited by the open light of the contractor or by a blown-through shot of permissible explosive. The explosion was carried to other parts of the mine by dust. Although the mine was well ventilated, gas was occasionally found by firebosses. Open lights were used, but a change was made to Hirsch electric cap lamps after this explosion. Two men were employed in sprinkling throughout the mine, but the State inspector had reported dusty places requiring more efficient watering. The second explosion probably occurred when gas came in contact with fire resulting from the first explosion. Use of safety lamps, removal of dust, and the application of stone dust on entries were recommended.

September 16, 1914; Lehigh No. 4 Mine (Anthracite), Lansford, Pa.; 7 Killed

(*From Bureau of Mines report, by Chas. Enzian*)

Four men were instantly killed and 3 others died in a hospital within 48 hours after a local gas explosion occurred at about 1:30 in the afternoon. Men with Wolf flame safety lamps and Hirsch permissible electric miners' lamps were clearing up a small fall of coal on an airway. The power wire to the booster fan in the tunnel had been broken by blasting on the night shift, and gas had accumulated in 3 breasts. It was detected and miners were kept out of the affected area except for the cleanup crews. Smoking was allowed in the gangway, and one man continued to smoke when he returned to his work in the airway.

Recommendations were made for prohibiting open lights, smoking, and use of booster fans except in temporary installations.

October 5, 1914; Mulga Mine, Mulga, Ala.; 16 Killed

(*From Bureau of Mines report, by E. B. Sutton*)

At 8:30 a. m. when the explosion happened, 283 men were in the mine. None were killed by violence or burns, but 16 died from afterdamp, and 16 had minor injuries. The explosion was confined to the 8th and 9th right entries. At 7:30 that morning a door was damaged by a trip of cars, short circuiting the air inby the 8th entry. Gas accumulated and was ignited by an open light; the explosion was strengthened by dust even though water for sprinkling was piped to all parts of the mine. After the explosion 100 Hirsch electric cap lamps were bought.

October 27, 1914; North or No. 1 Mine, Royalton, Ill.; 52 Killed

(From Bureau of Mines report, by J. W. Paul, H. I. Smith, and G. T. Powell)

There were 357 men in the mine at 7:25 a. m., and the mine manager was about to step in the cage at the surface when a blast of air and dust came up the shaft. He reversed the fan to make the hoisting shaft the intake to save 80 or 90 miners gathered at the shaft bottom. About 220 miners from unaffected sections were brought out, and 1 man was rescued from the explosion area 10 hours later by a rescue party wearing breathing apparatus. Only slight damage was done to the mine workings; probably 20 men were killed by violence or burns, while the others died from afterdamp. Gas had been found in an entry face on the night before and "boarded off" by the mine examiner of the affected section whose record showed gas in five places. A miner's open light set off a first explosion, followed quickly by a second stronger blast of gas, dust, and black powder in kegs exploded by heat. The ventilation was slack over the entire mine, gas was often encountered, and no provision was made for wetting the dust. Black powder and open lights were used by the miners.

February 6, 1915; Carlisle Mine, Carlisle, W. Va.; 21 Killed

(From Bureau of Mines report, by D. J. Parker)

At 7:50 a. m. an explosion in a section of the mine more than a mile from the shaft killed 20 men and injured 4 others; 1 of the latter died in the hospital. Three were killed by violence, 4 by burns, and 14 by suffocation. Rescue parties without breathing apparatus removed the four injured men within a few minutes after the explosion. Gas had accumulated overnight in faces of one section where a door was partly open. Although firebosses found gas in one room and closed the door before leaving, a miner with an open light ignited the gas. The last breakthrough in the room was 113 feet from the face and 110 feet of canvas brattice had been built. The mine is damp, but dust accumulated in entries and some other places. The explosion was spread by dust. Gas was found only in this section of the mine.

February 17, 1915; Prospect (Anthracite), Wilkes-Barre, Pa.; 13 Killed

(From Bureau of Mines report, by Chas. Enzian)

About noon 8 men were instantly killed and 5 others so injured and burned that they died within 30 hours. Three others were slightly injured. Gas that had accumulated near the roof of a chamber because the ventilating current did not reach the roof was forced down by the air currents caused by a rush of coal. This gas spread to where a miner was eating lunch and was ignited by his open light. Rescue parties brought out the killed and injured within an hour and a half, except for one body found later under a fall. Fires in 2 chambers were extinguished in 4 days. Permissible explosives, electric cap lamps, and closer supervision were recommended.

February 18, 1915; New Home No. 2 Mine, Rich Hill, Mo.; 5 Killed

(From Bureau of Mines report, by Daniel Harrington)

The No. 2 shaft, 287 feet deep, was connected to the old No. 1 mine, in which a fire was sealed off in 1914. In January 1915 the fire again broke out, and it was necessary to seal the escape shaft at the surface. To comply with the State law the mine crew had to be reduced to five men on each shift. These men formed an association and leased the mine. Contrary to law, the miners fired their own shots just before the end of the shift. The mine was dusty and gassy. Black powder was used, and all coal was shot off the solid. Open lights were used. The 5 men on the midnight shift had lit 10 holes in 6 working places and were coming out about 6:30 a. m. when the explosion overtook them. The day-shift men were lowered into the mine at 6:40 a. m., and noting the fumes and dust they sent a man to bring safety lamps from the engine house and followed the intake air to the inside. The bodies were found at the fringe of the explosion area, about 150 feet inby a door behind which was pure air. They were recovered without use of breathing apparatus. Overloaded and blown-out shots had ignited the dust, but the explosion died out on the entries because the dust from the fire-clay floor was intermixed with the coal dust there.

March 2, 1915; Layland No. 3 Mine, Layland, W. Va.; 115 Killed

(From Bureau of Mines report, by J. W. Paul, D. J. Parker, H. D. Mason, and W. J. German)

The explosion occurred at 8:30 a. m., resulting in the death of 114 men inside the mine and 1 outside. Fifty-four men afterward escaped alive from the mine. Seven came out from 2 to 5 hours after the explosion; 5 more escaped unassisted at 8 a. m. on March 6, and 42 others were rescued an hour later. Of those killed, 44 died from suffocation. The store porter passing the drift mouth at a distance of 100 feet at the time of the explosion was hurled against a post and killed. The force of the explosion bursting from the drift mouth shook buildings and broke windows in the vicinity. The drift mouth was wrecked and the fan doors blown off. The foreman and the superintendent immediately called on men that were nearby and patched up the fan doors, started the fan, and patched an overcast a short distance inside the mine. State mine inspectors, officials of other mines, and the Bureau of Mines were called on for assistance, and men and equipment were rushed to the mine. Organized rescue and recovery work was started with brattice crews; apparatus crews explored ahead of them as soon as they arrived. By direction of the mine officials and the State inspectors this work was turned to the sections of the mine away from the origin, thinking that in these sections there was a better opportunity of saving lives. The explosion extended over the major portion of the mine, and progress was difficult and dangerous. In reestablishing ventilation it became necessary to reverse the air in No. 3 main entry; on the night of March 5 the fan was stopped and all working parties were withdrawn until morning. This change in the air cleared the afterdamp from the No. 3 main, which had been on the return, permitting five men who had barricaded themselves in 9th left off No. 3 main to open their board stopping and walk out through the entry. They did not know of any other live men in the mine, but rescue parties soon found and brought out 42 other men from behind the gob stoppings they had built on 10th left (*25, pp. 28–30*). These men reached the outside by 11 a. m. on March 6. The action of these men in barricading themselves off from the deadly gases following the explosion was an example to other miners who might be entrapped. In 10th left the leadership of a younger miner, John Whalen, prevailed on many of the starved and sometimes fear-crazed men to stay inside the barricade until help came or the air outside became safe. Recovery work was completed March 8, except for bodies remaining under heavy falls. An accumulation of gas on 4 left entry off No. 4 mains was thought to have been ignited by an open light, which resulted in an explosion propagated by coal dust to other sections of the mine (figs. 40 and 41). Gas was

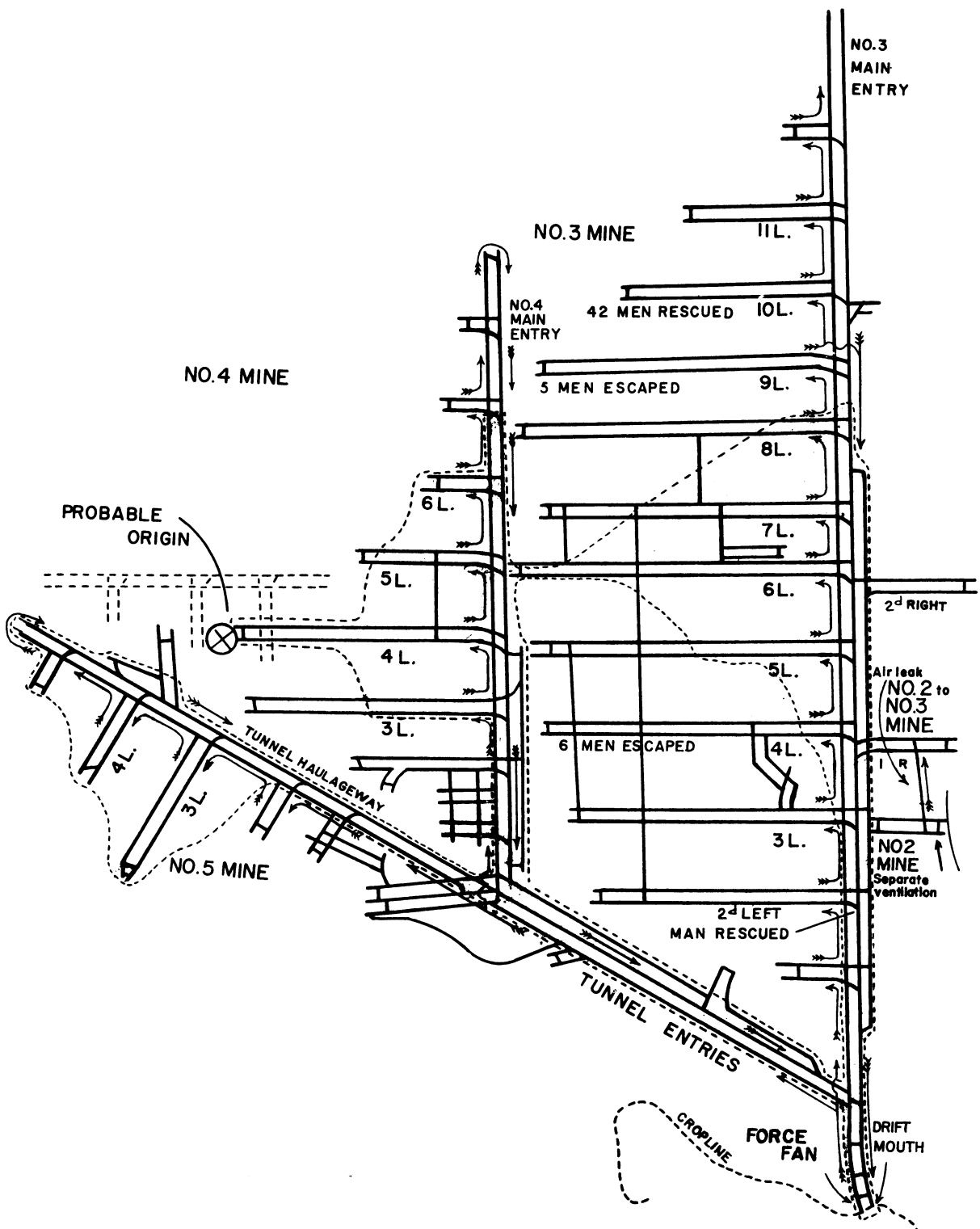

FIGURE 40.—Map of explosion area, Layland No. 3 mine, Layland, W. Va., March 2, 1915.

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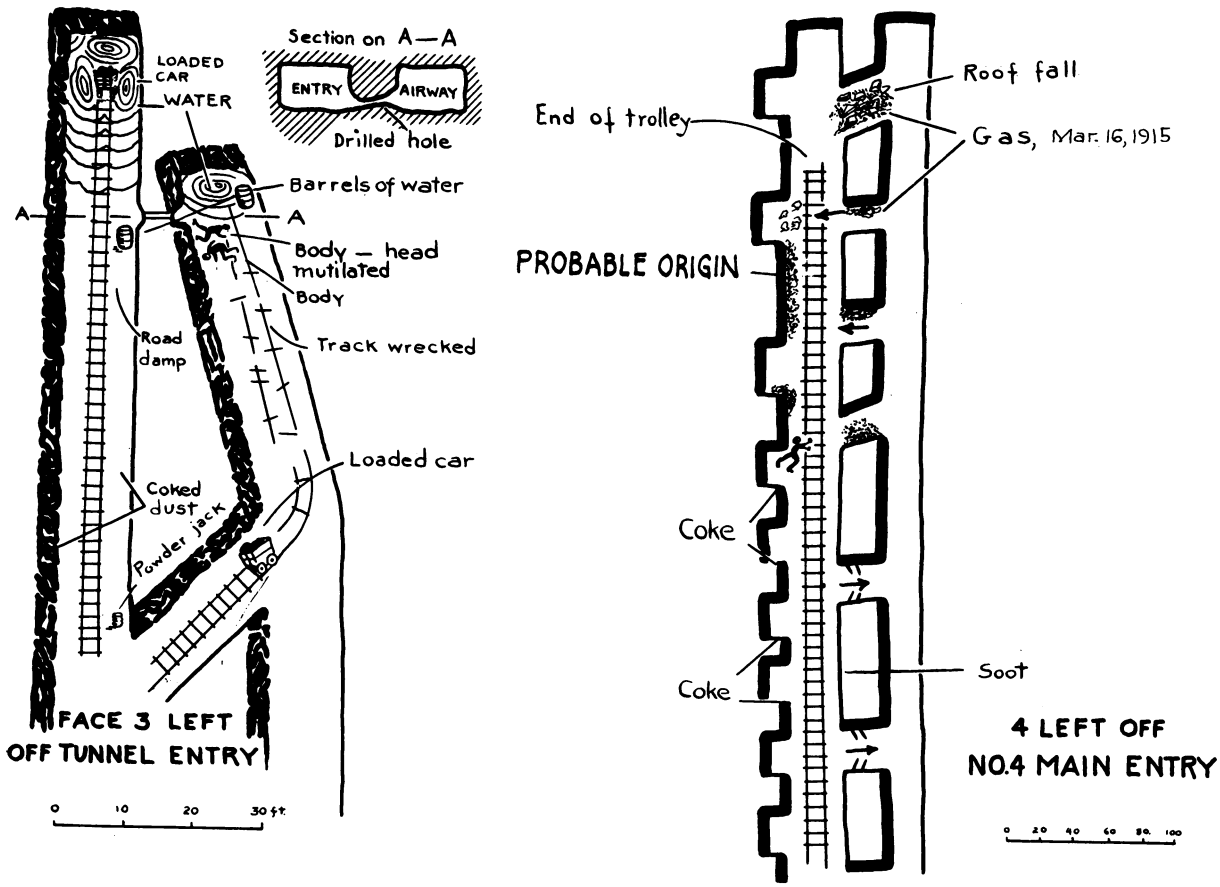


FIGURE 41.—Sketch at origin of explosion, Layland No. 3 mine, Layland, W. Va., March 2, 1915.

encountered infrequently, and no attention was given to maintaining ventilation on that account. No firebosses were employed. Black powder was used, tamped with coal dust and bottom dirt. Top cuts were made by picks. No sprinkling was done.

A text or handbook was issued by the Bureau of Mines in 1916, for instructing rescue crews and disseminating advice and suggestions for the best conduct of rescue and recovery operations (*47*). The details of such operations and the Bureau's place in them were explained clearly and carefully.

The efforts of the Bureau were divided between education on saving lives after disasters and in protecting them by preventing disasters. Training of rescue crews, in wearing breathing apparatus and teamwork, had been carried on since 1908. In 1911, a circular describing the use and care of mine rescue breathing apparatus was issued by the Bureau in connection with this training (*47*). In 1912 a pamphlet was published presenting in detail the Bureau's method of training rescue crews (*46*).

Some practices and equipment normal to coal mining at that time are shown in figures 42 to 47.

April 5, 1915; Shoal Creek Mine, Panama, Ill.; 11 Killed

(From Bureau of Mines report, by H. I. Smith, J. R. Fleming, and G. T. Powell

On Monday morning 300 men were entering the mine at 6:45 a. m. when a body of gas was ignited by the carbide light of a miner reaching the face of an entry. The explosion was spread by coal dust but stopped on the roadways by the inert dust of the clay floor. The fan was small, a continuous system of ventilation was used, and doors were often left open. There was little air movement at the faces. Gas was brushed out or burned out when found. Mine examiners made their rounds before men entered. The fan had been shut down over Saturday and Sunday. The entries where the explosion started were reported safe on the morning of the explosion. Ten rescuers were overcome but were revived. Apparatus crews were not called. Improved ventilation, examination, and rock dusting or sprinkling were recommended.

FIGURE 42.—Testing for gas with flame safety lamp, 1915.

May 24, 1915; Smokeless Valley No. 1 Mine, Johnstown, Pa.; 9 Killed

(From Bureau of Mines report, by D. Harrington, L. M. Jones, H. D. Mason, and W. J. German)

The mine had not been working for several days, and on Monday morning only 10 men were sent in. Two came out at noon. The fireboss came out before noon and reported everything clear. At 3:10 p. m. a rumbling was heard on the surface, and some smoke came out of the slope and fan. The fan stopped; but only the belt was off, and the fan was restarted within 15 minutes. The foreman was called from the mine office, and 17 men in the adjoining No. 3 mine were brought out by way of No. 3 shaft. Brattice crews with locked safety lamps were put to work to restore ventilation to reach the face of the entry where the eight men had been working. A 4-man rescue crew with Fleuss apparatus from a nearby mine was sent in to explore the heading and found 6 bodies. While searching for the other 2 bodies under low top, 3 of the apparatus men were overcome, and the fourth ran back to call for help. Although the unconscious men were soon brought out after rapid construction of brattices and by going ahead of fresh air without protection, one of them could not be revived. The victim had removed his mouthpiece after complaining of distress while in afterdamp (*23, pp. 7, 8*). A second team arrived soon afterward but was not allowed to go ahead of fresh air. The explosion was confined to one section of the mine by dampness. Gas had accumulated and was ignited by one of the open lights. Coal dust fed the explosion. Sprinkling had been done at 2- or 3-month intervals. More sprinkling and the use of rock dust and electric cap lamps were recommended. The use of closed lights had been avoided, although the mine gave off a small percentage of gas.

July 27, 1915; United Coal No. 1 Mine, Christopher, Ill.; 9 Killed

(From Bureau of Mines report, by H. I. Smith)

A full shift of 416 had gone down the 507-foot shaft on Monday morning. At 9:15 a. m. a body of gas was ignited by an open light, and the explosion was spread by gas and dust through one section of the mine. Further expansion was limited by the clay dust on the roadways and expansion into openings. Three men were killed by violence, 5 by flame and hot gases, and 1 by suffocation. Eight others were injured. All the men were removed from the mine without difficulty, and the bodies were recovered before noon. An apparatus crew then entered and looked for fires. The last examination for gas had been made on Saturday although the mine was known to liberate methane. The main roads were watered, but otherwise the mine was dry and dusty. Preshift examinations and sprinkling or rock dusting were recommended.

August 31, 1915; Orenda Mine, Boswell, Pa.; 19 Killed

(From Bureau of Mines report, by D. Harrington and H. D. Mason)

About 8 a. m. a local explosion blew down four doors, a few stoppings, and some curtains along 8 dip. The coal dust did not become involved other than for slight charring in rooms near the origin. Afterdamp from the exploded section passed directly into the main re-

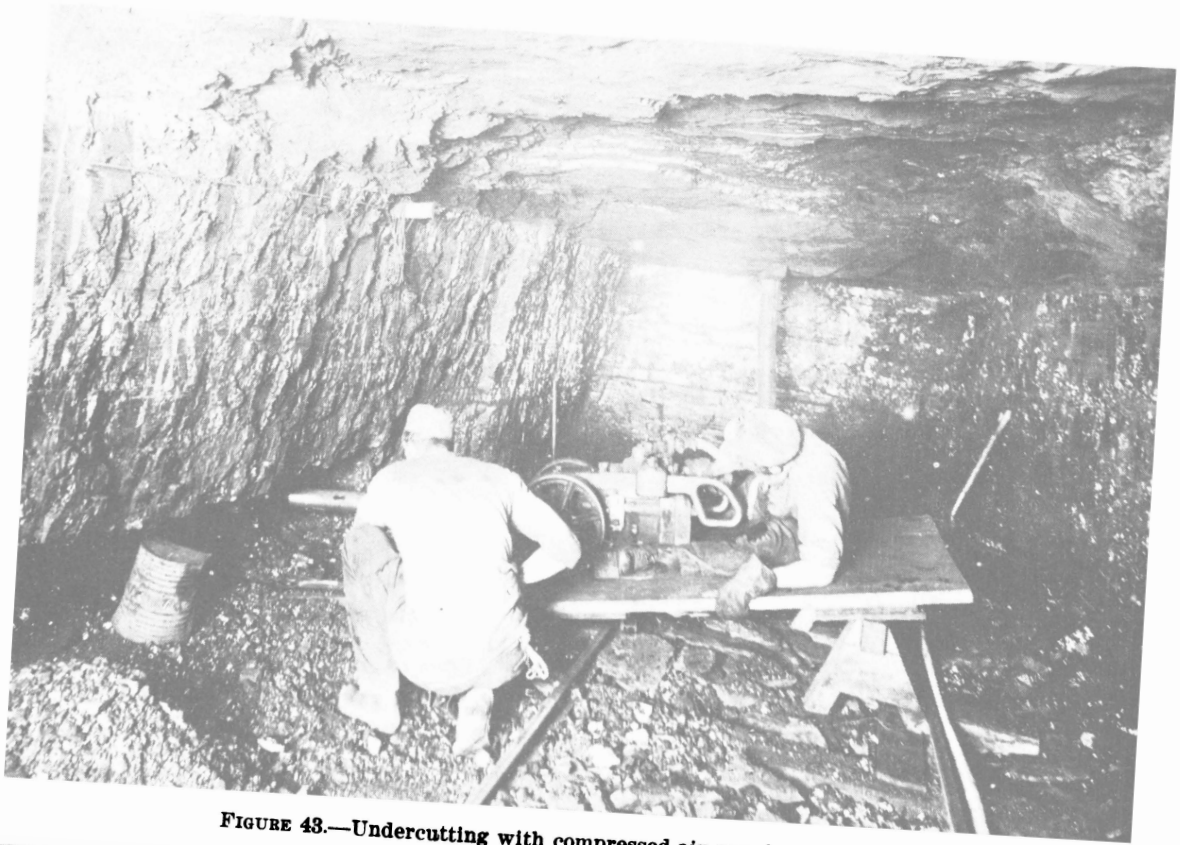


FIGURE 43.—Undercutting with compressed-air puncher, about 1915.

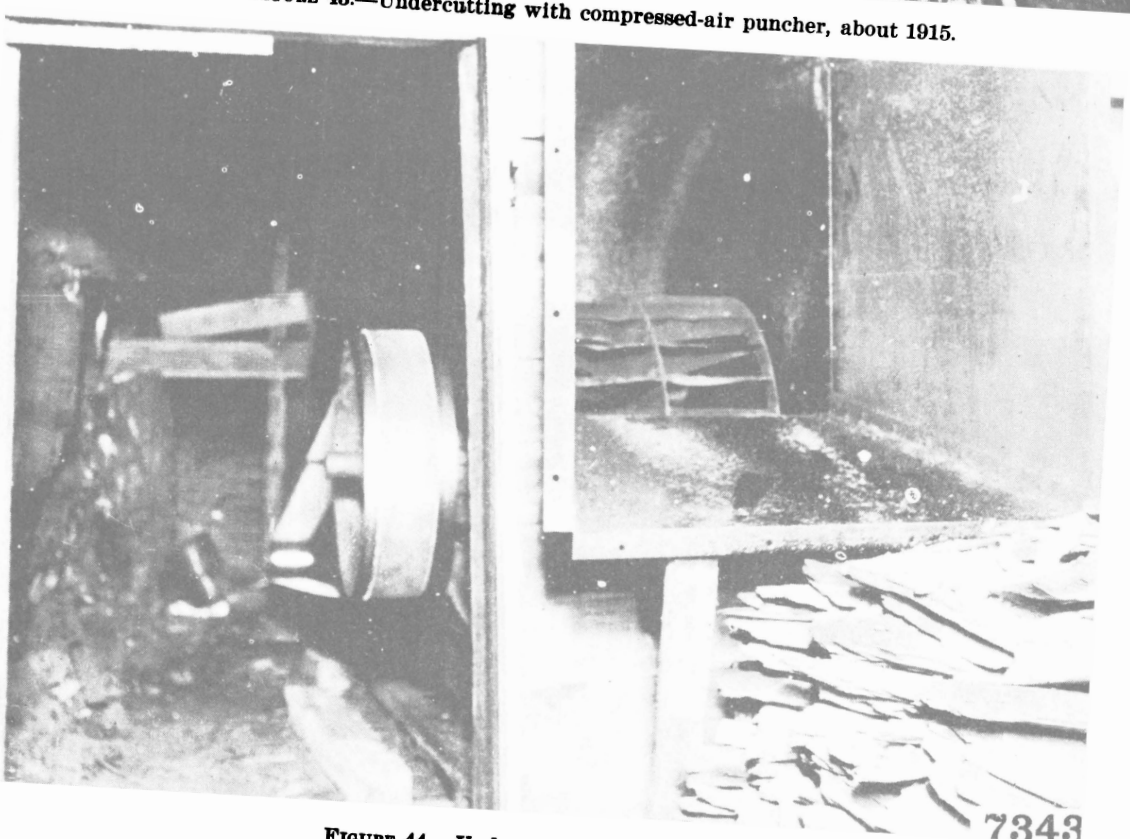


FIGURE 44.—Underground booster fan, 1916.

FIGURE 45.—Miners at face of entry, 1916.

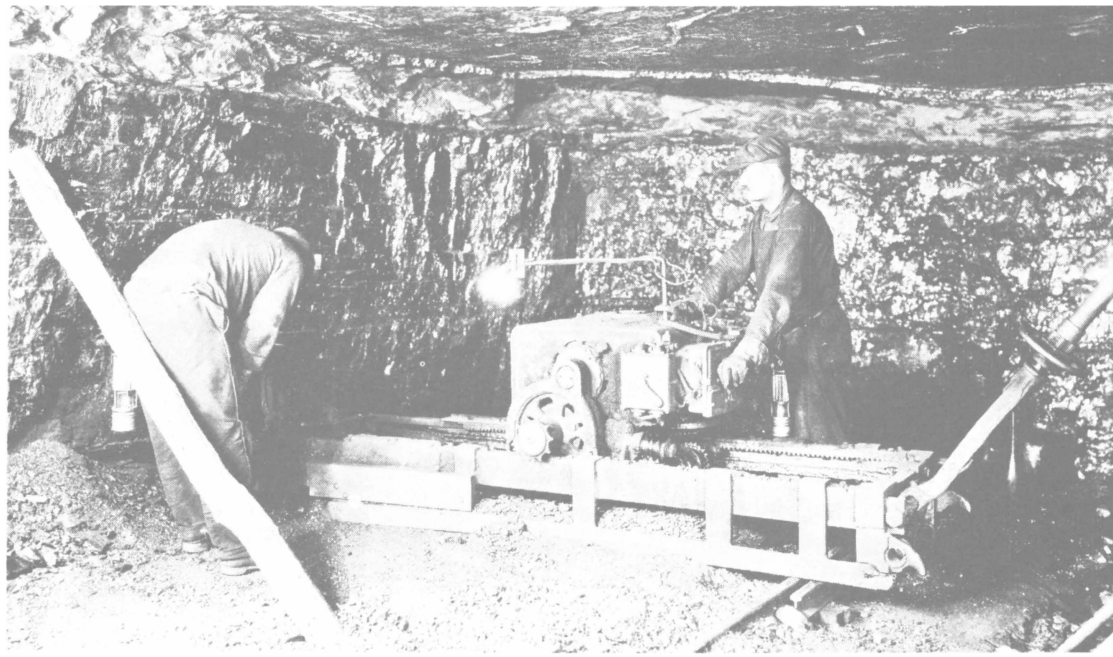


FIGURE 46.—Mining machine, breast type, 1916.

turn and did not enter other sections of the mine. Seventeen men were killed, and 10 others were overcome. They were rescued by the foreman and others without the aid of breathing apparatus, but 2 died afterward. All bodies were recovered within 13 hours. Gas had been reported in the section, and when a door was opened some of it was pulled out onto the 8 dip roadway where it was ignited by sparks from the trolley wheel of a locomotive bringing in a trip of cars.

November 16, 1915; Northwestern Mine, Ravensdale, Wash.; 31 Killed

(From Bureau of Mines report, by Edwin Higgins)

About 1:30 p. m. an explosion killed all but 3 of the 34 men in the mine. Recovery work by exploring crews in breathing apparatus and bratticemen without apparatus completed recovery of the area and removal of the bodies in 6 days. Progress was slow and difficult in the narrow entries and chutes. The coal bed dips 30° to 60°. Dense smoke and dust issued from the main and auxiliary slopes, but the headframes were not damaged. A rescue party under the superintendent at once commenced recovery and repair of the auxiliary slope and rescued 4 men; 3 were unconscious and were given artificial respiration, but 1 died. Apparatus men soon arrived and were organized into crews. Gas had been found previously at the top of No. 40, No. 41, No. 42, and No. 43 chutes, although none was reported on this day. Ignition of a body of gas in No. 41 chute by a match was the conclusion of the investigators. Closed lights were used above the entries, but most of the men in these chutes carried matches and smoking materials. Dust carried the explosion over the mine. Sprinkling on the entries did not control the dry dust.

November 30, 1915; Boomer No. 2 Mine, Boomer, W. Va.; 23 Killed

(From Bureau of Mines report, by J. W. Paul and others)

At 10:30 a. m. an explosion occurred; as a result 2 men were partly overcome by afterdamp. About 40 minutes later a second explosion of greater violence resulted in the death of 23 men—17 by burns, 2 by violence, and 4 by suffocation. Eleven were injured and 5 were rescued, 1 of whom died and 2 were paralyzed. Twenty-eight men barricaded themselves behind a rock and earth barricade and escaped 7 hours later (*24, pp. 49 and 52*). There were 300 men in the mine, but only 24 in the area affected. Gas from a pillar section was ignited by open lights. The mine was considered nongassy, and no inspections were made. The workings were moist, and the explosion was not spread by dust.

February 8, 1916; Lance No. 11 Mine (Anthracite), Plymouth, Pa.; 7 Killed

(From State mine inspector's report, 1916, pp. 12–16)

On the Southrise gangway safety lamps were used in the chambers, but the workmen used naked lights on the gangway. The fireboss had completed his inspection and had gone home when an explosion occurred at noon. The damage consisted of doors, brattices, and walls destroyed or dislodged. Some props were charred. Seven men were killed by flame and afterdamp, and one other was injured. The accumulation of gas in No. 5 slope and airway was due to a trapdoor remaining open. When someone closed this trapdoor the gas was moved upon the open light of a miner in the gangway.

February 11, 1916; Ernest No. 2 Mine, Ernest, Pa.; 27 Killed

(From Bureau of Mines report, by H. D. Mason, E. H. Denny, A. J. Strane, and R. J. Rahilly)

At 3:20 in the afternoon an explosion killed 27 men in the section of the mine that was affected and burned 4 others who escaped. The 150 men in other sections and those on the outside were not aware of the explosion until word was brought out. Gas over falls in a pillar area was ignited by an open light. The force was not great, and the explosion was local. Dust was ignited but did not carry the explosion, as

FIGURE 47.—Using jacket to brush out gas, about 1916.

haulageways were damp. Open lights were used, except in some pillar sections and in a section in which an explosion in 1910 killed 12 men.

February 29, 1916; Davis No. 42 Mine, Kempton, Md.; 16 Killed

(From State inspector's report, 1916, p. 28)

At 6:45 a. m. an explosion killed 16 and injured 2 of the 71 men in the mine. The explosion was local and was confined to rooms off the 1st left off dip heading. No gas was found, but a shot against the roof and 12 inches over the solid had blown out. Fuse, caps, and an unknown type of explosive had been used, igniting the coal dust. The company rule required the use of safety powder, fired with electric exploders and battery. The damage to the mine was very slight.

March 9, 1916; Hollenback Mine (Anthracite), Wilkes-Barre, Pa.; 6 Killed

(From State inspector's report, 1916, pp. 16–18)

About 12:45 p. m. an explosion and fire in the 1st east gangway killed the six men in that section. The fire prevented entrance by rescue crews, and after it was agreed that the entombed men were no longer alive the section was sealed. In May an investigation indicated that blasting in a chamber had released gas that was ignited, possibly by a Davy lamp used in this section.

March 28, 1916; King No. 98 Mine, Kimball, W. Va.; 10 Killed

(From Bureau of Mines report, by E. Steidle and J. W. Koster)

About 8:30 a. m. gas in a section marked off by a fireboss was ignited by an open light. Dust and powder kegs added to the explosion. Three men were killed and about 20 others injured, of whom 7 died a day or two after rescue. The damage was not great, and ventilation was soon reestablished. Electric cap lamps were adopted afterward.

March 30, 1916; Robindale Mine, Seward, Pa.; 8 Killed

(From Bureau of Mines report, by E. H. Denny, L. M. Jones, A. J. Strane, and W. J. German)

The mine had not been working full, due to a strike, and only eight men went in that morning. At 8:20 a. m. the explosion blew the cage and a car of rock into the headframe and damaged the tipple and headhouse. By 12:30 p. m. the fan was repaired and running, and an apparatus crew from another mine went down the slope. Other crews arrived later, and by evening seven bodies had been recovered and the mine explored. The other body was recovered later when the mine was fully unwatered. Ventilation in the mine was poorly regulated, permitting gas accumulation in headings, undetected because regular fireboss examinations were not made. Ignition was by an open light, and the explosion was spread by dust and gas through all of the mine with the exception of rooms off the main aircourse.

August 8, 1916; Woodward No. 3 Mine (Anthracite), Wilkes-Barre, Pa.; 6 Killed

(From Bureau of Mines report, by R. Y. Williams, R. H. Seip, and J. J. Forbes)

No. 26 slope was being put down double shift in a very gassy seam, using locked safety lamps, permissible explosives, and electric detonators. At the time of the explosion most of those working in the slope had left for the day. Three doors controlling the ventilation were left open long enough for accumulation of a large body of gas, which was ignited by a flame safety lamp, possibly defective. The great violence of the blast wrecked the walls and stoppings and killed 6 of the 10 in the section.

October 19, 1916; Jamison No. 7 Mine, Barrackville, W. Va.; 11 Killed

(From Bureau of Mines report, by D. J. Parker, and coroner's inquest)

The mine was not in operation because of a shortage of railroad cars, but 10 machine men, electricians,

FIGURE 48.—Portal of slope after explosion, Roden No. 1 mine, Marvel, Ala., October 22, 1916.

and a pumpman went down the shaft. A foreman also went down but came out before noon. Fireboss examinations were not made, and entry of these men was contrary to law. At 1:00 o'clock an explosion shook the surface and sent smoke and dust out both shafts. The headframes and the fan housing were damaged, and the cages were wrecked. In the mine practically all stoppings and overcasts were blown down. Rescue crews could do little until the fan housing was patched up. Apparatus crews made long exploration trips, and one Bureau of Mines crew leader died while wearing apparatus because the main oxygen valve was closed by mistake. Because of evidence of fire in one section, that part of the mine was sealed. On November 15 the seals were opened because of the clamor for recovery of three bodies not yet found. Small explosions warned the search parties, who rushed to the surface. In a few minutes another explosion of some violence shook the mine. A week before the first explosion gas had been found in an abandoned section, and more air was put into that section. The mine was gassy, and electric and flame safety lamps were used. Steam was put into the air to moisten the dust. The ignition was probably caused by smoking or possibly by an electric arc. Dust helped to spread the explosion.

October 22, 1916; Roden Mine, Marvel, Ala.; 18 Killed

(From Bureau of Mines report, by E. B. Sutton and W. T. Burgess)

Eighteen men entered the mine, 2 pumpers and 16 to change electric cables from the 9th left to the 12th left entries. At 2:45 in the afternoon all were killed except one pumper, who was burned but escaped. A rescue worker without rescue apparatus was overcome and was killed by a fall from a ladder. The explosion originated in the 12th left in No. 2 mine and extended into both No. 2 slope and the overlying No. 1 slope. The explosion was violent and damaged both slope portals (fig. 48) but did not extend far into other entries off the slopes because the dust was wet. The mine was gassy, but open lights were used. No fireboss inspection was made that morning. Panel entries were driven without air courses and were ventilated by blower fans and canvas tubing. As the air power was off for some time in No. 2 panel entry off 12th left gas probably accumulated, possibly a curtain was also removed, short circuiting the air in the entire 12th left. An open switch to the blower in No. 2 panel was found fused and was considered the cause of ignition (fig. 49). At the time of the explosion none of the men were in No. 2 panel entry. Dust entered into the explosion locally.

November 14, 1916; Bessie Mine, Palos, Ala.; 30 Killed

(From Bureau of Mines report, by E. B. Sutton)

A night shift of 38 men was in the mine. The fireboss found gas in four rooms and the entry and aircourse faces off 15 right and told the machinemen not to cut those faces. Gas had accumulated when a door was propped open. Machinemen went into the entry to cut a new room neck, igniting the gas with their lights. The explosion was carried through the mine by coal dust and came out the slope mouth, wrecking and burning the fanhouse and other buildings. Some stoppings and timbers in the mine were blown down, and the mine was wrecked. Eight men survived, 5 escaping after 3 hours through an opening distant from the slope. Three others remained at a break in a compressed-air line until a rescue party with breathing apparatus reached them 15 hours after the explosion. They testified that there was a very strong

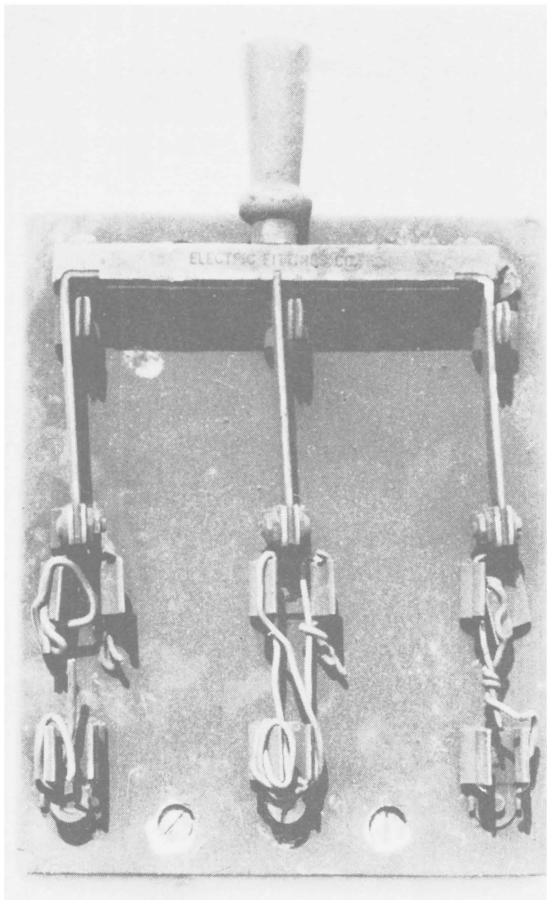


FIGURE 49.—Wired switch, origin of explosion, Roden mine, Marvel, Ala., October 22, 1916.

outward wave, followed by a return wave of equal force. Coke crusts were found in many parts of the mine on both inby and outby sides of projections. Closed lights, sprinkling, rock dusting, and split ventilation were recommended.

December 13, 1916; Fidelity No. 9 Mine, Stone City, Kans.; 20 Killed

(From Bureau of Mines report, by J. J. Rutledge and J. J. Forbes)

The 2-compartment shaft was 155 feet deep. On this day 67 miners were at work when the explosion occurred at 12:10 p. m. The explosion was violent, but damage did not extend out of the section in which it originated. Most of the victims were killed by suffocation or afterdamp, and 11 others were overcome but were rescued. Several rescuers were also overcome and had to be brought out and revived. Gas in a room face was ignited by an open light, the explosion being spread by coal dust and kegs of black powder. Although gas was often encountered, the miners used open lights and black powder, shooting off the solid. No sprinkling was done.

March 13, 1917; Henderson No. 1 Mine, Hendersonville, Pa.; 14 Killed

(From Bureau of Mines report, by E. H. Denny)

The mine has a hoisting shaft and an air shaft, both 260 feet deep. Thirty-eight men were in the mine at 6:20 a. m., as the night and day shifts were changing when the explosion occurred. Twenty-four were rescued or escaped by themselves. Rescue crews recovered all but 1 body within 24 hours. Gas accumulated in an entry face when doors and checks were left open and was ignited by a mining machine. The explosion was violent and was spread by gas and dust over a large section.

April 27, 1917; Hastings Mine, Hastings, Colo.; 121 Killed

(From Bureau of Mines report, by D. Harrington)

The workings are reached by a rock slope. The coal is undercut by hand, except that an electric cutting machine is used in slope entries. All workings are gaseous, and firebosses are employed. Prior to the explosion all places were reported "clear" unless tests with a flame safety lamp gave a cap greater than ⅝-inch in height. A continuous current is used for ventilating the mine. Nonpermissible electric cap lamps are used by all miners, inspectors carry key-locked flame safety lamps, and firebosses carry magnetic-locked Wolfe lamps. The mine is generally quite damp. Two firebosses made their rounds preparatory for the day shift on that morning and made written reports that the mine was clear of gas. A trip of cars on the rope going in after 9 o'clock had reached a point 1,300 feet inby the mouth when the explosion occurred. The trip rider neither heard or felt anything unusual, but the explosion caused the signal wires to cross and rang the bell to stop the trip. He then saw smoke coming up the slope and ran out to give the alarm of fire. He was the only man in the mine who escaped. Smoke issued from the main slope and the south manway, and an investigating party of officials followed fresh air until the affected area was reached. Oxygen-breathing-apparatus crews were then required, as practically all stoppings in the "B" seam were totally wrecked and heavy falls had occurred. Gas and dust had spread the explosion to every section of the mine (fig. 50). One apparatus man died under the severe strain, and another collapsed from overexertion but recovered. The explosion was caused by a mine inspector striking a match to relight his safety lamp about 120 feet from the face of 7 South entry (fig. 51).

Recommendations were made for adequate ventilation, competent inspection, permissible electric equipment, cap lamps and safety lamps, exclusion of matches and smoking materials, and regular sprinkling or rock dusting.

June 2, 1917; Rand No. 2 Mine, Herrin, Ill.; 9 Killed

(From Bureau of Mines report, by J. R. Fleming)

The night crew of 20 men had been in the mine only a short time when the night foreman took 10 men to the abandoned main south to remove old rails. That section was no longer ventilated, and gas was ignited by their open lights. Of that group 9 were killed and 2 seriously burned. The other men were uninjured. Rescue crews with breathing apparatus recovered the bodies. The explosion area was damp, and shale from the roof was mixed with the coal dust so that the explosion was not violent and did not spread through the mine.

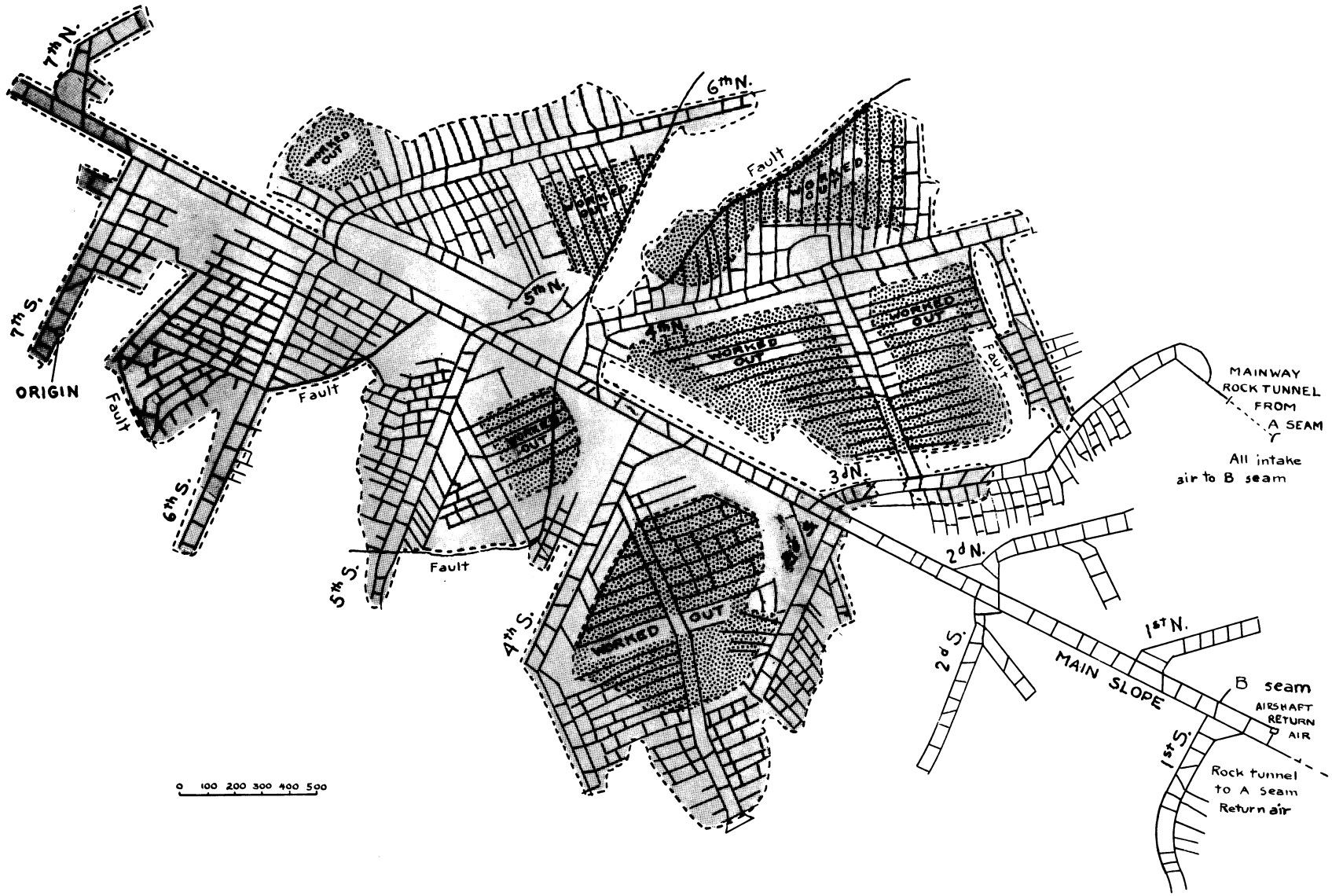


FIGURE 50.—Map of explosion area, Hastings mine, Trinidad, Colo., April 27, 1917.

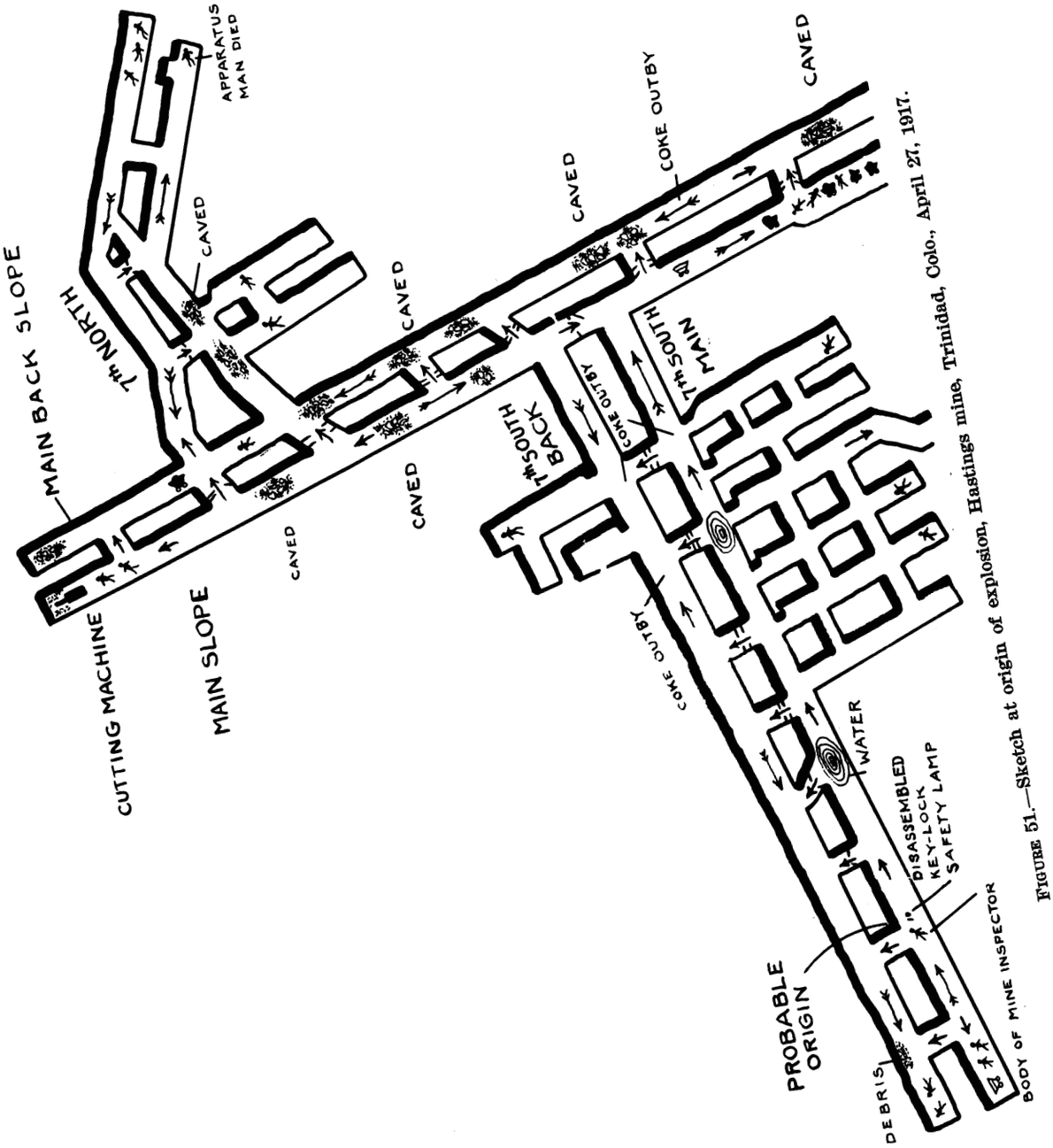


FIGURE 51.—Sketch at origin of explosion, Hastings mine, Trinidad, Colo., April 27, 1917.

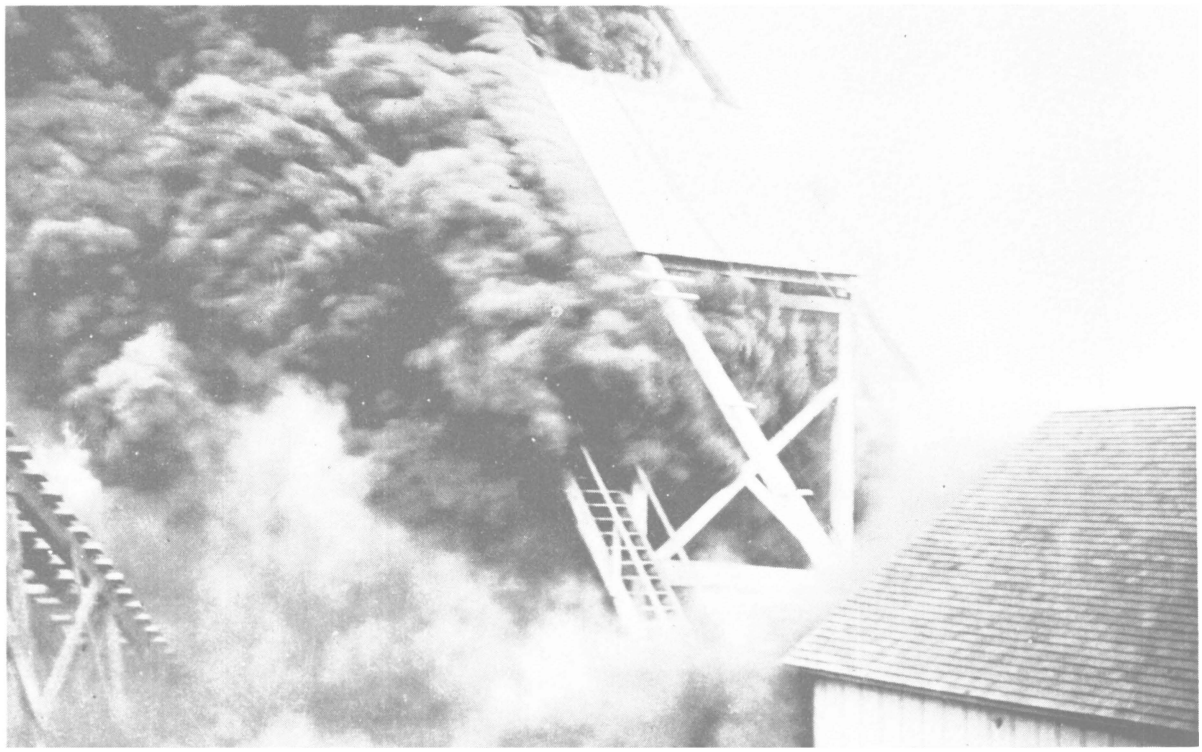


FIGURE 52.—Smoke from explosion, mine No. 7, Breezy Hill, Kans., November 1917.

June 13, 1917; Banner Mine, Banner, Ala.; 6 Killed

(From Bureau of Mines report, by E. B. Sutton)

At about 11:50 a. m. an explosion in the face of the 21 left entry extended to a large body of gas in the 21 left aircourse and traveled toward the main entry until checked in the main entries by wet conditions. Six men were killed by suffocation, 4 were injured, and 3 were rescued uninjured. Gas accumulated due to interrupted ventilation when a door was left open and a line brattice was displaced. Ignition was by open lights of men working at the entry face. Coal dust added to the explosion.

August 4, 1917; West Kentucky No. 7 Mine, Clay, Ky.; 62 Killed

(From Bureau of Mines report, by J. W. Paul, E. B. Sutton, and G. T. Powell)

About 7:30 a. m., when most of the men were traveling to their working places, an explosion caused the death of 62 persons and the injury of 3 others. Thirty-two men escaped without assistance, and 43 others who barricaded themselves in an unaffected entry were rescued 3½ hours later (*24, pp. 14–15*). The explosion was followed by a fire in the airshaft. A fireboss examination had been made; but the entries in the record were unintelligible, and the man was killed. After 2 hours the fire was extinguished, and the fan started exhausting. Rescue crews found 18 men overcome, 8 of whom died after rescue. Rescue and recovery consumed 2 days and nights, as the fire in the airshaft rekindled and had to be fought again by men with breathing apparatus. The explosion originated near an entry face, where gas was ignited by an open light. Gas accumulated because line brattices and curtains in that section were not in place. Dust spread the explosion. With normal ventilation gas was not in evidence, and little regard was given to the danger of an ignition.

November 1917; Mine No. 7, Breezy Hill, Kans.; Minor Disaster

No report was found on the circumstances of this explosion, which probably involved one or more shot firers. Figure 52 shows the smoke issuing from the shaft.

November 29, 1917; Old Ben No. 11 Mine, Christopher, Ill.; 17 Killed

(From Bureau of Mines report, by W. B. Plank)

About 9:40 p. m. an explosion ripped through the mine and damaged the airshaft and the hoisting shaft. All of the 17 men under ground were killed. The fan escaped damage, because the explosion doors were blown off, releasing the shock. After temporary repairs to the hoisting shaft rescuers entered. The fan was reversed to exhaust through the airshaft. Much of the search and recovery work was done by apparatus teams; and a number of men attempting to go into unventilated places without protection were overcome, and some were revived with difficulty. Some small fires were extinguished. Gas accumulated in the main east entries when two doors were left open. A pumpman entered and ignited the gas with his open light. Dust and possibly other pockets of gas spread the explosion with terrific violence. Where the roadways were covered with track sand the explosion was stopped, although fine, dry coal dust was thick in the mine. No firedamp examination was made before the men went in that night.

December 15, 1917; Yukon Mine, Bluefield, W. Va.; 18 Killed

(*From Bureau of Mines report, by E. B. Sutton*)

A crew was working in the main entry to prepare for resuming regular operation. Part of the crew was loading slate at the face, and the others were relaying track near 9th left entry. A door across main entry had been left open for this work, and when the rails were laid it would not close due to increased height of track. The foreman and superintendent started out to get more tools and material and were half way to the portal at about 4:15 p. m. when the explosion occurred. They were not injured, but the 18 men inside were killed. The motor driving the fan was damaged and had to be replaced. The explosion started in the face of 2d south off 9th left where accumulated gas was ignited by the open light of one man who went there while waiting. The explosion was confined to the left side of the mine by sand and fine shale in the floor of the main entry. Ventilation was reestablished, and breathing apparatus was not used in recovery work.

December 20, 1957; Mine No. 3, Catoosa, Tenn.; 11 Killed

(*From Bureau of Mines report, by E. B. Sutton*)

The explosion, at shooting time, 4:00 p. m., was caused by a blown-out shot in the first cross entry off the third right entry. Dust was ignited, and, as the explosion spread, several kegs of black powder were touched off, giving additional force. All shooting was done on the solid, using black powder. There was little violence but intense heat. Trees outside the pit mouth were covered with soot and dust. Twenty men were in the mine; 11 were killed by violence or burns; 3 escaped through an outcrop opening, and 6 came out a short way through afterdamp and escaped unassisted. The mine was free of gas and was ventilated by a furnace. The dust was moist, but the mine was not wet.

Figure 53 shows the workings and some details of the explosion.

August 7, 1918; Harmar Mine, Harmarville, Pa.; 8 Killed

(*From Bureau of Mines report, by Geo. S. McCaa*)

The explosion occurred at 3:20 p. m. while 8 men were in the mine, 5 engaged in moving a pump near the shaft bottom, and 3 in placing guides and buntons in the shaft. These 3 men were working about 40 feet below the collar and were blown to the surface, where they landed 30 or 40 feet from the shaft. The hoisting equipment was wrecked. Within a few minutes three men who were alive were pulled up the shaft by a rope that was let down to them. These three died a few days later. The other two bodies were recovered with the use of breathing apparatus. The mine had just been unwatered, and although a fan had been installed it was not used prior to the explosion. Electric incandescent lamps were being used. Gas accumulated in the workings at the bottom of the 90-foot shaft and was ignited by an open light or match. The mine was wet and dust was not ignited. No examination for gas had been made.

August 28, 1918; Burnett Mine, Burnett, Wash.; 12 Killed

(*From Bureau of Mines report, by K. H. Chisholm*)

An explosion on the 3d level in No. 3 seam at 4:20 p. m. killed 12 and injured 3 others of the 183 men in the mine. The fireboss was making his last round, and the men had left working places; all but these men from the No. 3 section had reached the rock tunnel or the slope bottom. A shot in No. 24 breast fired a mixture of gas and dust. The fireboss who fired the shot, on the run, had reached the gangway and was some distance away before he was caught and killed by the explosion. The air inby No. 21 chute had been short-circuited by pulling No. 19 and 21 chutes empty. Explosives used were dynamite and fuse, ventilation was poor, and the coal dust was dry.

September 28, 1918; North No. 1 Mine, Royalton, Ill.; 21 Killed

(*From Bureau of Mines report, by W. B. Plank*)

A fire caused by black-powder shots was discovered about midnight, Sept. 27, and a crew with several mine officials had nearly completed a seal on the intake when a man was sent to a telephone to order more materials. The telephone was through a door and in the return from the fire. His open light ignited gas, and he was burned. Although rescued he died the next day. Twenty-one men were killed by suffocation, and 13 others were slightly gassed. Apparatus men recovered six bodies, but the rest were sealed in until the fire was under control. Flame safety lamps were being used by the sealing crew; but there were not enough for all, and some had open carbide lamps. Air in part of the section had been short-circuited to increase the amount ventilating the fire area. The explosion did not propagate any great distance from its point of origin.

March 31, 1919; Empire Mine, Aquilar, Colo.; 13 Killed

(*From Bureau of Mines report, by D. Harrington*)

Thirteen men were in the mine at 8:45 a. m. when the explosion occurred. All were killed. A burned-out motor bearing caused the fan to stop about 7 o'clock, and the mine foreman was notified by telephone from inside the mine at 7:45 that the ventilation had stopped. He made a search for the mine electrician and at 8 o'clock the electrician went to examine the fan. He advised the foreman that it would take 2 to 3 hours to make repairs. The foreman decided to have the men withdrawn from the mine but had not given the order by telephone before the explosion occurred. Helmet crews were summoned, but it was evident from explorations in natural ventilation to the edge of the explosion area that there would be no survivors. The bodies were recovered after ventilation was restored in the area. The ignition of gas was by either a hoist motor or pump motor. Gas had been found earlier by the fireboss but not reported. The mine inspector declared the mine foreman and fireboss guilty of negligence and violation of the mining laws.

April 29, 1919; Majestic Mine, Majestic, Ala.; 22 Killed

(*From Bureau of Mines report, by W. B. Plank*)

Two rooms had passed through a roll and had been stopped. The roof was bad and needed timbering to maintain ventilation going to live workings in the adjoining entry. A contractor and his son attempted to put up a crib in one of the rooms and ignited gas by their open lights about 11:30 a. m. The explosion spread over that section of the mine but without much force. Dust was ignited, as the sprinkling of haulage entries had little effect. The 19 dead men and 13 injured men were removed without use of apparatus. Three of the injured died later. An explosion of the same type in 1913 in this mine, then called the India, killed 2 men and burned 6 others.

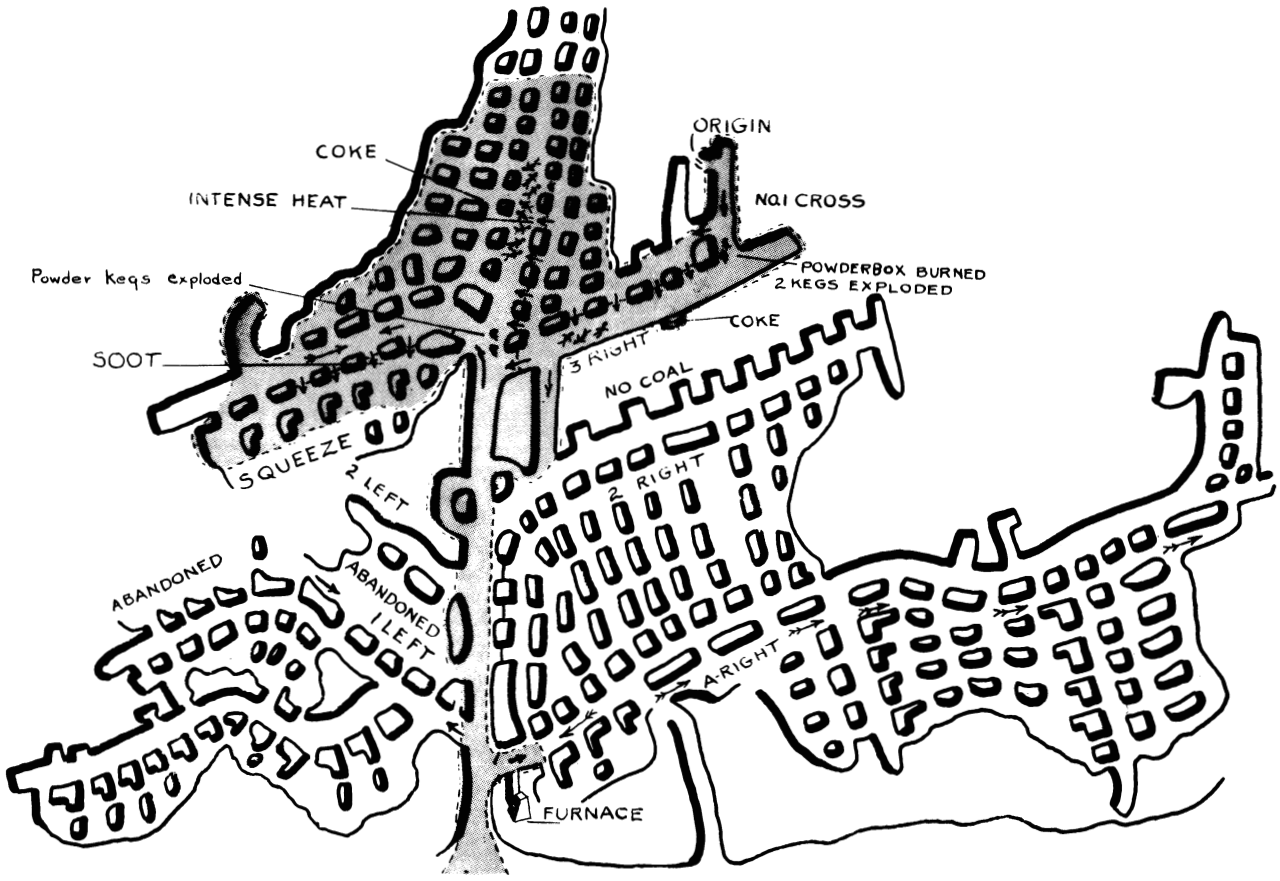


FIGURE 53.—Map of explosion area, mine No. 3, Catoosa, Tenn., December 20, 1917.

June 30, 1919; No. 5 Mine, Alderson, Okla.; 15 Killed

(*From Bureau of Mines report, by J. J. Rutledge*)

The main shaft was 555 feet deep with 2 hoisting compartments and a pipeway. There were two airshafts. The explosion about 11:15 a. m. was confined to the 3d east entry. Fifteen men working in this section were killed by burns and suffocation. The fireboss examined the places that morning and reported them free of gas. A local accumulation was ignited by an open light and spread by gas and dust, without violence. The company kept the roadways well watered and wished to have the miners use electric cap lamps but could not get them to do so. Ventilation was inadequate, and no examinations were made for gas during the working shifts.

July 8, 1919; Lansford Mine (Anthracite), Lansford, Pa.; 8 Killed

(*From State inspector's report, 1919, p. 302*)

An explosion of gas on a gangway killed 8 men and injured 3 others. A large quantity of gas was liberated by the firing of shots in the Mammoth Vein No. 15, filling Nos. 15 and 16 chutes in Skidmore Vein with gas. The cause of ignition was thought to be smoking or other open light.

July 18, 1919; Carswell No. 3 Mine, Kimball, W. Va.; 6 Killed

(*From Bureau of Mines report, by L. D. Tracy*)

On that morning the fireboss reported considerable gas in room 16 in 1st right entry. The mine foreman went into the room to make an examination soon after the day shift entered. As his light was found disassembled and in good order it was evident that it had been extinguished; and, being unable to light it with the automatic lighter, he took it apart and struck a match, igniting the gas. The explosion picking up coal dust was violent and came out through the shaft about 7:40 a. m. The explosion doors saved the fan. The bodies were recovered in about 3 hours by temporary ventilation of the area. Magnetically locked flame safety lamps, rock dusting and sprinkling, and improved methods of ventilation were recommended.

August 6, 1919; Weirwood Mine, Weirwood, W. Va.; 7 Killed

(*From Bureau of Mines report, by L. D. Tracy*)

The mine is opened by a 343-foot shaft and is gaseous. Although over 1 million gallons of water is pumped in 24 hours the 7th right section is inches deep in dry dust. The production was 200 tons per day. At 9:00 p. m. an explosion in room 11, 7th right, spread through the three adjoining rooms. The seven men working in these rooms were killed; all were badly burned. Ignition was caused by an arc from a locomotive cable.

August 18, 1919; Oakdale Mine, LaVeta, Colo, 18 Killed

(*From Bureau of Mines report, by J. J. Forbes*)

About 10:45 a. m. an explosion confined to one section of the mine killed 17 men in that section and another miner, who heard the report and was killed by afterdamp when he went to investigate. The section was gassy, and only electric cap lamps or flame safety lamps were to be used. The fireboss was thought to have ignited the gas from a defective safety lamp or by striking a match.

December 3, 1919; Bogle No. 3 Mine, Jacksonville, Ind.; 6 Killed

(*From Bureau of Mines report, by J. J. Bourquin*)

The mine was opened by a hoisting shaft and an airshaft. During a coal strike nine company men went down to get out coal for the powerplant. They drilled and loaded holes in two rooms and went out on the entry to wait for the shots to go off. The blast at 1:50 p. m. ignited dust because of a blown-out shot, killing 6 and burning and bruising the 3 others. The injured were rescued and the bodies recovered without using apparatus. The mine was free of gas, but black powder was used in blasting. Usually coal was undercut, and shooting was done by shot firers after the miners were out of the mine.

April 14, 1920; Stag Canon Nos. 1 and 6 Mines, Dawson, N. Mex.; 5 Killed

(*From Bureau of Mines report, by J. J. Forbes*)

About 8:25 p. m. an explosion in No. 6 mine was communicated to adjoining sections of No. 1 mine, partly wrecking the No. 1 fan and demolishing the No. 6 fan. The shot firers had loaded the holes, connected the leads, and signed out on the surface before the master switch was thrown to fire the shots. Also before the switch was thrown they had returned underground to hasten their reinspection of the faces required after shooting. The explosion caught them about 800 feet inside the portal. Gas and dust were ignited by overloaded blown-out shots or arcing lead wires as the switch was left in. Ventilation was neglected, in that accumulations of gas were not removed from idle sections after occasional fan shutdowns. This gas moved into active sections. Sprinkling had been discontinued. Electric cap lamps were used, and rock-dust barriers were installed in No. 1 mine. The explosion had almost died out when it reached the barriers.

May 3, 1920; Submarine Mine, Clinton, Ind.; 5 Killed

(*From Bureau of Mines report, by C. A. Herbert*)

Eleven men were in the mine on an idle day extending track for the motor haulage and digging a sump. A man going toward the face of some new entries about 8 a. m. ignited gas, killing 2 of the men and burning 6 others. No damage was done to the mine. About an hour later four men attempted to reach the body of the man who set off the explosion. They did not allow time for the gas to clear after rehanging the canvas curtains and were overcome. When another party reached them an hour later three were dead. One was revived by artificial respiration. As this part of the mine had not been worked, no fireboss examination had been made of it for several days. On September 9, another gas explosion ignited by an open light on an idle day killed 3 men. Electric cap lamps were not used.

June 2, 1920; Ontario Shaft, Cokeburg, Pa.; 6 Killed

(*From Bureau of Mines report, by D. J. Parker*)

The shaft was being sunk and had just reached the coal bed. Six men were in the crew, and all were killed by the violent explosion that wrecked the shaft and the headframe. Because of the presence of gas in the coal measures closed lights were being used, but ventilation or inspection for gas was neglected. The ignition was thought to have been from smoking.

July 19, 1920; Renton No. 3 Mine, Renton, Pa.; 9 Killed

(From Bureau of Mines report, by L. D. Tracy)

On Saturday, July 17, power was shut off for repairs to the line. The fan was put in operation about 6:30 Sunday evening, but trouble on the line caused it to be stopped again until 2 a. m. Monday. The foreman, 6 maintenance men, and 2 firebosses then went down. At 2:30 a. m. the foreman instructed the powerhouse to put on the power in the mine. At 3:20 a. m. there was a violent explosion, wrecking the mine workings and blowing the cages into the headframes. The men in the mine were killed, and much dangerous work was performed by rescue crews in finding and removing the bodies. The mine generated much more methane than was realized by the officials, because of the normally adequate ventilation, hence the foreman's violation of the mining law in permitting the men to enter before the firebosses' examinations were made. Dry fine dust was thick in the entries, and sprinkling was relied on to keep it damp. Ignition was evidently caused by an arc from a trolley locomotive moved into an entry not yet cleared of accumulated gas. This is probably the most violent explosion recorded in the State.

August 21, 1920; No. 19 Mine, Degnan, Okla.; 10 Killed

(From Bureau of Mines report, by J. J. Rutledge)

A local gas explosion in the 4th east entry occurred about 2 p. m., resulting in the death of 10 of the 120 men in the mine. Except for blowing out most of the stoppings between the entry and aircourse in the immediate area, the workings were undamaged. A strong gas feeder had been cut near the entry face. The fan had stopped only 10 minutes before the explosion due to the belt slipping off the pulley. Gas accumulated in the face and was ignited by a miner's open light. Ventilation was quickly reestablished and the bodies removed. The wetness of the entry and the small body of gas prevented spread of the explosion by coal dust.

November 23, 1920; Parrish Mine, Parrish, Ala.; 12 Killed

(From Bureau of Mines report, by J. J. Forbes)

An explosion at 8:45 a. m. brought death to 12 of the 145 men in the mine and slightly injured 8 others. The explosion was confined to one entry which had been "dangered off" because of standing gas. A miner crossed the dangerboard, and the gas was ignited by his open light. Gas accumulated because of inadequate ventilation. There was little violence, and dust was not raised and ignited.

February 12, 1921; Moffatt Nos. 1 and 2 Mines, Oak Hill, Colo.; 5 Killed

(From Bureau of Mines report, by H. I. Smith)

The two mines are connected workings at different levels in the same dipping coal bed. At about 6:00 p. m. a coal-dust explosion from blown-out shots of black powder resulted in the death of 2 shot firers and 3 miners in the No. 2 mine. A pumpman in No. 1 mine escaped uninjured, but a shot firer was overcome and was rescued an hour later. The explosion was violent throughout No. 2 mine and in parts of No. 1.

March 9, 1921; Rahn No. 11 Mine (Anthracite), Seek, Pa.; 5 Killed

(From State inspector's report, 1921)

A booster fan had been shut down overnight. The electricians moved the fan to a new location, and when they threw in the switch accumulated gas was ignited. Five men were killed, 6 injured and 3 escaped uninjured.

August 31, 1921; Harco Mine, Harrisburg, Ill.; 12 Killed

(From Bureau of Mines report, by C. A. Herbert)

The 11th and 12th North entries had been driven toward a connection and stopped. About noon on August 31, a miner drilled through into the face of these entries and ignited gas in the hole with his open lamp. An explosion occurred in the idle entries but did not affect the men who drilled the hole. Smoke and gases were carried over men in 1st and 2d North entries, resulting in the death of 11 men. On September 2 an apparatus crew was exploring for fires during the investigation. Three of the men became distressed, two being able to reach fresh air. The other two carried the third man until exhausted. When found 30 minutes later he was dead. The spalling roof keeps the road dust inert so that dust did not enter the explosion.

January 30, 1922; Layman Mine, Hulen, Ky.; 6 Killed

(From Bureau of Mines report, by C. A. Herbert)

On that night, eight men had gone back into the mine to get coal ready and fix up their places for the next day. Two of the men put in 6 shots on the solid across the face of a 22-foot room. They were heavily loaded with black powder. The fuse was lit, and the men were on the way outside when caught by the explosion. Five of the holes broke effectively, but one blew out, causing a dust explosion that came out the mouth of the drift. A rescue party quickly brought out the 2 injured men and the 6 bodies. The mine was very dusty.

February 2, 1922; Belle Ellen No. 2 Mine, Belle Ellen, Ala.; 9 Killed

(From Bureau of Mines report, by J. J. Forbes)

At 2:15 p. m. the day shift of 200 convict laborers was in the mine when an explosion at the face of the 1st left aircourse off 9th right killed 9 men and injured 2 others. The shift runner examining the face after a blast with an open light ignited an accumulation of gas; the explosion was spread locally by dry coal dust but was stopped by incombustible dust from rock brushing further down the heading.

February 2, 1922; Gates No. 2 Mine, Gates, Pa.; 25 Killed

(From Bureau of Mines report, by J. W. Paul and W. J. Fene)

About 12:45 a. m. the regular night force of 25 men was in the No. 2 main section, about 2 miles from the bottom of the 559-foot shaft, when a local explosion caused the death of all of them, 9 by burns and violence and 16 by afterdamp. The explosion was reported an hour later when a motorman took a trip to the affected area. The afterdamp and smoke passed directly to the airshaft from the split of the ventilating current in the section. Ventilation was restored and the bodies recovered by rescue crews. Apparatus crews were kept in reserve. Two small fires were found and extinguished. The 16 men who were killed by afterdamp had traveled into the return from the explosion instead of escaping into fresh air in the opposite direction (fig. 54). Three shots were fired in succession in a face in which gas was liberated (fig. 55). The mixture of gas, dust, and air was probably

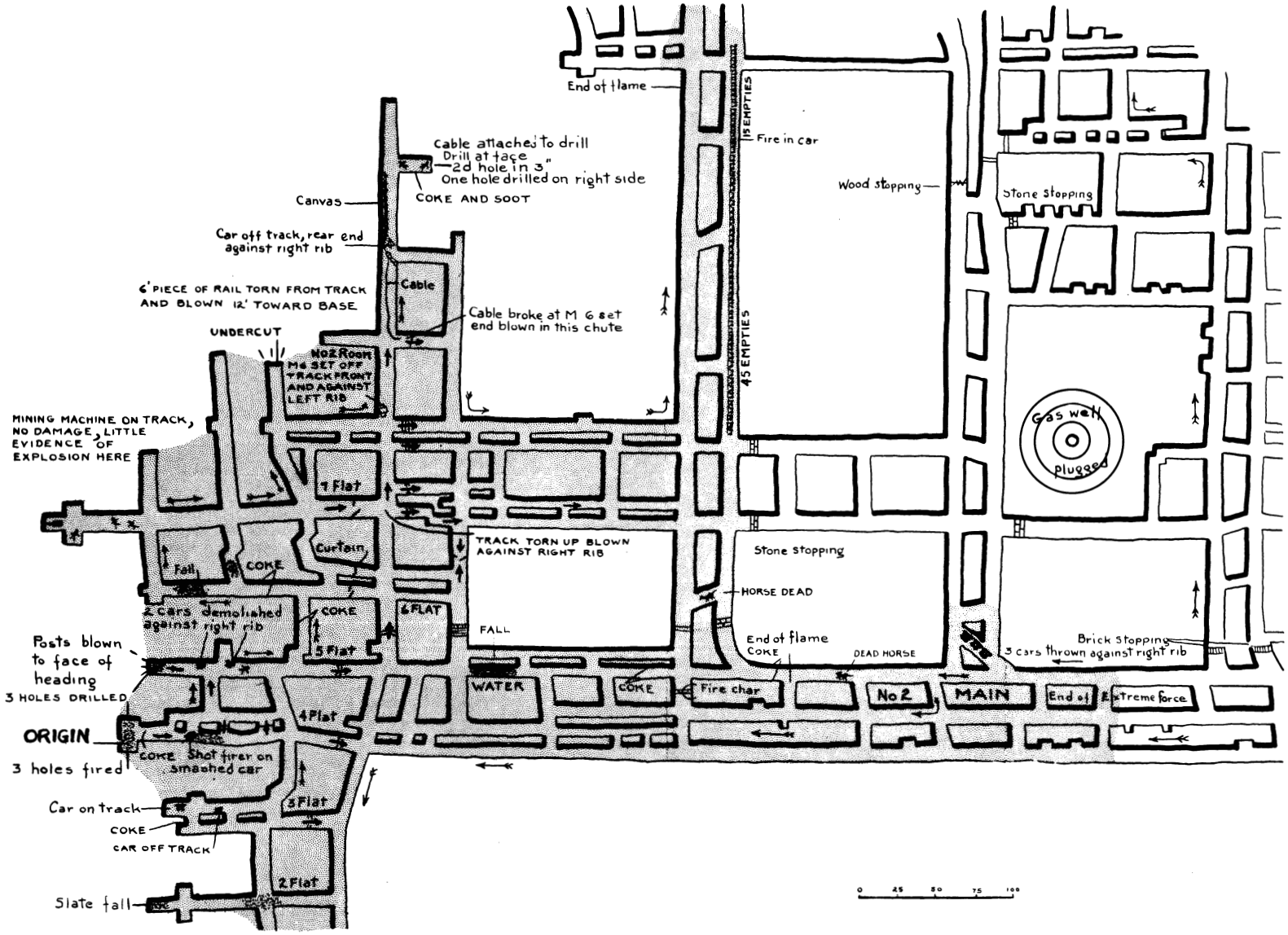


FIGURE 54.—Map of explosion area, Gates No. 2 mine, Gates, Pa., February 2, 1922.

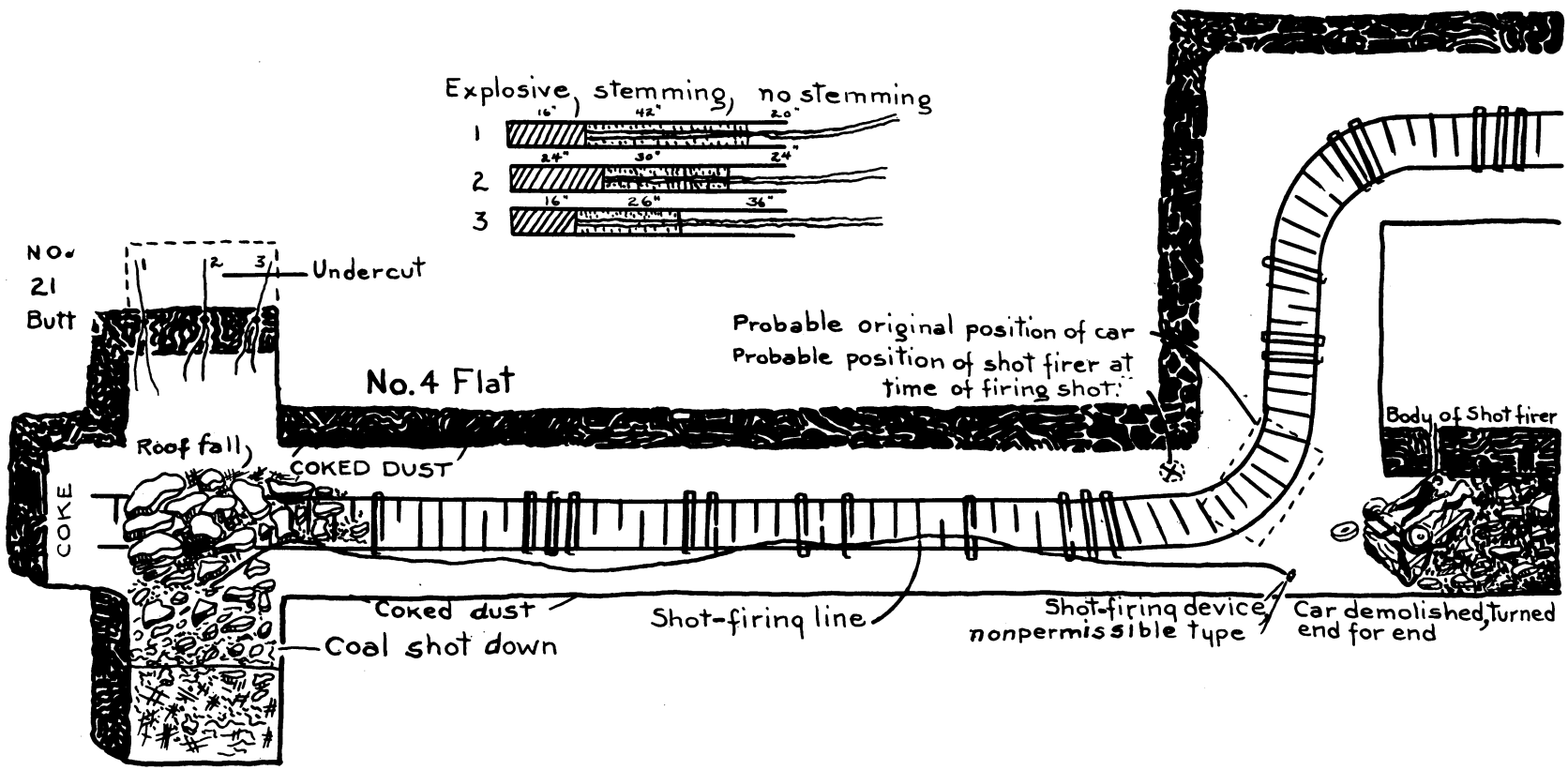


FIGURE 55.—Sketch of No. 4 flat after explosion, Gates No. 2 mine, Gates, Pa., February 2, 1922.

ignited by an arc from the firing wires caused by using a nonpermissible single-shot blasting magneto. The explosion picked up dust but lacked force to propagate because of the spalling of the weak shale roof along the haulage and airways. Sprinkling of face areas was found ineffective.

February 7, 1922; Marietta Mine, Pinson Fork, Ky.; 9 Killed

(From Bureau of Mines report, by L. D. Tracy and C. A. Herbert)

At 4:30 p. m. the men working in this part of the mine had all fired their shots except those in Nos. 1 and 2 rooms on 2d right entry and had gone out to the main entry at the mouth of 2d right. One of the men in No. 2 room told the others he was going to fire a windy shot, and the resulting explosion killed 9 men and burned 2 others. Rescue parties repaired the fan and restored ventilation without need of apparatus. Three blown-out shots of black powder on the solid were found in No. 2 room. This dust explosion was confined to 2d right entry and aircourse.

March 20, 1922; Dilltown No. 1 Mine, Dilltown, Pa.; 5 Killed

(From Bureau of Mines report, by W. J. Fene)

About 7:30 a. m., shortly after the 80 men began work, an explosion confined to a small section killed 5 men in that section. Three others who were overcome were rescued by a foreman and firebosses, who immediately restored ventilation. The weak explosion was caused by ignition of gas by an arc from an electric hoist in room No. 12. The fireboss had not examined the section before the men entered. Dust was involved only to a minor degree.

March 24, 1922; Sopris No. 2 Mine, Sopris, Colo.; 17 Killed

(From Bureau of Mines report, by D. Harrington)

All but 8 of the day shift had come out through the slope by 3:40 p. m. when the explosion spread through much of the mine and up the slope, injuring 2 of the men near the portal. The 17 men in the mine were killed, and many stoppings and doors were demolished. Within 40 minutes the fan was repaired, and rescue crews without apparatus restored ventilation. The company's rescue car and apparatus were at hand but were not needed. The bodies were recovered within 30 hours. Gas accumulations may have been present at several locations in the mine because of inadequate ventilation and doors held open. Ignition was evidently from arcing of nips of cutting-machine cables connected to the trolley wire. The mine was gaseous, electric cap lamps were used, and the dust was dampened from water cars. Gas and dust aided propagation of the explosion.

May 25, 1922; Acmar No. 3 Mine, Acmar, Ala.; 11 Killed

(From Bureau of Mines report, by J. J. Forbes)

At 12:15 p. m. when the explosion occurred, 80 men were in the mine. All escaped but 11 who were killed and 1 driver who was near the slope. The force of the explosion carried him about 50 feet and left him unconscious and burned about the face and arms. The explosion, in a pillar area, was caused when gas that accumulated from some derangement of ventilation was ignited by a miner's open light. The area had not been examined by the fireboss. Dry dust propagated the explosion. Rescue crews with oxygen breathing apparatus explored the mine and extinguished two small fires. Carbon monoxide detectors were used instead of canary birds and worked very satisfactorily. After this explosion the mine was put on closed lights.

September 29, 1922; Lake Creek Mine, Johnston City, Ill.; 5 Killed

(From Bureau of Mines report, by C. A. Herbert (32))

A survey party went into entries that were not working and had not been examined. Ventilation was lacking. Their open lights touched off a gas explosion, killing 5 men and injuring 3 others.

October 11, 1922; Progressive No. 11 Mine, McCurtin, Okla.; 8 Killed

(From Bureau of Mines report, by W. W. Fleming)

The explosion occurred about 8 a. m., when 12 of the miners operating this small slope mine on a cooperative lease were underground. Eight were killed, and 4 found unconscious near the slope were revived by artificial respiration. Eleven men had followed the fireboss into the mine and ignited gas with their open lights. The gas had accumulated in an entry when water shut off the ventilation. The men knew the pump had broken down. No apparatus was used, but line curtains were hung to clear the blocked entry.

November 6, 1922; Reilly No. 1 Mine, Spangler, Pa.; 79 Killed

(From Bureau of Mines report, by G. S. Rice, J. W. Paul, and L. D. Tracy)

At 7:20 a. m. on Monday 112 men had begun work when the explosion occurred, blowing out some stoppings and overcasts and also the side and end walls of the fan housing. Help was called from other mines and from the Bureau of Mines at Pittsburgh. The fan housing was patched and the fan started, making the concrete-lined, 112-foot, main shaft an intake. Recovery workers without apparatus encountered a live man making his way out to fresh air and brought him and four others out. All were badly affected by afterdamp, as were 18 of the rescuers. Apparatus crews were then admitted, and 22 other survivors were rescued. Five other men made their way out unassisted. Seventy-six bodies were found, and 3 of the rescued men died. Gas that had accumulated in one or more rooms through open doors and deficient ventilation was ignited by the miners' open lights. Fireboss examinations were neglected and incomplete. The mine had been rated gaseous in 1918, but at the instance of the new operators it was rated as nongaseous although a fireboss was employed and men were burned by gas on at least 4 occasions. The low-volatile dust of this coal helped to spread the explosion but without great force or flame. Conditions found by the investigators are shown in figure 56.

November 22, 1922; Dolomite No. 3 Mine, Dolomite, Ala.; 90 Killed

(From Bureau of Mines report, by D. Harrington and J. J. Forbes)

The No. 3 slope on a 30° pitch was 850 feet long from the surface to the coal seam at the bottom where a 500-foot yard was opened for handling loaded and empty trips. Electric locomotives hauled trips in the mine, and ropes raised and lowered 3-car trips on the double-tracked slope. About 2:40 p. m. the four-car trip became jammed in the rotary dump in the tipple on the surface. In trying to jerk them free three cars came loose suddenly and ran back down the slope, breaking through a rail stopblock and wrecking at the bottom against a loaded trip. As usual, the runaway cars raised a dense cloud of dust, and this

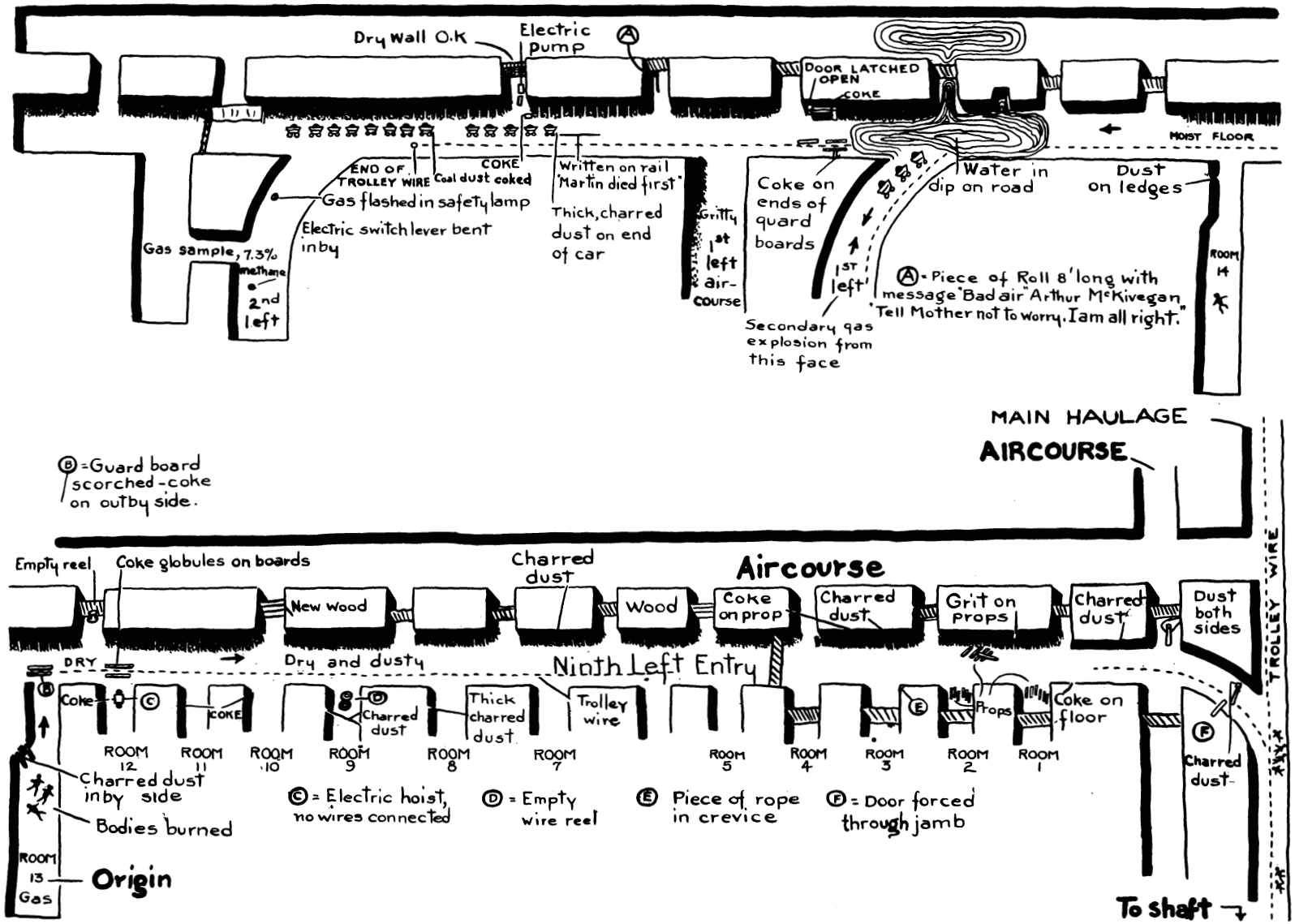


FIGURE 56.—Sketch of 9th left entry after explosion, Reilly No. 1 mine, Spangler, Pa., November 6, 1922.

FIGURE 57.—Slab of concrete from portal, Stag Canon No. 1 mine, Dawson, N. Mex., February 8, 1923.

was ignited by an arc from the 3,300-volt armored cable in the slope caused by damage from the runaway cars. Flame from the mouth of the slope burned the tipple, but there was little violence inby the yard. Because of the expansion into the yard the violence was confined to the yard and slope, and only heat and gasses penetrated beyond. About 475 men were in the mine; of these 90 were killed and 70 injured by burns and afterdamp. Rescue workers quickly removed the injured and dead. Most of the uninjured survivors came out through No. 2 and No. 3 slopes after the air had cleared. About 50 men saved their lives by building a rock stopping in a heading and remaining there until the air cleared (*2, p. 52*). Apparatus was used only for a short time, but rescuers equipped with gas masks found them handy and efficient. Most of the work was done with open lights, as ventilation was quickly restored. Dust had been controlled by sprinkling, but after this explosion the use of rock dust was recommended.

November 25, 1922; No. 4 Mine, Madrid, N. Mex.; 12 Killed

(From Bureau of Mines report, by C. A. Herbert)

About 2:30 p. m. a local explosion in a longwall section resulted in the death of 12 men and injury to 9 others. Men in other parts of the mine were unaware of the explosion. Ventilation of the section was restored and the dead and injured removed. The mine is gassy, and outbursts of gas had been occurring. Ignition was thought to have been from a conveyor motor. Electric cap lamps were used by the miners. The coal is a variety of anthracite, and the dust did not enter into the explosion.

January 10, 1923; Dolomite No. 1 Mine, Dolomite, Ala.; 5 Killed

(From Bureau of Mines report, by J. J. Forbes)

A local gas explosion occurred when a night track crew went into an entry before the fireboss had inspected it. Gas had accumulated, because a door had been left open, and the gas was ignited by their open lights. The five men in the crew were killed by burns and afterdamp. Smoke was noted in the return air, and four firebosses investigated and found the bodies. There was little violence, and the explosion did not propagate.

February 8, 1923; Stag Canon No. 1 Mine, Dawson, N. Mex.; 120 Killed

(From Bureau of Mines report, by D. Harrington)

About 2:20 p. m. an explosion on the main entry spread out the entry to the drift mouth (fig. 57) and over most of the workings, killing 120 of the 122 men underground. After repairing the fan housing rescue workers proceeded inside, restoring ventilation as they went. About 8 o'clock the next morning two men from an isolated section walked out unaided. The explosion demolished rock-dust barriers on the main entry and aircourse without stopping. A locomotive had put two loaded cars on the track after dragging them 100 feet, knocking out several timbers in doing so. The trolley and feed wires came down on the steel cars, and arcs set off the dense cloud of dust disloged from the timbers. The explosion was propagated through the mine by the coal dust. Sprinkling had been confined to wetting cars and floor of entries and was ineffective. Rock dusting and rock dust barriers were recommended.

February 21, 1923; Alliance Mine (Anthracite), Kaska, Pa.; 5 Killed

(From Bureau of Mines report, by J. Henson)

Gas was brought down a raise by blasting. As no check for gas was made it was not detected. When it was ignited by 1 of the men smoking, 5 men were fatally burned and injured.

March 2, 1923; Arista No. 1 Mine, Arista, W. Va.; 10 Killed

(From Bureau of Mines report, by K. L. Marshall)

About 9:30 a. m. on that morning a miner at the face of the main west heading tried to pull down an

undercut face by means of a center shot. Black powder followed by a stick of 60-percent dynamite with a short fuse was placed in the hole and tamped. The shot blew out and raised a cloud of machine cuttings that had not been loaded out. The explosion, propagated by dust, traveled down the heading and into three of the left room headings and the drainage heading. A timber cutter outside the drainage heading saw the explosion and notified the foreman, who hurried in and removed four men. Others were rescued by men using a motor as the afterdamp prevented walking. Rescue crews restored ventilation and reached two other men.

May 5, 1923; Southwestern Mine, Aquilar, Colo.; 10 Killed

(From Bureau of Mines report, by W. F. Sullivan)

On an idle day 10 men were working at odd jobs; advance workings had encountered gas, and electric cap lamps had been ordered but had not arrived. The fan was stopped for 45 minutes, and when it was again running a body of gas was moved over some of the men wearing open lights. The explosion at about 1:30 p. m. killed all in the mine and left it badly wrecked. Dust was stirred up and ignited. As a result two other mines in the State were closed until electric cap lamps were secured.

June 26, 1923; Richards Colliery (Anthracite), Mount Carmel, Pa.; 5 Killed

(From Bureau of Mines Inf. Circ. 6710, table 1)

A set of two doors in a haulageway were too close together to contain a trip and were left open for the trip to pass in and out. An accumulation of gas resulting from the interrupted air current was ignited, killing 5 men. Ignition was from smoking.

August 14, 1923; Frontier No. 1 Mine, Kemmerer, Wyo.; 99 Killed

(From Bureau of Mines report, by D. Harrington and H. E. Munn)

The coal bed pitching 15°–20° is opened by a slope 6,000 feet long; staggered cross entries are 400 feet apart. The explosion, about 8:20 a. m., covered a large part of the active workings but produced comparatively little violence, although the original gas explosion was propagated by dust. Of the 135 men underground, 99 were killed. At least 70 of these men lost their lives by attempting to travel through the smoke and gases and might have been saved if they had remained at the working faces. One group of men under the leadership of a shot firer and a driver barricaded themselves at the face of No. 29 entry, and 21 or 22 of these men came out about 3:00 p. m. after ventilation was restored (*24, pp. 52–56*). Several others who tried to escape before the bulkhead was built were found dead near the slope. Three others remained at their room face on the 28th level and came out at 6:00 p. m. The other survivors escaped during the rescue operations. Apparatus was used in exploring the mine, recovering the dead, and to a certain extent assisting the living. The explosion originated at the face of room 7 of the 30th level, when a fireboss who was restoring a wing brattice that had been disarranged went behind the brattice about 10 feet from the face and attempted to relight his flame safety lamp with a match. Evidently much more gas had accumulated than he expected. Electric cap lamps were used, but coal was shot with black powder, off the solid. Dust was sprinkled but not regularly or thoroughly.

October 7, 1923; Midwest Mine, Palisades, Colo.; 6 Killed

(From Bureau of Mines report, by H. E. Munn)

About 10:40 on Sunday morning seven men were in the mine to do clean-up work. Six of these men, including the superintendent, were killed when methane was ignited by their open lights during an attempt to move an accumulation. Gas accumulated overnight when the fan was stopped. Great force and heat were manifest in the area, and coal dust was involved. Spread of the explosion along the haulage road was stopped by a wet zone of 100 feet. The lone survivor was rescued soon after the explosion; apparatus was used in recovering three of the bodies before ventilation was restored.

November 6, 1923; Glen Rogers Mine, Beckley, W. Va.; 27 Killed

(From Bureau of Mines report, by J. W. Paul)

The mine had been producing coal for only 1 year. The 2 shafts were 648 feet deep and were connected, but all ventilation and hoisting were through the airshaft, which was divided by a concrete curtain wall. The mine was gassy, and several nonfatal ignitions had occurred. There were 64 men in the mine, 25 of whom were killed by force or heat and 2 were drowned by falling into a water-filled excavation near the airshaft where a hopper was to be installed. The other 37 men were not affected and were organized into a recovery crew by the foreman. Breathing apparatus was at hand but not used. The explosion was ignited by an arc from an electric drill at an entry face where ventilation had been interrupted by a disarranged curtain and an open door. The roadways were wet, but dust added to the intensity of the explosion. Figure 58 gives details of the course of the explosion.

December 7, 1923; Black Hawk Mine, Happy, Ky.; 9 Killed

(From Bureau of Mines report, by H. Cote)

At the time of the explosion between 3 p. m. and 4 p. m. most of the men had completed their work and gone home; 16 men were in the mine. The explosion at the face of room 1, 5th right entry, passed out the main haulageway and instantly killed a miner standing at the drift mouth, blowing him 150 feet into a gulch. Six others in the mine were found dead, and 7 were recovered or escaped after injury from flame and gases, two dying after removal. Three others escaped uninjured. Little damage was done to the mine, and the fan was soon restored and the bodies recovered. Misplaced, blown-out shots of black powder on the solid caused a dust explosion (fig. 59).

January 25, 1924; McClintock Mine, Johnston City, Ill.; 33 Killed

(From Bureau of Mines report, by C. A. Herbert)

The 1st stub entry off 11th north east pillar section had begun to squeeze, and the night before the explosion the fireboss had marked off the 1st stub as a precaution against a release of gas. The foreman examined the rooms the following morning and finding no gas directed two trackmen to finish removing the rails and switches. At about 2:40 p. m. gas from the broken roof in the squeezed rooms came in contact with the open lights of the trackmen, causing a local explosion that was propagated by coal dust over a limited area. There was little violence, and the spread was halted by clay dust where grading had been done on the 11th north entry. The explosion was not felt

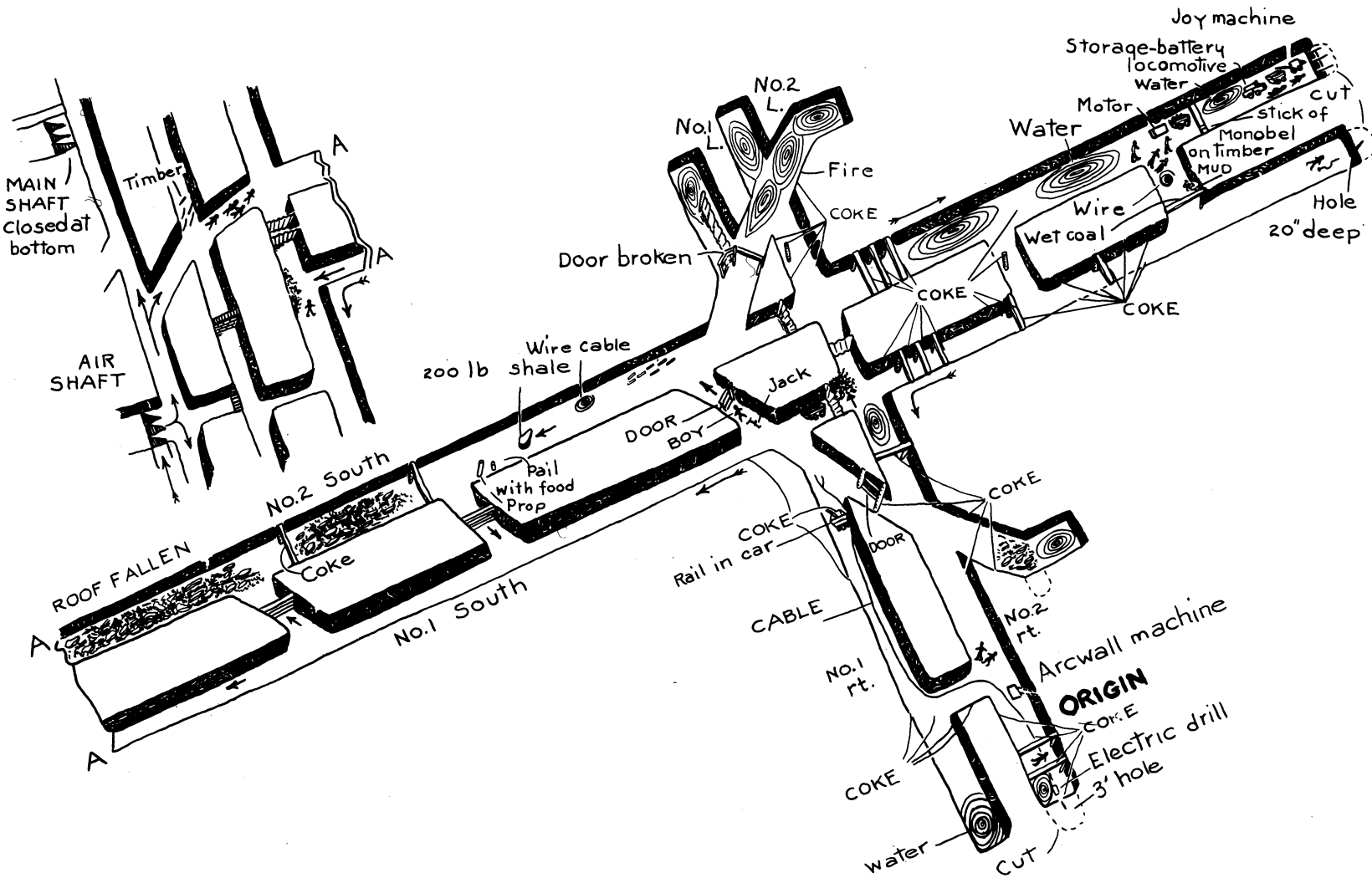


FIGURE 58.—Sketch of explosion area, Glen Rogers mine, Beckley, W. Va., November 6, 1923.

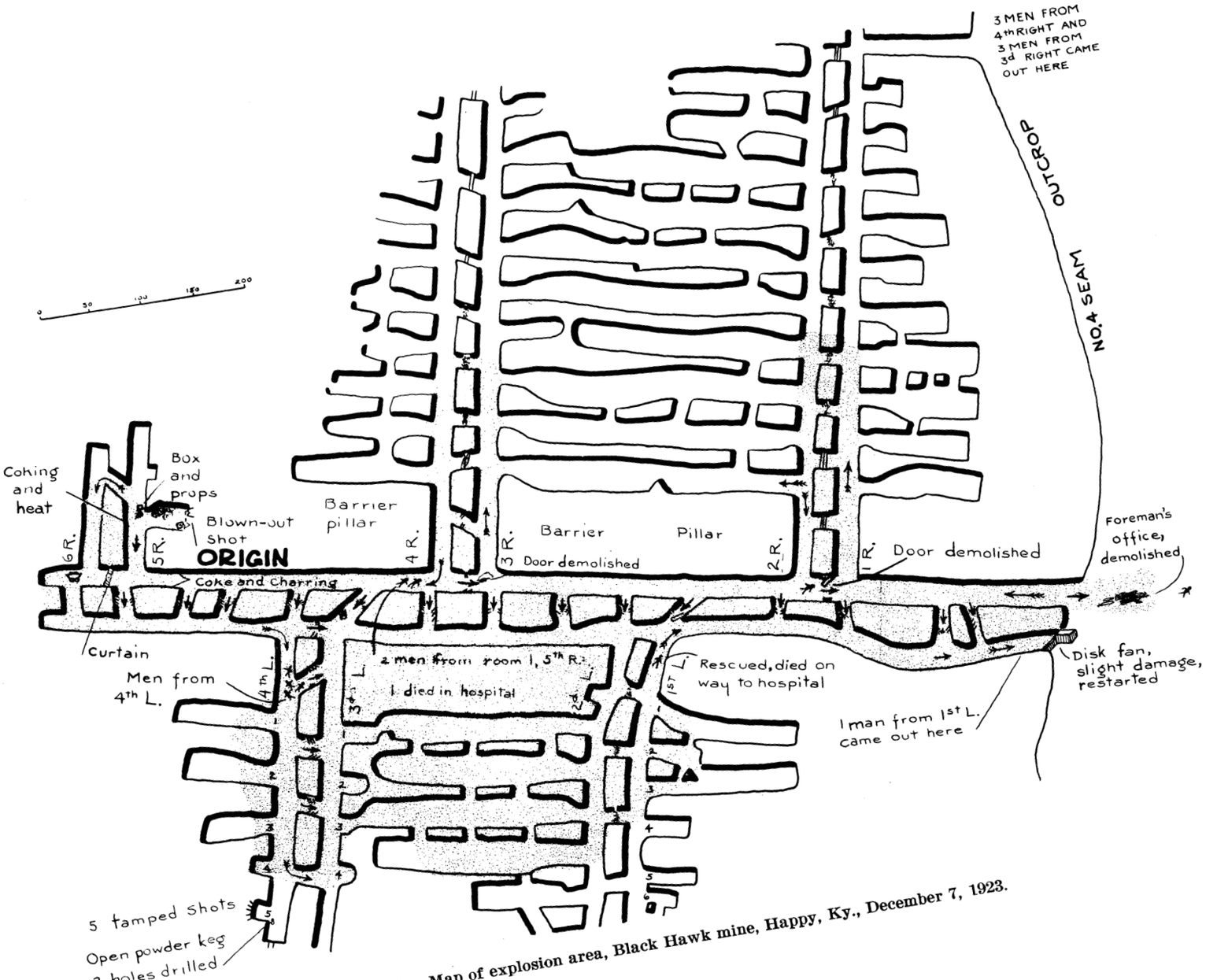


FIGURE 59.—Map of explosion area, Black Hawk mine, Happy, Ky., December 7, 1923.

at the shaft bottom, but smoke and fumes were noted on the return-air side and help was called. Electric cap lamps kept for emergencies were issued to rescue crews, who started to look for the men trapped by the spreading smoke and gases. Several groups had retreated to entry faces and erected temporary seals (*2, p. 35*). One group of 47 telephoned to the outside that gas was leaking through their brattice and were released after being shut in for 6 hours. Other smaller groups were not reached in time, and only five of the unconscious men were revived when found. Of the 370 men in the mine, 32 were found dead, 8 were injured (of whom 1 died afterward), 47 were rescued unharmed, and 330 escaped unaffected. Damage to the mine was negligible; the loss of life was charged to use of open lights, neglected ventilation, lack of rock dust, and possible nonuse of self-rescuers. A gas mask used by J. E. Jones of the Old Ben Coal Corporation was a distinct aid to exploration ahead of fresh air.

January 26, 1924; Lancashire No. 18 Mine, Shanktown, Pa.; 36 Killed

(From Bureau of Mines report, by J. W. Paul)

About 3:00 p. m. when the explosion happened, there were 47 men in the mine; 36 were killed and 11 escaped unhurt. The explosion originated at an aircourse face, where a "flameproof" mining machine had ignited gas. The ventilation of advanced faces was makeshift and irregular, and the cover of the rheostat on the machine was loosely bolted and part of the gasket missing; arcing was evident. The explosion, fed by dust, extended into a neighboring set of entries and up the slope with decreasing violence. At the surface the fan housing was slightly sprung and a volume of smoke and dust blown out of the main slope. Twelve men in 6th right felt the concussion and 11 escaped by a surface opening. One man went to the main slope and died there. All of the men in the gassy section beyond 6th right were killed where they were; the others died from afterdamp. Rescue teams with apparatus searched the mine and helped to recover the bodies (fig. 60). Operation of the mine was discontinued.

March 8, 1924; Castle Gate No. 2 Mine, Castle Gate, Utah; 172 Killed

(From Bureau of Mines report, by D. Harrington, B. W. Dyer, and H. E. Munn)

On that morning 171 men were in the mine, including the foreman and safety inspector. The three firebosses had reported no gas and had gone back in after the shift went on at 7:30 a. m. At 8:20 a. m. there were the sound and shock of a heavy explosion, followed a minute or so later by a second weaker puff. About 20 minutes later a third and more violent explosion occurred. The first and third explosions blew debris and smoke from the mine portal and the explosion doors at the fan opening. The explosions inside the mine were extremely violent and reached all parts of the mine. The explosion was the most widespread as well as the most violent in the experience of the investigators. The bodies of many victims were dismembered, cars, concrete stoppings and overcasts were totally wrecked and destroyed, and all loose material was torn from the ribs, although track and pipelines on the floor were hardly disturbed. The explosion started as a methane ignition in a room where a fireboss had started to move a body of gas in a pothole in the roof, left from shooting down top coal the previous night. He placed his cap and carbide light on the floor between the face and the pile of coal. He was using the water hose to brush the gas from the hole. His small, keylocked flame safety lamp was extinguished, and since the igniter had been plugged he disassembled it and took it to his cap lamp to relight. In doing so the gas was ignited, which communicated to stirred-up coal dust, and gas from other pot holes and standing in marked-out rooms. Fires were set, and the following explosions occurred when air movements or roof falls pushed gas and dust over them. The fan was restarted soon after the explosion, and rescue efforts were organized and underway by afternoon. Before experienced apparatus men arrived a member of a crew from a neighboring mine was killed by inhaling carbon monoxide due to removing his nose clip in some way. Later 3 shifts of 8 crews worked 8 days exploring the mine, extinguishing fires, and recovering bodies. The firebosses ignored gas in "potholes" in reporting the mine clear. Sprinkling, although carefully and thoroughly done, did not halt the propagation of the explosion. Magnetic locked safety lamps and rock dusting were recommended and to some extent adopted, together with more careful gas examinations. The use of rock dust followed a long period of study.

March 28, 1924; Yukon No. 2 Mine, Yukon, W. Va.; 26 Killed

(From Bureau of Mines letters and Inf. Circ. 6802 (15, p. 19))

The No. 2 mine, connected to the No. 1 workings, was in an isolated location. Three miners taking a short cut to their working places through unventilated abandoned workings set off gas with their open lights at 7:25 a. m. Dust was stirred up, and a violent explosion spread over much of the mine. The mine was very dry and dusty although an attempt was made to water haulageways once or twice a day. Of the 32 men in the mine, 26 were killed and 4 injured, and 2 escaped uninjured. Rescue and recovery crews, with some apparatus, removed the bodies and restored ventilation.

April 28, 1924; Benwood Mine, Benwood, W. Va.; 119 Killed

(From Bureau of Mines report, by J. W. Paul)

At 7:10 a. m. as the day-shift men reached their working places an explosion killed all of the 119 men in the mine. The 2 firebosses had reported the mine free of gas and had returned with the men. A miner found a fall of 8 feet of roof 22 feet from the room face. Thinking that the fall had been examined by the fireboss he went over it and ignited gas. The mine was dry and dusty, and the explosion carried through every part of the mine (fig. 61). The recovery work was very difficult, as the main entry from the bottom of the hoisting shaft was caved by roof falls for over 4,000 feet. Entrance was made by the new airshaft, which was not accessible by road and which was not equipped with a hoist. Breathing apparatus was kept in reserve and gas masks were used for most of the advance work (fig. 62). Although the mine was gassy, open lights were used before the explosion, and sprinkling and ventilation were inadequate. Better ventilation would have been provided when the connections to the airshaft were completed. The chief inspector of the State recommended rock dusting, use of electric cap lamps, and permissible equipment in all mines in the State in which gas was present.

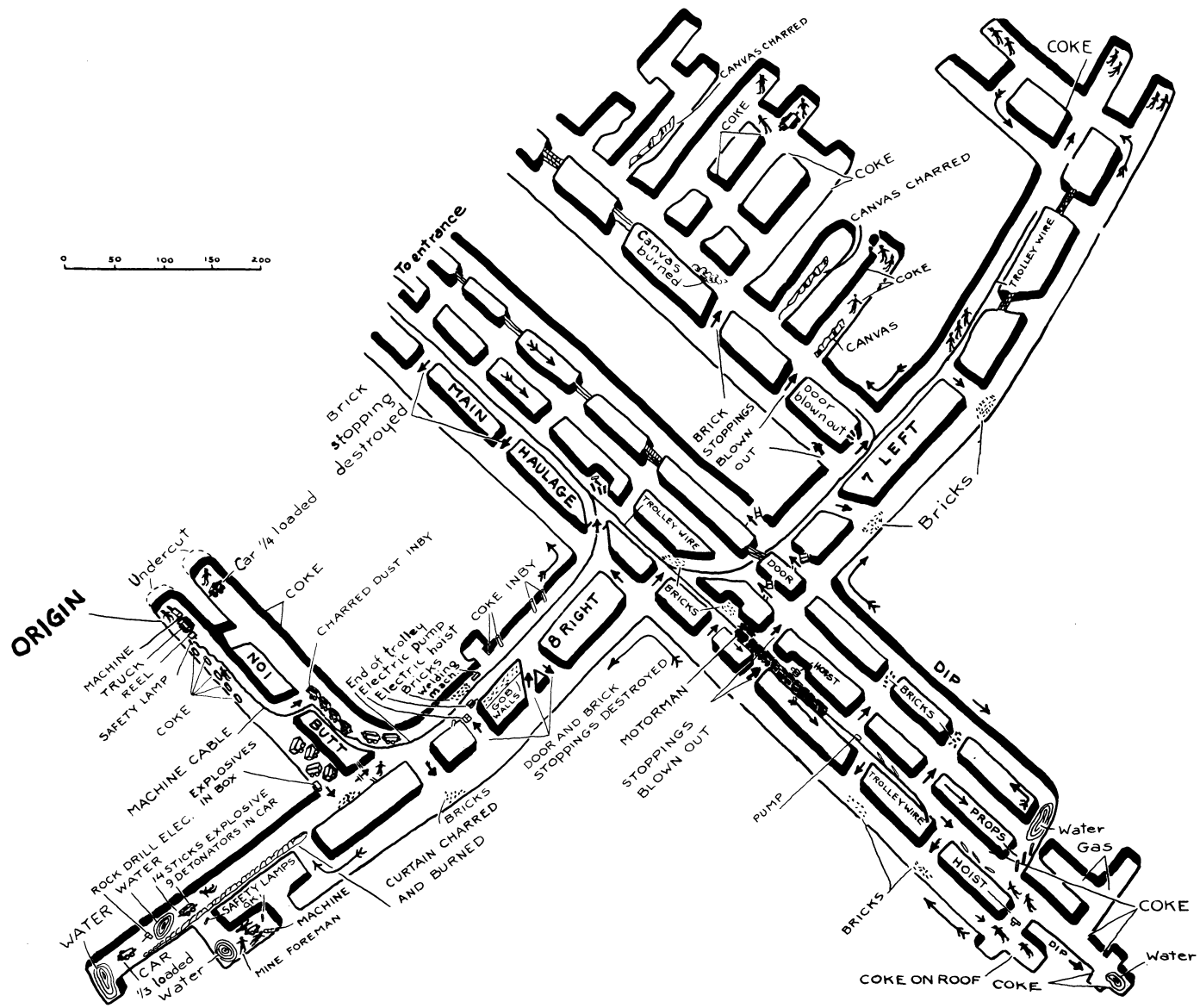


FIGURE 60.—Map of explosion area, Lancashire No. 18 mine, Shanktown, Pa., January 26, 1924.

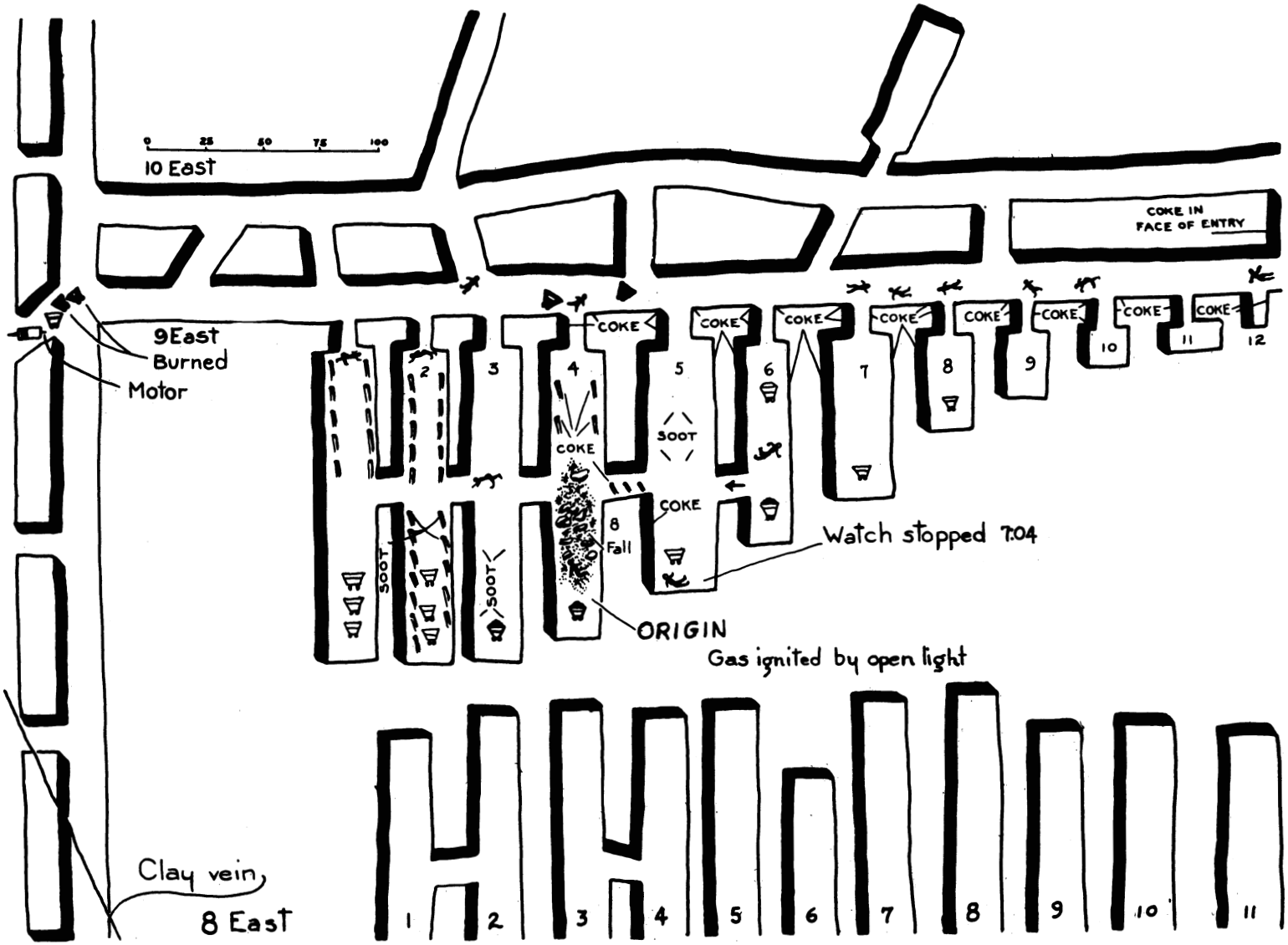


FIGURE 61.—Sketch of area at origin of explosion, Benwood mine, Benwood, W. Va., April 28, 1924.

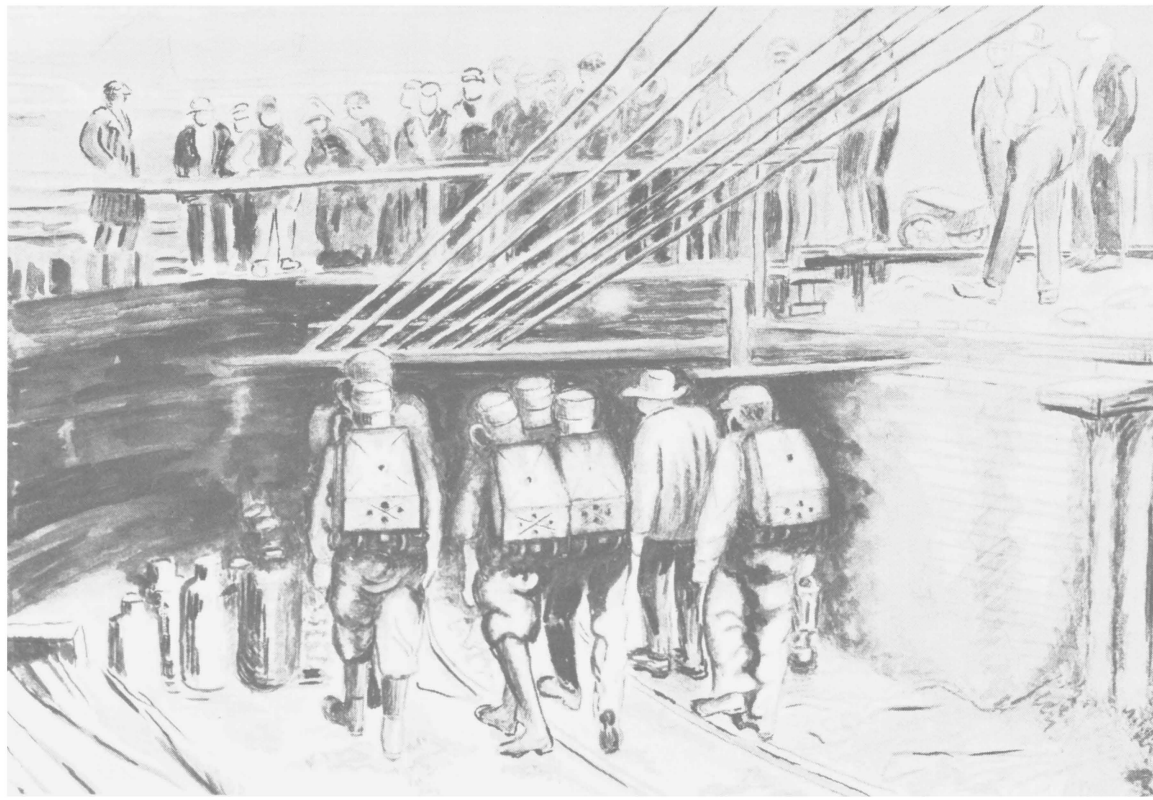


FIGURE 62.—Federal Bureau of Mines rescue crew entering Benwood mine, Benwood, W. Va., after explosion, April 28, 1924.

June 6, 1924; Loomis; Loomis Colliery (Anthracite), Nanticoke, Pa.; 14 Killed

(From Bureau of Mines report, by J. W. Paul and D. C. Ashmead)

A part of one section of this very gassy mine was on a squeeze and pillars were being robbed. A door had to be replaced, and during the change the air current was not directed into the robbed section, although canvas had been furnished for the purpose. Gas accumulated, and when the new door was in place the accumulation was moved through a crosscut where it was ignited by a miner striking a match to smoke a cigarette. The miner had left his working place and had gone to the crosscut to smoke undetected. The explosion resulted in 14 deaths; 6 other men were injured or were affected by afterdamp. Electric cap lamps, locked safety lamps, and storage-battery locomotives were used in that part of the mine. No locomotive was there at the time.

July 25, 1924; Gates No. 1 Mine, Brownsville, Pa.; 10 Killed

(From Bureau of Mines report, by J. W. Paul)

The night shift of coal cutters, timbermen, shot firers, and sprinklers to the number of 40 men were in the mine at 7:30 p. m., when an explosion in the 6 and 7 west butts section killed the 10 men in that area—6 by violence and heat and 4 by afterdamp. The crews in other sections were unaware of the explosion, which was confined by the thorough watering system. A fall in an unventilated, robbed-out section pushed gas into the live workings, where it was ignited by arcing of machine cable nips. The rush of air swayed the cable. The explosion was intensified by coal dust in the area until terminated by the release of pressure and dampness.

September 16, 1924; Sublet (No. 5) Mine, Sublet, Wyo.; 39 Killed

(From Bureau of Mines report, by E. H. Denny and K. L. Marshall)

The explosion, about 11:45 a. m., gave little surface evidence; two distinct reports and a cloud of dust came from the mouth of the rock slope. Most of the 39 victims were quickly killed by flame and suffocation. Twelve men of the 7 south entry walked out of the rock slope some hours after the explosion. Rescue experts and crews with apparatus were gathered from neighboring mines and from a distance, and labored until Oct. 14 to restore ventilation and recover the bodies, under the difficulties of rock falls, flooded workings, and general wreckage. The 12 north entry in which the explosion originated was caved for almost the entire length. Enough gas was regularly given off in the mine to entail immediate hazard if ventilation was even temporarily interrupted. Edison electric cap lamps were used; but regular tests for gas were neglected. Dust was sprinkled on entries and slope. Gas accumulated in 12 north when a timber crew deranged a line curtain; it was ignited by an arc from a locomotive trolley. Dust and gas spread the explosion to almost all parts of the mine. Rock dusting, improved ventilation, and permissible equipment were recommended.

September 21, 1924; Rains Mine, Rains, Utah; 5 Killed

(From Proceedings, Rocky Mountain Coal Mining Institute, 1925, pp. 104 and 105, and from a report to the Bureau of Mines by Bert Dyer, Federal Geological Survey)

On this Sunday 30 men who had been loading coal and rock dusting the slope and an entry had left the mine a little before 6 p. m. when the explosion happened. Five machine men were at work, and all were killed. The mine openings for a distance of 1,000 feet from the portals were in a burnt-coal area and were heavily timbered. These timbers were blown out, inside airshaft was wrecked, and damage done over most of the mine. Gas accumulated while the fan was stopped for repairs and was ignited by an arc from one of the machines. Dust and gas spread the explosion, although the flame was stopped where entries and the slope were rock-dusted. Electric cap lamps were used, but on this shift no examination was made for gas.

December 17, 1924; Burnett Mine, Burnett, Wash.; 7 Killed

(From Bureau of Mines consultant report, by Geo. Watson Evans)

A night shift of 8 men had gone in at 4 o'clock in the afternoon. At 6:00 p. m. an explosion in the gangway at No. 6 chute killed 7 and injured 1 of this crew. The explosion was local in character, and while coal dust was stirred up and burned at the point of origin, the rapid release of pressure prevented propagation. Most of those killed were suffocated. A large fall of roof in No. 6 pillar forced gas down into the gangway where it was ignited by a locomotive that was pulling a rope to hoist timbers up No. 9 chute and was "arcing and sparking near No. 6 chute." These conditions of gas and open equipment were usual in the mines of the district. Electric cap lamps were used, and the haulageways were sprinkled every other day. Rescue crews removed the injured man and the bodies within a short time.

January 15, 1925; Diamond No. 1 Mine, Providence, Ky.; 6 Killed

(From Bureau of Mines report, by C. A. Herbert)

Normally the mine is wet or damp except on the 10th south entries, which were dry and dusty. Usually the coal is undercut before shooting with black powder and fuse. The miners load and tamp their shots, which are fired by shot firers after the shift is out. Some places are shot on the solid, as was done at the face of 10th south at 4:45 p. m. on this day. Three shots were overcharged and poorly placed. A dust explosion traveled from the entry face to the slope entries, where the flame died out. The force extended partly along the slope entries, which were damp. Two shot firers in 10th south were killed by violence; 4 men found on the slope entry at 10th south had walked there from their working place and had died from afterdamp. The only other man in the mine escaped uninjured. The bodies were recovered by restoring ventilation without using apparatus. Gas is not found in the mine, and open lights are used. Permissible explosives and rock dust were recommended, also use of water on cutter bars.

February 20, 1925; City Mine, Sullivan, Ind.; 52 Killed

(From Bureau of Mines report, by C. A. Herbert)

About 10:45 a. m. 106 men were in the mine, when an explosion killed 51 and injured another, who died later. The others from the south side of the mine escaped uninjured up the stairway in the airshaft. The fireboss had reported the north section free from gas that morning, for the first time, showing no gas in the main east entries. At 10:00 o'clock the mine foreman was told that rooms in 4th north entry were squeezing; before he reached there the explosion occurred. Rescue crews were called, a larger fan motor was installed, and ventilation was restored. Gas masks were used ahead of fresh air. Gas released in the poorly ventilated squeezed area was ignited by open lights; the explosion was propagated by coal dust. Closed lights, rock dusting, and on-shift gas tests were recommended.

This occurrence stirred up the argument over use of open lights. The miners of this field, some of the operators, State officials, and interested suppliers contended that use of electric cap lamps would lead to poorer ventilation and failure to detect gas. The Bureau of Mines affirmed its stand against use of open lights.

Rescue crews equipped with approved oxygen breathing apparatus and trained in safe team procedure performed dangerous tasks at fire and explosion disasters. The precautions taken to prevent exceeding the capacity of the apparatus and of the men made possible organized exploration and recovery without waiting for restoration of ventilation and clearing unbreathable atmospheres from the workings. Because of the failures that did occur, sometimes fatal to an apparatus man, leaders of rescue operations restricted the use of apparatus crews to necessary explorations and assistance in prompt advancement of fresh air. Figure 63 shows a crew controlling a mine fire. Types of approved oxygen breathing apparatus included the Fluess-Davis (Proto), the Paul, the Gibbs, and the McCaa. The Fluess-Davis, the Gibbs, and the McCaa are shown in figures 64, 65, and 66. Training was carried on at central stations and at mines by personnel of mine rescue cars. Figures 67 and 68 picture crews receiving this training in 1926.

March 17, 1925; Barrackville No. 41 Mine, Barrackville, W. Va.; 33 Killed

(From Bureau of Mines report, by J. W. Paul)

The mine is developed by 3 shafts, 309 feet deep. At 9:30 p. m. an explosion caused the apparent instant death of the 33 men known to be in the mine and 40 horses. The damage in the mine was not very severe, but the main shaft, the headframe, and surface buildings were wrecked (fig. 69). Damage to the other shafts was moderate. The stairway in the man-shaft was usable, and the fan was restarted after the housing was patched. The surface shock and report were felt and heard for distances up to 100 miles, probably brought about by a violent secondary explosion in the tipple. Rescue crews were gathered, and ventilation was brought along behind apparatus and gas-mask crews (fig. 70). A fire discovered on the second night, close to gas accumulations, was heroically fought and sealed off. The mine was large, and the men were in scattered face locations. All were recovered within 5 days. Some bodies were dismembered, and some mine officials believed that parts of another unidentified

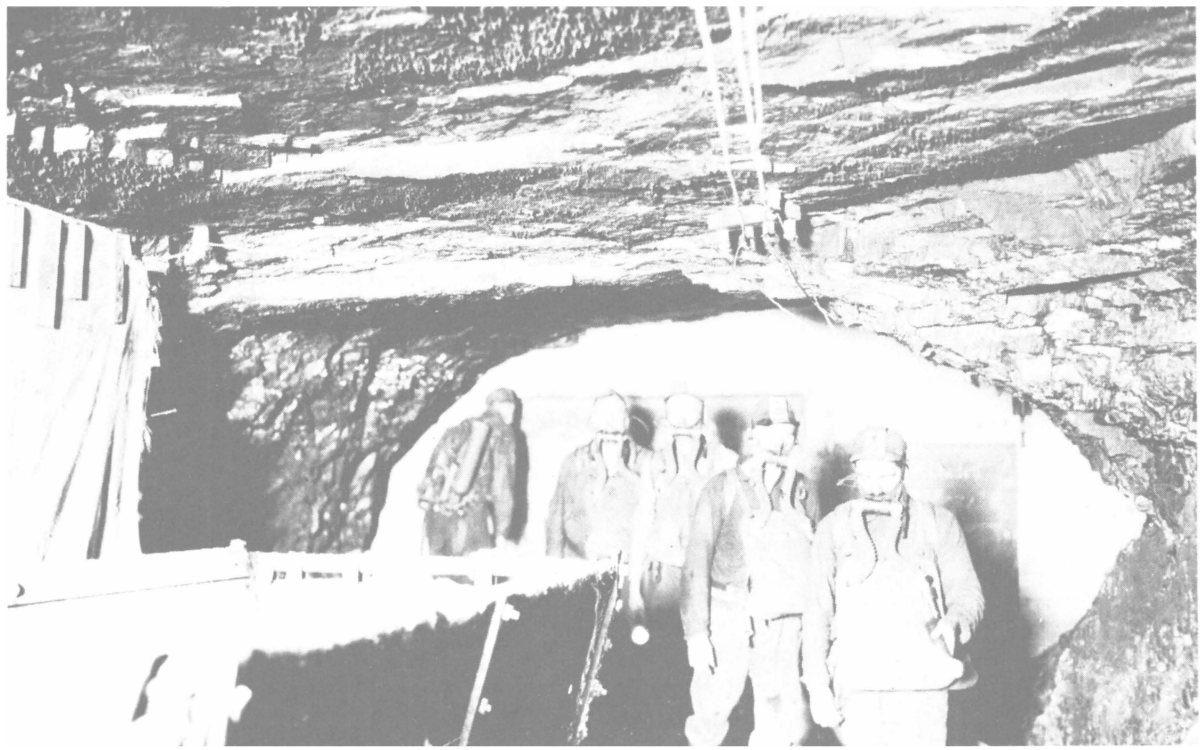


FIGURE 63.—Mine rescue crew leaving sealed fire area, Sunnyside No. 2 mine, Utah, September 1921.

body were found. Testimony on this point was not conclusive. The origin was thought to be an ignition of gas in a place where gas was found after the explosion. An accumulation might have occurred when a door was left open and an arc produced by a mining machine or its cable in return air. Although the mine was sprinkled it was dusty throughout. Rock dusting was to have been started soon. Coal dust propagated the explosion over most of the mine; and where deposits of fine dust were dislodged, as in the hoisting shaft and tipple, they boosted the explosion locally and sent pressure waves in two directions.

The teamwork and mutual respect between the State inspectors, the mining-company officials, other expert rescue leaders, and the Bureau of Mines representatives made the recovery operations on this occasion an example of efficient organization and accomplishment.

April 26, 1925; Hutchison Mine, Millgrove, Pa.; 5 Killed

(From Bureau of Mines report, by F. E. Cash and C. W. Owings)

The mine was in an early stage of development. A single rock slope on an 18° pitch had been driven 700 feet to the coal and 200 feet into the coal. The four men employed in the slope were carpenters who were building forms for concrete work. The fifth man, a signaler, was on the incline of the tipple when the explosion came about 10:00 p. m. He was blown to bits, and the four men in the slope were also badly mangled. The slope was cleared by compressed air for 300 feet; then the line was extended 150 feet by a crew using gas masks, permitting recovery of the bodies. Gas at the foot of the slope was ignited by an arc from electric-light wires. There was great violence because of the confined space. Coal dust added slightly to the force of the explosion.

May 22, 1925; Woodward Mine (Anthracite), Edwardsville, Pa.; 7 Killed

(From the Patriot, Harrisburg, Pa., May 23, 1925, and State inspector's report)

Three men were killed and 5 others seriously injured by an explosion of gas yesterday afternoon. Four of the injured died after removal to the hospital. Gas accumulated because a door was left open and it was ignited by an arc from a cable-reel locomotive.

Five of those killed or injured were haulage or day men, brattice men, and timbermen; two were miners. Most of the men working in the section were either out of the mine or on their way out at the time the explosion occurred. Only minor damage was done to the workings in the section.

May 27, 1925; Carolina Mine, Farmville, N. C.; 53 Killed

(From Bureau of Mines report, by J. J. Forbes and C. W. Owings)

The mine was started about 1775 as prospect shafts and was operated up to and during the Civil War. In 1922 it was reopened through a rock slope and two aircourses in the coal. About 9:30 a. m. smoke was noticed issuing from the fan. The superintendent and the mechanic went down the slope and found six men unconscious behind the door in second right. They car-

ried these men into fresh air on the slope then went up to a telephone near first right and called outside to have the explosion door closed at the fan and to ask for help from the nearby Cummock mine. While the mechanic repaired and closed the door at first left, the superintendent went into first right to an overcast and then returned to the main slope. He had gone up the slope about 150 feet when a second explosion occurred. He dropped to the floor and held to the track with hands and feet while debris passed over him. He was bruised and affected by afterdamp but managed to crawl to the surface. Help was requested from the Bureau of Mines, and rescue cars reached the mine the next day. The bodies of the 53 men who were in the mine were removed by May 30. The first explosion originated in a blown-out shot in the face of 4th right entry. The overcharged shot of permissible explosive was stemmed with coal dust and fired into an explosive mixture of gas and dust. The shot and another which burned but did not blow out were fired on the solid.

FIGURE 64.—Fleuss-Davis oxygen breathing apparatus, 1924.

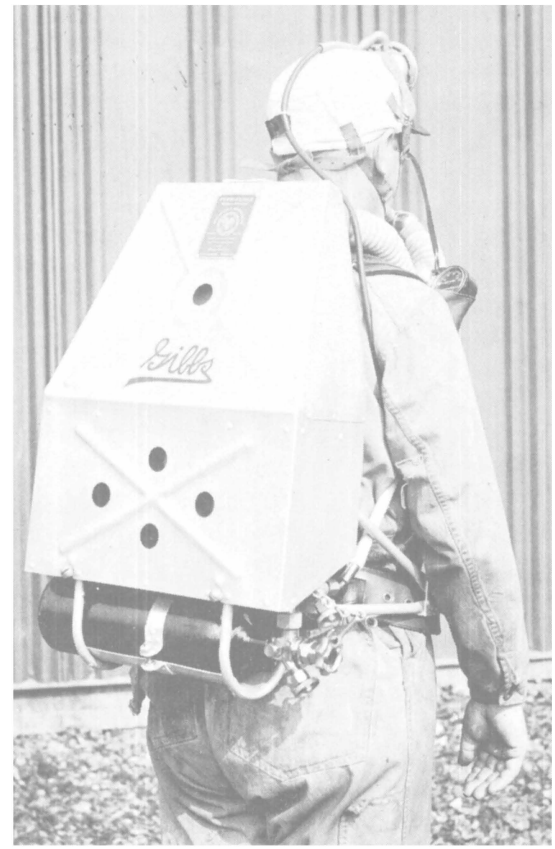


FIGURE 65.—Gibbs oxygen breathing apparatus, approved 1920.

Dust and gas from sluggish ventilation propagated the flame and moderate violence over some parts of the mine. Expansion and water limited the spread. In 4th left a sack of explosives in a mine car was set smoldering, and the closing of the repaired door in 1st left provided air to increase the rate of burning until the explosives detonated and set off a second explosion. Electric cap lamps were used; but gas was present throughout the mine, and excessive charges were fired on the solid. No rock dust was used or sprinkling done.

May 31, 1925; Piper No. 2 Mine, Piper, Ala.; 6 Killed

(From Bureau of Mines letter reports, by J. J. Forbes and F. E. Cash)

A fire in this mine was sealed about March 26. By May 11 samples from the sealed area showed no carbon monoxide, but caution was given against opening the seals without having a trained apparatus crew present to explore the area. On May 29 the seals were opened by an untrained crew without notice to the State inspector. Nothing more was done until the morning of May 31, when six men entered the area. A gas explosion occurred, which killed all of the crew by burns and violence. Another crew removed the bodies, and while they were replacing the stoppings a second blast occurred which bruised but did not kill them. A third blast followed but resealing was completed.

FIGURE 66.—McCaa oxygen breathing apparatus, approved 1925.

June 8, 1925; No. 9 Mine, Sturgis, Ky.; 17 Killed

(From Bureau of Mines report, by C. A. Herbert)

The mine has 2 shafts 420 feet deep. The explosion, at 8:45 a. m., was confined to the un-rock-dusted portions of the 3d and 4th entries off the east slant. Of the 200 men in the mine, 54 were in the east slant section; all 16 men in 4th left and those in 3d left were killed; the others in 1st and 2d left escaped. The bodies were recovered without employing breathing apparatus, but gas masks were used. The bodies from 4th left were badly burned. The origin, in a room off 3d left, was an ignition of methane by an open light. The gas had not been found or reported by the fireboss. The explosion was propagated by coal dust but was confined to a limited area by shale dust applied with a distributing machine made by the mine and by dust left by taking up bottom in 4th left. After this occurrence the rooms were rock-dusted, as well as the entries, and electric cap lamps were installed.

July 23, 1925; Rockwood Mine, Rockwood, Tenn.; 10 Killed

(From Bureau of Mines report, by F. E. Cash)

The mine, opened in 1876, has a main haulage level branching from the slope 600 feet down. During April a fire occurred from the ignition of gas feeders in a section off the main haulage level more than 2 miles from the slope. A pair of entries 1,300 feet long were sealed and reopened July 18. On July 22 smoldering coals were discovered, and a crew of 11 men under the superintendent and the foreman was gathered at the fire about 1 a. m. July 23. The section contained accumulations of methane on both sides of the fire; and the entry, in which the men were moving and watering the burned material with buckets, was filled with gas from the roof to within 2 feet of the floor.

The fireboss was sent to make a fireboss run over other sections of the mine at 2 o'clock. At 5:10 a. m., when he was returning to and within 2,000 feet of the fire, an explosion occurred, followed closely by another of greater violence. His safety lamp was extinguished, and he was knocked down. He walked out about 1,200 feet with the aid of a flashlight until he found a mule and a mine car and rode to the slope bottom and was hoisted outside. Help was called, and 2 bodies were found, badly mutilated, 600 to 800 feet outby the fire and 50 feet outby the waterhole, from which the water had been carried to the fire. The other bodies were in the smoke, which was steadily expanding in area.

New seals were put up, enclosing double the original area. The seals were opened by organized apparatus crews under Bureau and State experts from West Virginia and Tennessee on October 22 and 23, 1925; the remaining eight bodies were removed, and the area was ventilated. The gas was ignited either by the fire or by an open lamp carried by one of the victims; all had unlocked flame safety lamps.

The explosion was propagated by dust to water pools on the incoming entries. Explosion hazards found during the investigation included thick layers of dry dust, persistent methane, poor ventilation, open lights, open-type electric equipment, gasoline locomotives, solid shooting, and overcharged holes. The recovery work, accomplished without loss of life or injury, was notable because of the existing hazards.

August 3, 1925; Dorrance Colliery (Anthracite), Wilkes-Barre, Pa.; 10 Killed

(From State and company inspectors' reports and news accounts)

Two chambers were being driven to the dip, and an electric hoist on the gangway handled the mine cars to and from the faces. The chambers had been advanced 5-crosscut distances from the gangway, and 8 men worked at the faces of the 2 chambers and a crosscut. Haulage was through the second open crosscut from the faces, where a single door was installed. Air entered through the airway and returned through the haulage chamber.

Although methane was known to be liberated freely at the working faces and gas feeders could be heard, the ropeman blocked the door open while changing cars. Methane accumulated, and when the door again was closed the accumulated gas was pushed over one of the men at the face as he was lighting a cigarette with a match. The other men were at lunch on the gangway. A total of 17 men were in the affected area, 2 of whom were killed outright. The other 15 men were burned but walked out unassisted. Eight of these men died within 10 days; the remaining 7 recovered.

November 13, 1925; Finley Mine, Madisonville, Ky.; 5 Killed

(From Bureau of Mines report, by G. T. Powell)

The night shift of seven men was in the mine. At 11 o'clock a round of holes was lit, and all the men came out to the safety chamber in a crosscut near the

FIGURE 67.—Rescue team training with McCaa oxygen breathing apparatus, Federal Bureau of Mines rescue car, 1926.

shaft. They counted all the shots, and 2 men went into main east and 1 into 2d north. At about 11:30, as two others were leaving, an explosion blew them into the sump. The two men remaining in the safety chamber were uninjured. They removed the bodies from the sump and climbed out of the shaft. The explosion had piled a trip of cars into the sump and onto the cage at the shaft bottom.

Rescue men were called, and the other three bodies were recovered and three small fires extinguished. The explosion was caused by ignition of black powder by one of the men making up a charge at a powderbox while wearing an open light. Powder kegs were exploded, and coal dust ignited.

December 10, 1925; Overton No. 2 Mine, Irondale, Ala.; 53 Killed

(From Bureau of Mines report, by F. E. Cash)

A day shift of 108 men and 16 mules was in the mine when the explosion occurred at 10:10 a. m. The explosion originated in 6 right and extended to most of the workings between 7 right and 3 left and right, resulting in the death of 52 men and serious injury to 3 others. One of these died in the hospital of pneumonia January 3, 1926.

The fireboss had found gas in four places on 6 right that morning, and these places were supposed to have been cleared before the men entered. Gas was issuing from a feeder in the face of 6 right and probably from the roof of room 7 off 6 right, which was idle because the roof was working. Two men sent into room 7 to see if the roof could be timbered carried carbide lights and matches for shooting, as well as electric cap lamps and flame safety lamps. Gas was ignited near this room, and dry coal dust spread the flame and violence. Dust was sprinkled, but ineffectively. Rescue teams with breathing apparatus explored the mine, and bodies were recovered after ventilation was restored. Self-rescuers were used by a number of men in escaping.

December 14, 1925; Wilkeson Mine, Tacoma, Wash.; 5 Killed

(From Bureau of Mines report, by J. G. Schoning)

About 9:30 a. m. a section foreman and a chute starter attempted to start a chute that was blocked by niggerheads or sulfur balls by placing a stick of 60-percent gelatin dynamite on a large chunk and firing it with fuse. The dynamite was covered with clay in the usual practice. The report of the shot was followed by a blast of wind and fire. These two men were burned; and the chute starter, in trying to run, fell down a chute and suffocated. The section foreman, unconscious, was found by rescuers and revived. Five others were also found overcome and revived by artificial respiration. Four others were killed by afterdamp. Although the mine was damp in most places, dry dust was stirred up and ignited; no gas was detected. No damage was done to the mine.

January 13, 1926; No. 21 Mine, Wilburton, Okla.; 91 Killed

(From Bureau of Mines report, by W. W. Fleming and C. A. Herbert)

The coal bed is about 4 feet in thickness and is reached by shafts and slopes about 200 feet deep. At about 8:15 in the morning when the explosion occurred, 101 men and boys were in the mine, including 2 firebosses who had earlier reported the workings free of gas. The timbers in the hoisting shaft were blown out, and the cages fell to the bottom with other

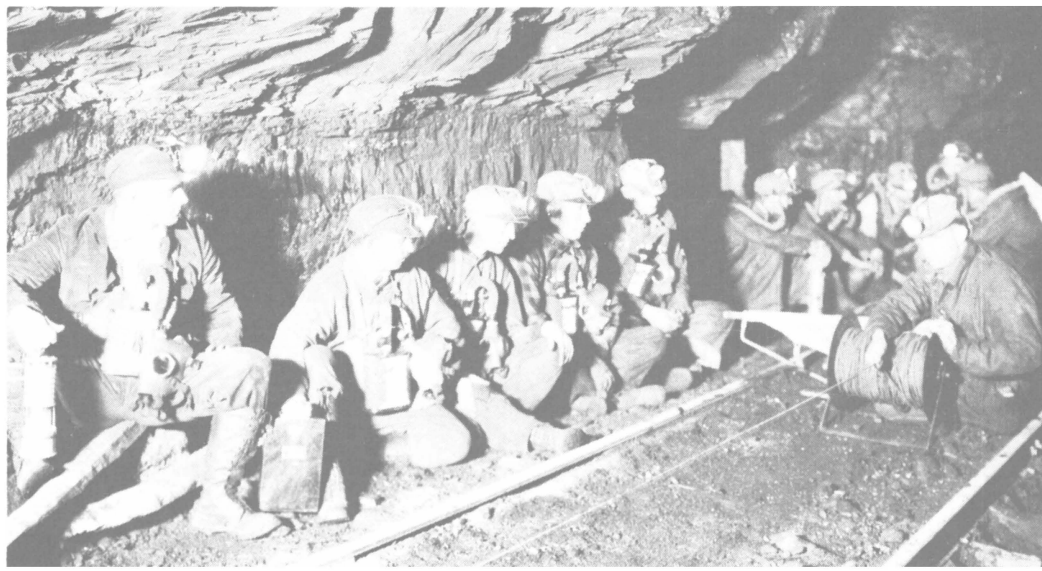


FIGURE 68.—Mine rescue crews in training, 1926.

FIGURE 69.—Surface destruction by explosion, Barrackville, W. Va., March 17, 1925.

FIGURE 70.—Apparatus crew and advance workers being checked in at Barrackville mine, March 1925.

debris. A small steam hoist was rigged and a bucket swung in the hoisting shaft when voices were heard at the bottom. A rescue party finally reached them by the stairway in the airshaft and over large falls. Eight men were taken out unharmed.

Rescue parties found and put out three fires, using gas masks for protection. Another man and a boy were found alive. The 91 victims were nearly all killed by afterdamp as they were making their way to the shaft.

All recovery work except fire fighting was in fresh air. The explosion was not violent, and the destruction of the shaft timbering was due to its badly decayed condition. The origin was a room face where gas was lit by an open light. Gas had been coming in large quantities from roof cracks in this section. Dry coal dust entered into the explosion, but the low violence and the mixture of fine shale dust from the roof prevented a more widespread explosion. Had the men stayed in their places, many would have been saved.

January 14, 1926; Jamison No. 8 Mine, Farmington, W. Va.; 19 Killed

(From Bureau of Mines report, by G. S. Rice and J. W. Paul)

The mine, about 26 years old, is reached by 2 shafts, each 250 feet deep. The explosion, at 10 p. m., was confined to the 7th right section and died out in the main haulage road, where naturally wet conditions and sprinkling prevented dust from rising. There were 47 men in the mine, of whom 28 were uninjured; 7 men near the shaft bottom went to the surface on the cage; 4 men remained in a wireman's shop on 20 right entry until fresh air was restored and they were reached by recovery crews. Eighteen others of the group gathered and, led by the machine boss and the compressor man, had retreated to the feedroom adjoining the stables in 20 right. Hay was used to seal the doorways, and the men remained for 18 hours with no discomfort until it was noticed that fresh air was moving inby on the entry, and 16 men walked out. Three of this group had attempted to escape through the afterdamp 12 hours after the explosion; 2 were suffocated, and the third managed to return (*24, pp. 58–60*).

Recovery crews found and extinguished 13 small fires. Gas masks were used. The evidence of the source of the explosion was not conclusive, but it was thought that gas accumulated when one or more doors were left open and was ignited by an arc from an open-type mining machine or its cable nips. Dust spread the explosion. Rock dusting and permissible equipment were recommended.

January 29, 1926; New Orient No. 2 Mine, West Frankfort, Ill.; 5 Killed

(From Bureau of Mines report, by J. B. Fleming)

At about 7:40 a. m. an explosion at the face of 7 north entry killed 5 men in the new entry. Gas had

been reported in the 7–8 north entries, and the gangmen were held out while a bratticeman was sent in to remove it. His flame safety lamp was extinguished on his first inspection of the face. He came back 29 feet to the mouth of a canvas tube carrying air from a blower, took his lamp apart, and struck a match to relight the lamp. A violent gas explosion burned the 3 gangmen about 200 feet away and another man just outside the mouth of 7 north panel entry.

Rock dust had been applied to within about 250 feet of the faces. Coal dust was ignited but did not extend the explosion into the rock-dusted areas. The coal dust and rock dust were damp.

January 29, 1926; Mossboro No. 1 Mine, Helena, Ala.; 27 Killed

(From Bureau of Mines report, by F. E. Cash)

At 4 p. m. an explosion resulted in the death of 27 men; 6 more were affected by gas, requiring artificial respiration; the remaining 9 escaped. Blown-out shots raised and ignited coal dust, assisted by a little methane from the face of 5 right. The ignition was propagated by dust from its origin to the face and outby to No. 1 room, where it was checked by water. Stoppings on 5 right were blown out, but elsewhere little force was evident. Rescue crews and apparatus were called from other mines and from the Bureau of Mines station; exploring crews found the men dead, and bodies were removed in fresh air.

Holes were drilled on the solid, loaded with black powder, and fired with fuse. Coal-dust stemming was used. The mine was gassy, but open-flame lamps were used. Rock dusting, closed lights, improved ventilation, and permissible explosives were recommended.

February 3, 1926; Horning No. 4 Mine, Horning, Pa.; 20 Killed

(From Bureau of Mines report, by H. C. Howarth)

A clay vein was being cut about 10 a. m., when there was a sudden increase in the flow of gas from the undercut. The foreman had the open-type machine stopped and backed out from the cut a short distance when the gas ignited. None of the men were burned, but the feeder continued to burn. Attempts to put out the fire with permissible explosives and wet clothes and water failed. After several hours brick seals were started. At 3:55 p. m. an explosion killed 20 men working on the sealing job, including 7 officials.

A second explosion took place during recovery operations about 8 hours later. No one was injured, but it was decided to seal off the entire section, in which 17 bodies remained. Apparatus was used extensively. The first explosion was propagated by coal dust but was localized by rock dust. The seals were opened and the bodies recovered 10 days later.

February 16, 1926; Nelson Mine, Nelson, Ky.; 8 Killed

(From Bureau of Mines report, by G. T. Powell)

At the end of the shift the men were gathering at the shaft bottom when an explosion in the main south killed three men. The explosion was felt at the shaft, and the foreman led a rescue party with a car and a mule toward the area. After going 240 feet the mule collapsed from afterdamp. The men went on by two routes. Those on the main south reached the bodies at a distance of 500 feet. These men felt in distress and retreated but fell down. Although removed by a following party, 2 died quickly and 3 others that night. The explosion was limited by the absence of spilled coal and the presence of shale flaking off the roof. The origin was a blown-out shot of black powder in the entry face.

March 8, 1926; Eccles No. 5 Mine, Eccles, W. Va.; 19 Killed

(From Bureau of Mines report, by L. D. Tracy)

About 6:55 p. m. an explosion in No. 5 mine extended into No. 6 mine in an overlying coal bed. In No. 5 mine 18 men were killed and 10 rescued; in No. 6 mine 1 was killed, and 29 escaped. Smoke, dust, and some debris issued from both shafts at the same time. A motorman in No. 6 mine risked his life to open a door that short-circuited the air from the affected section and prevented smoke and fumes from reaching the part of the mine where the 30 men were working. These men were brought out safely, except for one who died in the mine from electric shock or from afterdamp.

Rescue crews were called and arrived promptly. Exploration around the bottom of No. 5 shaft showed heavy damage, growing less toward the active faces. The recovery crews found some bodies and signs that survivors might be in the mine (*24, pp. 56–58*). Ten men were found behind a barricade and were released after the ventilation had been restored, about 9:30 p. m. on March 9. Some of the rescue crew were overcome by going ahead of fresh air without masks or apparatus but were revived by artificial respiration. Apparatus crews completed the exploration and recovery of bodies. Several small fires were found and extinguished in one section.

Gas had accumulated at an entry face and was ignited by an arc from the controller of a cutting machine as it was brought to the face. The machineman failed to test for gas before entering. Dust was ignited, as the mines were not rock-dusted.

May 6, 1926; Randolph Colliery (Anthracite); Port Carbon, Pa.; 5 Killed

(From Bureau of Mines letter, by Jesse Hensen)

A gangway being driven from the tunnel that connected the coal beds had reached a distance of 200 feet from the tunnel without a second opening and was ventilated by compressed air. About 2 p. m. the miner was at his powderbox preparing a charge of 40-percent dynamite to shoot a hole in the face when the explosion blew him to pieces, killed 4 other men at considerable distances, and caused severe burns to 4 others. Apparently gas had been forced back from the face and was ignited when the detonator was accidentally exploded by contact with a dry-cell battery or the gas was ignited by a match, in turn setting off the dynamite.

July 3, 1926; Pettebone Colliery No. 6 (Anthracite), Kingston, Pa.; 7 Killed

(From report by State inspectors)

On the morning of July 3 a squeeze along the robbing line of a pillar section caused the men to be withdrawn to another part of the section. When the fall came at about 2:00 p. m., an accumulation of gas was forced into the area where the men were working, and the gas was ignited by matches, smoking, or a defective flame safety lamp. Seven men were killed and 8 others injured.

July 21, 1926; Dixie Mine, Moffat, Ala.; 9 Killed

(From Bureau of Mines report, by F. E. Cash)

On that night, while 11 men were in No. 3 wall, a feeder of gas was ignited by a carbide light about 80 feet up the wall, but was extinguished. Again, another feeder was ignited 150 feet up the wall, and the flame singed a machine man. The flame was extinguished with difficulty. About 3:30 a. m. gas was again ignited, killing 9 men and injuring 2 men who had started out of the mine. The door to No. 3 east

was found propped open, causing the air to short-circuit. The force traveled some of the haulage roads for short distances by picking up dust, but faded out because the dust was wet and high in inert material. Ventilation was easily restored, and the bodies were removed without calling rescue crews. An ignition of gas by an open light in this mine November 12, 1923, caused the death of 2 miners and injury to 12 others.

August 26, 1926; Clymer No. 1 Mine, Clymer, Pa.; 44 Killed

(From Bureau of Mines report, by J. J. Forbes, J. N. Geyer, and H. C. Howarth)

There were 62 men underground when the explosion occurred at 1:00 p. m. Of these, 27 were killed by violence, 17 by afterdamp; 4 were overcome but were revived later in the hospital; and 14 escaped uninjured. Eleven could have been saved by erection of a barricade, and most of those killed by afterdamp might have gotten out by using self-rescuers. The fireboss did not report any gas in the mine. The main fan on the surface was not damaged, as the explosion doors opened. Rescue work was organized by 5 p. m., and the last bodies were removed on August 27. The recovery work was mostly done without apparatus. Gas masks were used for short trips. The explosion was confined to the 1st north section, although it was violent.

Gas had accumulated in places ventilated by a blower fan when a door was left open or dust was raised by a roof fall; ignition was by electric arc from trolley wire or electric equipment. Gas and dust were involved. Ventilation was inadequate, and the mine was dry and dusty.

September 3, 1926; Tahona Mine, Tahona, Okla.; 16 Killed

(From Bureau of Mines report, by C. A. Herbert)

The fireboss had examined the 7½ west entries at 6:30 a. m. but had made no report of gas. At 8:40 a. m. an ignition of gas by open lights killed all but one man on that level. When men on the level above were leaving the mine, their open lights ignited some methane from the explosion region, and seven were burned but not fatally. The mine was little damaged, and the bodies were recovered quickly.

The mine had been rock-dusted in the spring, but there was little evidence of rock dust left. Rock-dust barriers installed were ineffective. The affected workings were damp to wet, and dust was not raised. The fireboss may have been moving a gas accumulation when the ignition occurred.

October 4, 1926; Rockwood Mine, Rockwood, Tenn.; 27 Killed

(From Bureau of Mines report, by F. E. Cash)

The explosion occurred about 9:20 on Monday morning in a region where the coal was about 80 feet thick and worked unsystematically. There were 244 men underground, 23 of them in the Rogers section; all 23 were killed, 6 by violence, 5 by flames and violence, and 12 by flame. Four others died from afterdamp in nearby entries. One man overcome by gases was found by two survivors from another entry and was taken with them on their retreat to their working face. They short-circuited the air and waited over 4 hours until rescuers restored ventilation to their place. Another man affected by gas was also rescued.

The explosion was confined to the Rogers section, because the connecting entries were in rock. Recovery work was slow due to inability to ventilate the affected area, and gas masks and breathing apparatus were used extensively. Recovery was completed October 17. The booster fan supplying air circulation to the section was under repair on Sunday. Monday morning 2 or 3 places were "marked out" because of methane. Slow movement of this gas to the return brought it in contact with the open lights. Dust was ignited in the section. Closed lights, improved ventilation and inspection, rock dusting, and many other changes were recommended.

October 30, 1926; No. 7 Colliery (Anthracite), Nanticoke, Pa.; 9 Killed

(From Bureau of Mines report, by Geo. S. McCaa)

The fireboss had found gas that morning at the gangway face. Before the faces to the rise were examined, the miners started the booster fan, moving the gas back to the rock tunnel where two men were smoking. The nine men in the section were killed. Apparatus was used in recovering the bodies.

November 15, 1926; Mound Mine, Moundsville, W. Va.; 5 Killed

(From Bureau of Mines report, by W. H. Forbes and C. W. Owings)

About 2:15 a. m. an explosion killed 5 of the 18 men in the mine. Two died of burns and 3 from carbon monoxide. Two injured men were rescued several hours later, and 11 escaped uninjured. The night foreman encountered the smoke and fumes when he approached the section to see how repairs were progressing on a door that had been wrecked by a runaway car. Rescue crews from other mines were needed for recovery work.

Gas accumulated by the wrecking of the door was ignited by arcing of the trolley wheel of a locomotive. Coal dust was ignited, but the explosion was stopped by rock dust and water on the entries.

December 9, 1926; Francisco No. 2 Mine, Francisco, Ind.; 37 Killed

(From Bureau of Mines report, by C. A. Herbert)

Six cage loads, totaling 71 of the normal day shift of 325, had been lowered into the mine, when the explosion occurred at 6:30 a. m. An accumulation of gas in the south west section, where five rooms had been caving, was found by a fireboss, who did not report it but stayed in the mine to try to clear it out. Open lights of incoming men caused an ignition that picked up dust and traveled to the shaft, damaging it so that the cages could not be used. Crews were sent in by the stairway in the escape shaft. A bucket was rigged in the air compartment of this shaft, and the seriously injured and dead were hoisted out. Men who were outside the explosion zone or not badly hurt went up the stairway. The explosion doors were blown open, but the fan was undamaged. Oxygen breathing apparatus was not used; but gas masks were, to good advantage. After 24 hours all but 3 of the 26 bodies had been found and the 45 survivors removed. Eleven of the injured died from burns.

Smoke had been found coming from main west entries, too dense to penetrate to the fire. Because of the danger of an explosion of methane in 2 sealed panels in that section, all men were withdrawn, leaving 5 bodies inside. A slight explosion occurred shortly afterward. The shafts were sealed. On January 27, 1927, these seals were removed, and the main west section was sealed off. The five bodies were removed.

March 30, 1927; Saline No. 2 Mine, Ledford, Ill.; 8 Killed

(From Bureau of Mines report, by A. U. Miller)

On that morning the examiner had found gas at the roof in No. 18 northwest entry. Checks were

withheld from the men working in No. 17 and 18 entries, but men working the entries on the return side were allowed to work and were not told of the gas. About 8:10 a. m., the gas moved and was ignited by an open carbide lamp. The body of gas was small, and the explosion only traveled about 600 feet. Dust did not enter into the explosion to any great extent. Of the 196 men in the mine, 8 were killed and 3 others injured. The bodies were recovered by an apparatus crew, but ventilation was then restored without use of apparatus.

April 2, 1927; No. 53 Mine, Cokeburg, Pa.; 6 Killed

(From Bureau of Mines report, by J. J. Forbes and H. P. Greenwald)

At the time of the explosion, about 8:00 a. m., 306 men were in the mine; all escaped unharmed, except the 13 men in the affected area. Four were killed, 2 died while being given artificial respiration, 5 were injured or gassed, and 2 had cuts and scratches. Three of the injured were revived by artificial respiration. Only a small area was involved, and the dead and injured were soon removed without calling outside aid.

The explosion was started by blasting a large piece of fallen sand rock at a room face. The shot firer placed 2 charges of 2 sticks of 40-percent gelatin dynamite on the rock and covered them with dirt and rock. He fired them together, and the explosion made him dizzy and burned his face and hands. He was rescued. The entries had been rock-dusted, and this stopped the spread.

April 30, 1927; Federal No. 3 Mine, Everettville, W. Va.; 97 Killed

(From Bureau of Mines report, by H. C. Howarth and G. S. McCaa)

A gas and dust explosion at 3:20 p. m. killed 6 men in the tipple and 91 in the mine; 86 of those underground met instant death, 2 traveled about 500 feet before they were overcome by afterdamp, and 3 attempted to barricade themselves in a pumproom but were overcome by afterdamp. Messages left by 1 of the 3 men showed that they lived 3 hours or more. Nine men were cut off in the south main section until one came out through the smoke and returned with a party wearing self-rescuers. The eight men who had barricaded themselves in a room were supplied with self-rescuers and walked out. Five men in the tipple were seriously injured.

The explosion originated near the farthest working face in the mine when an open-type storage-battery locomotive ignited an accumulation of gas. The explosion was propagated by methane and coal dust to all of the mine except the south mains (fig. 71).

The mine had been partly rock-dusted, but the rock dust was not maintained. Assistance was called, and many recovery experts and apparatus crews assembled. The 21 apparatus crews built 80 stoppings while wearing apparatus. Ventilation was reestablished and the mine cleared 12 days after the explosion. The last bodies were removed May 24. Property damage was extensive (fig. 72). Automatic doors on the main haulage road were being repaired, and this interruption of air currents to the faces caused the accumulation of gas in the mine's inner workings.

May 13, 1927; Shanon Branch No. 3 Mine, Capels, W. Va.; 8 Killed

(From Bureau of Mines report, by W. H. Forbes)

That night 22 company men were in the mine when men on the sprinkling and the supply crew felt a rush of air at 11:20 p. m. These men and 10 others repairing the haulage road hurried outside and called the mine officials. Rescue crews had reached the affected section about 5 hours later when a succession of minor air blasts drove them out. Some hours later crews restored ventilation and recovered the 8 bodies of 4 machine crews who were in the explosion area. Apparatus crews were used in part of this recovery work.

Gas had been released by breaking of the sandstone roof, and all crews carried flame safety lamps. Apparently a thorough check was not made before taking a machine into a face area, and the arc from nipping along the trolley wire up to the face caused an ignition. Coal dust was ignited, but the spread of the explosion was limited by expansion and standing water. No rock dust had been applied. This was the fifth explosion in this mine. All were on the night shift, and all occurred in the same manner. The preceding explosion on January 19, 1927, killed four men.

May 26, 1927; Woodward No. 3 Shaft (Anthracite), Edwardsville, Pa.; 7 Killed

(From Bureau of Mines report, by Jesse Henson)

A rapidly developing squeeze in No. 2 west gangway caused a fall in the mine and the settling of several acres of surface about 11:50 a. m. Gas from the squeezed area was ignited, probably by short-circuited power wires. The explosion killed 7 men and injured 20 others, 9 of whom were taken to a hospital. The explosion was local, and two bodies were soon recovered. Rescue crews without apparatus were recruited from other collieries to help find the five others.

At 5:30 a. m. May 27, while recovery crews were outside, a violent explosion damaged the airduct from the fan to the shaft, wrecked the headframe (figs. 73 and 74), and injured two workers. As a fire was burning in the mine the shaft was sealed with timbers and concrete. At 1:30 a. m. May 29, a third explosion destroyed the seal and damaged surface buildings. The shaft was resealed.

May 27, 1927; Delagua No. 3 Mine, Delagua, Colo.; 7 Killed

(From Bureau of Mines report, by K. L. Marshall and E. H. Denny)

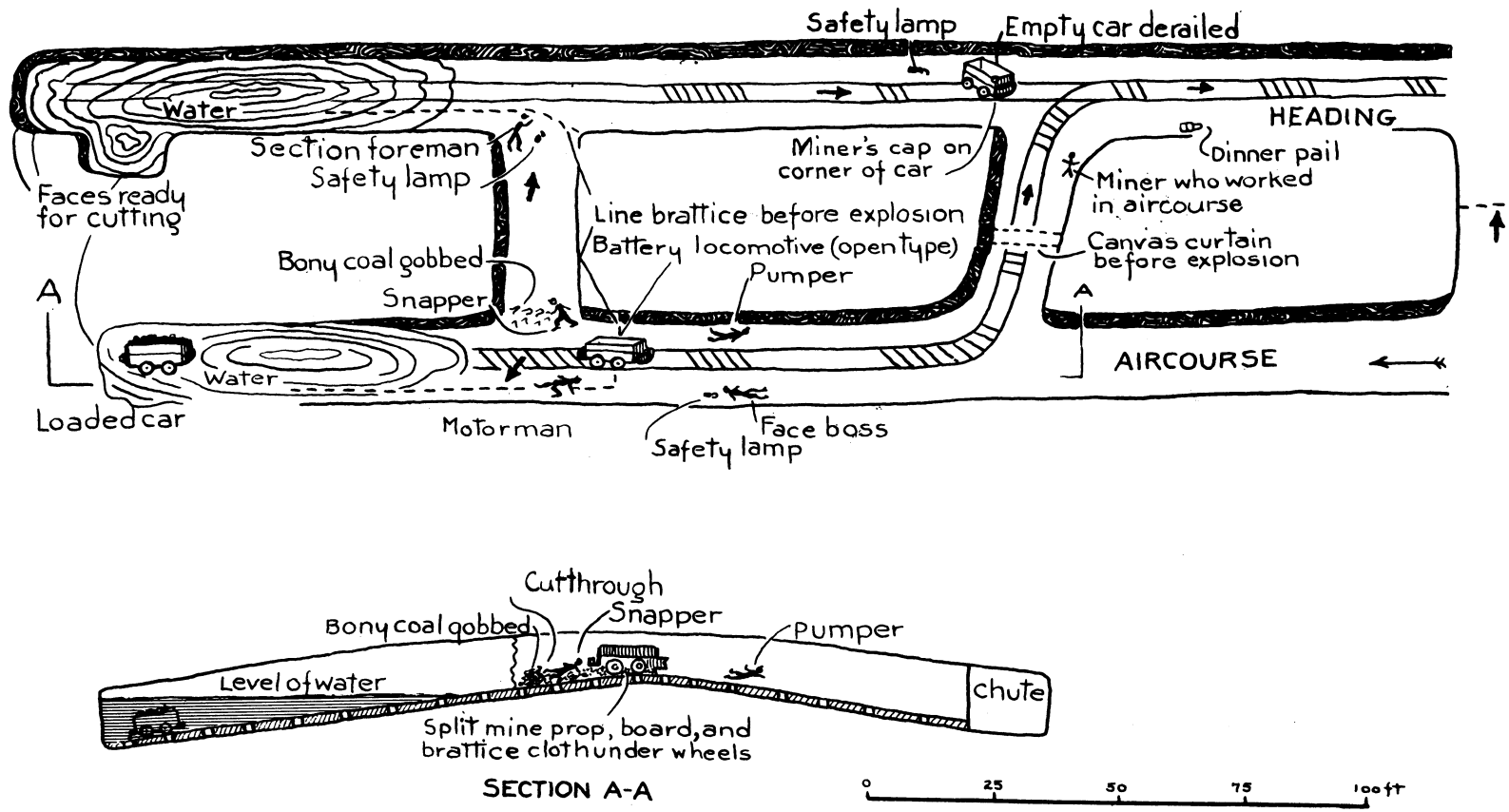
A coal-dust explosion about 12:45 p. m. in the main slope killed seven men. Two men were killed in the explosion zone; 4 uninjured men came up into the slope and attempted to carry an injured man with them through the afterdamp. These four collapsed and died; the injured man was rescued but died several days later. The explosion came out the portal and also traveled several hundred feet down the slopes from the point of origin.

A runaway trip of 16 cars was derailed by a drag, and the wreck caused a dust cloud from fine coal in the cars and on the slope, also arcs from power wires that were torn down and damaged. The explosion was limited by adobe dust applied some months earlier and by water put on the floor that morning. Rescue cars and crews arrived within an hour and assisted about 125 men to come out from the mine workings as the air cleared. Gas masks were used to a limited extent; oxygen breathing apparatus was not needed. The bodies were recovered and all men were out within 5 hours. The mine was not gassy.

August 3, 1927; West Kentucky No. 7 Mine, Clay, Ky.; 15 Killed

(From Bureau of Mines report, by C. A. Herbert)

About 3:30 p. m., a few minutes before the end of the shift an explosion at the face of 10 left entry



FACE OF SHAFT HEADINGS AFTER EXPLOSION

FIGURE 71.—Sketch of origin of explosion, Federal No. 3 mine, Everettville, W. Va., April 30, 1927.

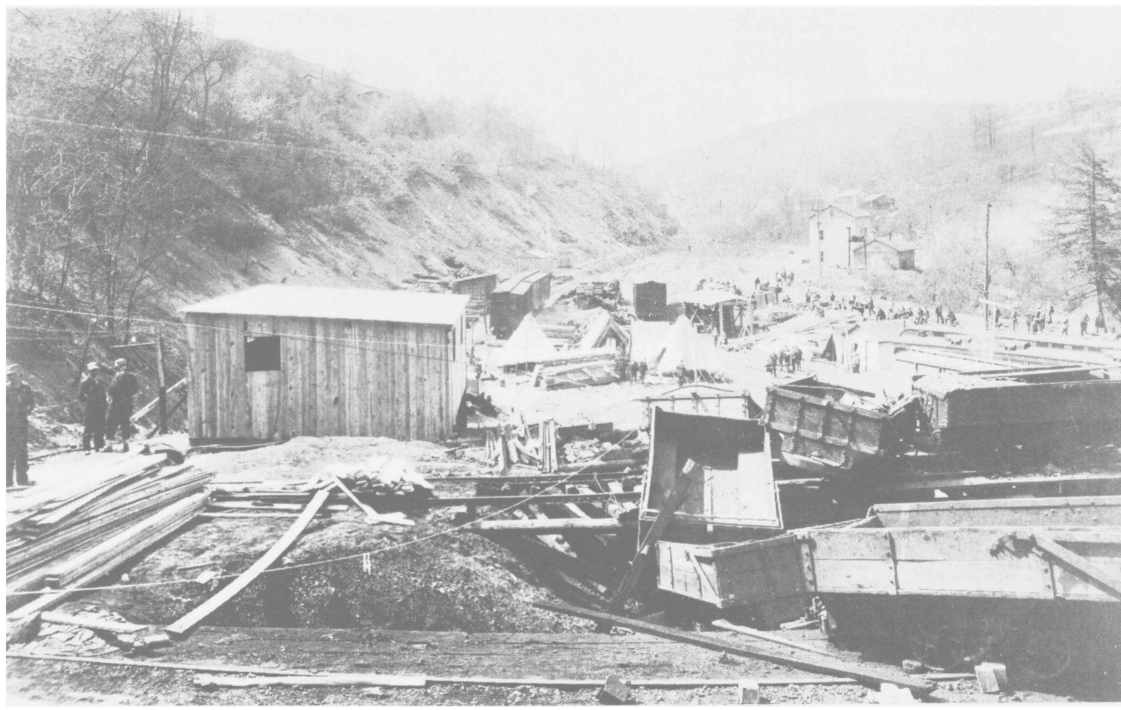


FIGURE 72.—Surface wreckage after explosion, Federal No. 3 mine, Everettville, W. Va., April 30, 1927.

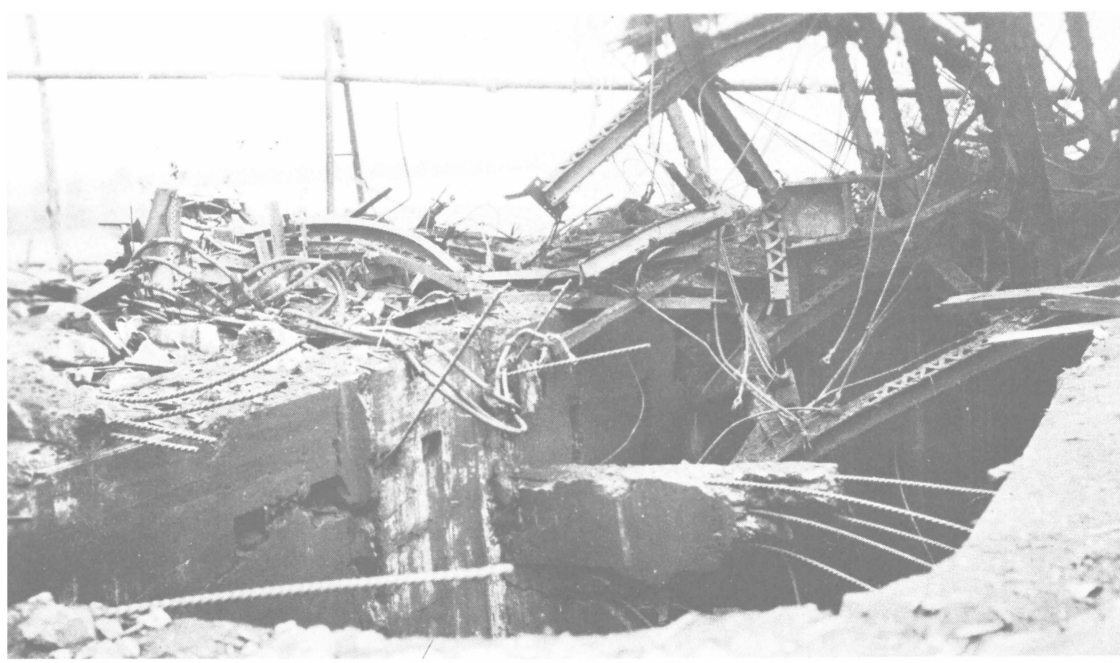


FIGURE 73.—Wreckage at surface of Woodward No. 3 shaft, Edwardsville, Pa., after explosion, May 26, 1927.

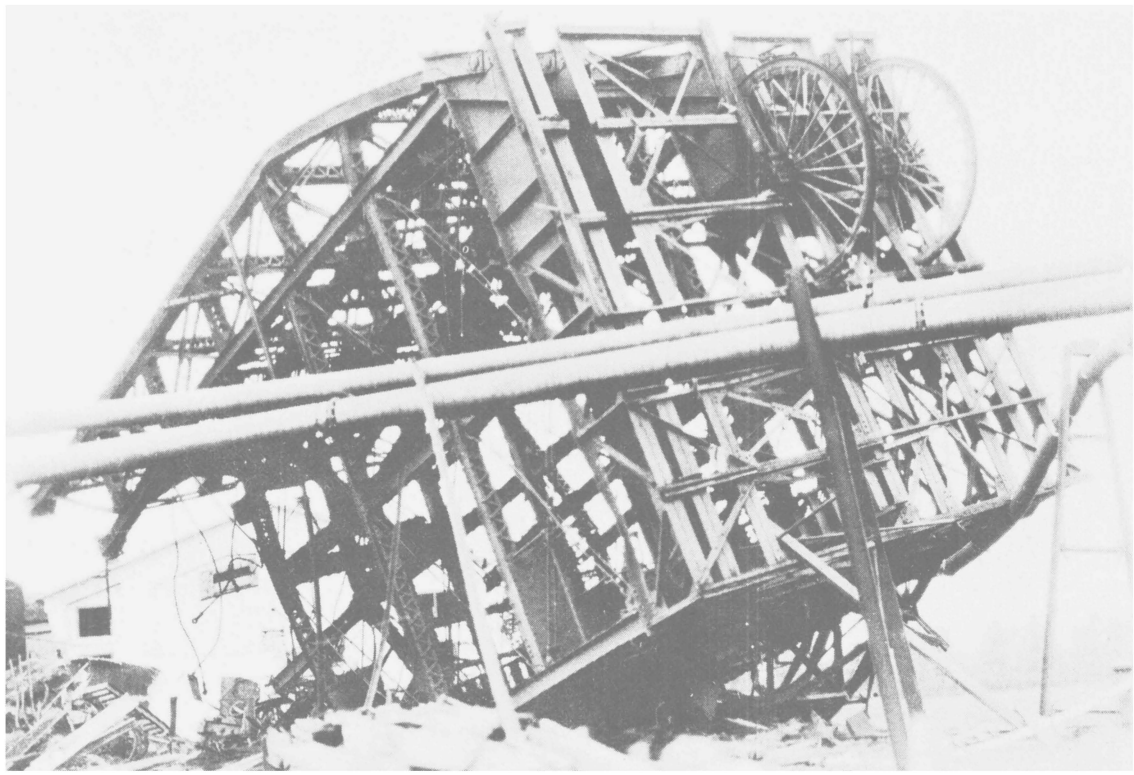


FIGURE 74.—Headframe of Woodward No. 3 shaft, Edwardsville, Pa., after explosion, May 26, 1927.

killed 15 men. Fifteen others were overcome but were rescued; 12 revived quickly, 3 others after several hours. The superintendent was at the shaft bottom, and although the force of the explosion was scarcely felt there the power went off. He went inside to find the trouble and encountered afterdamp in the west dip section. With others, he attempted to rescue some of the men found unconscious but was in turn overcome. A rescue crew with gas masks brought the stricken men out. As more help arrived, including a rescue car with men and equipment, ventilation was restored, and advance trips were made by gas-mask crews. A smoldering fire in a near explosive atmosphere was put out.

In the 5th left entry 17 men who had retreated from the workings next to the explosion area and erected canvas barricades were found and released. Two others who had attempted to seal themselves in the entry in which they were working were found dead. The barricades of canvas and clothing were ineffective, and the air was contaminated by carbon monoxide (*24, pp. 15–17*).

Gas had been liberated by cutting, drilling, or unsuccessful blasting of two holes in one of the 10 left entries. The gas moved into the adjoining entry face, where it was ignited by an open-type cutting machine. The explosion was spread by coal dust; but rock dust placed on haulage roads some months before and road dust from the clay bottom helped to confine the extent. Trough barriers in the 7 right aircourse were destroyed and did not have a noticeable effect on the propagation of the flame.

December 20, 1927; Franco No. 1 Mine, Johnson City, Ill.; 7 Killed

(*From Bureau of Mines report, by Alex U. Miller*)

A local explosion near an entry face killed 7 of the 30 men in the mine about 8:10 p. m. The others escaped to the surface. The night boss was ill, so the night examiner was put in charge and the motorman acted as examiner, being certified. The motorman and his helper took a locomotive and cars up to the entry face before making an examination.

Gas was ignited, either by the trolley locomotive or by smoking. The explosion was spread by coal dust, as no rock dusting had been done. The wet condition of the mine limited the explosion, and it was not noticed at the shaft bottom; but word was telephoned from another section. A rescue car arrived at midnight, and apparatus crews were used to explore the area and to bring out two bodies; the others were removed by restoring the air.

January 9, 1928; No. 18 Mine, West Frankfort, Ill.; 21 Killed

(*From Bureau of Mines report, by Alex U. Miller*)

About 15 minutes after the day shift of 672 men had started work, an explosion, at 7:45 a. m., caused the death of 21 and injury by afterdamp of 3 others. Three more men attempting to come out encountered the afterdamp and retreated to the faces of their entries until ventilation was restored 4 hours later. Rescue crews, including car 4 of the Bureau of Mines,

arrived promptly after being called. Apparatus crews made exploration trips and extinguished a small fire, also rescuing three unconscious survivors. Recovery work was completed in 12 hours.

Gas had accumulated in three rooms in which line curtains were needed. Apparently a machineman lit a cigarette while his helper went out to the entry to hook the machine cable to the trolley wire. Dust was ignited, and the explosion traversed the section. Some rock dust had been put on the haulage roads about a year earlier, and this may have helped to prevent propagation to other sections.

February 20, 1928; Kinlock Mine, Parnassus, Pa.; 12 Killed

(From Bureau of Mines report, by G. S. McCaa and H. C. Howarth)

The Kinlock mine was opened by shafts and slopes and connected to workings of the Valley Camp No. 1 mine. These openings were closed by double doors. The No. 1 mine, in turn, was connected to the Boyd mine. At 9:30 p. m., when 19 men were in the Kinlock mine and 3 in the No. 1 mine, an explosion originated in a room and spread over much of the Kinlock mine and a short distance into No. 1. Ten men were killed in the Kinlock mine, and 9 escaped. Two escaped from No. 1 mine, and 1 was rescued by a gas-mask crew, furnishing him with a self-rescuer and directing him up the shaft through the return. Five men entered the Boyd mine about 5 a. m., not knowing about the explosion; 2 were killed by afterdamp, and 1 was overcome but was picked up by the other 2 who were going back after encountering afterdamp.

Gas accumulated in a room because of an open door or other interruption to ventilation. No examination was made for gas before a machine crew went in, igniting the gas by nipping to move the machine. Coal dust was ignited. Rock dust placed on the haulage roads more than a year before was ineffective. Rescue men were called, and it was found necessary to rearrange the ventilation to put the main slope in return air. The mine was heavily damaged, and it was the morning of February 23 when the last of the bodies was removed.

February 24, 1928; Mama No. 3 Mine, Jenny Lind, Ark.; 13 Killed

(From Bureau of Mines report, by K. L. Marshall and P. E. Keegan)

About February 19 a connection had been made between Mama Coal Co. No. 3 mine and the adjoining No. 18 mine of the Consolidated Sales Co. A wooden stopping with a slide regulator had been put in to seal off the connection. The No. 3 mine had been idle and the fan not running from February 21 to the morning of February 24. At 8:30 a. m. gas was ignited at this regulator by the open light of a man from the No. 18 mine who had been sent to change the opening. His body was found under the debris of the stopping.

The explosion was propagated a short distance into the No. 18 mine by dust but was stopped by dampness and expansion. The same conditions arrested propagation in the No. 3 mine, where 12 men were killed and 115 escaped. In No. 18 mine 14 men came out unaided. Little damage was done, and the bodies were soon recovered. Ventilation in both mines was inadequate; open lights were used; no rock dust was applied; and holes were shot on the solid with black powder. Fireboss examinations were made.

April 2, 1928; Keystone No. 2 Mine, Keystone, W. Va.; 8 Killed

(From Bureau of Mines report, by S. P. Howell and Jesse Redyard)

A local explosion about 10:30 a. m. killed 8 of the 120 men in the mine; the rest escaped. Gas moving off a gob area was ignited by a carbide light. The mine had been idle for 3 days; but the fans were running, and a fireboss examination was made at 5:00 a. m.

Dust was ignited and helped to extend the explosion through the section. No rock dust was applied. The mine was gassy; ventilation was on four splits, including a booster fan on this section. Ventilation at the point of origin was inadequate and irregular. Open lights, open-type electric equipment, and dynamite used in blasting rock were all potential explosion hazards.

May 19, 1928; Mather No. 1 Mine, Mather, Pa.; 195 Killed

(From Bureau of Mines report, by G. S. McCaa and H. C. Howarth)

At 4:07 p. m., while the day and night shifts were changing, an explosion of gas and dust killed 193 of the 270 men in the mine; 2 others died after being rescued. Of the 209 men in the part of the mine affected by the explosion, 14 escaped safely. About two-thirds of the victims were killed outright by violence or flames, and one-third were overcome by afterdamp an hour or two after the explosion. One group of 6 men attempted unsuccessfully to erect a brattice-cloth barricade about 500 feet beyond the flame zone.

The explosion originated in the northwestern corner of the mine in solid workings where an accumulation of gas was ignited by an arc from a nonpermissible storage-battery locomotive. Gas accumulated due to an open door or other interruption to ventilation. About one-fifth of the entire mine was involved, but the violence was moderate (fig. 75).

Although rock dust was not applied in accordance with the recommended standards, the applications that had been made and possibly some of the untested rock-dust barriers installed in aircourses diminished the force and helped to limit the propagation. The fireboss report showed that gas had accumulated at the place where the explosion originated, but a line brattice had been extended and the place cleared by 9 a. m. Men working near this place left about 2 hours before the explosion. Rescue crews and equipment arrived in 1 to 2 hours, and apparatus and gas-mask crews were used extensively to explore the explosion area and to extinguish 10 incipient and 1 active mine fire. Fire extinguishers and rock dust were used.

May 22, 1928; No. 30 Mine, Kenvir, Ky.; 8 Killed

(From Bureau of Mines report, by Alex U. Miller and G. T. Powell)

The explosion, about 6:30 p. m., killed 7 of the 68 men in the mine; the rest escaped unassisted. Eight of these men were trapped until ventilation was partly restored, after about 8 hours. The explosion, originating in 3 right main entry, was due to a mud-cap shot on a fall of slate and had considerable voilence. Two men were issued 36 sticks of 40-percent dynamite to use in breaking the slate. Only 8 sticks were found afterward, and evidence indicated that 2 charges of about 12 sticks each were placed on the slate about 10 feet apart, possibly covered with fine road dust. After lighting the fuse, the men separated to warn others of the blast, but both were killed. A coal-dust explo-

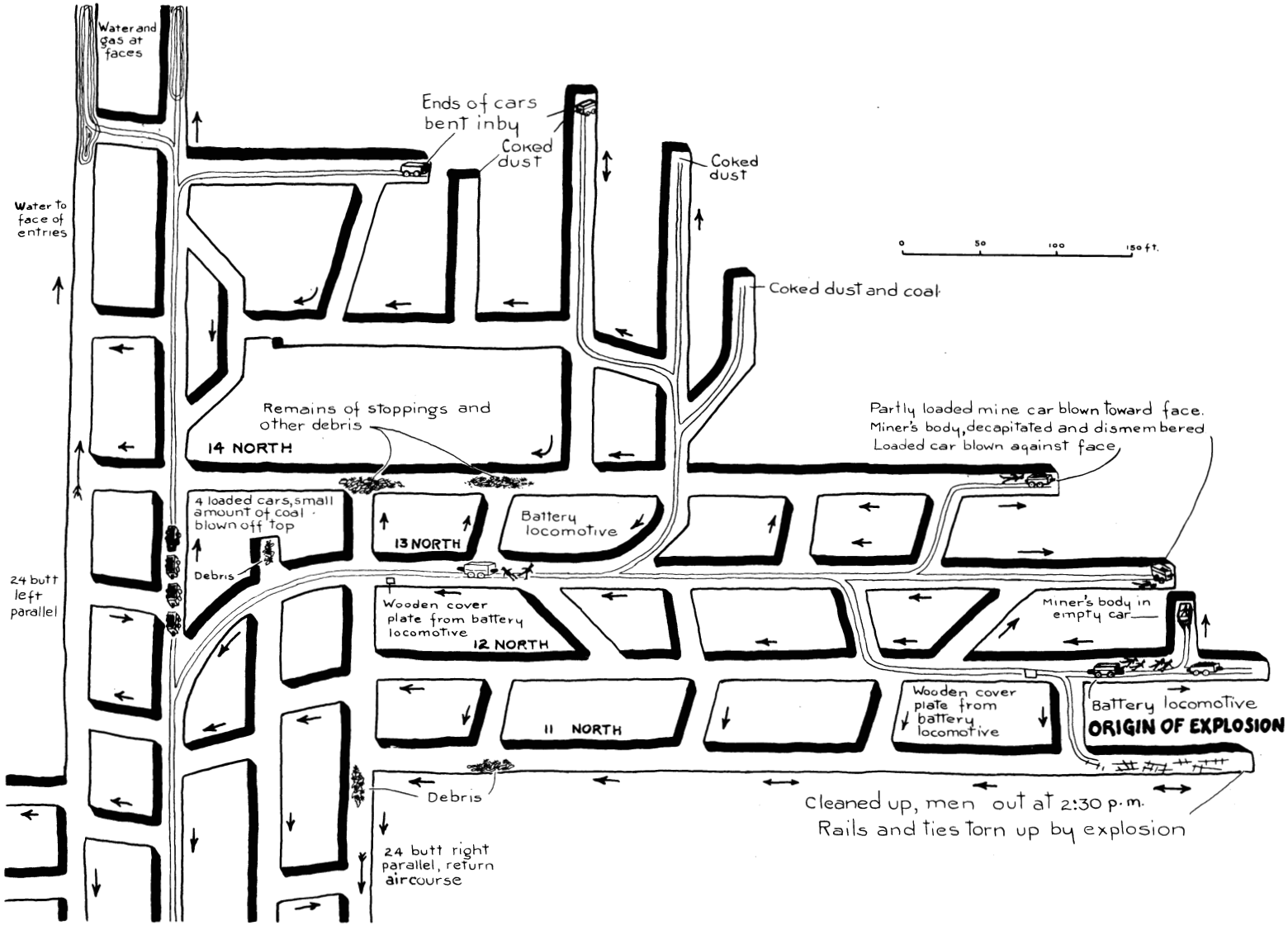


FIGURE 75.—Map of explosion area, Mather mine, Mather, Pa., May 19, 1928.

sion traveled out to the surface, damaging the fan, and inward over about half of the mine before dying out. No rock dust had been applied. Most of the survivors came out through openings to the outcrop.

Rescue crews and a mine rescue car were sent to help, and the bodies were recovered by restoring ventilation. During recovery of 3 bodies from the underground motor barn, 3 of the recovery workers attempted to go into the barn before the air was cleared and without any protection. One of the 3 was overcome. He was removed to fresh air and given artificial respiration, but he died.

May 22, 1928; Yukon No. 1 Mine, Yukon, W. Va.; 17 Killed

(From Bureau of Mines report, by G. W. Grove)

During the night shift when 40 men were in the mine, at 7:45 p. m., an explosion killed 17; the rest escaped uninjured. The explosion of gas and dust in 1st right off 19 left was ignited by an open-type mining machine. Only a small portion of the mine was involved, as the explosion force diminished because of expansion into open workings and because of the low volatile content of the mine dust. Rock dust had not been applied. Word of the explosion did not reach outside the locality until the following day, and the bodies were recovered before outside assistance arrived.

The gas accumulated when a door was left open; no examination for gas was made before the night shift entered. Previous explosions in the connecting Yukon No. 1 and No. 2 mines were: 1913, 13 killed; 1917, 18 killed; 1924, 26 killed—all from gas ignited by open lights.

May 25, 1928; Baltimore No. 5 Mine (Anthracite), Parsons, Pa.; 10 Killed

(From Bureau of Mines report, by Jesse Henson)

About 9:25 a. m. a gas explosion caused death to 10 men in the No. 2 gangway, Red Ash bed, No. 1 slope, Conyngham shaft. Eight were found dead, 2 died later of burns, and 5 others were injured. Gas accumulated in a large cavity over a working place, when a door was kept open to change cars for miners. The gas was mixed with air by a local blower fan and moved over men in the gangway when the door was closed. A violent explosion was caused by ignition of the gas by smoking, indulged in by the men. Other sources of ignition present were open-type electric equipment and nonpermissible explosives.

June 20, 1928; National No. 1 Mine, National, W. Va.; 6 Killed

(From Bureau of Mines report, by Jesse Redyard)

A local explosion about 1:30 a. m. caused death to 6 of the 22 men in the mine and injured 7 others. The night foreman gathered the 16 men and directed them to the outside. Gas from a caved section along the pillar line in 5th right butt entry was forced by a fall into the entry, where it was ignited by a machine helper's open-flame lamp. The flame traveled about 600 feet; and some dust may have been ignited, but there was little violence. Rock dust had not been applied. Gas masks were used in dead ends, but most of the recovery work was accomplished as ventilation was restored. Gas had been found since March 1928, but no fireboss was employed.

August 9, 1928; Hillside No. 1 Mine, Johnstown, Pa.; 5 Killed

(From Bureau of Mines report, by S. P. Howell)

The mine was working about 2 days a week, and all of the 10 underground men were in the mine at noon when a local explosion killed 5. The others escaped. A nonpermissible mining machine cut through a clay slip in a room face, releasing gas, which was ignited by an arc from the machine. Although some dust was stirred up and ignited, the explosion was limited by wetness. No rock dust had been applied. Rescue teams were called from other mines, and oxygen breathing apparatus was used in recovering the bodies. As the machine was of a closed type, the management thought it was safe in a gassy atmosphere.

August 15, 1928; Irvona No. 3 Mine, Coalport, Pa.; 13 Killed

(From Bureau of Mines report, by S. P. Howell)

Some of the 102 miners were leaving the mine when the explosion occurred at 3:15 p. m. In the section to which the explosion was confined, there were 14 men; 13 were killed, the other man was rescued and resuscitated. Eight of the victims were killed by violence or flame.

The mine was rated gassy, and a fireboss was employed, but no examination appeared to have been made in the room in which the explosion originated for more than a week. A gas feeder had been found in the room, and as the face was ahead of air it was stopped until a crosscut was connected. The crosscut was completed, and a machine crew was unloading an open-type machine in the room when the accumulated gas was ignited. Dust was involved, but wetness of the mine outside this face section prevented further propagation. Rescue teams from nearby mines explored the section and restored ventilation. Evidence of smoking was also found.

October 22, 1928; McAlpin Mine, McAlpin, W. Va.; 6 Killed

(From Bureau of Mines report, by R. D. Currie)

About 200 men were in the mine at 2:15 p. m., when the explosion killed 6 of the 22 men in 5 panel, 9 right. An open shot of 10 sticks of 60-percent dynamite was set off on a piece of sandrock at the face of 4 room of 5 panel. A dust explosion, extending only 100 feet from the room face, produced afterdamp that was carried throughout the panel. The mine foreman just outside the panel heard a loud concussion and saw the doors collapse and black smoke came out. He took several men through the smoke into the intake aircourse and replaced damaged doors and stoppings, releasing men from rooms and entries.

Sixteen were brought out, including 1 man who was revived by artificial respiration. At 4:00 p. m. the first bodies were found, and rescue crews arrived and took over the work. The bodies were all recovered by 8:30 p. m. without use of apparatus or gas masks. The mine was nongassy, and no rock dust was applied.

November 30, 1928; Princess Pocahontas No. 1 Mine, Roderfield, W. Va.; 6 Killed

(From Bureau of Mines report, by W. J. Fene and Jesse Redyard)

A local gas explosion about 8:00 p. m. killed 6 of the 7 men in the mine. The other man, not in the explosion area, escaped and spread the alarm. Rescue crews and equipment were summoned and entered the mine at midnight. The long distances over which ventilation had to be established (since the haulageway was on return air) made progress slow; the bodies were all out by 9:00 p. m. December 1. Gas masks were used ahead of air.

The mine had been rated gassy a year before; but no fireboss was employed, although the foreman made some examinations. Weak ventilation of the entry face allowed gas to accumulate, and it was ignited by

an open-type mining machine being taken to the face. The flame extended about 1,000 feet from the face. Water holes on the haulageway helped to prevent propagation by dust. No rock dust was used.

December 18, 1928; No. 2 Mine, Drakesboro, Ky.; 6 Killed

(From Bureau of Mines report, by G. T. Powell and A. U. Miller)

Eleven men were on the night shift when the explosion occurred about 7:45 p. m.; 6 were killed; and the others, on the intake side of the air, escaped. At 2:45 p. m. a trackman ignited gas on 5 west 4 north entry with his carbide lamp. He was blown about 30 feet but was uninjured and watched flame roll to the face of 3 rooms. The foreman examined the area but did not find gas.

After the second explosion, the foreman took men into the mine to attempt to reach the affected area; but he and others were overcome, and all came out after they were helped back to fresh air and revived. Rescue crews arrived in the early morning; ventilation was reestablished, and the bodies were recovered.

Some rooms in 5 west entry were caving, and gas apparently accumulated. It was ignited by the night boss attempting to relight an opened flame safety lamp or by carbide lights, or by the trolley locomotive. Some coal dust was ignited, but the explosion was not violent and did not spread.

January 26, 1929; Kingston No. 5 Mine, Kingston, W. Va.; 14 Killed

(From Bureau of Mines report, by J. J. Forbes, Jesse Redyard, and F. E. Griffith)

Sixty-five men of the night shift were in the mine at 1:45 a. m., when an explosion near 13 left on No. 1 main entry extended in as far as 14 right and out to the portal. The explosion gathered force as it traveled out the main entry and wrecked the motor barn, shops, and fan installations outside the portal. Fourteen men were killed outright, and 2 others who were affected by afterdamp escaped 8 hours later; 49 men working on the right of No. 1 main came out safely shortly after the explosion. Gas masks were used to a limited extent in the recovery work.

The mine was rated nongassy, and carbide lamps were used. The mine was dry and dusty; no rock dusting or watering was done. From the evidence, 3 open shots of 40-percent dynamite on a fallen piece of roof rock initiated a dust explosion. It was also possible that gas in a pillar section was ignited by open lights.

March 21, 1929; Kinlock Mine, Parnassus, Pa.; 46 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, and R. D. Currie)

A slope 300 feet long on a 30° pitch is used as a manway and intake airway and contains a supply track and a 5-foot, apron-type steel conveyor. The mine is also cut into the old Valley Camp mine. Coal was dumped in a bin at the foot of the slope and conveyed to the tipple. The conveyor carried 65 tons, and the driving motor and controls were in the tipple. About 7:25 a. m. a signal to stop the conveyor was given from the bottom. The operator on the tipple shut off the power. The conveyor broke near the head sprocket and slid down the slope. A dust cloud was raised and ignited by an electric arc from open electric equipment near the slope bottom.

The explosion was violent, traveling up the slope where it destroyed the conveyor structure and part of the tipple by force and fire and damaged the fan duct; traveling into the mine the explosion destroyed doors, stoppings, overcasts and all equipment through about half the mine (fig. 76).

There were 258 men in the mine; 45 were killed; 212 escaped through the Valley Camp openings that day and 1 on the next day; 1 was killed, and 4 were burned on the tipple. Rescue crews and equipment arrived promptly, but work was impeded by damage to the fan and slope (fig. 77).

After the fan was repaired a systematic exploration of the entire mine was made, using oxygen breathing apparatus and gas masks and restoring the ventilation (fig. 78). This was completed and the bodies removed by evening, March 23. One body was recovered several days later from the sump near the foot of the slope. Three fires were found and extinguished, and 2 others were sealed.

Some foremen and others of the survivors displayed unusual foresight and courage in gathering the 212 men in groups from the widely scattered workings and conducting them to the Valley Camp openings. Most of the route was through old workings and part through waist-deep icy water.

An assistant foreman assembled the 16 men from his section, and after encountering smoke they barricaded themselves in a room; after an hour the air outside was found clear, and they escaped. One man working in a pillar section barricaded himself in his working place and met an exploring crew on his way out the day after (*25, pp. 18, 19*).

The area around the slope bottom, in the passageway and trackless entries, was deep in fine dust. Rock dust had been placed near the slope bottom and on haulage roads, and a spray had been installed over the bin at the slope bottom but had not been used for 3 months because of trouble from freezing. The explosion was propagated in some areas by gas. The propagation was limited by the rock dust applied, wetness of local swamps, and expansion into open workings.

May 27, 1929; Connellsville Mine, Yolande, Ala.; 10 Killed

(From Bureau of Mines report, by F. E. Cash)

At 5:15 p. m. a blower fan in the right slope aircourse stopped when power was cut off by a low-voltage release. The mine foreman restarted the blower and came outside. A main fan at the top of the manway slope also stopped and was not restarted until about 8:15 p. m.

The night shift of 12 men went into the mine about 6 p. m., the night boss going with them without making a fireboss run ahead of the men or before the explosion at 7:25 p. m. Six men were killed by flame and violence and 3 by afterdamp; 2 that were badly burned were rescued. One died 2 days later. One man escaped uninjured. Help was called, and rescuers entered by the manway slope after starting the fan. Oxygen breathing apparatus was used to recover one body.

The working places had been driven too far ahead of air, the ventilating current was loosely conducted by curtains, and blowers and fans were operated intermittently. Examinations for gas were made only irregularly, although gas had been detected in the explosion area for several days. The explosion originated at a hoist on 1 right after gas accumulated because of the interrupted ventilation and was ignited by starting to operate a hoist. The explosion was spread by coal dust but was localized by rock dust and water.

September 27, 1929; Covington Mine, Tahoma, Okla.; 8 Killed

(From Bureau of Mines report, by J. B. Hynal)

About 4:30 p. m., after the day shift had left the mine, the shot firer was firing shots at the face of

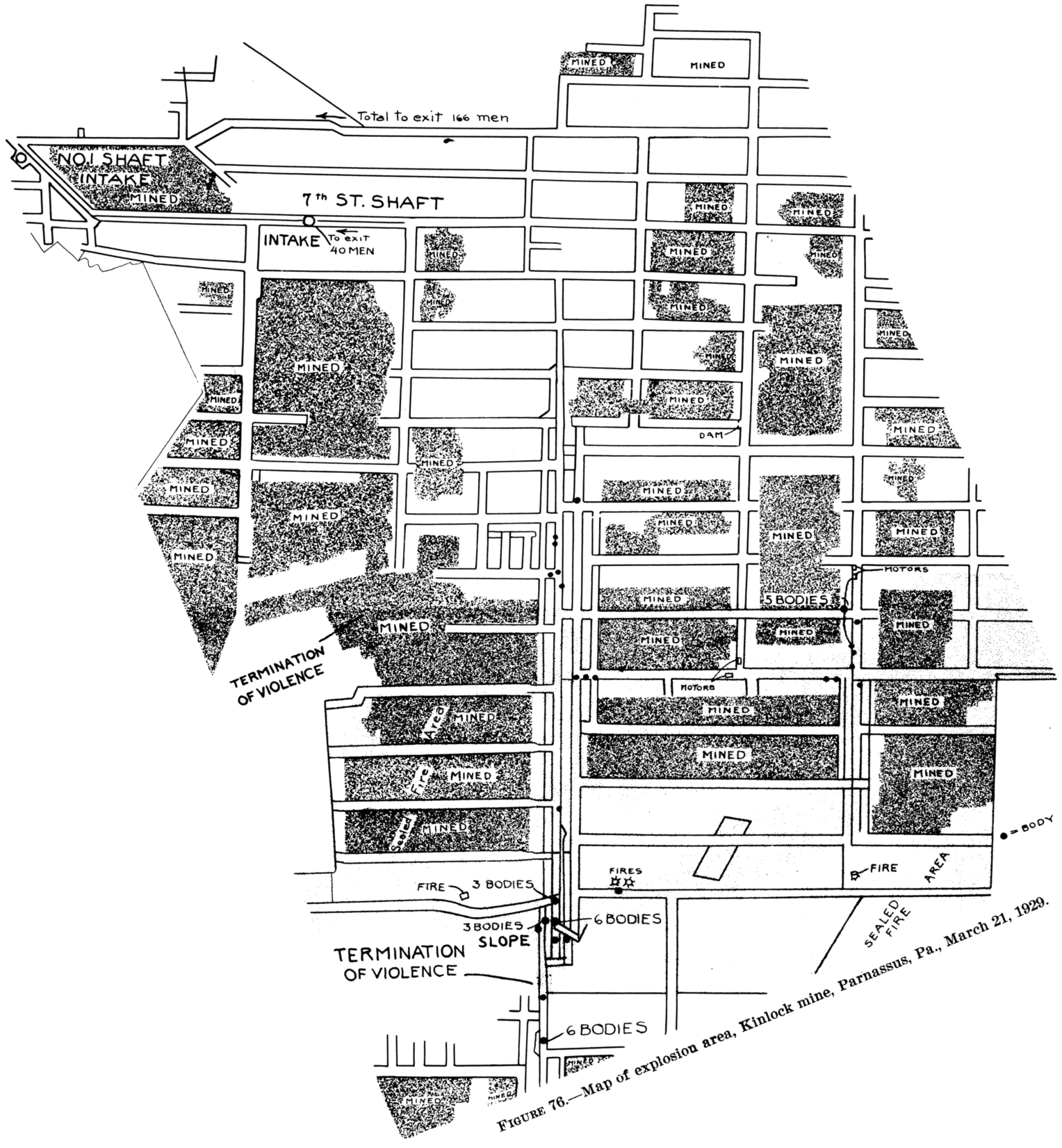


FIGURE 76.—Map of explosion area, Kinlock mine, Parnassus, Pa., March 21, 1929.

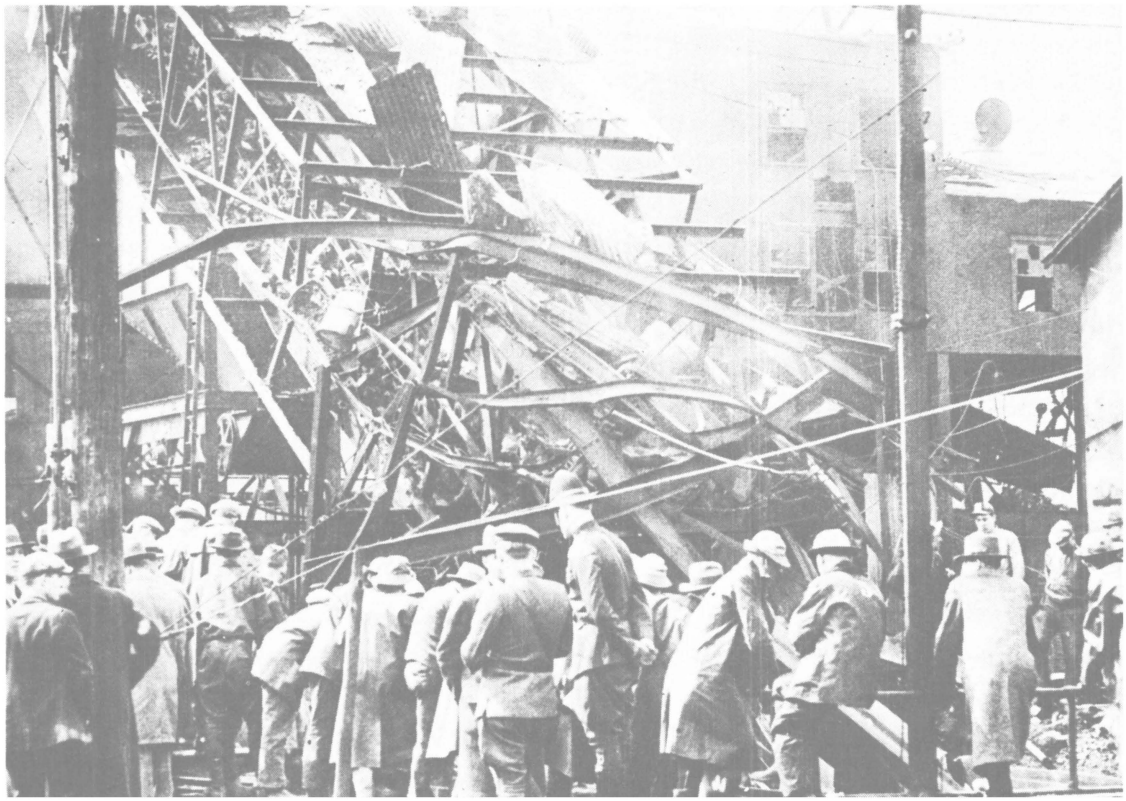


FIGURE 77.—Destruction of conveyor and tipple, Kinlock-mine explosion, Parnassus, Pa., March 21, 1929.

the main slope, and the night shift was starting down. Six of these men were well down the slope, and a seventh was at the slope mouth when the explosion caught them, blowing the top man 200 feet and through the corrugated-iron engine house. Three of 5 holes charged with Cardox were fired in the face of the slope. They were fired singly from a 220-volt powerline at a switch about 50 feet from the face.

Gas, accumulated at the face or released by the first shots, was ignited by the arcs as the firing cable nips were attached. Dust was ignited and propagated the explosion out the slope. The bodies were recovered by other employees within a short time. The mine was dry and dusty, sprinkling was ineffective, and no rock dust was used. The mine was examined for gas before the day shift entered, but no other examinations were made.

December 1, 1929; Old Ben No. 8 Mine, West Frankfort, Ill.; 7 Killed

(From Bureau of Mines report, by Alex U. Miller)

A crew of the night shift of 24 men was recovering rails and other material at the mouth of No. 6 slab entry of 20 north 5 east, which was squeezing and falling, probably liberating methane. At 2:30 a. m. an explosion killed seven of the men; the rest escaped uninjured. The night foreman saw a cloud of dust as he approched the section; and, after finding ventilation destroyed in the area, he called for help. Crews from other mines assisted, and apparatus was used in exploring and in constructing brattices. The bodies were recovered without delay, except for one under a large slate fall.

The explosion was localized by expansion into old workings and by rock dust on the haulage entries. Gas from the caving roof was forced by falls over the locomotives used by the men getting out the rails and was ignited by an arc. Dust helped to intensify the explosion at room 3 in the 3d east slab, where some explosives may also have been ignited.

December 17, 1929; Old Town Mine, McAlester, Okla.; 61 Killed

(From Bureau of Mines report, by C. A. Herbert)

The main slope was driven down the pitch, and the manway slope some 600 feet distant served as the return aircourse. Sixty-six men were in the mine at about 10:30 a. m., when an explosion in the west slope aircourse near the lower end at 9th west killed all the men below the 5th east and west entries instantly by violence and burns. In the 5th west all men were overcome by afterdamp while attempting to escape, as were those in 5th east, with the exception of three who turned back on encountering the smoke and retreated behind a curtain into No. 9 room. Two remained near the curtain and were found unconscious by rescuers at 5 o'clock in the afternoon; the other went up to the face of the room and suffered no ill effects. He joined the rescue crew after release; the other two were revived and taken outside.

Three men working on haulage at the inside rope hoist went into the smoke on the main slope and got into an empty trip and and signaled to hoist. When the trip reached the surface, one was missing. His body was found along the track; apparently he had raised up and struck against a timber, breaking his neck and knocking him out of the car.

FIGURE 78.—Rescue crew entering Kinlock mine, Parnassus, Pa., after explosion, March 21, 1929.

The explosion was only moderately violent; flame and force were confined to the lower workings. Help was called, and the bodies were recovered and the three men rescued without use of breathing apparatus or gas masks. The main exhaust fan was not in use, as it was usual to rely on a booster fan, blowing off the main slope. This fan had stopped before the explosion as the belt was off the pulley.

The face of the aircourse was far ahead of air; and a small blower fan recirculated and mixed air and gas in the 9th west aircourse, where the explosion originated from striking a match to light a cigarette or from arcing of the fan motor. Dust was ignited, and a slow, low-pressure explosion extended to the faces of all the lower entries (fig. 79). No rock dust was used, and occasional sprinkling of the entries did not change the dry and dusty conditions.

January 13, 1930; Peerless Mine, Straven, Ala.; 7 Killed

(From Bureau of Mines report, by F. E. Cash)

A local gas ignition at 3:35 p. m. resulted in the death of 7 of the 25 men in the mine. The body of gas was small; and the large gob area back of No. 8 right longwall allowed expansion, so that no pressures built up and coal dust was not raised or ignited. Seven men were working on No. 8 wall and 2 others on the entry at the bottom of the wall.

A mining machine was cutting near the top of the wall where the air current did not circulate, because the packwall had not been brought closer than 35 feet to the end of the wall. Gas accumulated and was ignited by the open-type mining machine. All seven men were in the rather small area covered by the flame and were killed (fig. 80). There was no damage to the mine, and the victims were removed at once. One was living but died the next day. The wall boss had left his flame safety lamp on the entry, and no examination for gas had been made after a shot had been fired shortly before the explosion.

January 19, 1930; No. 1 Mine, Lillybrook, W. Va.; 8 Killed

(From Bureau of Mines report, by W. J. Fene and L. L. Naus)

At 3:30 a. m. 23 men were in the mine, when a local explosion caused the death of 8 and injury by burns to 4 others, the rest escaping uninjured. Three of the injured were assisted out of the mine by the night foreman, and the other injured man was rescued 4 hours

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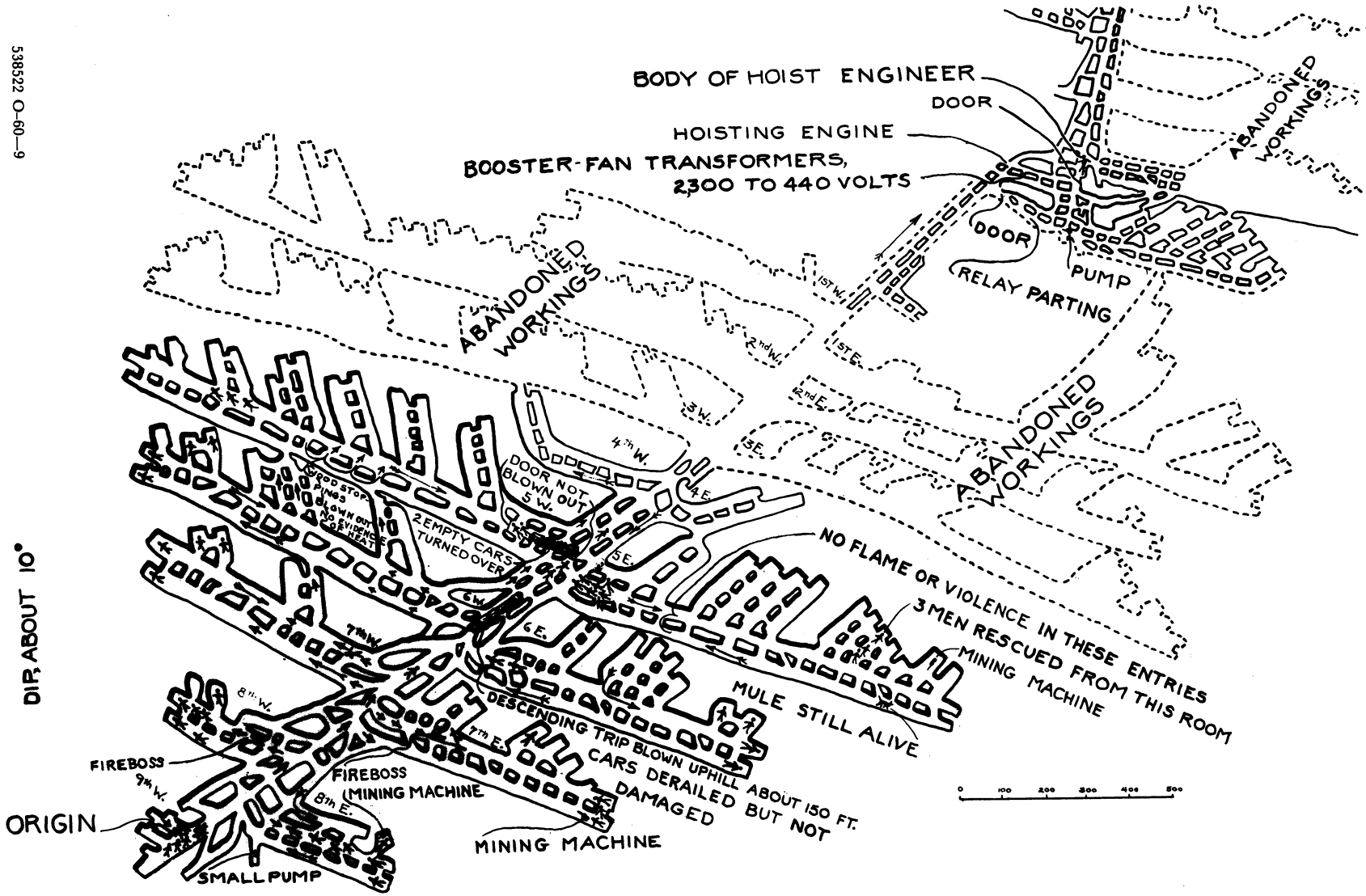

FIGURE 79.—Map of explosion area, Old Town mine, McAlester, Okla., December 17, 1929.

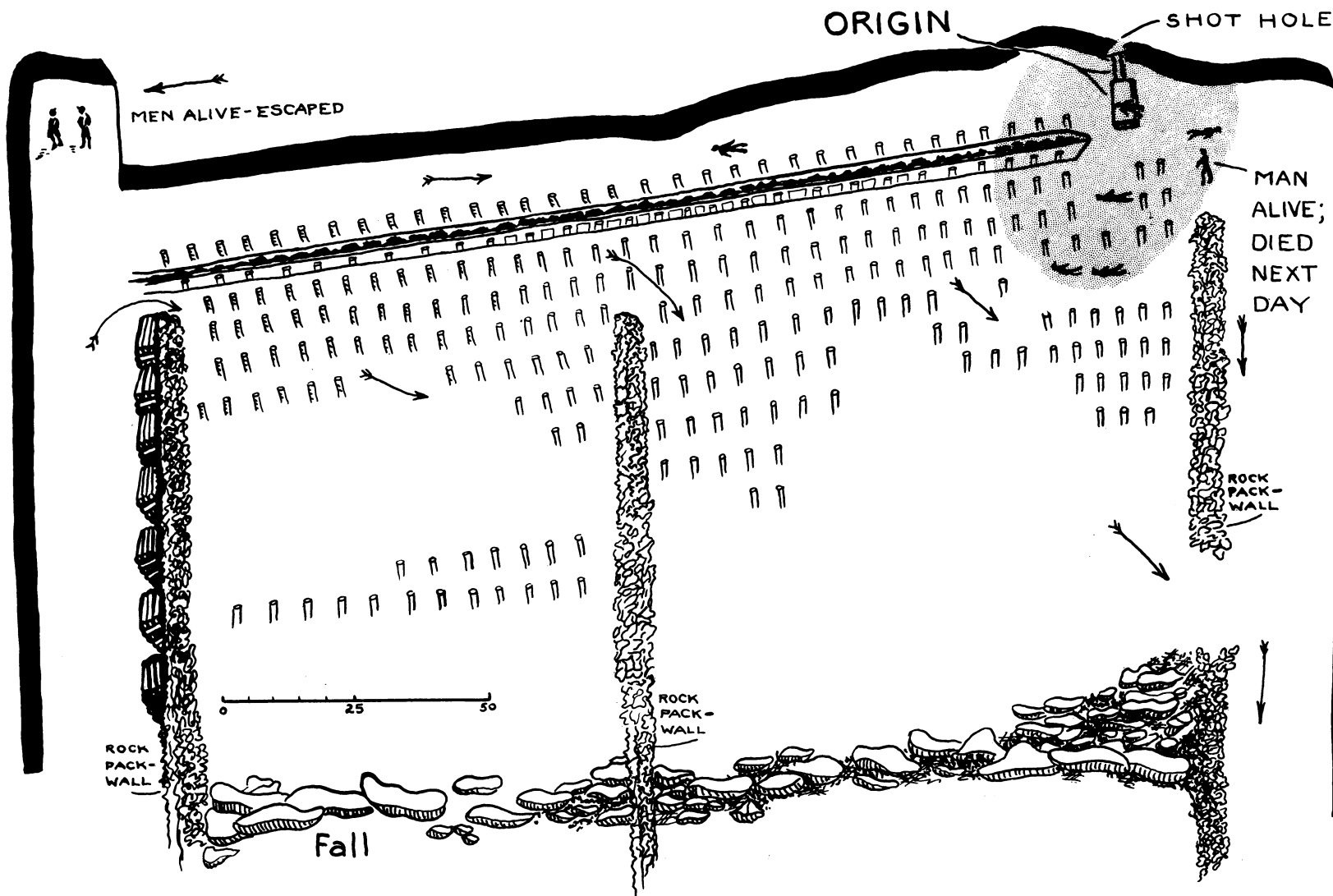

FIGURE 80.—Map of explosion area, No. 8 wall, Peerless mine, Straven, Ala., January 13, 1930.

later. The explosion, confined to 4 or 5 rooms, was not violent and did almost no damage to the mine.

A cable-reel locomotive was being coupled to loaded cars at the face of a room, when the motorman saw flame burst from the resistance coils, followed by an explosion. He was thrown about 10 feet but was able to walk out with 2 miners from an adjacent room. Gas from falls in several rooms beyond the point of origin had collected and was not detected by the foreman. Coal dust was ignited but did not cause propagation. Some of the victims might have been saved if apparatus crews had been available to reach them promptly.

February 6, 1930; Standard Mine, Standardville, Utah; 23 Killed

(From Bureau of Mines report, by D. J. Parker and R. I. C. Manning)

At 8:50 p. m., about the time of the explosion, 26 men were working in No. 1 mine and 3 men in the connected No. 3 mine. Dust issued from the portals of the rock tunnel, and the abandoned main entries of No. 3 mine but did not damage or stop the fan, as the explosion doors over the airshaft were blown off. This short-circuited the air until the covers were replaced 2 hours later.

A 2-mile trip in deep snow was required to reach the airshaft. The explosion was violent in No. 3 mine but did not extend into No. 1 mine. The 3 men in No. 3 mine were killed, and 17 of those in No. 1 died in the afterdamp. Five of the men in No. 1 mine successfully barricaded themselves in a room, using boards, props, and brattice cloth. One of them left the barricade to obtain still more material and was overcome (*24, pp. 34, 35*). He was found by a rescue party 12 hours later and revived by artificial respiration. The other four were rescued at the same time unharmed. Another unconscious survivor was also found with two dead men, and he was also revived.

Rescue crews and equipment were called from the nearby Spring Canyon rescue station and from other mines. Apparatus crews recovered the three bodies from No. 3 mine, but other work of recovery was done as ventilation was restored. Three men of a fresh-air crew were killed by a falling roof slab on February 7.

Gas accumulated by leaving open one or more doors and was ignited by an open-type mining machine in No. 20 room barrier crosscut. Coal dust was thrown up and ignited, so that the explosion became widespread and violent. Rock dusting and rock-dust barriers had been applied to a few locations, but not enough to check an explosion.

March 8, 1930; New Peerless Mine, Lynn, Utah; 5 Killed

(From Bureau of Mines report, by D. J. Parker and James Westfield)

Five men were killed and 2 others seriously injured by an explosion about 4:45 p. m. Six others were uninjured, and survivors were hoisted to the surface within an hour. The bodies were removed soon afterward by an apparatus crew. Three were badly burned, and 2 died by asphyxiation.

The fan was operated only occasionally; normally natural ventilation was relied upon. Compressed-air lines, from which jackhammer drills operated, were used to supply air to the working faces. One line had been shut off for an hour before the explosion, and gas that accumulated at the face was ignited by an open-type mining machine. Coal dust was involved only to a small extent, as water was used liberally while cutting and blasting were done. No rock dust had been applied.

March 26, 1930; Yukon Mine, Arnettsville, W. Va.; 12 Killed

(From Bureau of Mines report, by R. D. Currie)

A coal-dust explosion, local in extent, killed the 12 men in the affected area, 9 right off 1 main, at 2:06 a. m. A fireboss in an adjoining area felt the vibration and then encountered smoke; a machineman also felt the pressure wave and brought out the first report. Officials were notified and assistance called. Ventilation was soon reestablished in the area, and the bodies were recovered without use of apparatus.

A heavy fall in a pillar area raised a dust cloud, probably mixed with gas, that was ignited by an arc from a cable-reel locomotive. Rock dust was not used, and water was not applied to allay the dust.

March 30, 1930; Pioneer Mine, Kettle Island, Ky.; 16 Killed

(From Bureau of Mines report, by J. F. Davies)

About 2:15 p. m. an explosion in a section of the mine known as No. 2 opening killed all of the 16 men in the section. The explosion was moderately violent throughout most of the section. State and Federal mine-safety officials were in a meeting at the office of the chief mine inspector; when notified of the disaster, all traveled to the mine, first by auto to Pineville, then by special train to the mine. Recovery operations were conducted by restoring ventilation, as the fan was not damaged.

Gas accumulated near a partly sealed unventilated area and was ignited by the carbide light of a motorman who entered from a nearby haulageway. The section was dry and dusty, and coal dust propagated the explosion. No rock dust had been used, and watering was not done. Although the mine was known to liberate gas, carbide lights were used.

April 12, 1930; Carbonado Mine, Carbonado, Wash.; 17 Killed

(From Bureau of Mines report, by S. H. Ash and J. G. Schoning)

An explosion in 2d level workings in Douty No. 8 bed at about 5:30 p. m. killed all of the 17 men in the section. The Bureau of Mines rescue truck was called from Seattle, and rescue crews recovered the bodies by 1 a. m. the next morning. Ventilation was easily restored, and apparatus men made explorations ahead.

The explosion originated at the face of No. 5 chute, when two holes were fired in the presence of gas. The holes were loaded with permissible explosive and fired electrically; however, they were overloaded, and either one might have been almost an open shot, as the other could have broken out all the burden. The chute was dry and the air very dusty. The face was ventilated by compressed air only. The explosion was propagated and probably initiated by a mixture of gas and dust. No watering was done and no rock dust used. Some of the workings were wet, and this limited the explosion.

October 27, 1930; Wheatley No. 4 Mine, McAlester, Okla.; 30 Killed

(From Bureau of Mines report, by C. A. Herbert)

About 9:30 p. m. the underground night shift of 30 men was all killed by an explosion. One, a trip rider, was killed at the mouth of the slope as he was loading material into a car. Almost every stopping in the mine was blown out, as was much of the timbering, resulting in heavy falls of rock, except along the slope. Rescue crews and equipment arrived during the night, and temporary stoppings of brattice cloth were put in to restore ventilation into the section where the night

shift had been working. The work was done without the use of apparatus except for the recovery of the last 3 bodies in the 15th west, removed by a crew at 4:00 p. m. October 30.

Explosive gas had accumulated in the face of a crosscut and aircourse after the line curtain was removed while coal was loaded out. A mining machine cut into the crosscut from the other side, and the gas was carried over the controller and ignited. The explosion was propagated by coal dust over the entire mine. Rock dusting was so limited in extent that the effect was negligible. Ventilation was inadequate and carelessly maintained. Figure 81 gives details of the explosion.

November 5, 1930; No. 6 Mine, Millfield, Ohio; 82 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, S. P. Howell, and M. J. Ankeny)

A localized gas and dust explosion in the northwest section of the mine occurred about 11:45 a. m., killing 82 men—2 outright by force and flame, 6 by burns and afterdamp, and 74 by afterdamp alone. Two men were rescued promptly after the explosion, 19 were released from behind a barricade, and 119 escaped unaided. The fan was not damaged, and although there was a small air movement at the bottom of the main shaft it was not realized there that an explosion had happened.

A farmer living near the new airshaft, which was not yet in use, saw a mechanic blown from the top of the shaft. The farmer rushed to the telephone and called the company offices. Underground officials were notified to send the men out, and several heroic rescues were made of men overcome or injured. As rescue crews arrived a start was made in organized exploration and recovery. About 9:00 p. m. 19 men were found behind canvas brattices in the face of a pair of entries and released by bringing up fresh air (*24, pp. 21, 22*). Another barricade was found a little later, but the 7 men in the small area enclosed had been dead for some time (figs. 82 and 83). Apparatus crews helped to explore ahead of fresh air.

Gas had accumulated in the 3 and 4 north section when automatic doors were not installed as planned. The area was inactive; but power was left in the trolley wire in the section, although fireboss examinations were omitted. A fall carried the wire to the rail, causing an arc and igniting the gas. The mine was classed gassy, but open lights were used. Coal dust entered into the explosion, but a high percentage of incombustible matter in road dust and room for expansion limited the spread. No rock dusting or watering was done.

November 29, 1930; Lutie No. 5 Mine, Lutie, Okla.; 15 Killed

(From Bureau of Mines report, by C. A. Herbert)

About 12:30 p. m. 15 men were killed and 2 others seriously burned by an explosion originating at the face of the 11th east entry. The explosion was confined to that one entry, and men from other sections made their way out unassisted. Thirteen of the 17 men in the 11th east were killed outright: of the 4 injured men, 2 died soon after rescue. The rescue of the live men and recovery of the bodies were completed within 3 hours, without the use of breathing apparatus or gas masks.

Coal was being run down the chutes from the long face on 11th east, and as the curtains in the chutes were raised the air to the face of the entries was short-circuited. Gas accumulated and was ignited when one of the miners attempted to smoke. Coal dust was ignited, but wet conditions in the entry outby the face helped to prevent propagation. No rock dusting was done. Figure 84 (p. 128) shows the workings and the exent of the explosion.

December 6, 1930; Lamb Mine, Madrid, N. Mex.; 5 Killed

(From Bureau of Mines report, by G. M. Kintz and E. A. Anundsen)

An explosion in the 6th left entry at 10:35 a. m. resulted in death to 5 men, serious injury to 2 others, and slight injury to 5 more. The remainder of the 81 men escaped uninjured. Explosive accumulations of methane had been found for some days between crossbars near the faces of the 5th, 6th, and 7th left entries, and it accumulated rapidly when ventilation was interrupted. Construction of an overcast required cutting and splicing a feedline carrying power for electric equipment in the area. Blowers used to ventilate working faces were cut off, and gas accumulated and was pushed back over the blowers when power was restored. The foreman tested and found gas at the blower in 6th left and told the electrician with him to pull the switch.

As the switch was thrown off, it arced and ignited the gas. The explosion was increased by coal dust but was checked by rock-dust barriers and by some rock dust applied to the entries so that the flame did not travel out of 6th left. Rescue crews were organized on the surface, and the injured men were removed. Ventilation was restored up to the last crosscut, and an apparatus crew explored the faces and removed the bodies.

January 3, 1931; Midvale No. 4 Mine, Midvale, Ohio; 5 Killed

(From Bureau of Mines report, by J. J. Forbes and M. J. Ankeny)

Nineteen men were in the mine about 8:50 a. m., when a local coal-dust explosion killed 5 men, 1 by violence and burns and 4 by burns and afterdamp. These five men were working in 8 west. The foreman, a motorman, and a trip rider were in 1 east when they felt the blast, and they came to the main entry, bringing three men with them. The other eight men from 4 and 5 west also came out. Afterdamp prevented entrance into 8 west, so they all came to the surface and notified the superintendent.

The fan housing over the airshaft was partly blown out, but the fan was undamaged. Repairs were started, and a crew went in by the haulage drift to a fall. While cleaning up the fall the group became distressed from afterdamp; 4 reached the airshaft, and 4 went back toward the locomotive left at a parting, but 3 were overcome. The fourth man reached the locomotive and ran it outside, and others came back and rescued the three who were overcome.

Two Bureau of Mines men reached the mine from Pittsburgh, Pa., by airplane at 1:30 p. m. and advised that all entrance be through the airshaft instead of through the main haulage road in return air. Other rescue men arrived; ventilation was restored and the air cleared. The bodies were removed through the main haulageway.

A cut of coal had been blasted down in the face of 8 west. One of the three holes blew out and ignited dust stirred up by the others (fig. 85, p. 129). The holes were charged with pellet black powder and stemmed with coal dust. Fuse was used to ignite the powder. No rock dust had been applied. Methane had not been found, and open lights were used.

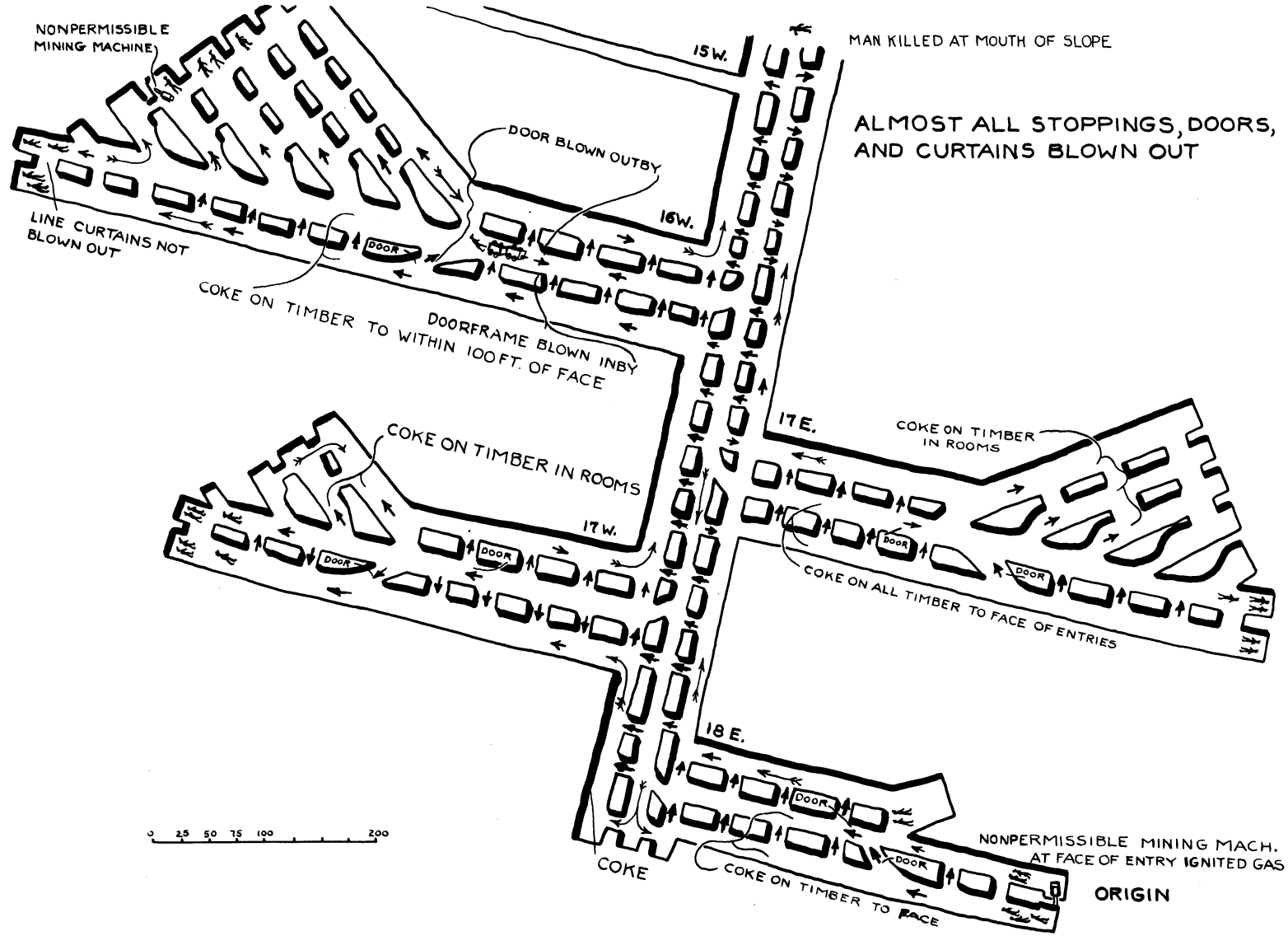

FIGURE 81.—Map of explosion area, Wheatley No. 4 mine, McAlester, Okla., October 27, 1930.

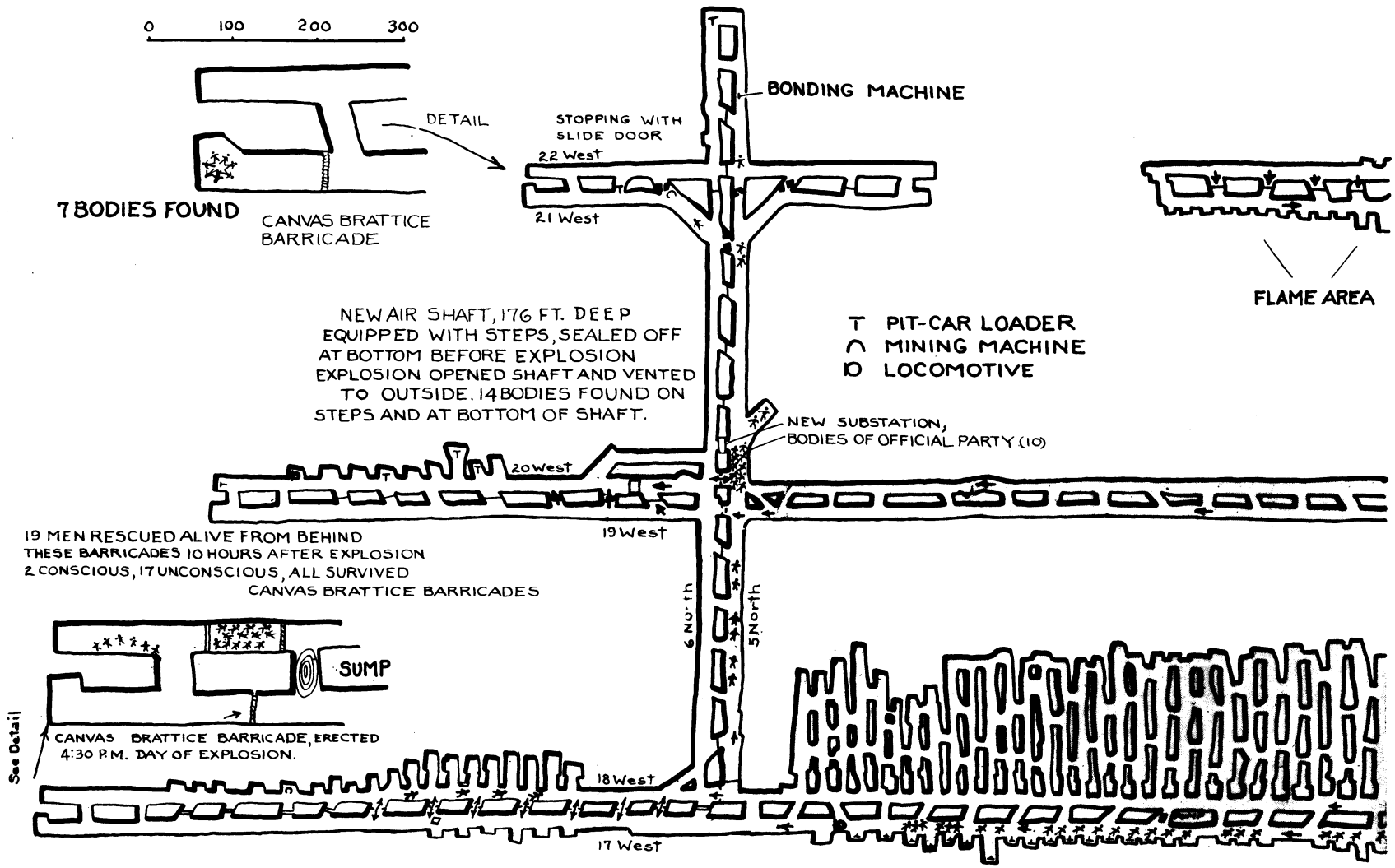

FIGURE 82.—Map of explosion area, mine No. 6, Millfield, Ohio, November 5, 1930. See also figure 83.

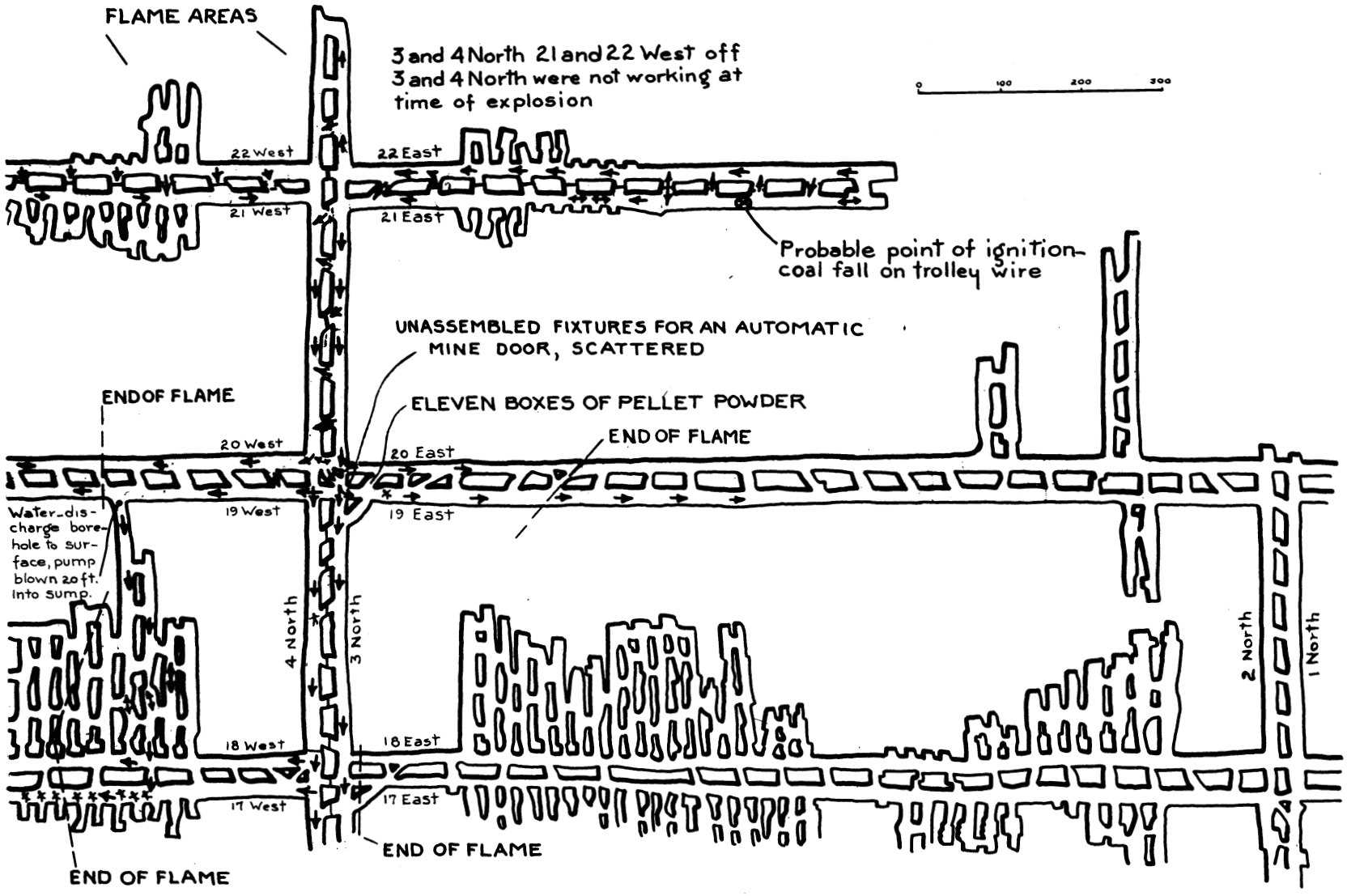

FIGURE 83.—Map of explosion area, mine No. 6, Millfield, Ohio, November 5, 1930—Continued.

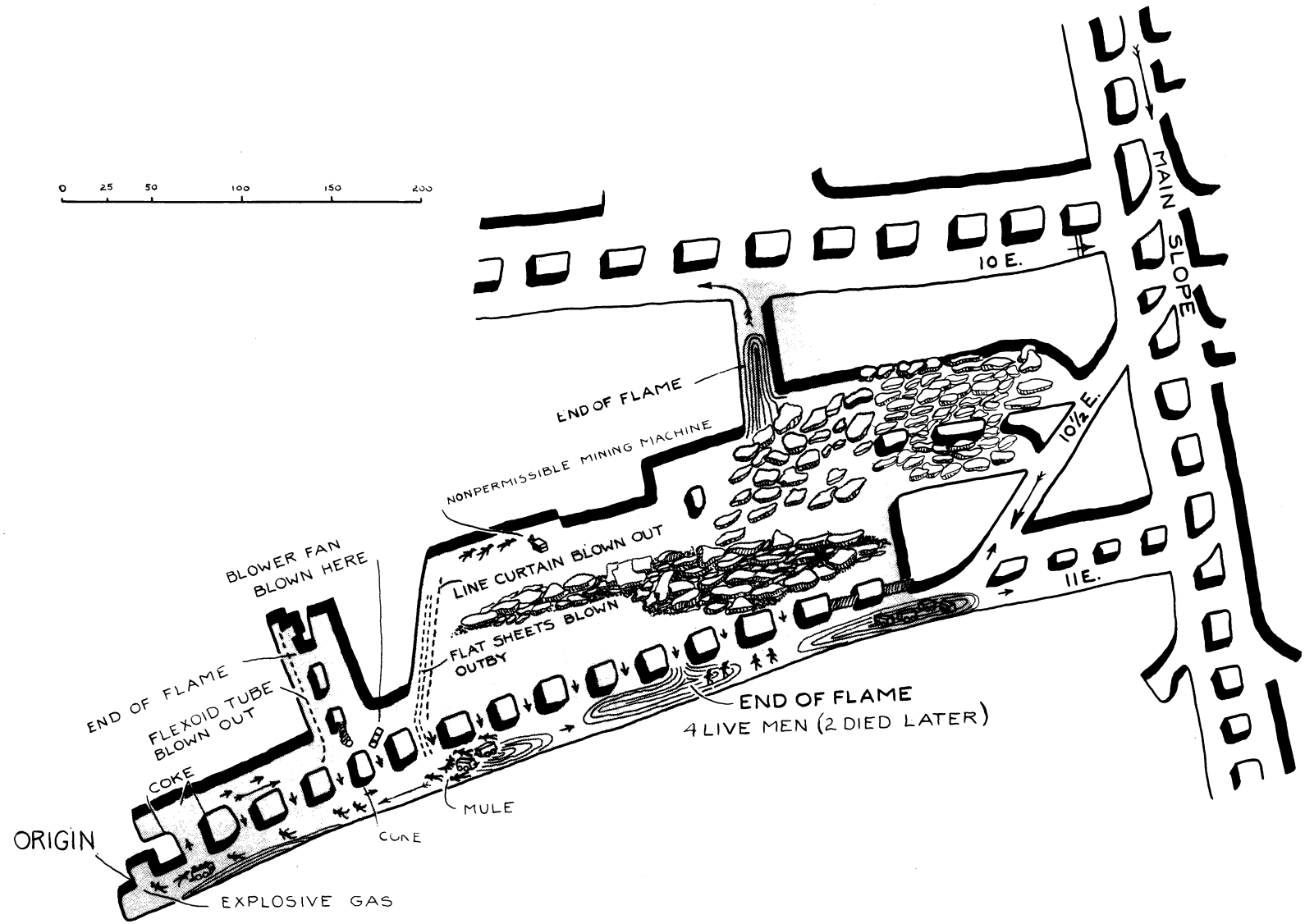

FIGURE 84.—Map of explosion area, mine No. 5, Lutie, Okla., November 29, 1930.

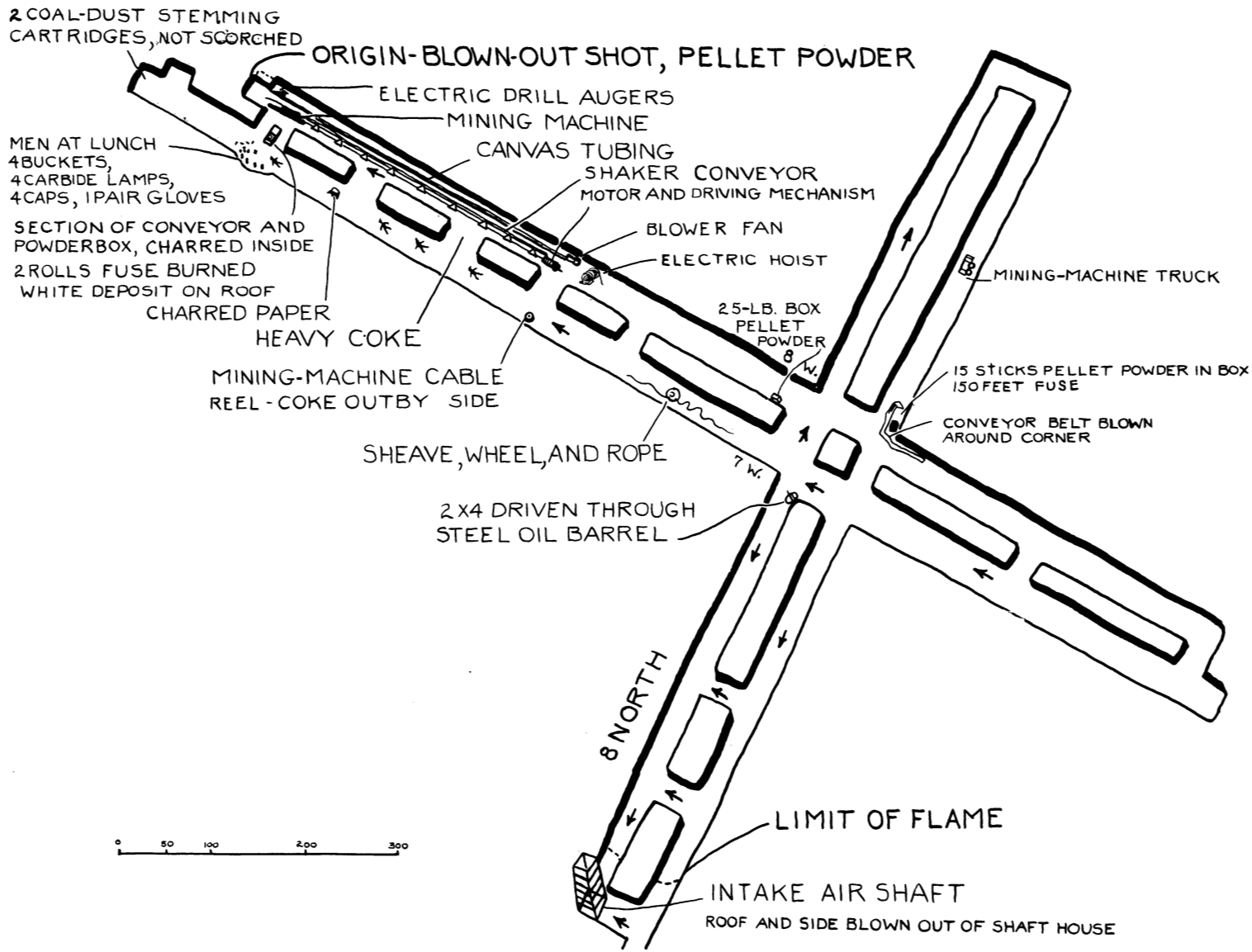

FIGURE 85.—Map of explosion area, mine No. 4, Midvale, Ohio, January 3, 1931.

January 6, 1931; Raleigh-Wyoming No. 2 Mine, Glen Rogers, W. Va.; 8 Killed

(*From Bureau of Mines report, by W. H. Tomlinson*)

A local gas and dust explosion at 2:50 a. m. killed 8 men, 4 by burns and violence and 4 by poisonous gas behind a poorly erected barricade in the panel next to that in which the explosion occurred. Fifty others were not affected and left the mine unaided. Flame of the explosion extended about 300 feet from the origin at the face of a panel entry; violence was felt out to the main entries about 1,800 feet and for a short distance into the 2 adjoining entries.

The night foreman telephoned to the outside, and a rescue party came to the affected area and advanced by temporarily restoring ventilation until they discovered the bodies of the four men behind the canvas barricade. Rescue teams with oxygen breathing apparatus were called in to explore the entry where the explosion started and bring out the four men killed there. The entry was blocked by falls, so that ventilation could not be restored until a connection was made from another pair of entries approaching it.

They were holed into the explosion area on January 11, and an investigation showed that an accumulation of gas, caused by a door being left open, was ignited by an arc from a storage-battery locomotive. The locomotive, with a loaded car, was found leaving the face on the 7-percent grade with the controller in reverse as a brake. Although the mine had been rock-dusted throughout, the amount of rock dust in most of the workings would not have prevented dust from propagating an explosion in so gassy a mine. The affected entry had been rock-dusted 5 days before the explosion, and this limited it to a small area (fig. 86).

January 28, 1931; Little Betty Mine, Dugger, Ind.; 28 Killed

(*From Bureau of Mines report, by C. A. Herbert*)

Three minutes before the end of the day shift, 2:57 p. m., a gas explosion propagated by coal dust resulted in the death of 28 of the 123 men in the mine. Twenty-seven were killed, 13 were rescued from the explosion area, 1 of whom died, and 83 escaped unassisted. Seven of those rescued had gone into a room near the face of a pair of entries and hung a curtain across the mouth of the room (*25, p. 21*). A door and stoppings at the outby end of these entries had been blown out so that the air current and afterdamp did not reach them. No apparatus or gas masks were used in recovery.

A room had been cut through to another idle room in which roof falls released gas and pushed it through the cut and over the open lights of loaders. The explosion was not violent and it covered only a small section before it died out because of dampness and expansion (fig. 87). The mine was gassy, but all men used open lights. No rock dusting was done.

May 29, 1931; Richards Colliery (Anthracite), Mount Carmel, Pa.; 5 Killed

(*From Bureau of Mines report, by S. P. Howell*)

About 12:20 p. m. a local explosion in 38 breast, east north dip gangway, No. 4 vein, No. 12 slope, killed 4 men outright and injured another who died 12 hours later; 9 others in the section were not endangered. Rescue and recovery were effected promptly, as little damage was done to the workings. Oxygen breathing apparatus was used in recovering the bodies.

Gas had been found in the breasts and an accumulation formed when a fall from a pillar blocked the return air. It was thought that a blown-out shot of permissible explosives or an arc from the firing wires ignited the gas. Smoking was a possible source but was not indicated.

November 3, 1931; No. 20 Mine, Holden, W. Va.; 5 Killed

(*From Bureau of Mines report, by J. F. Davies*)

About 9:00 a. m. an explosion in a pillar section killed the 5 men in the section; 130 men in other parts of the mine were not affected. Pillars were being slabbed or cut and for several days squeezing had developed and falls occurred. Equipment was being recovered, some or all of the men using open lights; a fireboss and a section foreman were included in the party.

The fireboss was thought to have encountered gas while wearing an open light on his cap as he went beyond the place where the others were to work. Dust was not involved, and the explosion was limited by rapid expansion in the open area.

December 28, 1931; Overton No. 1 Mine, Irondale, Ala.; 5 Killed

(*From Bureau of Mines report, by F. E. Cash*)

About 4:30 p. m. gas was ignited by a nonpermissible mining machine on a wall off 13 left, burning 1 white man and 4 Negroes, who died from 1 to several days later. Nine men were in close proximity to the ignition, 4 escaping uninjured. No rescue action was necessary, as the injured men walked or rode in cars to the back slope with the uninjured men.

The fireboss had found a "slight cap" on the wall and had told the wall boss about it but had not mentioned it in his written report. Because of meager air circulation along the right wall face, the gas built up to an explosive mixture during the day and was ignited when the mining machine was started. There was no violence, and dust was not ignited. The mine was gassy, and electric cap lamps were used. Rock dust had been applied to some of the haulage roads but not enough to insure against propagation of a strong explosion.

January 18, 1932; Parrott Mine, Parrott, Va.; 6 Killed

(*From Bureau of Mines report, by J. F. Davies*)

A local explosion in the 5 east section about 5:25 p. m. resulted in the death of the six men in that section. The remainder of the night crew, 12 men, were not injured, although some were in the zone of violence in the west section. All escaped. The mine officials did not call for assistance or notify the State mine inspector or the Federal Bureau of Mines. Rescue parties recovered the bodies by advancing the air by means of canvas brattices. No rescue apparatus was used. The mine was known to be gassy, and a fireboss went into the mine at 4:00 a. m. His examinations were not thorough and the written reports were vague. Methane was present in the air in almost all the workings, and ventilation was so arranged that methane-laden air from inactive sections was carried into active sections.

The ventilation in 5 east section was deficient, and an explosive accumulation had built up near the face of the entry, which was ignited when two of the men attempted to light cigarettes. A nonsmoking rule was commonly disregarded. The coal is a variety of semi-anthracite, and the dust did not propagate an explosion.

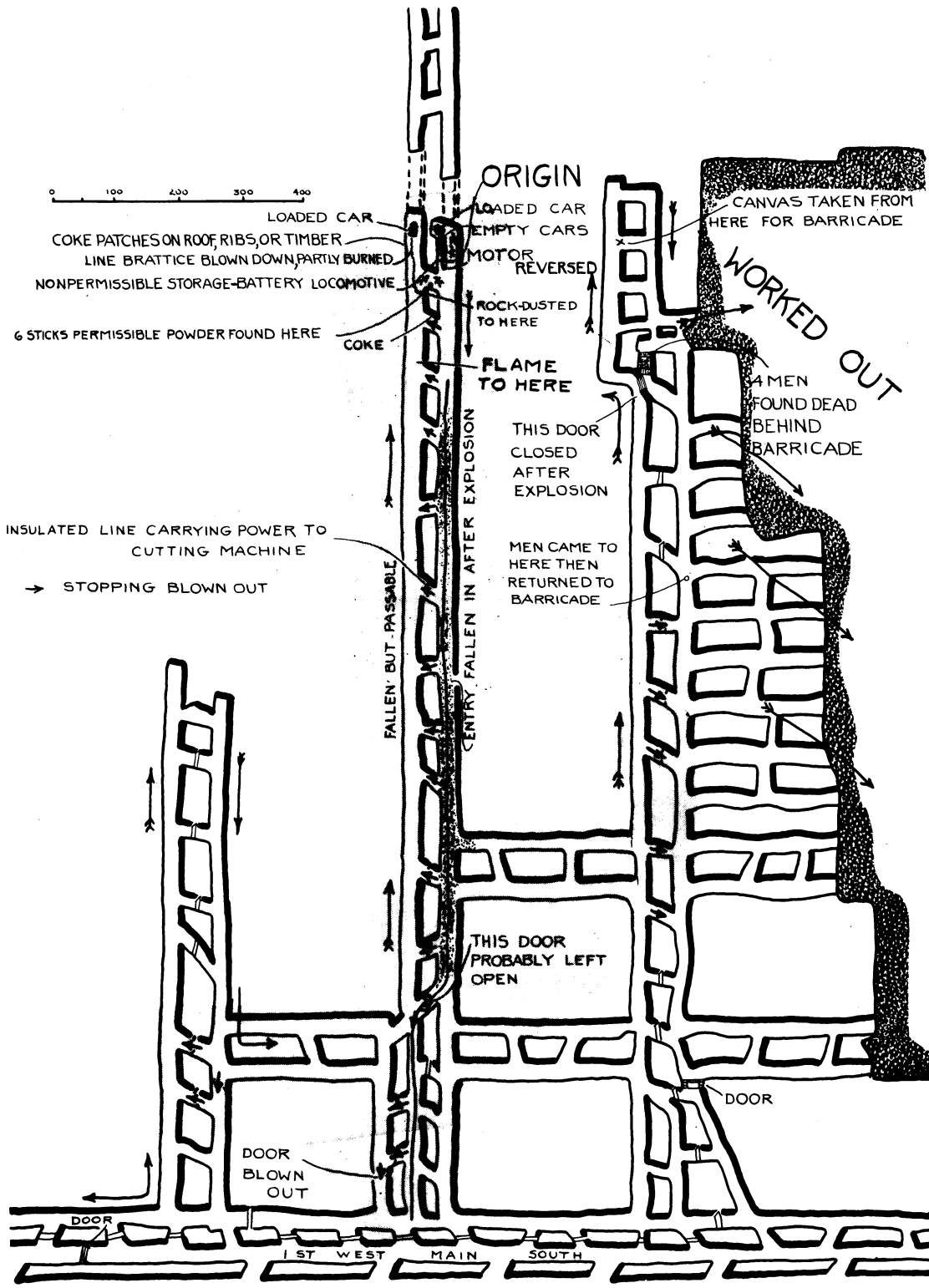

FIGURE 86.—Map of explosion area, mine No. 2, Glen Rogers, W. Va., January 6, 1931.

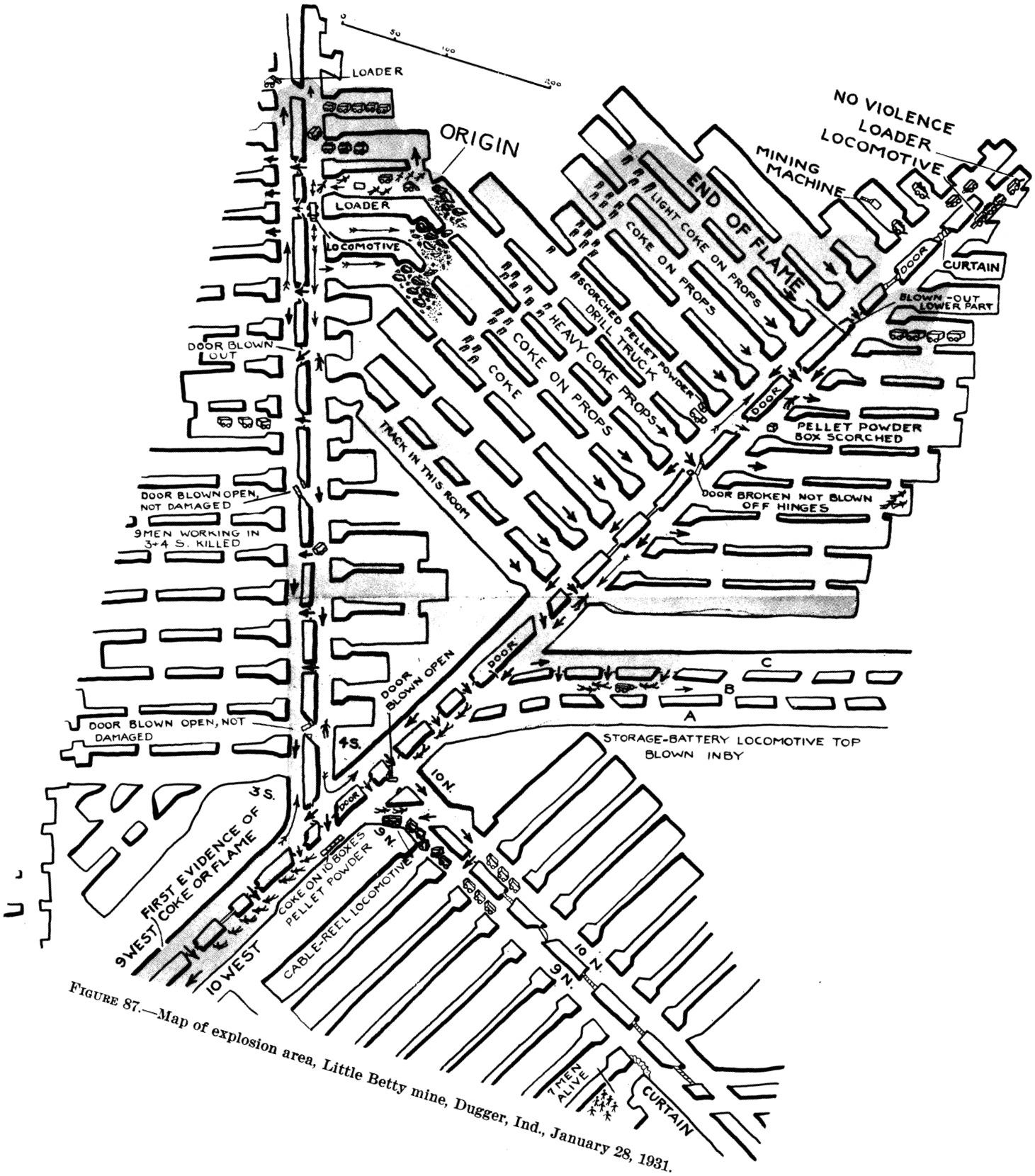

FIGURE 87.—Map of explosion area, Little Betty mine, Dugger, Ind., January 28, 1931.

February 27, 1932; Boissevain Mine, Boissevain, Va.; 38 Killed

(From Bureau of Mines report, by J. F. Davies)

Thirty-eight men were killed by an explosion at 4:05 a. m. in the basin main section. All the bodies were burned, and apparently all died immediately. There was evidence of great force and heat throughout the area. Four other men escaped from other portions of the mine not affected by the explosion. Assistance was called, and company officials and rescue teams, State and Bureau of Mines inspectors, and crew leaders arrived during the day. Because timbers were knocked out and equipment and stoppings destroyed and heavy falls covered much of the area, restoring ventilation and recovering the bodies were difficult. Many of the bodies were buried under falls. Gas-mask crews made short exploration trips ahead of the brattice crews.

Origin of the explosion was fixed as the face of room 26 off 3 left off basin main, caused by blasting four holes in the upper bench simultaneously. The four shots had too much burden, as a portion of each drill hole was left. The explosive used may have been either a permissible or dynamite. Dust, from firing the holes in the bottom bench immediately before the top holes and from the windy shots, was ignited; and the explosion propagated throughout the basin mains before it was checked by expansion and wet spots (fig. 88). The mine was nongassy, and because of the supposed low-volatile nature of the coal, no rock dust had been applied.

June 13, 1932; Splashdam No. 6 Mine, Splashdam, Va.; 10 Killed

(From Bureau of Mines report, by J. F. Davies and H. B. Humphrey)

A gas and dust explosion at 8:30 a. m. resulted in the death of the 10 men in the mine—1 by violence, 6 by flame and afterdamp, and 3 by afterdamp alone. The fan had been started about 7:00 o'clock on Monday morning before 11 men went in to perform jobs left for an idle day. One man finished drilling a brushing hole at the face of the main entry and came out. The explosion traveled out the main entry from 2d south to the portal with increasing force. Leaves were scorched and burned 300 feet outside the portal.

Gas had been found in the 1st east off 2 south of 6 main, and during the period the fan had been shut down before this morning an explosive mixture had accumulated in that section. A complete inspection was not made before the crew entered, and the gas was moved gradually into the path of the men and was ignited by their open lights. Dust from the gas explosion and from the place where some of the men were loading fines off the track into cars helped to increase and propagate the explosion (fig. 89). No rock dust had been used.

December 7, 1932; Morgan-Jones Mine, Madrid, N. Mex.; 14 Killed

(From Bureau of Mines report, by G. M. Kintz)

At 7:43 a. m. a gas explosion caused the death of 14 of the 51 men in the mine. Two others were overcome but revived as soon as fresh air reached them; 35 others were uninjured and escaped unassisted. The fireboss examined only the working places, came out, and checked the men into the mine. They reached their working places between 7 and 7:30 a. m. Cars had been loaded by miners in idle days; and a contractor in 2d dip, 4th right main, had 16 cars to change. In taking out the loaded cars, bringing in the empties, and distributing them, he left 1 or 2 ventilating doors open for over half an hour.

Gas accumulated in 2d dip and was ignited by an arc when a signal was given on the bare 60-volt a. c. signal wires by shorting them with a metal rod. One of the miners who escaped from the affected section telephoned the mine office from inside the mine, and officials promptly started rescue and recovery work. No apparatus was needed, although it was available at the mine; some blownout stoppings were replaced with canvas, and line curtains were hung to clear the rooms.

Rock dust placed on the 4th right entry and the dumping of several rock-dust barriers localized the explosion (fig. 90). Some coal dust was ignited in the affected area, but the explosion did not propagate through the protected entries. Underlying causes of this disaster were the dependence on doors for maintaining ventilation and the unsupervised activities of the section contractor.

December 9, 1932; Zero Mine, Yancy, Ky.; 23 Killed

(From Bureau of Mines report, by J. F. Davies and E. H. Hodgson)

Zero mine was opened by 2 drifts, 1 serving as main haulageway and intake airway. Connections were made to No. 2 mine, one serving as return airway to No. 2 fan. The mine was nongassy. The day shift of 47 men was in the mine when the explosion occurred about 8:30 a. m., involving all the active portion of the mine and bringing death to 23 men. Several of the bodies were severely burned, but eight of the victims had moved about before being overcome by afterdamp.

The superintendent and others noticed a reversal of the air current at the portal and heard a hissing sound; the mine engineer was in No. 2 mine and felt a sudden pressure and saw a door blow open. He closed the door and telephoned outside, saying there had been an explosion. Shortly afterward the surviving 14 men came out. Help was called, and rescue crews were assembled. Ventilation was restored in the affected area by temporary brattices, and the bodies were removed by the next morning. The explosion originated in a crosscut between rooms 5 and 6, 1st left off 2 south. A shot firer regularly loaded and fired holes after the shift had left the mine, using pellet powder and clay dummies. Miners also fired shots during the shift, and some used coal dust as stemming.

Two holes were fired in the crosscut, both of which blew through as the holes were drilled on the solid and were within 14 inches of being drilled through. One shot broke out most of the coal and allowed the other to explode as an open shot. Both were windy shots; but the second ignited coal dust, which propagated an explosion over almost one-third of the mine before the forces died away because of expansion and rock dust on some of the back entries applied a year earlier.

December 24, 1932; Moweaqua Mine, Moweaqua, Ill.; 54 Killed

(From Bureau of Mines report, by C. A. Herbert)

The mine had been shut down by the owners and leased to the local employees, who worked it on a cooperative plan, there being 104 employee stockholders. That morning 56 men went underground between 7:30 and 8:00 o'clock; the 2 bottom cagers stayed at the shaft bottom, the rest being taken inside on mule and motor trips. At 8:00 o'clock, as the hoisting engineer was blowing the starting whistle, the circuit breaker

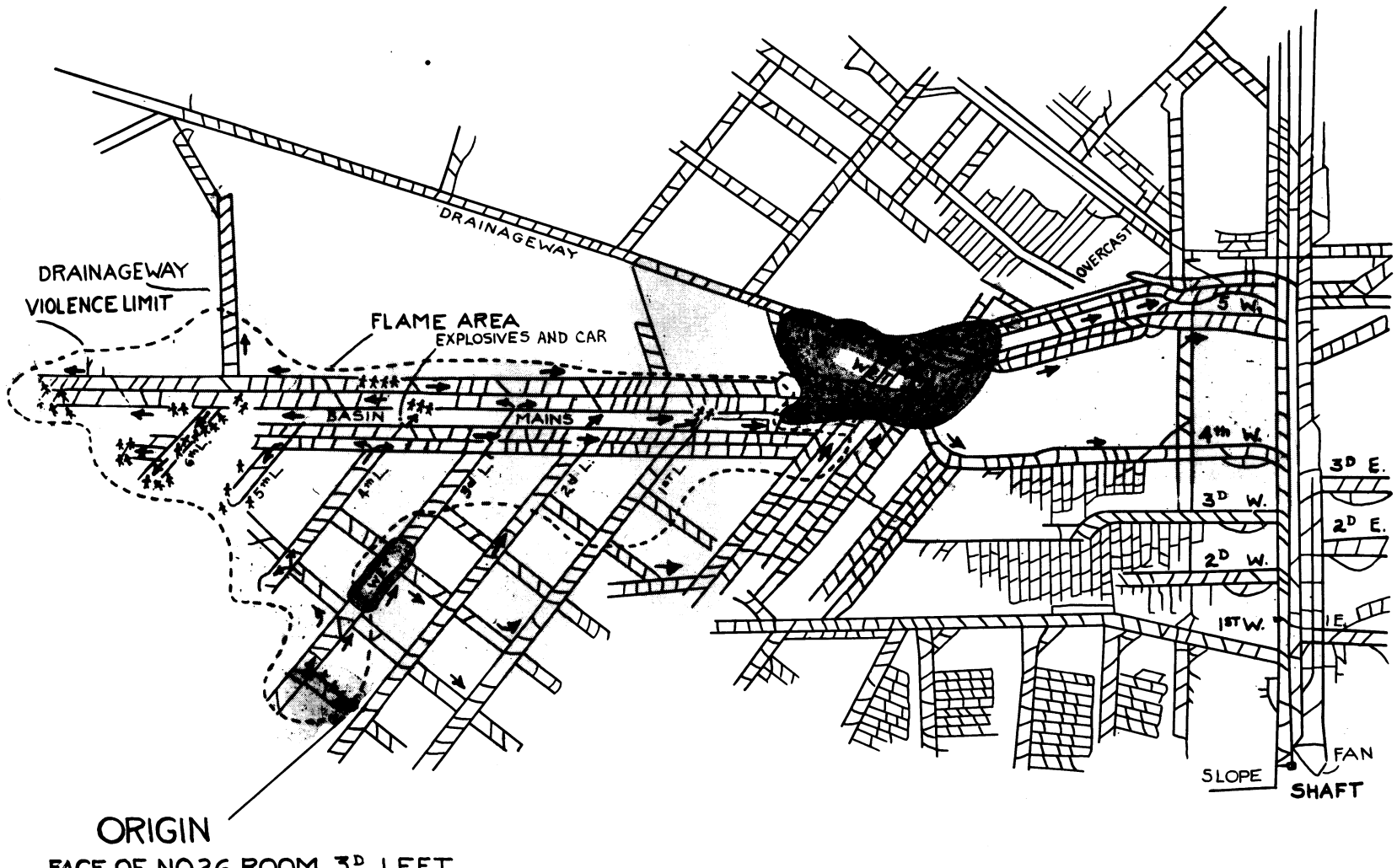

FIGURE 88.—Map of explosion area, Boissevain mine, Boissevain, Va., February 23, 1932.

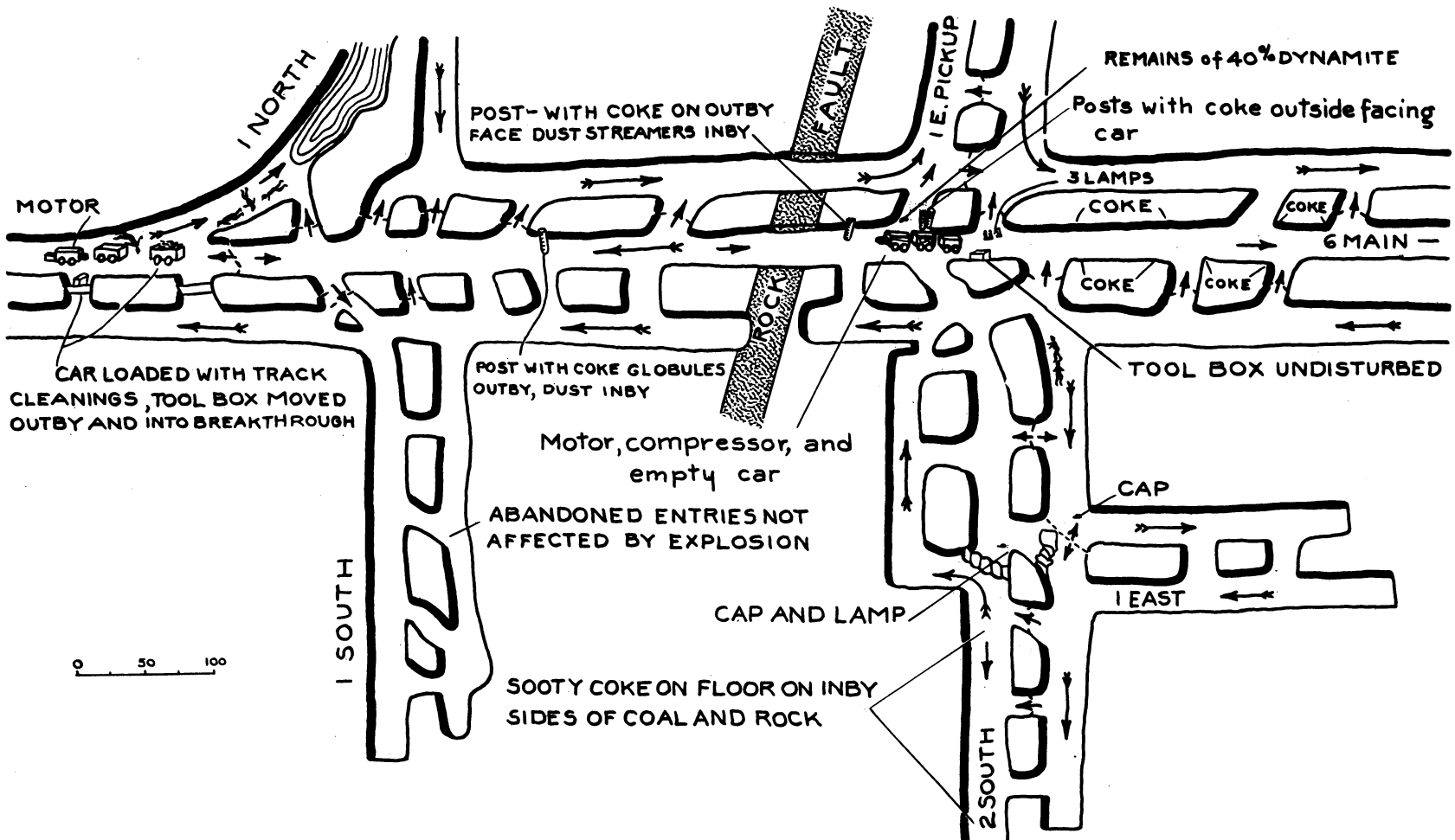

FIGURE 89.—Map of explosion area, mine No. 6, Splashdam, Va., June 13, 1932.

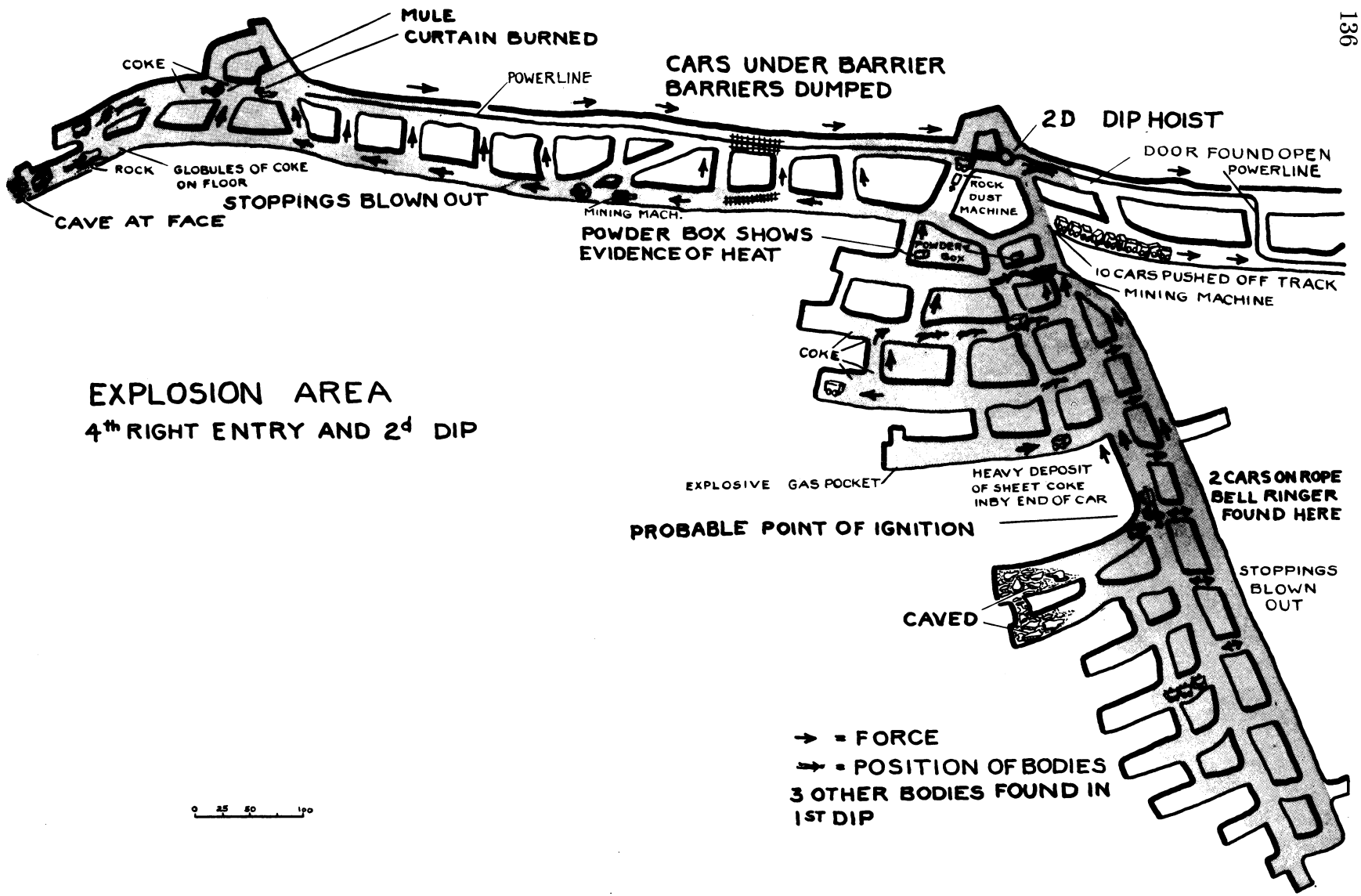

FIGURE 90.—Map of explosion area, Morgan-Jones mine, Madrid, N. Mex., December 7, 1932.

blew out, and a shock was felt at the shaft bottom. Calls for assistance were made, and official and volunteer rescue workers and leaders arrived during the day as word was relayed after the serious nature of the disaster was realized. No evidence of the explosion was found within 1,700 feet of the shaft, but farther inside stoppings, doors, and overcasts were destroyed, timbers were knocked out, and falls choked the entries for hundreds of feet. Apparatus crews were needed to hang brattice curtains to move the small current of fresh air up the choked workings. The work was slow and dangerous. The bodies were found with the man-trips at a number of locations, the last being removed on December 29.

Panels had been sealed off on both sides of the haulageways; high percentages of methane were behind these seals, and due to changes in pressure methane leaked out into the entries from the poorly built seals. As a trip with six men in a car passed 3d and 4th east, the open lights ignited the gas. Dust helped to spread the explosion through the gas-laden air (fig. 91). Although the mine was gassy it was rated nongassy, and open lights were used. A fireboss inspected the mine before the day shift entered; and he had been in the mine with a crew constructing a seal early that morning, leaving before 7 a. m. Some rock dusting had been done several years before.

September 11, 1933; Oakmont Mine, Barking, Pa.; 7 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, K. L. Marshall, and E. R. Maize)

About 8 a. m. a local explosion near the face of 14 butt heading off 6 face entry killed seven men. One other was burned but escaped unassisted with the remaining 276 of the shift. The explosion originated about 40 feet from the face of 14 butt and traveled about 400 feet, also passing through a crosscut into 13 butt, and went about 280 feet from the face, being stopped by rock dust and water. One of the seven victims was burned; the others were killed by afterdamp. Some stoppings were blown out but were easily replaced by temporary brattices and the bodies removed after the air was cleared.

The gas, which was ignited by an open-type locomotive, apparently came from cracks in the bottom as the car and locomotive passed. Similar but light ignitions had occurred before. In this case coal dust was raised and ignited, adding to the force and flame.

August 6, 1934; Derby No. 3 Mine, Big Stone Gap, Va.; 17 Killed

(From Bureau of Mines report, by J. F. Davies)

The mine had three main drifts and several outcrop openings. Coal was being produced from pillars, except in the main west section, which was advancing to the right from the main entries about 400 feet from the portal. Three disk fans, all inside the mine, and a number of auxiliary blowers were used to move air without regularly placed stoppings and line curtains.

The mine was idle on Sunday, and the blower fans were started as they were reached by the men going in. The main fan 125 feet from the portal of the main aircourse may have been left running but would not ventilate the main west faces with the blowers shut down. A total of 95 men went into the safety room at the intersection of the main haulageway and main west entry where the foreman assigned the men. Two were sent ahead to start the other two disk fans, and two were sent out to return on the next shift. These men had just reached the portal at 7:20 a. m. when the explosion picked them up and threw them 50 to 75 feet, causing slight injuries. Dust, smoke, and hot gases blackened the hillside across the creek bottom, a distance of 300 feet from the portal.

Two other men had also left the mine on errands and escaped. Eight men in the safety room and 9 men in the main west were killed. The superintendent saw the explosion and came out of the mine and called the mine office. The State inspector and the Norton, Va., station of the Bureau of Mines were called, and assistance arrived in a short time.

The main fan was demolished, and smoke and gases issued from the entry portals. The superintendent entered through one of the outcrop openings, gathered the men from unaffected sections of the mine, and sent them out through the opening. One survivor (overcome by shock and afterdamp) was carried out with them through water that reached to within a few inches of the roof. While blower fans were being set in temporary brattices at the portals, a party of officials penetrated the bad air for about 300 feet and found several bodies and 2 live men who were barely able to crawl; these 2 were rescued. As temporary ventilation was established, the west mains were explored and the bodies recovered. Gas was encountered and cleared.

The explosion originated near the face of the 1st right heading off main west butts, where an accumulation of methane was ignited by smoking or by an arc from an electric drill or from a blower fan or its open switch. Examinations for gas were not made before starting work. Dust was ignited, but the force and flame were dissipated at the intersection with the main entries. No rock dust had been applied in the explosion area.

January 21, 1935; Gilberton Colliery (Anthracite), Gilberton, Pa.; 13 Killed

(From Bureau of Mines report, by R. D. Currie and W. D. Walker)

The mining in the Mammoth vein, 6th left, in which the explosion occurred, is by breasts and chutes from rock holes driven from rock gangways through the Skidmore vein. Rock tunnels are driven in the Skidmore vein, which is 4 feet thick, and chutes are driven through this vein to the Mammoth vein, which is 48 feet thick with 26 feet of rock between the veins. Development is in the Skidmore vein, with rock holes at 50-foot intervals to the Mammoth vein, which runs readily. The return air from the 6th left bypassed the 5th left and ventilated the 4th left.

The mine was gassy; and closed lights were used, with permissible flame safety lamps for testing for gas. Miners were not trained in using the flame safety lamps. The day shift had been at work 2 hours when the explosion occurred about 9 a. m., killing 11 of the 69 men working on the 4th and 6th lifts. About 30 others were sent to hospitals after being seriously affected by carbon monoxide; 1 of them died.

Rescue work was started immediately by those not affected by the explosion and from other sections of the mine. One of these rescuers succumbed to afterdamp after saving several of those unable to escape by themselves. All survivors were removed before outside assistance was called. The explosion originated in No. 1 breast, where the bodies of two men were found nude, badly burned and broken. A flame safety lamp was broken apart, and parts were scattered along the breast.

Gas had accumulated because of inadequate ventilation and neglect to make thorough tests or inspections. The cause of ignition may have been openchute blasting with nonpermissible explosives and blasting units, a defective flame safety lamp, or one unsafely used. Smoking was possible but not indi-

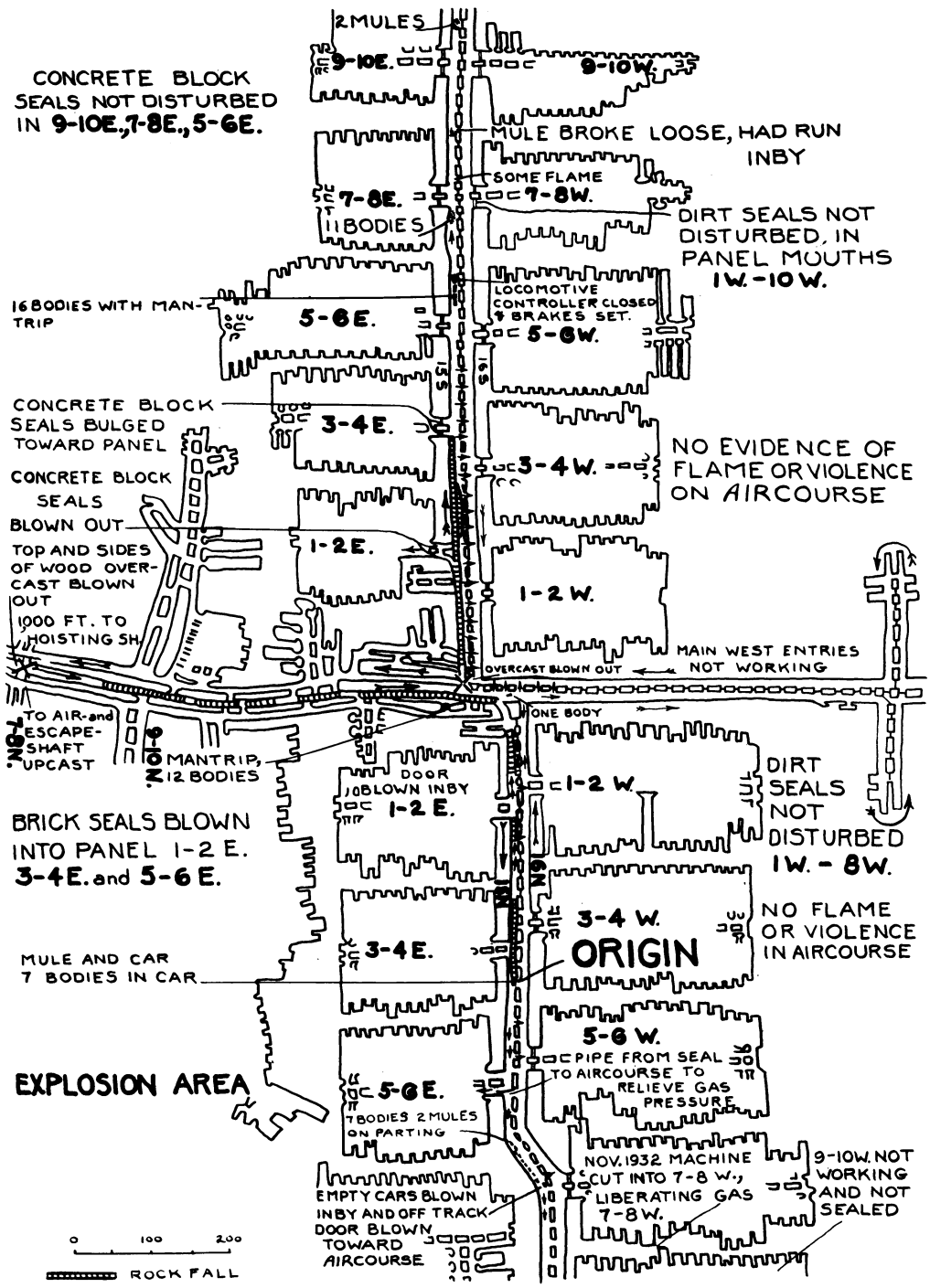

FIGURE 91.—Map of explosion area, Moweaqua mine, Moweaqua, Ill., December 24, 1932.

cated. Several official investigations were made of the circumstances of this disaster because of the violations of State mining laws revealed. The mine officials were held responsible, and court action was taken against them.

July 17, 1935; No. 155 Mine, Van Lear, Ky.; 9 Killed

(From Bureau of Mines reports, by J. F. Davies and H. B. Humphrey)

The mine had two shallow slopes and an airshaft and was connected to No. 154 mine. On that morning a section foreman and eight men were sent to 1st right entry to salvage track in the rooms off both entry and aircourse, which were squeezing. The floor was heaving, so that the rooms had to be abandoned.

At 8:40 a.m. men on a locomotive approaching 1st right felt a heavy concussion, and after looking into the mouth of 1st right they telephoned outside that an explosion had occurred. Calls for assistance were sent to the State mine inspector, the company offices at Jenkins, Ky., other mines, and the Norton Station of the Bureau of Mines. Crews and rescue leaders arrived promptly.

Ventilation was advanced by erecting brattices and curtains. Progress was impeded by roof falls, especially where timbers were knocked down or broken in the squeezed area. A gas-mask crew explored ahead of the brattice men, and an apparatus crew made one trip to look for a possible fire, but none was found. The bodies were removed by July 19, two from under heavy falls.

Gas had accumulated in the squeezing rooms, in which ventilation was almost cut off; it moved onto the entry, where it was ignited by an arc from the wiring or motor of a pump. An open-type electric locomotive nearby was not in operation. The explosion picked up and ignited a small amount of coal dust but did not propagate out of the immediate section. The mine was not rock-dusted, but dust on the entries contained material from the clay floor and brushed roof. The bodies were burned, broken, and crushed. Electric cap lamps were used, but the mine was not considered gassy.

January 20, 1936; Monarch No. 2 Mine, Broomfield, Colo.; 8 Killed

(From Bureau of Mines report, by E. H. Denny)

About 6:20 a. m. an explosion killed 8 of the 10 men in the mine; the other 2 men escaped uninjured up the airshaft stairway to the surface. The explosion extended over half of the mine, wrecking stoppings, doors, and overcasts and knocking out timbers, resulting in extensive caves of roof. The subbituminous coal of the region was thought to be free from dust explosions, as only gas ignitions had occurred for about 50 years. No rock dust or water was being used. Some men attempted to enter the mine by the airshaft after the two survivors came out but were overcome and had to be pulled out with wire and chains.

Experienced rescue crews were called, and they were able to follow natural ventilation and restore some stoppings. Gas masks were also used in exploration. Extensive falls made finding and removal of some of the bodies very difficult. One body could not be found, and search was abandoned after 11 days.

The explosion was attributed to ignition of gas by a trolley arc. Gas may have escaped from sealed areas and accumulated in active workings when doors were left open. Because of the extent and violence of the explosion, dust was thought to have been involved. A fire area was under seal, but this fire played no part in the explosion.

August 24, 1936; Clear Springs Colliery (Anthracite), West Pittston, Pa.; 5 Killed

(From Bureau of Mines report, by R. D. Currie and L. L. Naus)

About 7:15 a. m. an explosion confined to a gangway and 6 chambers killed 5 and seriously burned 1 of the 7 men in the section. The other man escaped without injury after being knocked down by the explosion. He was on the gangway, where he had started the conveyor motors a few minutes before the explosion. The injured man made his way out over fallen top rock, and apparatus crews explored the area, which was then ventilated before the bodies were removed.

Gas accumulated when the blowers were shut down from Saturday afternoon to Monday morning, and the fireboss did not make a complete inspection. An arc from the electric equipment ignited the gas.

September 2, 1936; Macbeth Mine, Macbeth, W. Va.; 10 Killed

(From Bureau of Mines report, by C. W. Owings and F. E. Griffith)

An explosion of gas and dust about 1:15 p. m. resulted in the death of 10 men (8 by burns and violence) and the injury of 1 man from afterdamp. This man was rescued and revived. The explosion, which was restricted to 12 and 13 right entries, was felt by the section foreman, who was on the main entry at 11 right. He notified the main office, and a gas-mask crew was sent in; 1 man was removed alive from 11 right, where 2 other miners had died from afterdamp; these bodies were removed and efforts made to revive them but without success.

State apparatus crews arrived, but gas masks were used in completing the recovery. Roof falls delayed recovery of four of the bodies until 3 p. m. September 3.

Gas had accumulated near the face of room 14, 13 right entry, when a door was left open. An arc from a splice in the cable of a cable-reel locomotive ignited the gas, and dust propagated the explosion. Its spread was stopped by rock dust placed in the entries some months earlier and by a pool of water on 12 right (fig. 92).

November 19, 1936; Bates Mine, Bates, Ark.; 5 Killed

(From Bureau of Mines report, by C. A. Herbert)

An explosion about 5:45 a. m. killed 4 of the 5 men in the mine instantly and burned and injured the other so that he died the next day. Violence was moderate, and dust was not involved.

Gas accumulated on the longwall when a trapdoor was left open and a feeder was cut by the mining machine. An arc from the controller ignited the gas as the machine was moved back from the cut. The entries were wet and covered with shale dust from the roof and ribs.

March 11, 1937; Macbeth Mine, Macbeth, W. Va.; 18 Killed

(From Bureau of Mines report, by K. L. Marshall and M. C. McCall)

An explosion covering the workings from 11 right to 18 right, about one-fourth of the mine, killed all of the 18 miners in that section. At 7:50 p. m. the night foreman and others on the slope bottom felt a concussion and were enveloped by whitish dust. Most of the men ran to the surface. The fireman called for help by phone, and a rescue crew advanced into the affected zone but was severely affected by afterdamp. Rescue crews and officials arrived, and

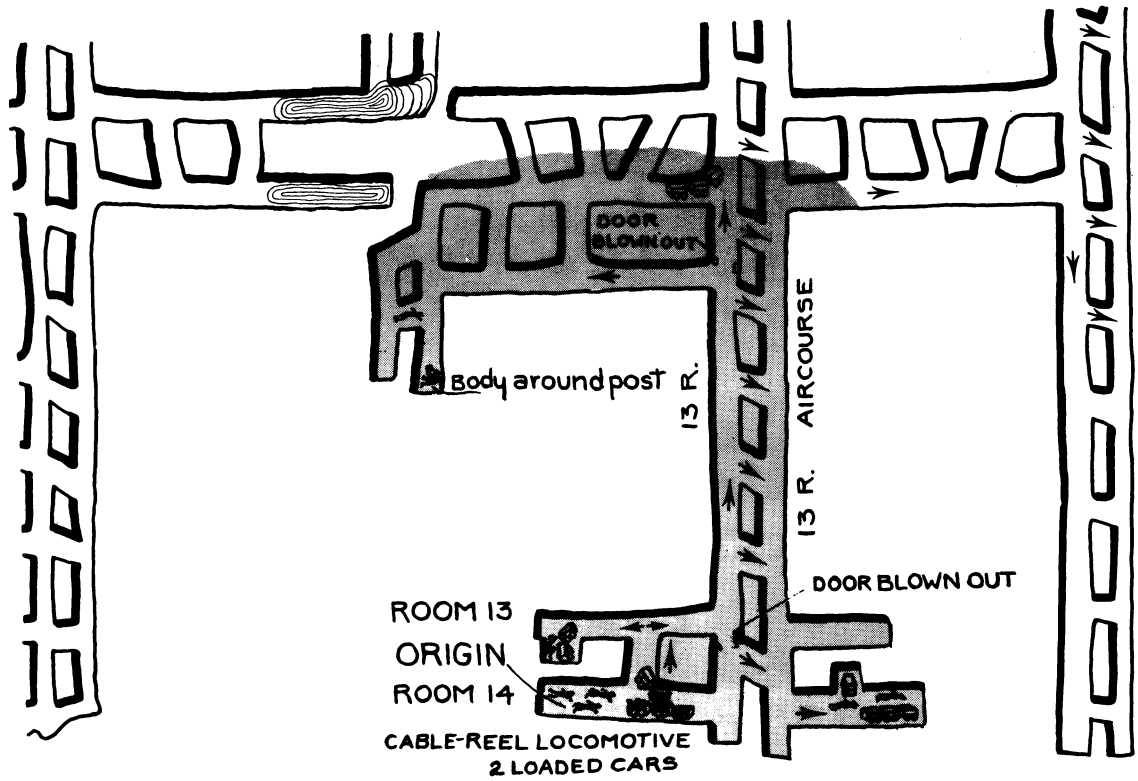

FIGURE 92.—Map of explosion area, Macbeth mine, Macbeth, W. Va., September 2, 1936.

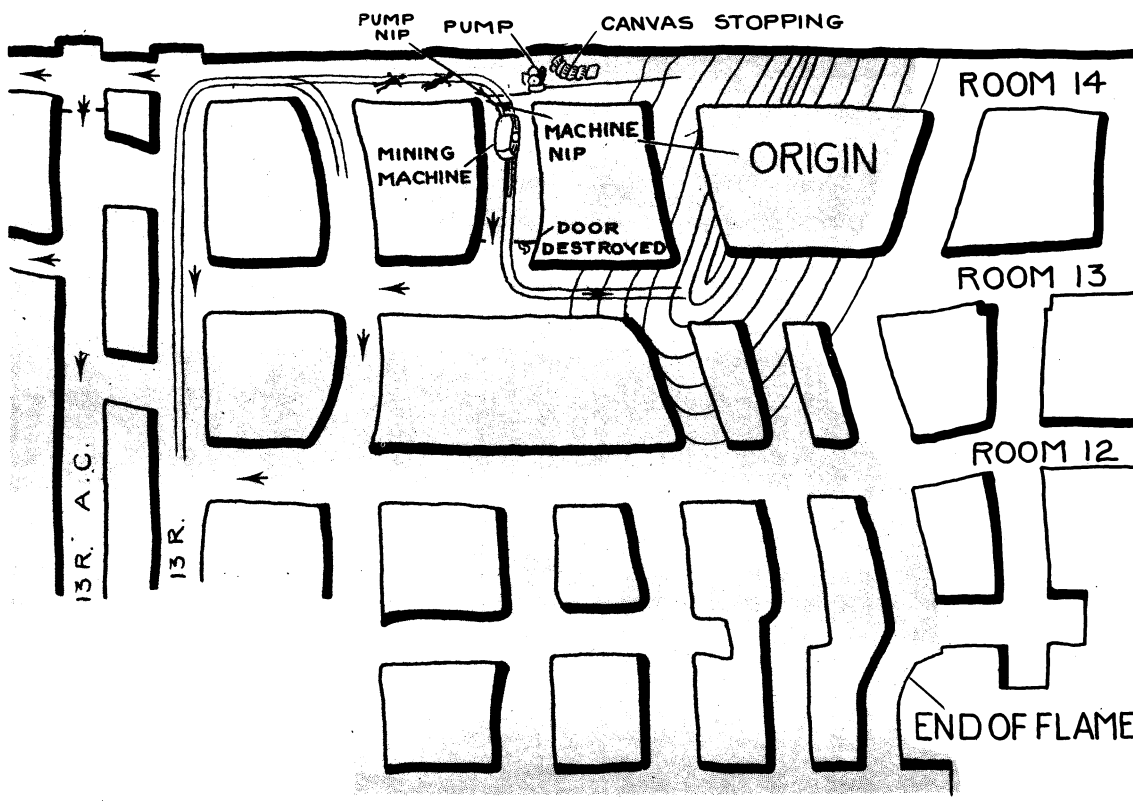

FIGURE 93.—Map of explosion area, Macbeth mine, Macbeth, W. Va., March 11, 1937.

the operations were organized. Temporary brattices were put up to restore ventilation, and the bodies were found and removed over 16 days, as the work was hampered by heavy and extensive roof falls.

Inadequate ventilation and neglect to make necessary inspections for gas allowed gas to accumulate in the area, where it was ignited by an arc from the nip of a mining machine being trammed from room 13 to room 14 off 13 right. This point was within 20 feet of the point of ignition of the explosion of September 2, 1936. The explosion, propagated by coal dust, was violent and was only stopped on the haulage roads where rock dust had been applied (fig. 93). The face areas were dry and dusty and untreated.

March 28, 1937; Kramer Mine, DuBois, Pa.; 9 Killed

(From Bureau of Mines report, by J. J. Forbes, M. J. Ankeny, and F. E. Griffith)

Because of a power interruption, the mine was idle and the fan shut down from 7:05 a. m. to 4:21 p. m. At 4:40 p. m. a group of eight mine officials went underground to do several tasks in different parts of the mine. They did not carry flame safety lamps, and no examination was made for gas before they went down. The mine was rated as gassy and was operated as such.

The officials, in groups of 2 or 3, started toward their assignments with trolley locomotives and a rock-dusting machine. When one of the locomotives reached 14 west off 11 northwest entry (where it was in return air from a large section of the mine) at 5:41 p. m. an explosion occurred, killing the two men with the motor trip. The power was knocked out, and the hoistman found that the circuit breaker would not stay in and called the superintendent and foreman.

The other six men gathered at main west and 11 northwest and were joined by the superintendent and mine foreman, who found stoppings and overcasts destroyed and prepared to restore temporary ventilation to reach the 2 missing men.

The superintendent went to the surface to secure additional help and supplies, and as he boarded the cage with other men and the district mine inspector at 8:14 p. m. a vibration was felt followed by a heavy muffled sound. This explosion killed the seven men in the mine. After investigation more assistance was called, and recovery work proceeded slowly as fires were encountered and extinguished with rock dust and extinguishers. Exploration was by apparatus crews in some places, as was recovery of the last two bodies.

The second explosion was ignited by a fire set by the first explosion, and both were propagated by coal dust. Rock dust applied to the haulage roads helped to check and stop the spread.

July 15, 1937; Baker Mine, Sullivan, Ind.; 20 Killed

(From Bureau of Mines report, by C. A. Herbert)

At 7:00 a. m. there were about 175 men in the mine, when an explosion in the 15 and 16 east section killed 20 and burned 4 of the 25 men in the area. The other man escaped with almost no injury, and those in other parts of the mine were not affected. A Bureau of Mines rescue truck and instructor were at a neighboring mine, and the equipment and crews arrived shortly.

The 1 and 2 south entries off 16th east had been worked out and sealed off with plastered-wood seals. A heavy fall in these entries blew out the seals and knocked over a trip rider in No. 2 room off 15th east. He relit his lamp and ran out, calling others to follow (fig. 94). He reached a point 800 feet outby 15 east when an explosion knocked him down, causing bruises. He saw no flame in either instance. He made his way to the shaft. Gas masks were used to explore for fires as ventilation was restored and the bodies removed. The area had been heavily rock-dusted, and coal dust did not enter into the explosion. The second blast was ignited by carbide lights * * *.

October 15, 1937; Mulga Mine, Woodward, Ala.; 34 Killed

(From Bureau of Mines report, by F. E. Cash)

At the time of the explosion, 10:45 p. m., 229 men were in the mine, 65 of them in the 2X haulage section where it occurred. Thirty-three were killed, and 1 died 2 days later from burns. The face of an aircourse had been shot, and the coal was being loaded when the shotfirer tried to relight his key-locked flame safety lamp with a match. Gas had accumulated because of the blasting, weak ventilation, and an open door. Dust was ignited, and the explosion traveled slowly over the section before it was stopped by rock dust on the entries (fig. 95, p. 143).

Gas-mask crews restored ventilation and recovered the bodies. Apparatus crews explored two entry faces. Although rock dust was applied by hand to the faces, the explosion was propagated to the end of the trolley wires, where the rock dust was applied by machine.

October 26, 1937; Jonesville Mine, Jonesville, Alaska; 14 Killed

(From Bureau of Mines report, by H. B. Humphrey)

About 2:10 p. m. an explosion of gas and dust killed 14 of the 19 men in the mine. One other was severely injured, and four escaped unharmed. Little damage was done to the mine. The mine was small with a single drift entry in the inclined coal bed, which outcropped at the top of a long ridge. Rooms were driven up the bed as the face was advanced and pillars were taken about 10 rooms from the face.

Five miners in the pillar section felt a concussion and a rush of air. Some thought it due to caving roof, others to blasting, but then realized that something was wrong when fumes and smoke came up with the air going out the chutes opened to the surface. Three of them went down and reached freshening air on the gangway, where they found the foreman burned and with a broken leg entangled in a pile of blown-out timbers. They brought him out of the fumes to fresh air at a large roof fall, and two went out for help while the other stayed near him. The other two pillarmen started down an inner manway to find a helper who had gone that way just before the explosion. Smoke and fumes drove them back, and they tried to go up the airway. One fell outside unconscious but revived; the other collapsed just inside the opening and died when his partner could not lift him.

The foreman was removed by the night-shift men, who came in at once. Help was called from Anchorage and a special train rushed to the mine. The air cleared quickly as ventilation was not greatly disturbed except at the advance faces. The bodies were brought out the following day, except one that was found and removed a day later from under the fall on the gangway at chute 35.

Methane had not been found in the mine, but investigations showed that it was present in the workings inby a fault through which the gangway had been driven in August. The gangway face was ventilated by a blower fan and tubing, because the counter had not been advanced beyond room 42. Rooms 43 and 44 had been started. The blower fan was placed so that air and gases were recirculated and an explosive mix-

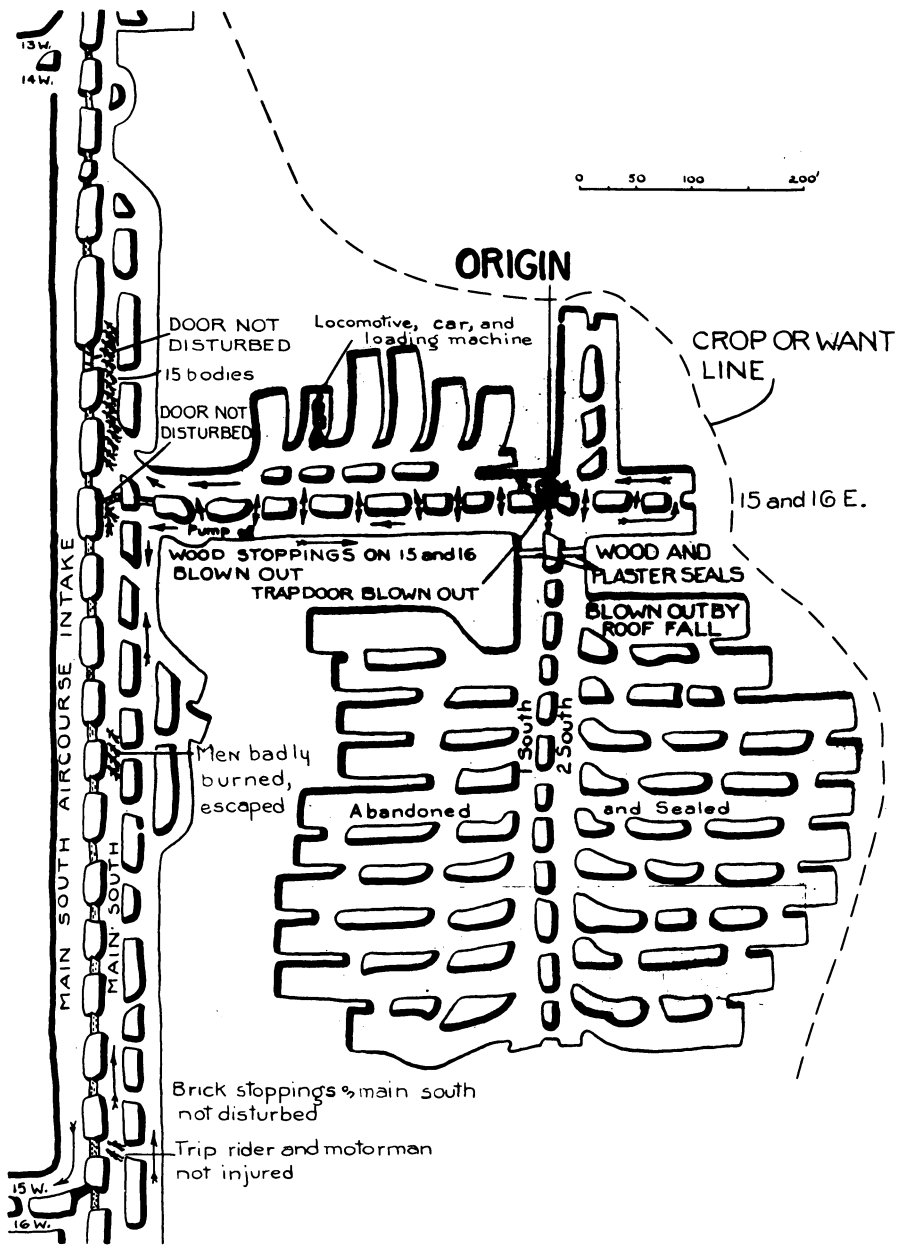

FIGURE 94.—Map of explosion area, Baker mine, Sullivan, Ind., July 15, 1937.

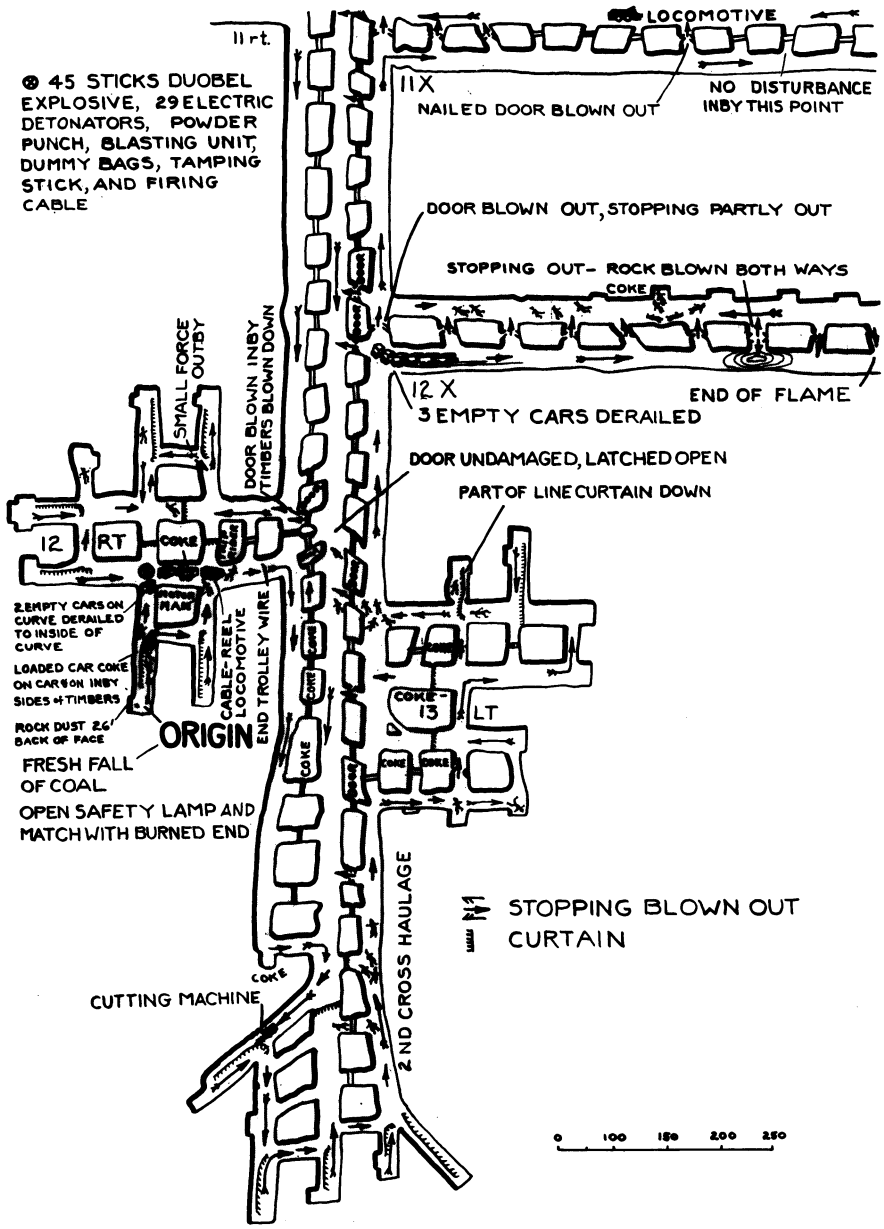

FIGURE 95.—Map of explosion area, Mulga mine, Woodward, Ala., October 15, 1937.

ture built up that was ignited by one of the men attempting to light a cigarette.

Dust helped to propagate the explosion with moderate force back to the pillar section where dust from loading a trip of cars increased the force (fig. 96). Inert dust from fallen shale, on the gangway outside this point, stopped the spread. No tests for gas had been made, and no rock dust had been used.

January 12, 1938; Harwick Mine, Harwick, Pa.; 10 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, and W. J. Fene)

A gas and coal-dust explosion at 11:10 a. m. resulted in the death of 10 men and injury to 2 others. The mine was idle, and only 38 men were in various parts of the mine; 7 in the explosion area were killed by violence and burns. Three others in adjoining sections died in the afterdamp, and two others were affected but recovered. The force of the explosion was confined to one section of the mine but was extremely violent in certain portions and did considerable damage.

One hundred and twenty concrete-block stoppings and 17 doors were blown out; a number of steel cars were demolished, and considerable track was displaced.

No regular inspection for gas was made on idle days, and it is probable that the fireboss on the night shift did not inspect the entries that were not active. One entry had cut through four clay veins within 325 feet of the face and gas feeders had been encountered. A door, left open, permitted an accumulation, and the source of ignition was not determined. It may have been an arc from a trolley locomotive, smoking, or other arc or flame. Rescue crews were called, and oxygen breathing apparatus was used in some exploration ahead of ventilation. The bodies were recovered within 24 hours. Coal dust added to the force and propagated the explosion, and rock dust checked it away from the dusty face workings.

February 11, 1938; Vail Mine, Afton, Wyo.; 5 Killed

(From Geological Survey report, by B. W. Dyer)

This truck mine was on Deadman Creek at an elevation of 8,200 feet, 6 miles from Young's ranch. Young's is 78 miles from Afton. Mining was discontinued December 20, and five men remained to regrade the main entry and extend the back entry. The foreman's wife acted as cook, and when she heard a call she found 1 man injured 225 feet from the portal. She helped him into the house and using skis traveled through 4 feet of snow to Young's ranch for help. State and Federal inspectors and volunteer helpers were called in by phone. They traveled by plane and by skis. The injured man was found dead, as were the others.

A violent explosion of dust from a blown-out shot of black powder had blown cars and three of the bodies out of the mine, but damage to the mine was slight.

April 22, 1938; Keen Mountain Mine, Hanger, Va.; 45 Killed

(From Bureau of Mines report, by G. W. Grove)

A coal-dust explosion about 4:45 p. m. killed 45 men and injured 2 others. All but 1 of the men in the part of the mine affected by the explosion were killed, and 3 men were killed outside the mine openings. The mine was opened by numerous drifts from the outcrops, and many of these sections had not been connected underground. At the time of the explosion the night shift was going in, and some of the men were still outside. It covered the entire portion of the mine in which it originated, an area 2,000 feet by 1,500 feet, destroying all of the stoppings and 2 fans and badly damaging 2 mine locomotives and a sandhouse outside the mine. Seven drift mouths were damaged. No severe damage was done inside the mine, as only minor roof falls occurred. Heat and flame extended into nearly all of the affected workings and for a considerable distance from the drift mouths.

Officials and men on the outside rescued an injured man on the outside and another a short distance inside one of the drift mouths but could not continue recovery until a fan was brought over and installed. State and Federal officials were called, and help arrived from other mines during the night. Ventilation was restored, and the bodies were removed within 22 hours. Gas masks were used in exploration ahead of fresh air.

The firing of 2 adobe shots at the face of 1st left off the mains raised and ignited coal dust. Dust was thick in the workings, and the explosion spread through the connected workings (fig. 97). Only a small amount of rock dust had been used in the mine. About 3 pounds of permissible explosive was used in each shot. Blasts were fired by touching the ends of the firing line to the trolley wire.

April 27, 1938; No. 1 Slope, St. Clair Colliery (Anthracite), Pottsville, Pa.; 8 Killed

(From Bureau of Mines report, by R. D. Currie)

The shift had gone in at 7:00 a. m., and the men in the water-level tunnel section were preparing timbers and lagging on the gangway to be taken to their working places when the floor began to cave. The fireboss sent a miner to bring out the men from the inby places through the monkey heading to avoid the hole in the floor. All the men in the vicinity were using electric cap lamps, and none of the group made any test for gas with their flame safety lamps.

At about 7:30 a. m. a chuteman wearing an open light reached a point 30 feet from the hole, when the gas ignited, killing him and burning several others. As men came out, a second and more violent explosion occurred. A motor crew felt the concussion and encountered smoke, dust, and broken boards. They came out and notified the superintendent. Rescue crews were gathered, and recovery proceeded in fresh air, as ventilation was not interrupted. Seven men were killed by the force and flame and 11 men injured, 1 of whom died the next day.

June 2, 1938; Butler Slope (Anthracite), Pittston, Pa.; 10 Killed

(From Bureau of Mines report, by R. D. Currie and Norman King)

An explosion in a small leased pillar section known as Permit No. 5208, Revised 10–23–37, killed or injured all the 16 men in the area; 8 were killed, and 2 of the 7 taken to a hospital died; 1 man was sent home with a dislocated shoulder. On the night before a nearby pillar section started to cave, and cracks appeared on a concrete highway on the surface. The fireboss kept men out of the caving section but did not find gas. A large accumulation built up because of the caving and a door left open between 1st and 2d chambers.

At 9:20 a. m. an overcharged shot of pellet powder, fired from the powerline, ignited the gas, causing a violent local explosion that was quickly dissipated by the large area of openings in this pillarwork. The mine foreman heard the explosion and felt a wind; he took the men from the working place he was in and investigated. They came across an injured man walking out and notified the management. Rescue crews were quickly assembled, and apparatus crews were used to recover some of the bodies.

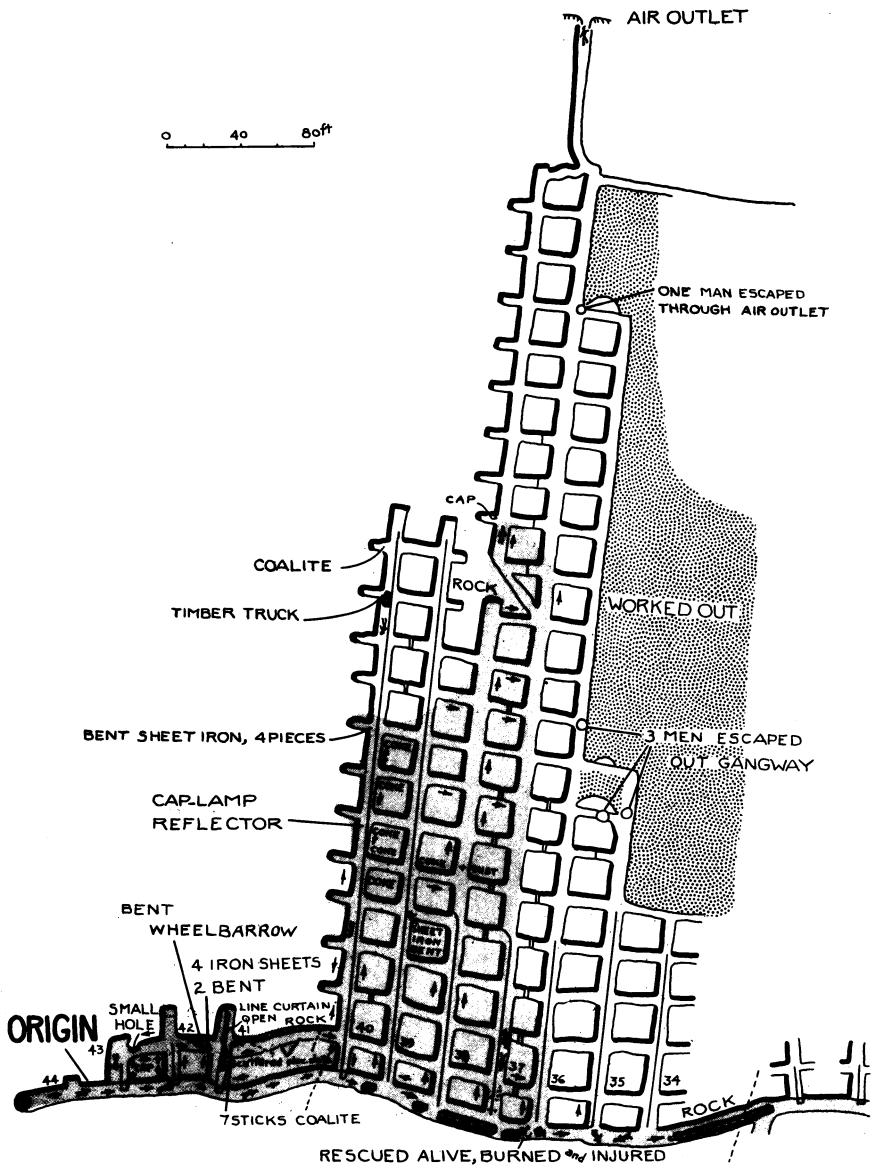

FIGURE 96.—Map of explosion area, Jonesville mine, Jonesville, Alaska, October 26, 1937.

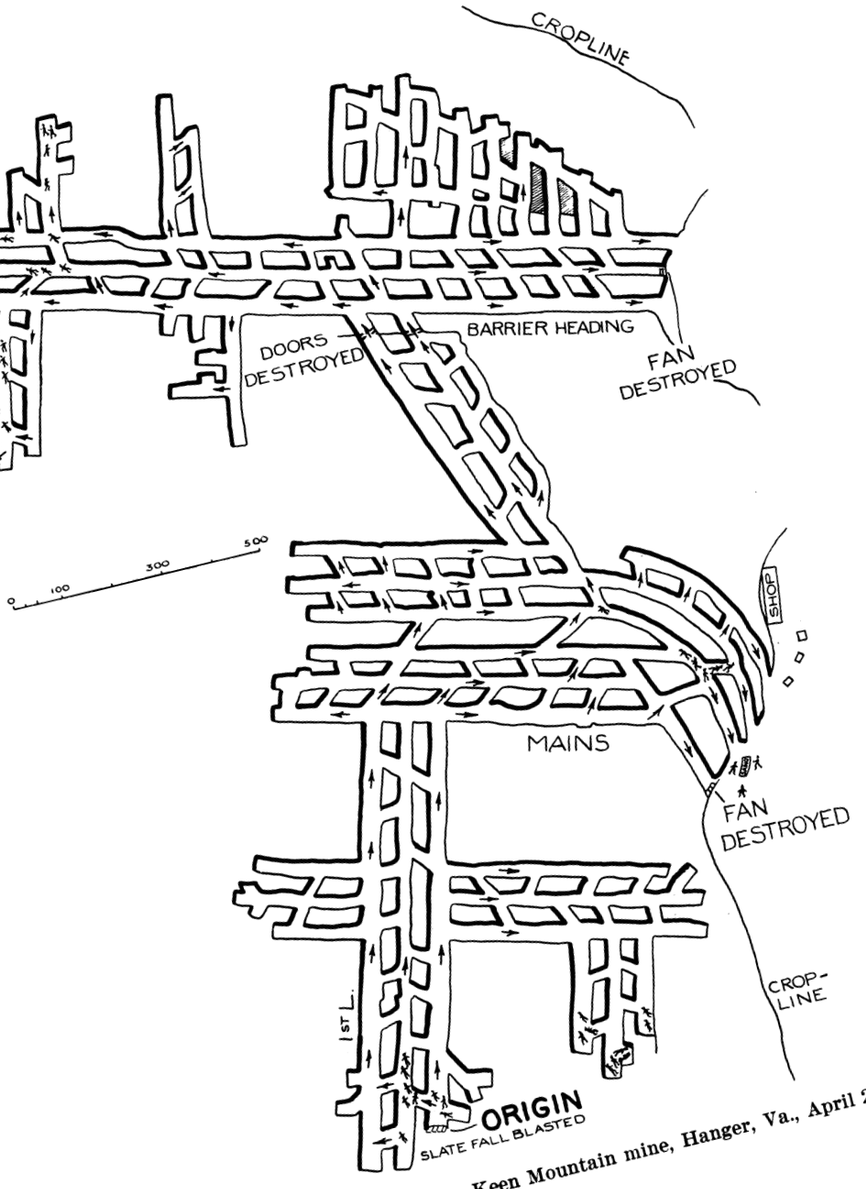

FIGURE 97.—Map of explosion area, Keen Mountain mine, Hanger, Va., April 22, 1938.

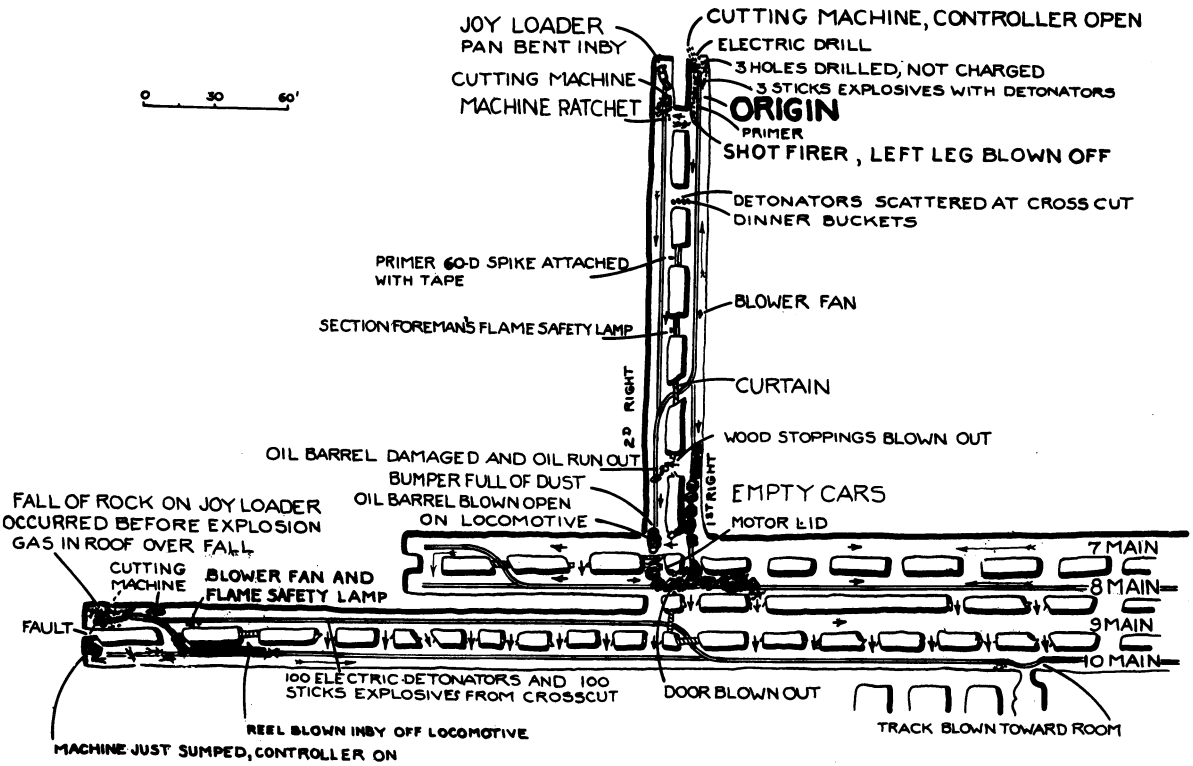

FIGURE 98.—Map of explosion area, Duvin mine, Providence, Ky., July 14, 1939.

July 14, 1939; Duvin Mine, Providence, Ky.; 28 Killed

(From Bureau of Mines report, by C. A. Herbert)

At the time of the explosion, about 7:20 p. m., 38 men were in the mine, 5 of whom were at the shaft bottom, where they felt only a slight rush of wind and did not realize that anything had happened. Five of the men in the explosion area escaped, 4 being slightly cut and bruised. A trip rider standing near a telephone at a parting was knocked down but received no injuries; he called the top foreman and then helped two injured men out of the smoke and fumes to a place where a locomotive was sent to bring them to the shaft. Two other motormen also came out with their locomotives. The main haulage was on a separate circuit and was not affected by the explosion.

Help was called, but as a trained apparatus crew was not available rescue crews used gas masks and put up temporary brattices to advance the air into the affected areas. The work proved difficult and dangerous as the airways were caved and blocked so that it became necessary to reverse the fan and bring fresh air up the haulage entries.

It was the afternoon of July 17 before entrance was made into the left entries off the 14th entry, where nine men had hung curtains across the entries in a futile attempt to keep back the afterdamp (*25, p. 18*). The curtains were poorly hung and of little benefit, although notes left by the men showed that they were alive 6 hours after the explosion. The bodies of the 19 others who were killed instantly were recovered from the explosion area by July 18.

The body of a shot firer was the only one mutilated, and parts of his cap lamp were blown outby, others inby. His explosives box had disappeared. Evidently while making up primers he removed the shorting clips from legwires of detonators, and the wires contacted the rails or poorly insulated cables of a cutting machine (fig. 98). Coal dust was ignited by the explosives blast. Rock dusting had been neglected, and the mine was in poor condition throughout.

January 10, 1940; Pond Creek No. 1 Mine, Bartley, W. Va.; 91 Killed

(From Bureau of Mines report, by M. J. Ankeny, E. J. Gleim, M. C. McCall, and C. W. Owings)

At 2:30 p. m. there were 138 men in the mine, when an explosion brought death to 91 of them. The west side of the mine was not affected, and the 37 men working there escaped uninjured. Ten men at the shaft bottoms also escaped. The mine foreman and the others near the bottom of the manway shaft felt a strong rush of air, which had a sound like a fire siren, and dust filled the air. The men from the west section and from the shaft bottoms were quickly hoisted out.

The top operating officials were holding a safety meeting at the general office nearby, and rescue work was organized at once. The explosion doors at the fan had blown open; these were closed, and a rescue party entered the mine about 3 p. m. They traveled in fresh air to the explosion area, repaired an overcast, extinguished some small fires, and were replacing a stopping with a temporary brattice when a second explosion occurred. This explosion 7 hours after the first did no damage and was evidenced only by a strong air movement.

The party returned to the surface. Apparatus crews and other rescue men had arrived, and work was

resumed that night, using apparatus crews to erect temporary brattices across the intakes ahead of the crews bratticing the breakthroughs, so that only safe areas were ventilated at a time. No additional fires were found. Extreme precautions were necessary in this very gassy mine. Large falls hindered the work, and crews were put to clean them up as the air was cleared.

The bodies were removed by January 14, and men withdrawn. Permanent ventilation had to be restored to permit thorough investigation, as the temporary stoppings allowed so much leakage that only a section at a time could be ventilated. The investigation from January 24 to February 2 did not find the exact point of origin, because evidence was destroyed by the second explosion and because the explosion covered pillar areas in which several bodies of gas over falls may have been ignited as the explosion progressed. The ventilation provided could not prevent gas accumulations from forming or being pushed out into working places by a fall.

The source of ignition was probably an electric arc. The explosion was propagated by coal dust. Rock dust had been applied over thick accumulations of coal dust, and back entries were not treated. Dust from this low-volatile coal was ignited in the violent gas explosion. Figures 99 and 100 show the mine working and details of the explosion.

March 16, 1940; Willow Grove No. 10 Mine, Neffs, Ohio; 72 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, W. J. Fene, and M. J. Ankeny)

On this Saturday morning 176 men were in the mine, when an explosion killed 66 by burns and violence and 3 by burns and afterdamp. Two others attempting rescue were asphyxiated, and 1 rescued man died 6 days later from effects of afterdamp. One man was severely burned and injured by the explosion, and two recovery workers were injured by a rock fall. Twenty-two men overcome by afterdamp were rescued and revived, and 79 men trapped for 5 hours were released uninjured; 2 others escaped unaided. The explosion traversed the 22 south section and a short distance inby and outby 22 south on the main west haulage entries (fig. 101, p. 151).

A telephone call to the surface from the dispatcher in the mine about 11:10 a. m. reported that smoke and fumes were coming down the main west and driving men from the underground shops and that they could not go through it to the airshaft to see if a motor or transformer was burning. The assistant superintendent and the mining engineer drove to the airshaft and went down in intake air as the fan was blowing, noting only a burned smell in the air. They encountered burning fragments on the main west, stamped them out, and then found a badly burned man, who had staggered out from the explosion area. Other men from outside the affected section were found and helped to take the injured man outside. Help was called from available outside sources.

A motorman leaving 19 north and south junction with a loaded trip about 11:10 a. m. was enveloped in a cloud of dust and smoke; he put the controller on full and lost consciousness on the way out. At the outside loop the trolley pole flew off, and the trip coasted back into the mine about 900 feet. He was found by the superintendent and the outside foreman, who had gone in the pit mouth with two other men to investigate. The two outside men brought the motorman and trip out and revived him. The officials remained at a telephone at this point and talked to men at the dispatcher's shanty, who were being rapidly overcome. Some men from the shop and others gathered at the shanty hurried out and made it safely; those remaining, including the two officials, were killed by the onsweeping smoke and fumes that reached the pit mouth and prevented entrance about 12 noon. The two officials attempted to get out but fell less than 100 feet from the outside. At 12:30 the air had cleared and their bodies were recovered. Efforts to revive them failed.

Gas-mask and working crews were organized and started an exploration and carrying ventilation into the explosion area. Men in unaffected parts of the mine were located and sent out. Many were unaware of any trouble. A group of 23 men was found overcome by afterdamp and removed. After fresh air was put onto the haulage roads, loading machines were used to clean up falls, continuing until March 28, when the last body was recovered. Apparatus crews were present, but no work was done under apparatus. The explosion did not extend farther because of considerable expansion at 22 south and main west and because of the incombustible content of road dust in the main west headings.

A shot of pellet black powder in the left rib near the face of 8 west was fired in starting a room neck. An excessive amount of powder was used, and "bug-dust" stemming as well as coal dust stirred up by this and preceding rock shot were ignited by the flame (fig. 102). Gas at the face of 7 west, black powder in a storage box on 24 south between 7 and 8 west, and coal dust in all the workings added to the explosion. Rock dust had been applied only on the main west haulageway. No water was used to allay coal dust. The mine was classed as nongassy, and no firebosses were employed, although section foremen had flame safety lamps. The company had a commendable safety record and an active safety program, but the latent explosion hazards were not recognized.

July 15, 1940; Sonman E. Mine, Portage, Pa.; 63 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, M. J. Ankeny, and H. B. Lindeman)

An explosion that traversed a limited area in Nos. 16, 17, and 18 right entries off north dip caused the death of 63 of the 350 men in the mine at about 10:40 Monday morning. Probably all died from afterdamp, although eight were also burned. Eighteen men escaped from the area without help, as did 12 others from adjoining workings. The mine had been idle for 2 days, but the fireboss reported no gas in the affected headings. The first word was a telephone call to the superintendent from underground that the air was reversed, and the foreman was sent to investigate. He met a group of men coming from the affected section and took some of them with him to check the ventilation. They found the airlock doors blown inby on 17 left, causing a direct shorting of the air. They replaced one door and went on making repairs to other doors until stopped by smoke and dust in 18 right.

Help summoned by the superintendent arrived, and apparatus crews made explorations. Air was brought into the area by putting up canvas stoppings and a smoldering fire in a jacket was extinguished. Footprints in the dust led to discovery of a canvas barricade in 16 right by an apparatus crew and then a second stopping partly completed 52 feet inside (*25, pp. 24–26*). Thirty-four bodies were found here about 10:30 p. m. Some of the men had been alive as long as 7 hours after the explosion, but all had died from afterdamp that had come in through other openings not sealed off. All bodies were found and removed within 22 hours.

A body of methane was released from overlying rock strata by a fall in a room. Pillars were not removed

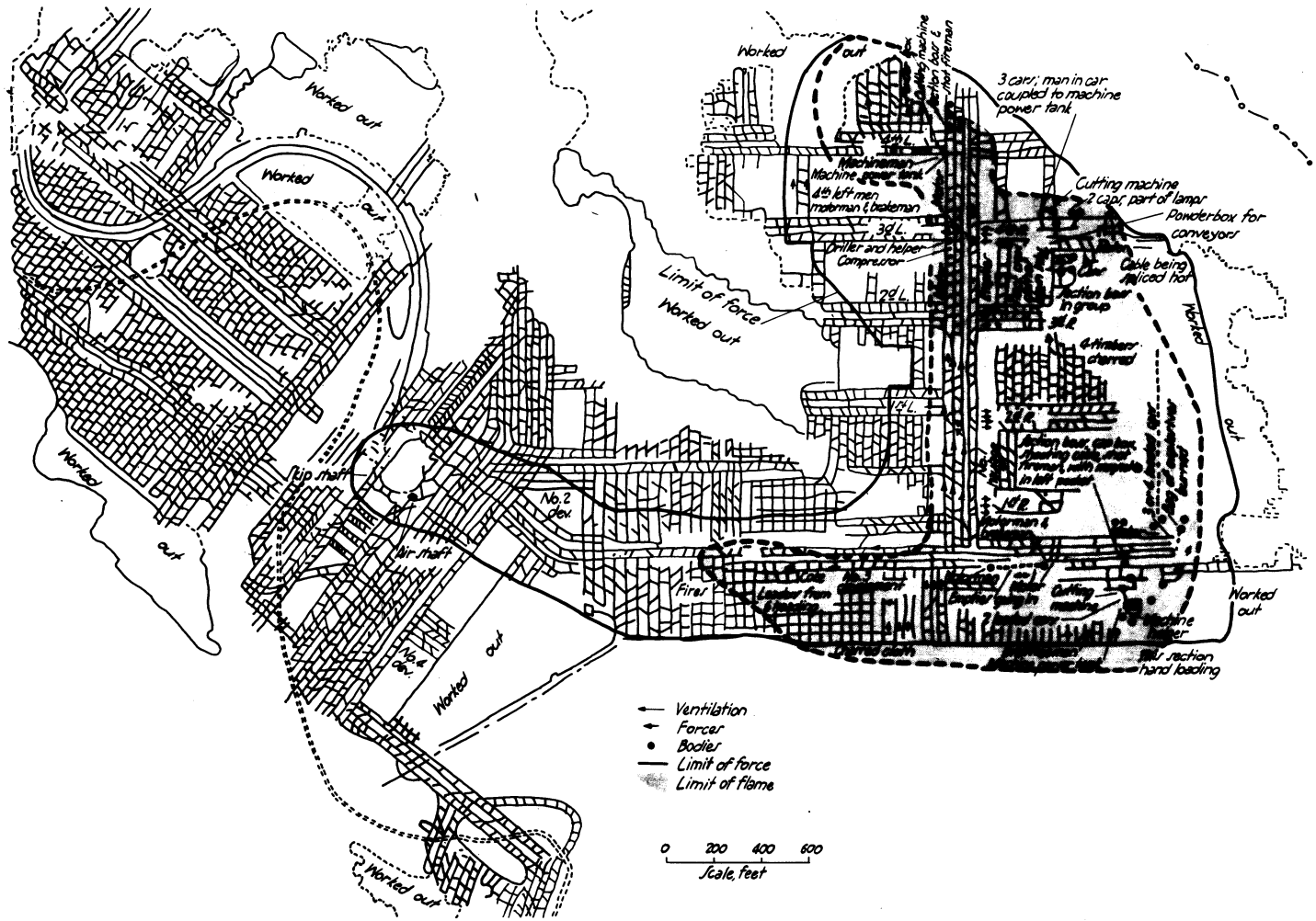

FIGURE 99.—Map of explosion area, Pond Creek No. 1 mine, Bartley, W. Va., January 10, 1940.

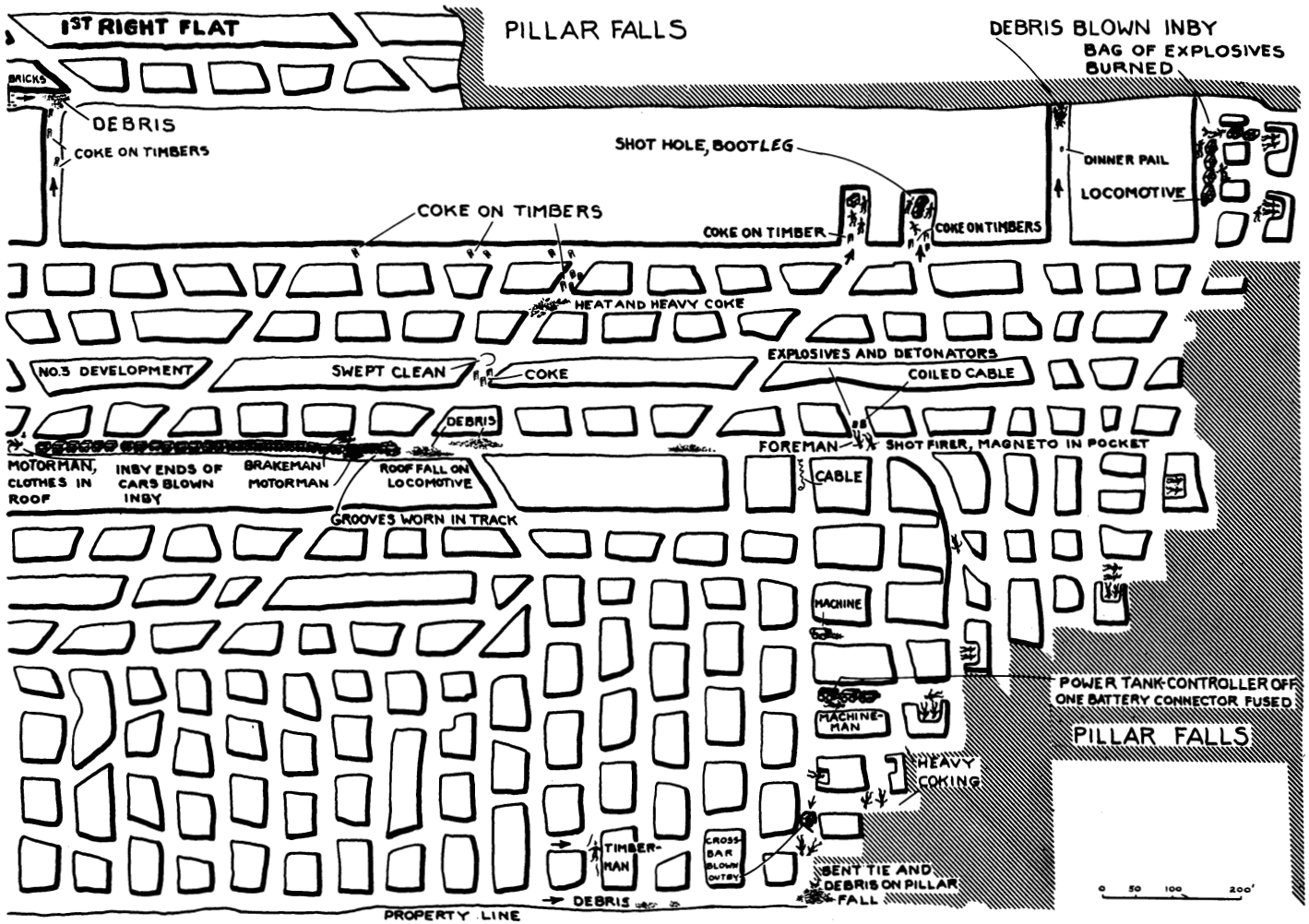

FIGURE 100.—Sketch of area at origin of explosion, Pond Creek No. 1 mine, Bartley, W. Va., January 10, 1940.

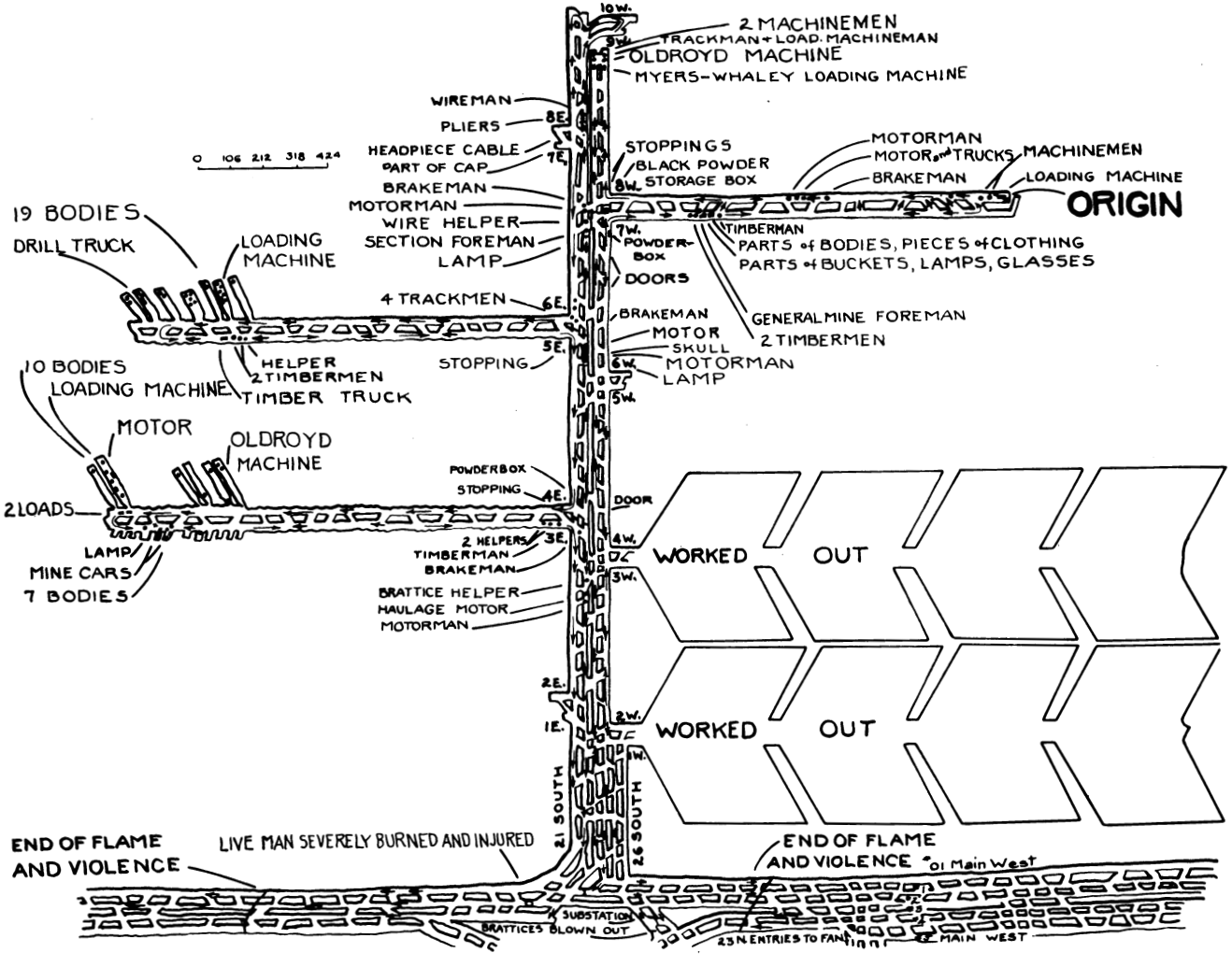

FIGURE 101.—Map of explosion area, Willow Grove No. 10 mine, Neffs, Ohio, March 16, 1940.

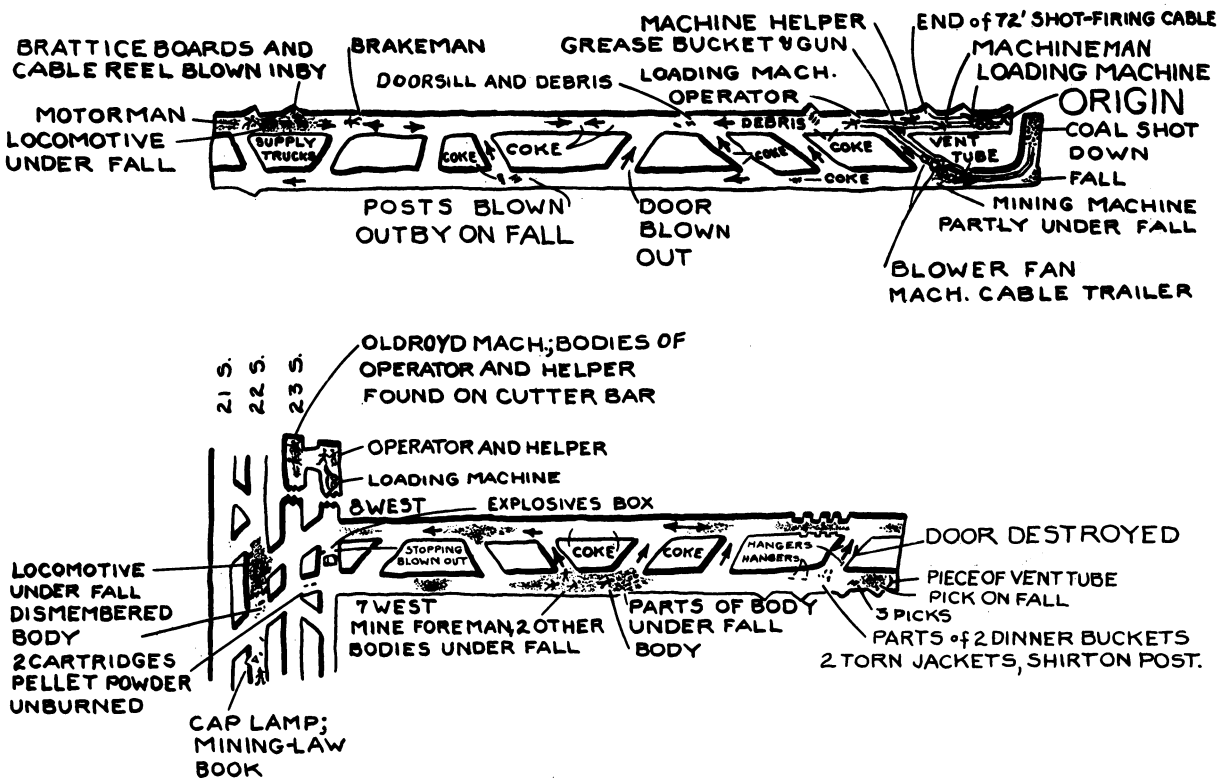

FIGURE 102.—Sketch of area at origin of explosion, Willow Grove No. 10 mine, Neffs, Ohio, March 16, 1940.

in this mine, and large areas of open workings were poorly ventilated. The gas mixture reached a haulageway and was ignited by an arc from a trolley locomotive (figs. 103 and 104). The explosion was not strong enough to raise enough coal dust into the air to propagate the flame beyond the gassy area although no rock dusting had been done. The mine was moderately gassy, and it was the practice to fence off gassy places until ventilation could be arranged to clear them.

August 27, 1940; Bates No. 2 Mine, Bates, Ark.; 10 Killed

(From Bureau of Mines report, by G. M. Kintz and J. B. Hynal)

The mine had been operated by various leasers for years, and at this time a longwall method was being used. About 5:35 p. m. the 10 men in the mine on night shift were killed by an explosion; 7 in the 2d east died in their places; 3 from the west longwall traveled 600 feet before being overcome. Heat was evident in most of the open sections below the overcast on the main slope. The mine is damp, and 6 feet of clay is brushed along the floor of the entries so that dust entered into the explosion only to a limited extent. Damage to the mine was minor, some wooden brattices and props being knocked out. The bodies were recovered in fresh air without help.

Gas from feeders cut by a cutting machine at the face of 2d east entry was ignited by an arc caused by shutting off the machine or by the flame of a match (fig. 105, p. 155). The mine was known to be gassy, but open-type machines were used and shots were fired with fuse after the shift was out. Smoking materials and matches were found on some of the victims.

November 29, 1940; Nelms Mine, Cadiz, Ohio; 31 Killed

(From Bureau of Mines report, by J. J. Forbes, G. W. Grove, C. W. Owings, and James Westfield)

Two shafts intersect the coal bed at 425 feet, 1 for hoisting, the other for air and supplies. At 1:20 p. m. there were 135 men in the mine, when an explosion killed all of the 31 in the workings driven from the 8 east aircourse. The remaining 104 escaped unassisted and uninjured.

The company safety inspector, in 1 east off 12 north, was knocked down by a rush of air; he was dazed but recovered and went to a telephone at the dispatcher station. Finding that conditions were normal in other sections but that 8 east did not answer he informed the superintendent, who called in from the foot of the shaft. The general superintendent was called in, and at 2:20 p. m. State officials were notified. Assistance was sent when the news was made public. Rescue crews were organized, and gas-mask crews explored ahead as ventilation was advanced. All of the bodies were recovered by December 4. Repair work on a door and other interruptions to local ventilation caused accumulation of methane in room 13 off 8 east aircourse.

An arc from a nonpermissible drill or from a mining machine ignited the gas and coal dust propagated the explosion in the section. It was stopped by wetness and rock dust on the haulage roads and rock falls in other entries (figs. 106 and 107, pp. 156 and 157). Inby the haulage roads were rock-dusted. Tests for gas were not made before and during the operation of machines and drills.

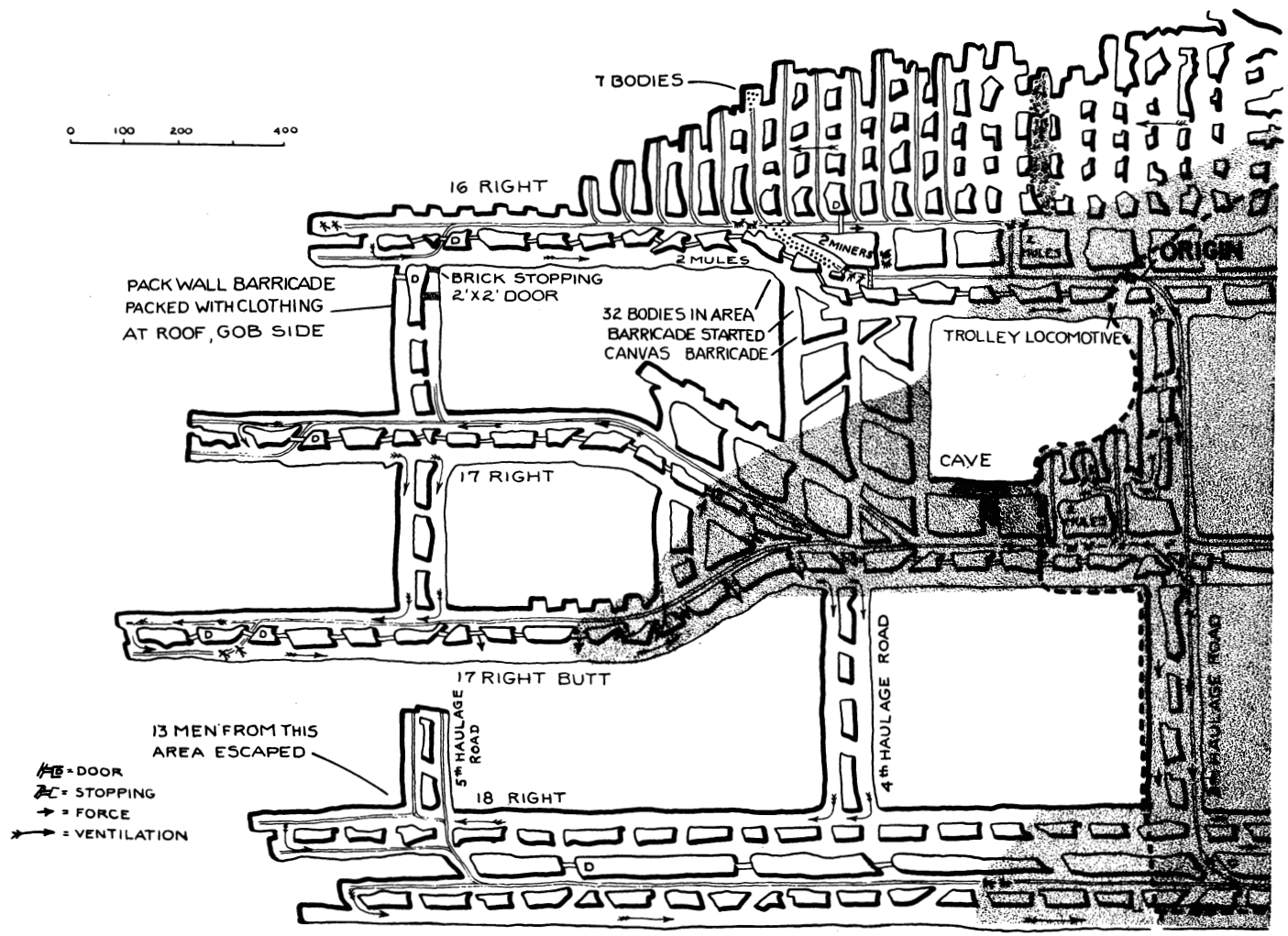

FIGURE 103.—Map of explosion area, Sonman "E" mine, Sonman, Pa., July 15, 1940. See also figure 104.

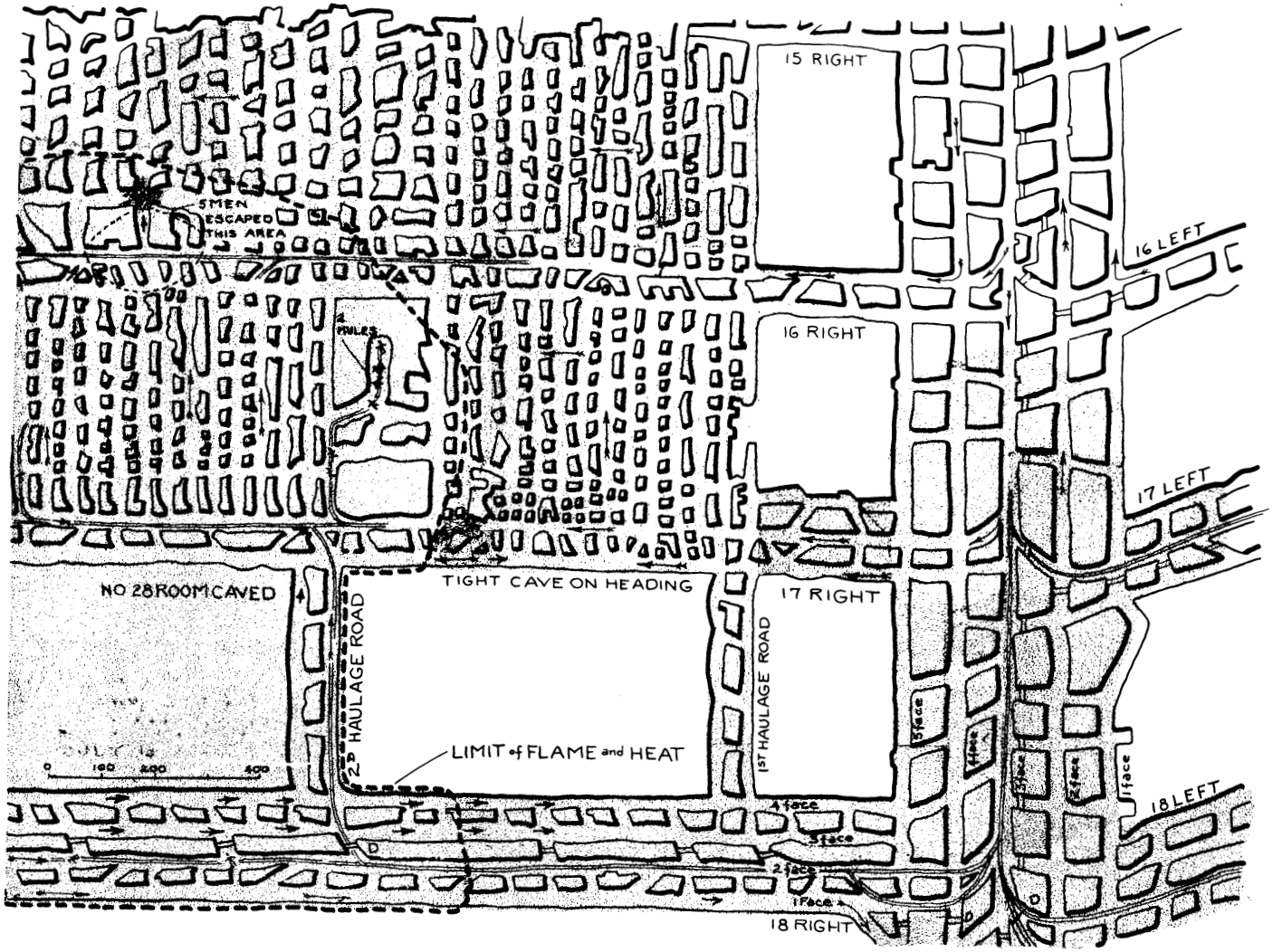

FIGURE 104.—Map of explosion area, Sonman "E" mine, Sonman, Pa., July 15, 1940—Continued

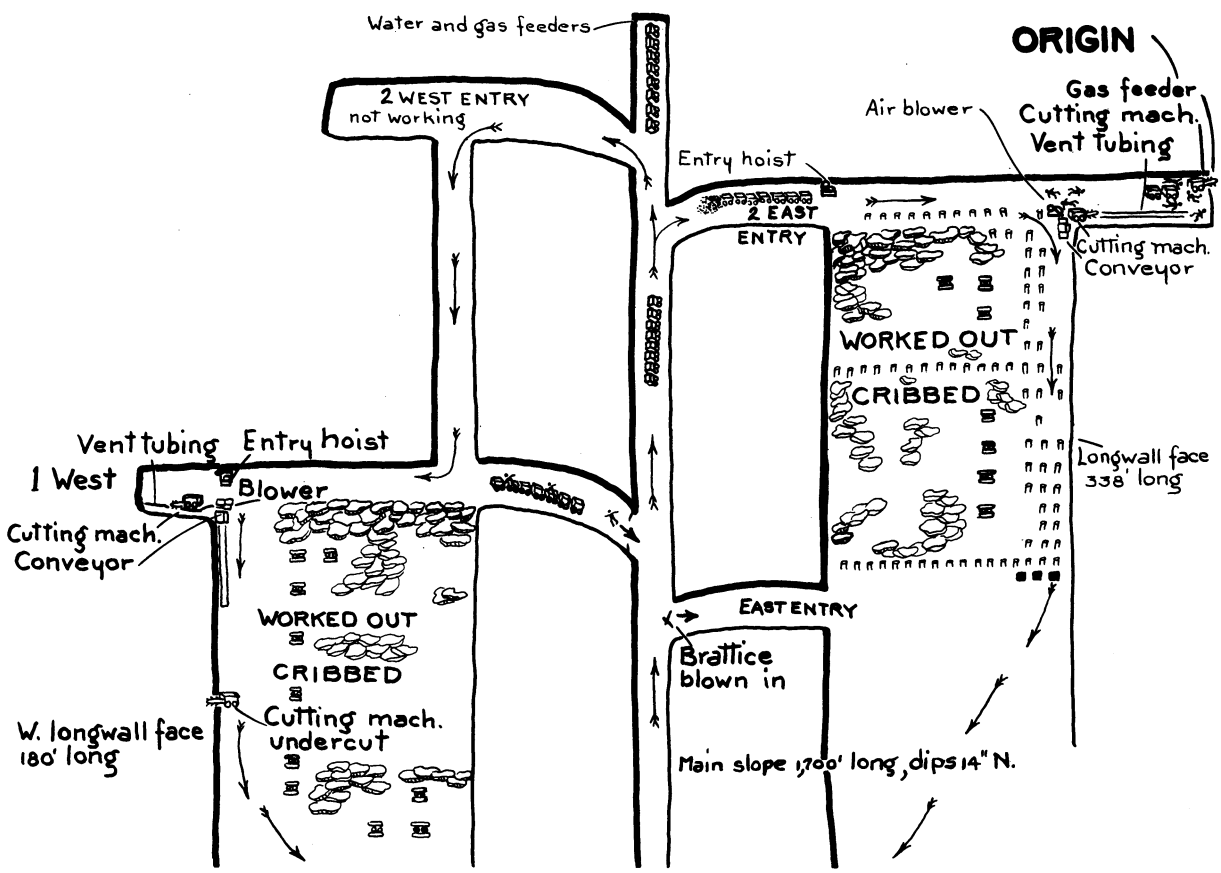

FIGURE 105.—Map of explosion area, Bates mine, Bates, Ark., August 27, 1940.

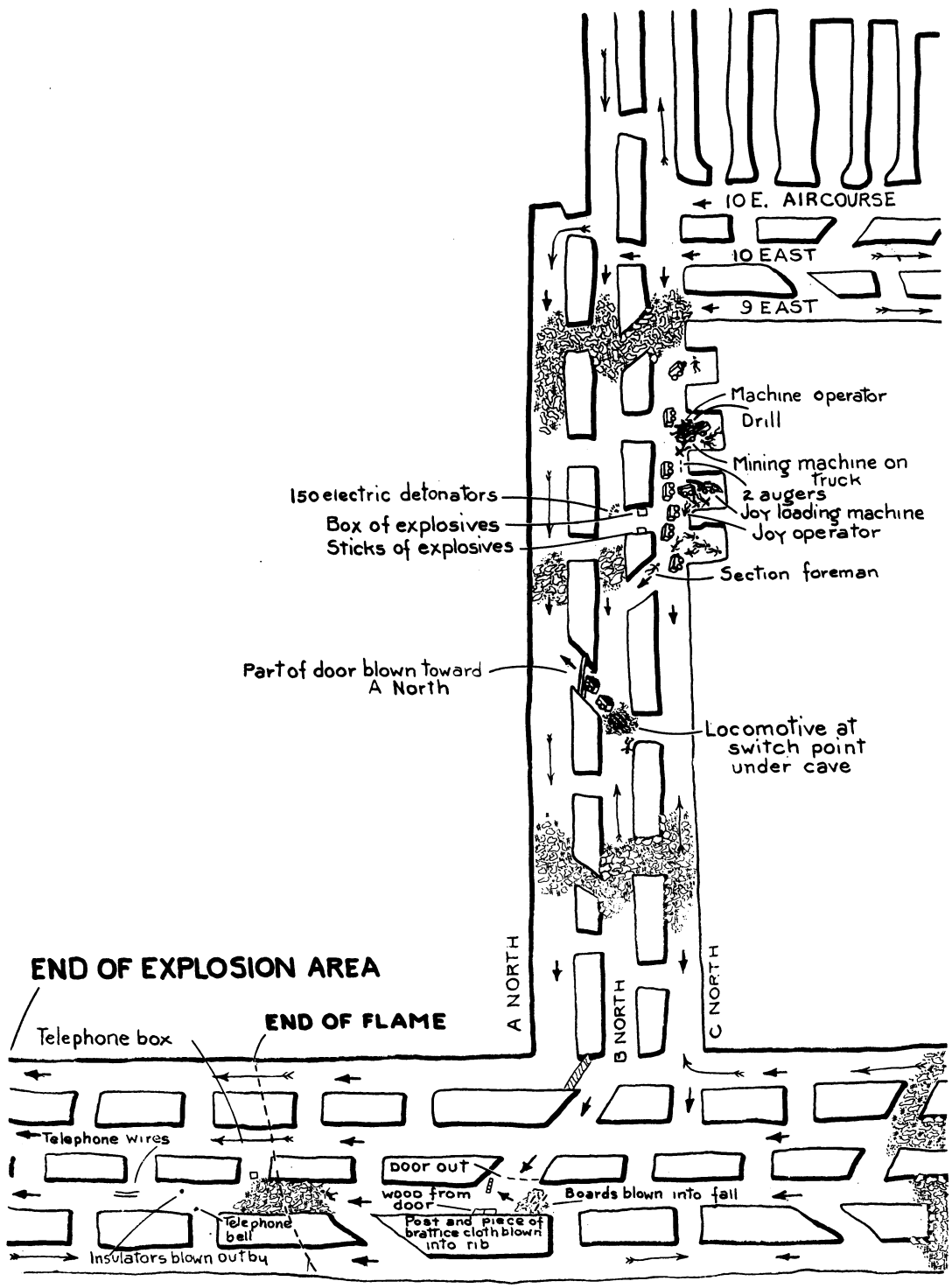

FIGURE 106.—Map of explosion area, Nelms mine, Nelms, Ohio, November 29, 1940. See also figure 107.

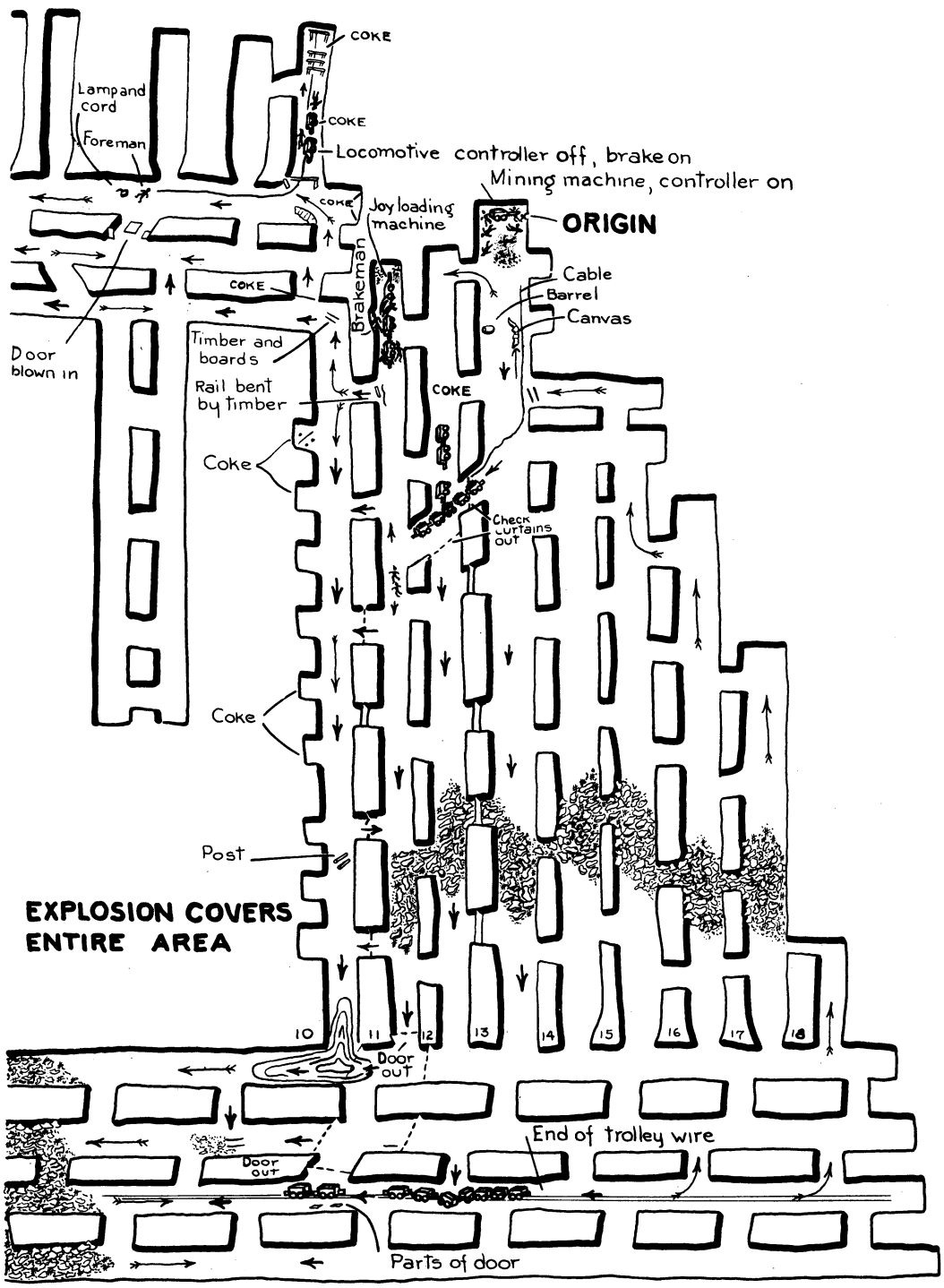

FIGURE 107.—Map of explosion area, Nelms mine, Nelms, Ohio, November 29, 1940—Continued.

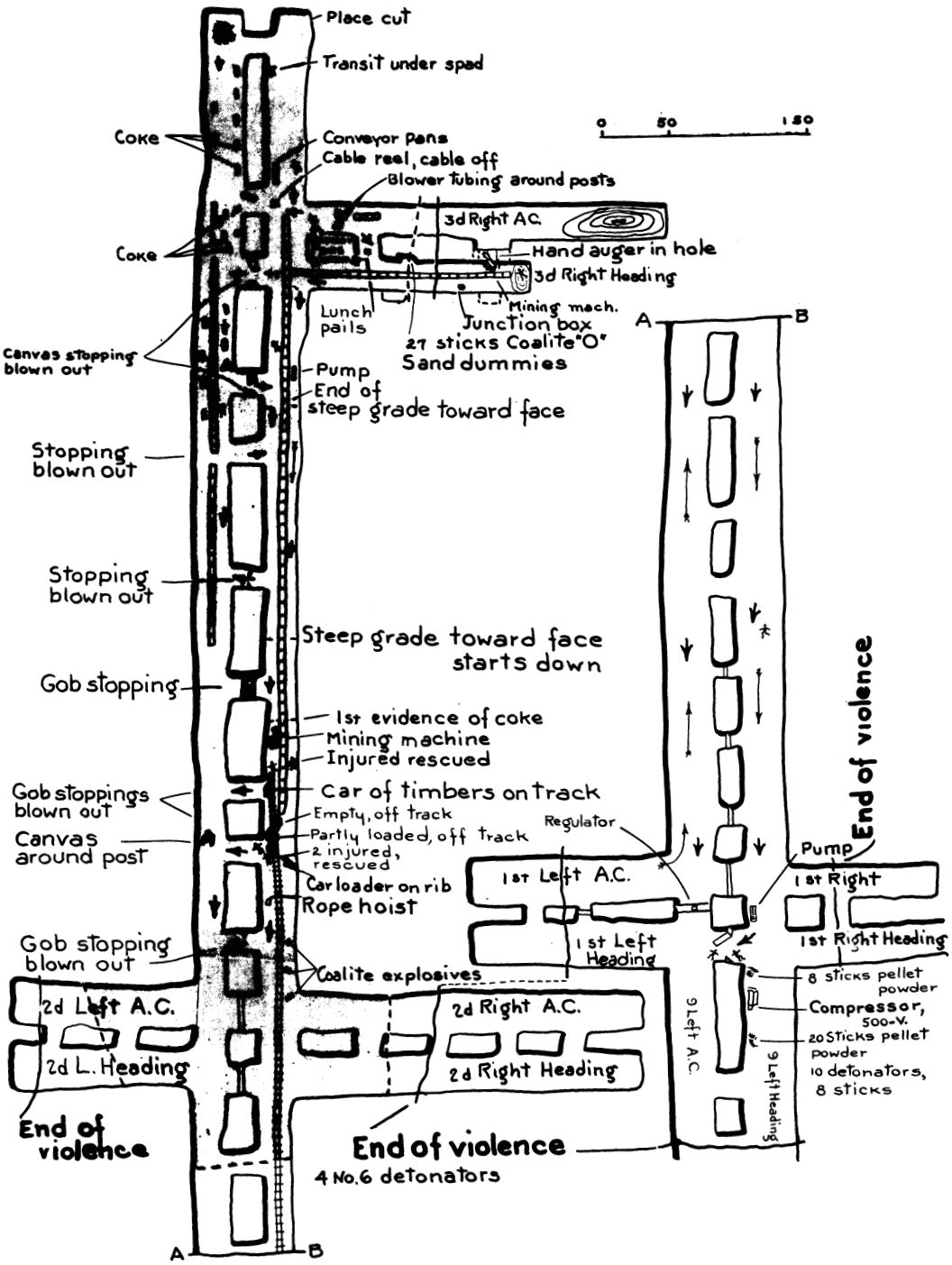

FIGURE 108.—Map of explosion area, No. 4 mine, Raleigh, W. Va., December 17, 1940.

December 17, 1940; No. 4 Mine, Raleigh, W. Va.; 9 Killed

(From Bureau of Mines report, by W. J. Fene, F. E. Griffith, and E. E. Quenon)

A local gas and dust explosion, about 10:30 a. m., killed 7 men outright and injured 4 others, 2 of whom died in the hospital. Two others of the 13 men in the affected area escaped uninjured, as did 57 men from other sections who rode out on a trolley-locomotive trip on the haulageway in return air. They brought the first word, as the mine opening is a mile or more from the tipple and there were no telephones in the mine. Rescue crews, State officials, and others arrived during the afternoon and evening, some from over 300 miles away.

The mine foreman and assistant, standing at a door, were blown in opposite directions but were soon able to start looking for the location of the blast. They found smoke and gases coming from 9 left section and led men from other sections into the area, finding 2 injured men and 1 dead man. They brought out the injured, and rescue crews helped to recover the bodies. Oxygen breathing apparatus was used in recovering one body; all were removed by 3 p. m.

The explosion was not violent and was confined to 9 left section, since the low-volatile dust does not ignite without high initiating temperature and pressure (fig. 108). Dust entered into the explosion locally, but propagation did not follow. The mine was considered nongassy, but no work had been done in 9 left for 4 weeks, and ventilation near the faces was not kept up. Gas collected in this area and was ignited by an engineer who was smoking while setting line sights near the face. No regular gas tests were made, and little rock dusting was done.

METHODS AND PROCESSES IN CONTROLLING AND PREVENTING EXPLOSIONS

CHANGES IN MINING METHODS

At the beginning of this 30-year period, the conditions and problems responsible for founding the Bureau of Mines, of course, prevailed. Some causes of mine explosions had been known for many years, but methods of control were not being adopted because mine officials and mine workers either did not believe they were needed or persistently followed unsafe but familiar mining practices. Coal mining involved the use of hand loading, open lights, and black blasting powder. Untrained men were hired as mine workers; many were foreign laborers who never learned English. Foremen and superintendents were sometimes careful and capable men; but many were careless or simply uninformed beyond the methods learned from predecessors. The lingering effects of these conditions were not abated until late in the period. By that time mechanization, through the installation of mechanical loaders, conveyors, coal saws, scraper loaders, shuttle cars, and other machines, removed some old hazards but introduced a few new ones. One effect resulting in easier supervision was to bring men into crews instead of distributing 1 or 2 in each room or heading.

SAFETY PROGRAMS

The company safety programs grew from nothing more than the ideas of individual foremen to planned training and inspection under a safety director or inspector. Figure 109 shows a cutting machine in use in 1931. More often these activities were conducted through local associations of mines or companies under a safety director conducting a program for the group, some also having a company safety man. Safety engineers of casualty insurance companies gave similar services and promoted adoption and improvement of safer practices. In many of the coal-producing States the State mine inspectors were active partners and leaders in these activities. The results of their participation in group safety programs aided in the understanding and adoption of safer practices, while their regular inspections and enforcement of safety laws attempted to secure observance of the minimum requirements placed in the laws.

STATE LAWS AND RECOMMENDED PRACTICES

In most coal-producing States the opposition to regulation prevented the passage of laws adequate to prevent explosions, and in some instances political pressures were employed to prevent strict enforcement. Resistance to curbs on unsafe practices (such as smoking, use of open lights, blasting off the solid, use of black blasting powder, coal dust for tamping, overcharged shots, and open shots) and neglect of ventilation (such as leaving doors open and curtains down and entering unventilated places) were not uncommon. Only a few of these explosion hazards were prohibited by State laws at the beginning of the 30-year period, and up to 1940 revisions of the laws were blocked more often than they were passed. Acceptance and observance of safety practices to prevent explosions could be advanced mainly by education and by the example of the better managed mines. Other incentives to correction of tolerated hazards were the lesson and shock of repeated disasters. After their occurrence some reformation usually followed, often extending far beyond the district in which the explosions happened.

WORK OF THE BUREAU OF MINES

The role of the Bureau of Mines in promoting mine safety gave particular attention to explosion disasters. At the start, assistance in

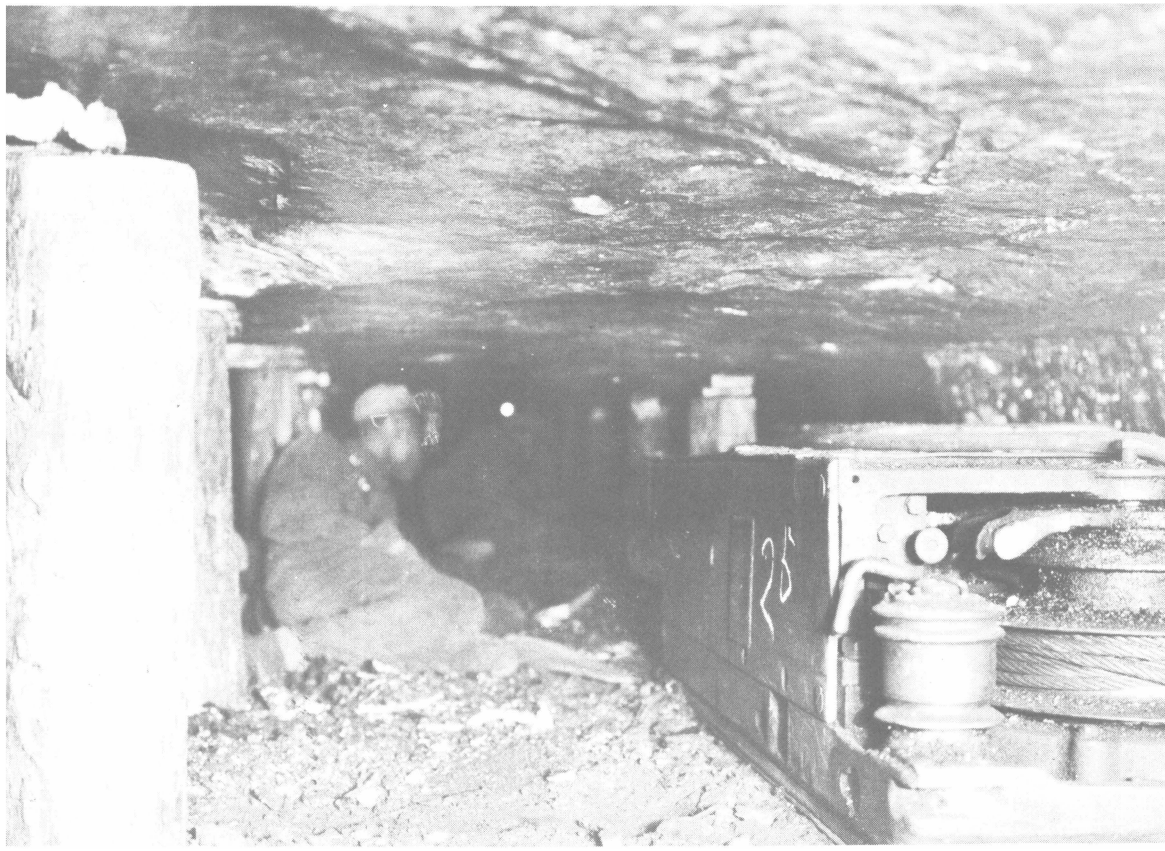

FIGURE 109.—Cutting longwall face, 1931.

recovery and rescue work at mines torn by explosions kept the Bureau's engineers busy helping at the explosions, investigating and reporting on the causes and conditions responsible, recommending changes to avoid recurrences, and training crews in mine rescue. Opposition to participation of Bureau of Mines engineers in directing recovery work and in making investigations of causes of explosions sometimes prevented effective cooperation, but this conflict gradually decreased as cooperation was established with State mine inspectors and local safety associations. It did not disappear, however, owing to the conflict between the ideas of State and Federal authority.

The investigation of the conditions under which explosions of methane, coal dust, or both may take place or be prevented or controlled was centered at the Experimental Mine established by the Bureau of Mines at Bruceton, Pa., in 1910 for making actual, full-scale tests and demonstrations, so that there would be no doubt as to the application of the results to mine hazards (*49*). The tests primarily centered on the explosibility of coal dust, because many coal-mining men held the belief that an explosion could not take place unless methane was present. In 1911 a coal-dust explosion was demonstrated during a program that was given national attention (*65*, *pp. 29–53*). Planned series of tests and frequent demonstrations have been carried out at the mine and at the adjoining testing laboratories since that year (*39*). This work has been correlated with that of testing stations in Europe. Demonstrations of coal-dust explosions and of the quenching effect of rock dust have moreover been made in wooden galleries at field-day exercises in mining districts all over the country. The tests in the Experimental Mine also provided examples of the effects of various types of explosions and of evidence from which to judge the origin and direction of forces. The results of the Bureau's tests on explosions and their prevention were published and explained to the industry at safety meetings and training courses.

Education of miners and officials to know and recognize explosion hazards and the practices needed to prevent them was a continuous function of the Bureau of Mines. The initial train-

ing courses on first aid and mine rescue were to instruct the miners and bosses in skills they might have to use to save themselves or fellow workers after explosions, fires, or other accidents. In the course of the training, attention was called to the dangers of an explosion and the effects of afterdamp. An advanced mine rescue course for mine officials dealt with recovery and rescue procedures after an explosion, as well as with causes and prevention. An accident-prevention course for coal-mine officials, started about 1930, included full discussion of ventilation, testing for methane, use of closed lights, permissible explosives and electrical equipment, allaying of coal dust, rock dusting, and other factors in explosion prevention. A shorter training course covering the subjects with which miners were directly concerned was introduced about 1940. At many mines, between 1930 and 1940, all or selected groups of miners were brought together to attend the accident-prevention classes with the supervisors. Although this helped to spread ideas of safer practices to the working force, the best results were not obtained for either group, because the officials needed more time and smaller groups to discuss the subjects with which they should be familiar; so a separate shorter course was devised. State inspectors attended these classes and often helped to organize them.

PERMISSIBLE ELECTRIC CAP LAMPS

Methods and equipment designed to stop mine explosions were devised early in the 30-year period, but they had been adopted by 1940 only in varying degrees. Electric cap lamps, developed between 1910 and 1915, began to replace open lights about 1915 (*35, pp. 2–5*). Some early makes of portable electric lamps were used in Pennsylvania mines about 1907 and in other States before 1913. In that year the Bureau of Mines issued its first schedule for approving cap lamps for use in gassy mines, based on a study of the good and bad features of existing models. New permissible models were developed and improved by manufacturers, replacing open lights and obsolete electric cap lamps. The rate of change is shown in figure 12 (p. 44); approximately 53 percent of the underground coal miners had closed electric cap lamps by 1940. The number of these men did not increase very greatly between 1925 and 1940 because of the steady decline in the number of men working in the mines. Adoption of electric cap lamps was opposed by some workers on the ground that, by their use, ventilation would be neglected, since gas accumulations would not be ignited, as with open lights. In other mines not considered gassy electric cap lamps were used to comply with State laws or for their more efficient light, but carbide lamps were used to ignite fuse in blasting. Smoking in gassy mines was curtailed by strict rules and inspections in some States or districts, but regulation of the practice was only nominal in others. Although continued efforts were made by all agencies and officials to combat this practice, little headway was gained.

PERMISSIBLE EXPLOSIVES

A special feature of the testing station established in Pittsburgh in 1908 by the Technologic Branch of the Federal Geological Survey was testing devices for investigating various explosives to determine their suitability for use in coal mines. Methods were developed for testing explosives in gas and coal dust. Those not producing explosions under test conditions were approved as "permissible." Investigation and testing of explosives, blasting units, and blasting devices has been continued and broadened since that time by the Bureau of Mines, and lists of permissible explosives and blasting devices are continually revised as new brands of explosives are produced and new blasting agents are perfected and submitted for scheduled tests. This cooperation of the manufacturers of explosives and the Bureau of Mines produced relatively safe explosives for use in mining coal when they are used within prescribed limits and conditions. Adoption of permissible explosives by the industry was gradual.

The use of permissible explosives was steadily widened, as shown by figure 13 (p. 44). In 1910 black powder was used in 80 percent of the blasting in coal mines, with 10 percent dynamite and 10 percent permissible explosives. By 1940, slightly over 50 percent was permissible, and part of the black blasting powder and dynamite still in use was employed in open-pit workings. In addition, a much greater portion of the coal was undercut, and fewer holes were overloaded. Firing of open shots to break large pieces of rock or coal was prevalent, but relatively few explosions resulted from this dangerous practice. The mortality among shot firers hired to fire the shots in gassy and dusty mines after the shift was high for the first half of the period. This system was resorted to in several mining districts where lack of adequate ventilation or of tests for gas allowed accumulations to be a daily occurrence and where, by habit, coal was shot off the solid with heavy charges of black blasting powder. Frequent explosions and ignitions occurred, many of them never recorded. The system prevailed in the Southwest more than in other districts and was improved in part by the persuasion of engineers representing Government agencies su-

pervising mines on leased lands. Gas accumulations were reduced at the faces by tightening stoppings and by closing doors. Regular tests for gas before any shots were fired helped to avoid some otherwise certain disasters. Better placing of holes, limiting the amount of explosive in each hole, and removal of dust accumulations followed. The miners and operators both opposed use of permissible explosives in some States, and not until 1939 did the amount of permissible explosives used equal that of black blasting powder. Reduction in the production of coal resulting from the use of oil as a fuel closed many mines in the Southwest, and some of the rest changed mining methods, so that fewer shot firers were employed in the latter half of this period. Even in 1940 many mines used the system, with refuge holes on entries in which shot firers remained under cover after lighting shots in the faces.

PERMISSIBLE ELECTRICAL EQUIPMENT

To obtain manufacture and use of safer electrical equipment in coal mines the Technologic Branch of the Geological Survey established an electrical section and testing laboratory in 1909, which was continued by the Bureau of Mines. The section tested equipment in mixtures of gas, dust, and air and supplied the results to State officials, to the industry, and to the makers of the equipment. Testing schedules for "explosion-proof" equipment were set up, the first in 1912, with later revisions as needed to keep pace with new designs. Before 1912 preliminary investigations were made of the danger of gas ignition by the indicators of closed fuses and by broken incandescent lamps, and of the safety of "explosion-proof" switches and motors offered by manufacturers (*7*). Permissible equipment for nearly all purposes was developed and sold by makers of mining machinery during the period 1910–40. Except in very gassy mines, only a few mine operators made permissible equipment standard, and many explosions resulted from arcs produced during operation of open-type equipment. The Bureau of Mines consistently recommended that permissible equipment be used in all gassy mines; but requirements, even for enclosed types, were included in only a few State mining laws. Where enclosed equipment was so required the definition of gassy mines covered only the most gassy workings. There is no way in which the number of explosions prevented by using permissible equipment can be estimated, but the need for it was evident and is indicated on figure 11 (p. 42), the chart giving the sources of ignitions. This hazard and the recommendation for permissible machines were stressed by the Bureau of Mines in annual published reviews of mine explosions and fires from 1928 to 1940 and later. In 1940 about 40 percent of the explosions were of electrical origin. All were from nonpermissible mining machines, drills, and switches, although in preceding years trolley and cable-reel locomotives were the origin of about one-third of the explosions started by electric arcs.

CONTROLLED VENTILATION AND TESTS FOR METHANE

In 1910, 983 coal mines were reported operating in Ohio, of which 318 were ventilated by means of fans, 260 by fires in furnaces or baskets, 14 by steam jets and pump exhausts and 391 by natural draft (*11, p. 260*). Similar accounts for other States would show wide variation but in general it is evident from explosion reports and published articles that adequate ventilation at working faces was exceptional. Continuous ventilating currents carrying the air through all the workings were usual and much of the air was lost through leaking stoppings and open doors. Descriptions by inspectors and in Bureau of Mines reports show slow improvement during the 30 years to 1940. By 1930 most of the mines regularly operated were equipped with fans, and only a handful used furnaces. The split system of ventilation was used in most of the mines in the more progressive districts, and permanent airtight stoppings were standard. The ventilation systems were modernized much more between 1930 and 1940 (figs. 110 and 111), and reversible fans, automatic warning signals to sound if the fan stopped or slowed, recording pressure gages, and regular checks on air-flow volumes in the mine were normal installations and practices. A standard of minimum air current passing the working faces was advocated but not often maintained. Where doors were used, it was recommended that they be in pairs, so that one could be kept closed. Inspection reports of mines in all parts of the country made by Bureau of Mines engineers at the request of operators between 1930 and 1940 showed that installations and careful maintenance of good ventilation systems were spotty. Even where the systems were well planned and engineered, keeping a continuous uniform air flow at the faces could not be automatic, and much negligence was noted. Practices of this nature cannot be described in any general terms; the variations ran from no ventilation at all to excellent, and averages cannot be drawn. The difficulties in maintaining enough air flow at the working faces and in idle workings with the ventilation systems in use were clearly evident, but there was no attempt to plan, or try, or change to new systems in which the air current would not be

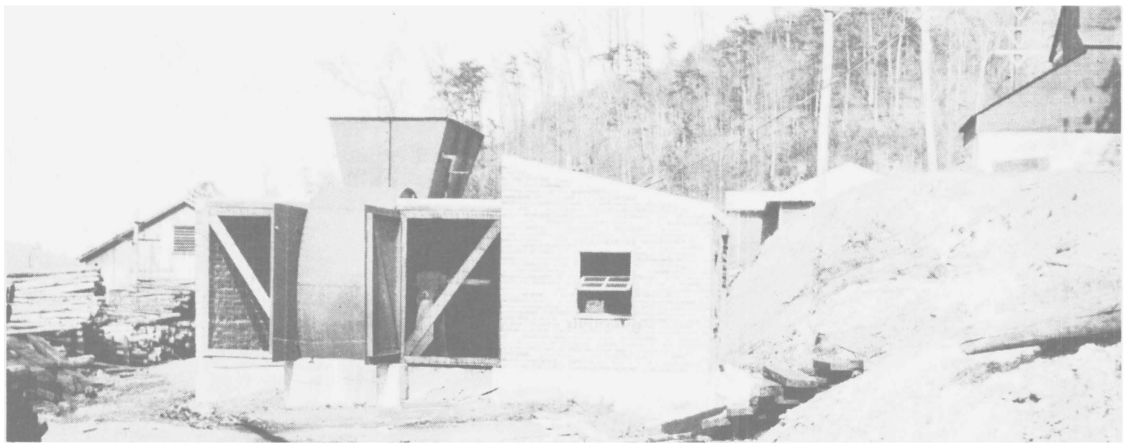

FIGURE 110.—Centrifugal fan and mine timbers, 1925.

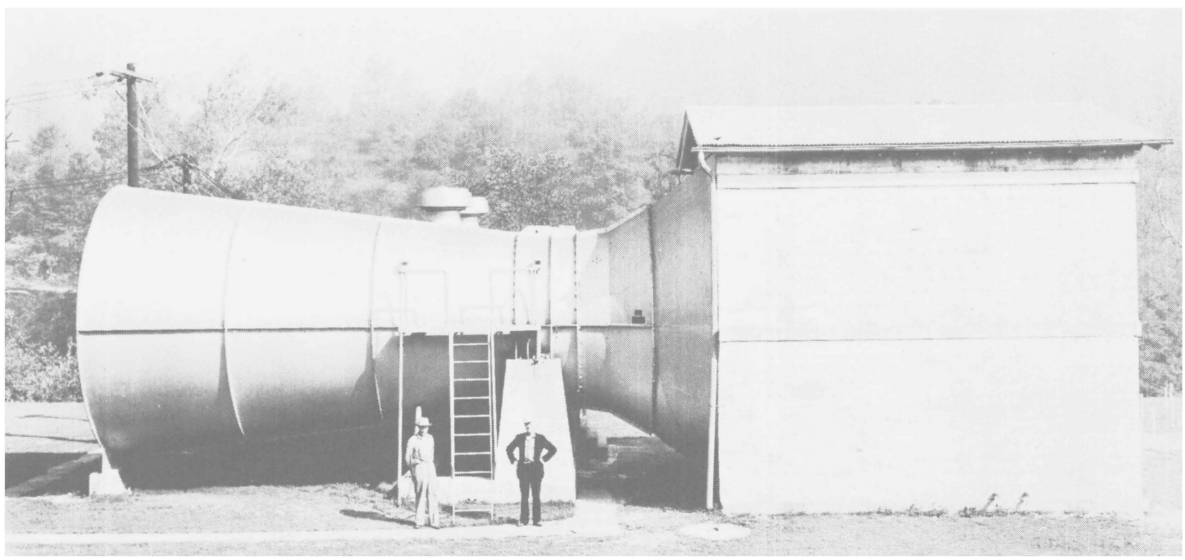

FIGURE 111.—Propeller-type fan, 1940.

returned from the faces and brought out through airways paralleling the intake for part or all of their length. Fireboss inspections were required by law in many States, but only in distinctly gassy mines. Here again the observance of strict standards of compliance varied from one locality to another. Approved flame safety lamps were designed and used throughout the 30-year period; the magnetic-locked type appeared before 1915, when a Bureau of Mines testing schedule was established for flame safety lamps.

WATERING

The intention in watering and sprinkling the roadways and sometimes the working places was to keep the dust from being stirred up and possibly ignited by some flame or arc. Since many mine officials thought that dust could not be ignited unless gas was also in the air and because it was a never-ending struggle to keep the dust wet in dry workings, only a few mines followed a thorough wetting system. Between 1920 and 1930 cutting machines in a number of mines were equipped with pipes and hose connections to spray water on the cutter bar during operation; by 1940 this system was regarded as standard, although adopted in only part of the mines (*26*). Sprinkling pipes to wet the tops of loaded cars were placed at sidetracks and gathering points in many mines to reduce the blowing off or leaking out of fine dust on the haulageways. Wetting the broken coal and mine surfaces was advocated in 1911 and later years by the Federal Bureau of Mines; but reservations were added, as rock dusting was found a more reliable means of preventing the propagation of dust explosions.

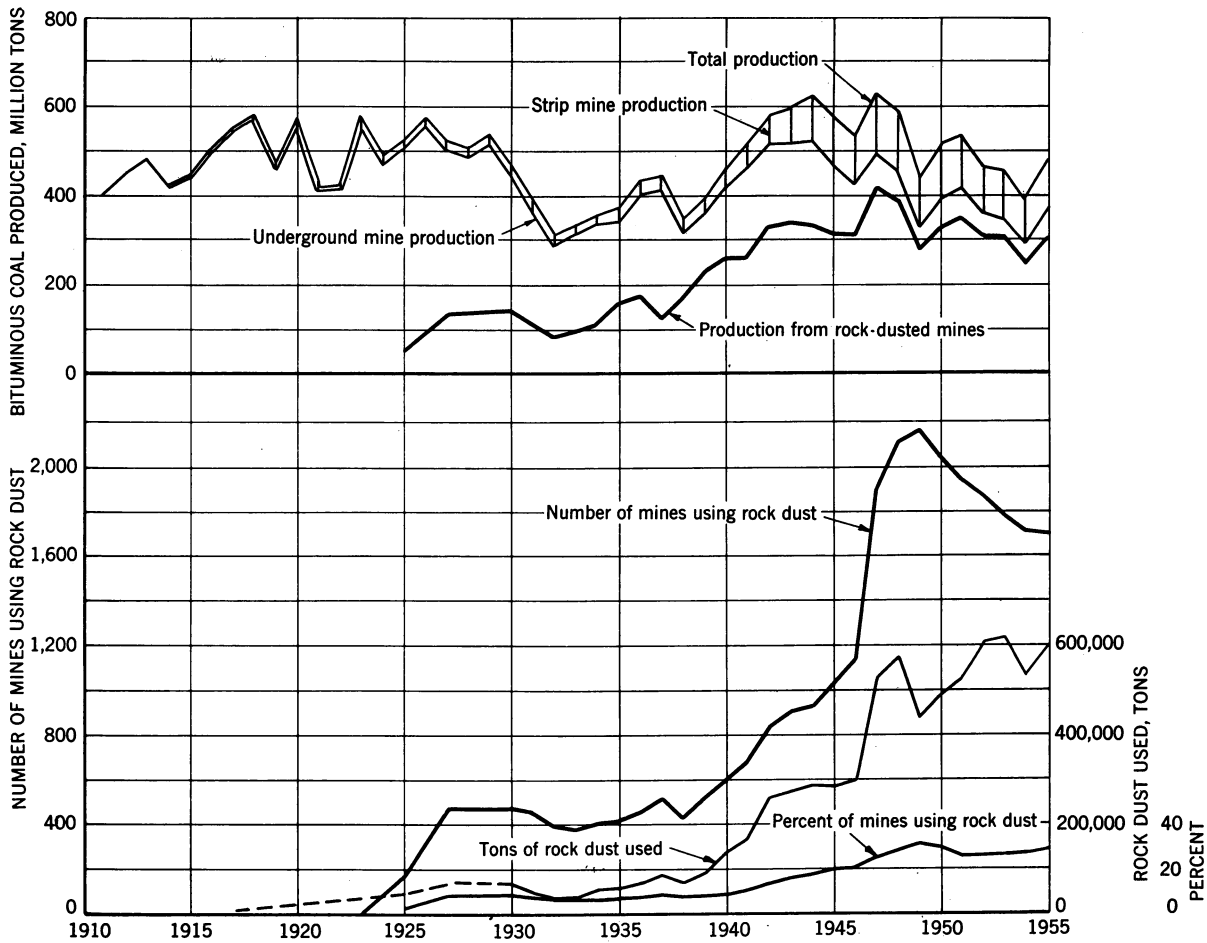

FIGURE 112.—Use of rock dust in bituminous-coal mines, 1911–55.

ROCK DUSTING

Although the explosive possibilities of coal dust were recognized and stated by investigators before 1870, the hazard was disputed by some in the industry, even in 1940, although the fact was generally accepted before 1930 (*51, p. 8; 52, pp. 3–4; 53, p. viii*). The tests at the Bureau's Experimental Mine showed that fine coal-dust particles, such as float dust, will ignite and propagate an explosion without gas being present. Coarser dusts will be consumed and add heat and pressure. Firedamp increases the sensitiveness of all coal dusts to ignition and propagation; it has the most marked effect on the low-volatile coal dusts and on coarse coal dusts, which are not readily explosive when it is absent (*53, p. ix*).

In 1911, George S. Rice, in Bureau of Mines Bulletin 20, The Explosibility of Coal Dust (*48, p. 33*), said:

> The question of the day no longer is "Will coal dust explode?" but "What is the best method of preventing coal-dust explosions?"

His opinion, as given in that bulletin, was (*48, p. 107*):

> The use of stone dust is the most recent suggestion for either preventing or limiting explosions of coal dust. As the method is only in the experimental state, it is too early to express any decided opinion. Tests at Altofts in Great Britain appear very favorable.

In 1922 it was stated that the results of extensive experiments in using rock dusts at the Experimental Mine "gave great promise as a method to prevent coal-dust explosions" (*52, pp. 19 and 147*). The tests showed that, with a mixture of Pittsburgh coal dust and rock dust, having an incombustible content of 64 percent, no ignition was obtained.

The first practical application of rock dust in coal mines in this country to prevent the propagation of an explosion probably was in 1912 in the mine of the Victor American Fuel Co., at Delagua, Colo. Taffanel barriers were installed, and the roof and ribs along haulageways were coated by means of a compressed-air machine made at the plant. In 1917 the Old

Ben Coal Corporation mines in southern Illinois were rock-dusted. The practice spread slowly, but by 1930 manufacturers were making efficient rock-dusting machines of both high- and low-pressure types. Reports gathered by the Bureau of Mines showed that by 1925 approximately 10 percent of the bituminous-coal production was from mines using rock dust. About 10 percent of the underground employees in bituminous-coal mines worked in these mines. By 1927 mines producing about 28 percent of the coal from underground bituminous-coal mines and employing about 20 percent of the underground workers were using rock dust. By 1930 these mines were producing over 30 percent of the coal; and, as mechanization advanced, the proportion of production from mines in which rock dust was applied also increased. By 1940 over half of the total bituminous-coal tonnage was from these mines. The relations of rock-dust use and coal production are shown in table 9 and figure 112.

TABLE 9.—*Rock dusting in United States coal mines*

Year	Bituminous coal (million tons) produced from—			Underground-bituminous-coal mines			Rock dust (tons)	Coal from rock-dusted mines (million tons)	Underground tonnage (percent)
	Underground mines	Open Pits	Total	Total	Rock-dusted				
					Number	Percent			
1911			405. 9						
1912			450. 1						
1913			478. 5						
1914	421. 4	1. 3	422. 7						
1915	439. 8	2. 8	442. 6						
1916	498. 6	3. 9	502. 5						
1917	546. 0	5. 8	551. 8						
1918	571. 1	8. 3	579. 4						
1919	460. 1	5. 6	465. 7						
1920	559. 8	8. 9	568. 7						
1921	411. 2	4. 7	415. 9						
1922	412. 4	9. 9	422. 3						
1923	552. 8	11. 8	564. 6		12				
1924	470. 1	13. 6	483. 7						
1925	503. 2	16. 9	520. 1	5, 600	177	3. 2		54. 0	10. 7
1926	556. 5	16. 9	573. 4						
1927	499. 4	18. 4	517. 8	5, 370	463	8. 6		137. 3	27. 6
1928	480. 9	19. 8	500. 7						
1929	514. 7	20. 3	535. 0						
1930	447. 7	19. 8	467. 5	5, 643	474	8. 4	68, 869	148. 6	33. 2
1931	363. 2	18. 9	382. 1	5, 410	449	8. 3	59, 811	115. 9	31. 9
1932	290. 1	19. 6	309. 7	5, 240	393	7. 5	37, 469	88. 6	30. 6
1933	315. 4	18. 2	333. 6	5, 305	382	7. 2	36, 575	96. 7	30. 7
1934	338. 6	20. 8	359. 4	5, 989	407	6. 8	51, 617	112. 5	33. 2
1935	348. 7	23. 7	372. 4	5, 943	416	7. 0	54, 994	161. 0	34. 2
1936	409. 3	27. 2	436. 5	6, 216	460	7. 4	71, 409	177. 4	39. 3
1937	415. 4	31. 6	447. 0	6, 094	518	8. 5	86, 595	126. 6	42. 7
1938	319. 2	30. 3	349. 5	6, 016	431	7. 2	72, 215	174. 9	39. 7
1939	359. 4	37. 2	396. 6	6, 648	526	7. 9	91, 167	233. 2	48. 7
1940	419. 0	42. 3	461. 3	6, 552	599	9. 1	140, 736	262. 9	55. 7
1941	460. 3	55. 5	515. 8	6, 617	678	10. 2	172, 302	262. 9	57. 1
1942	516. 2	65. 5	581. 7	6, 185	838	13. 5	260, 555	328. 6	63. 7
1943	513. 7	79. 8	593. 5	5, 624	910	16. 2	274, 986	339. 3	66. 1
1944	519. 9	101. 4	621. 3	5, 348	934	17. 4	288, 854	334. 2	64. 3
1945	467. 5	109. 0	576. 5	5, 146	1, 033	20. 0	286, 897	315. 8	67. 5
1946	421. 7	111. 8	533. 5	5, 623	1, 145	20. 4	294, 175	311. 5	74. 0
1947	494. 1	133. 9	628. 0	7, 489	1, 906	25. 5	529, 093	417. 5	84. 3
1948	457. 4	135. 5	592. 9	7, 633	2, 120	27. 9	578, 493	391. 5	85. 6
1949	330. 2	105. 5	435. 7	6, 968	2, 171	31. 0	437, 758	280. 4	85. 0
1950	394. 8	123. 1	517. 9	6, 923	2, 053	29. 7	493, 856	333. 5	84. 5
1951	417. 7	115. 5	533. 2	7, 792	1, 952	25. 0	525, 617	356. 3	85. 3
1952	358. 9	110. 5	469. 4	7, 178	1, 882	26. 2	603, 472	309. 0	86. 1
1953	349. 3	106. 6	455. 9	6, 783	1, 795	26. 4	617, 409	306. 7	86. 7
1954	290. 5	101. 5	392. 0	6, 270	1, 715	27. 5	532, 095	256. 5	88. 3
1955[1]	370. 0	100. 0	470. 0	6, 000	1, 700	28. 3	600, 000	300. 0	88. 0

[1] Estimated—tabulation incomplete.

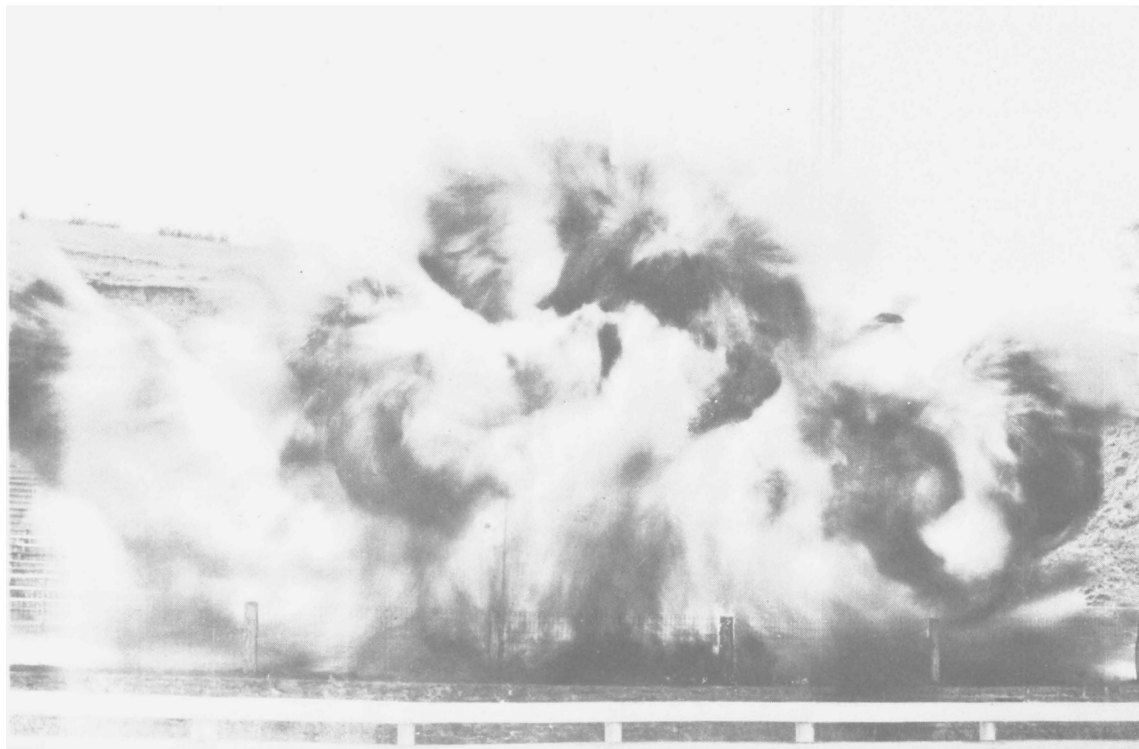

FIGURE 113.—Demonstration of dust explosion in Bureau of Mines surface gallery, 1938.

From 1927 to 1938 the number or percentage of underground mines using rock dust did not increase, probably because of the depressed market and because there was a period of several years with few explosion disasters. From about 1939 rock dusting was introduced in more mines every year. Figure 113 shows a coal-dust explosion demonstration to impress viewers with the reality of the danger and to show the effect with and without rock dust. Figure 114 shows rock dusting in a mine in 1938.

The adoption of rock dusting as a protection against explosion disasters did not mean that all of the mines credited with using rock dust did so effectively. From 1925 to 1935 only token applications were made in a majority of the mines reported as rock-dusted. The sudden rise from 1923 to 1927 in the number of rock-dusted mines came about because of explosions, costing great loss of life, in Utah and other States in mines that were exceptionally well sprinkled. As a result, many companies turned to rock dusting, and several States enacted laws requiring it. However, Dan Harrington stated in 1927 (*28, p. 5*):

> Although the recent survey indicates that rock dust is being used in 463 mines in the United States, it is decidedly improbable that 50 of these mines are *adequately* rock-dusted. Bureau of Mines field men have reported a number of mines as being fairly well protected from widespread explosions where combined rock dusting and watering systems are in use, but few if any mines are being adequately rock-dusted where dependence is placed on rock dusting alone. Most mines distribute rock dust where it can be done conveniently from a haulage track and are credited with having rock-dusted the mine, although no rock dust has ever been placed in parallel entries or rooms or abandoned entries in dry and dusty mines. In many instances, rock dust is applied in open and active workings, and then no additional dusting is done within 1 or 2 years.

These conditions and practices continued in a great many mines well after 1940 (*1, pp. 1–2*). A review of the major explosions in 1940 and 1941 says that:

> All but one occurred in mines that were wholly or partly mechanized. One of the mines in which major explosions occurred was reported to have been well rock-dusted, 9 were reported to have been partly rock-dusted, and 1 had no rock dust. Had proper rock dusting to prevent propagation of explosions been in effect in all these mines, the death toll undoubtedly would have been reduced greatly and possibly one or more of the explosions would have been prevented (*25, pp. 19–20*).

FIGURE 114.—Rock dusting with low-pressure machine, 1938.

Although the history of explosions between 1930 and 1940 showed that in many mines where rock dust had been applied it had not been regularly extended and maintained, the reports show that some of the old applications helped to check the propagation.

OBSERVANCE OF SAFETY STANDARDS

In reporting on the mine explosions during 1940 and 1941, the Bureau of Mines summed up the current situation in these words:

> The record of fatalities from mine explosions during the past 2 fiscal years has been anything but encouraging; more men were killed by explosions (379) than were killed from the same cause during the preceding 6 years combined (368).
>
> The reason for the large increase in the number of explosion fatalities during the past 2 years as compared with the previous 6 years is not entirely clear. In some instances, there has been laxity in the enforcement of State mining laws; in others, both workers and operating officials have failed to observe recognized precautionary measures to prevent explosions. In many of the explosions that have occurred within the past few years in mechanized mines it has been evident that speed of operation and a demand for maximum tonnage at a minimum cost resulted in neglect of ordinary safety measures (*25, p. 1*).

In 1940, Dan Harrington warned, in a similar report for that year, that:

> Coal-mining men deserved to rejoice over the splendid record for the fiscal year 1939, which was the first consecutive 12-month period in the present century without a major disaster in the coal mines of the United States, but gloom prevails when the record for the fiscal year 1940 is considered. During the past fiscal year 18 explosions, of which 3 were major disasters, resulted in 206 deaths compared to 14 minor explosions and 16 deaths in 1939. The absence of coal-mine explosions does not always indicate that effective efforts have been made to prevent them but rather that the mine has been fortunate in that the combination of circumstances necessary to cause an explosion has not existed. In view of the present knowledge of the methods of preventing explosions, disasters are inexcusable and discredit the mining industry. The methods of preventing explosions are known to experienced, well-informed persons engaged in coal mining, yet despite this knowledge far too many coal-mine operators continue to use practices and methods that they should know have resulted in numerous explosions. Moreover, many mine workers persist in following past procedure irrespective of consequences and in breaking safety rules or indulging in practices almost certain eventually to result in disaster. Continued failure to apply known commonsense methods of accident and explosion prevention unquestionably will call for ultimate enforcement of law.

1941–50

HAZARDS AND OCCURRENCE OF EXPLOSIONS

The results of methods adopted in these 10 years to reduce the number of explosions and the loss of lives from them were not satisfactory, as is shown by the chart of explosion fatalities in figure 2 (p. 14). A downward trend for both explosions and deaths is indicated for the 5 years 1946–50 in figures 2 and 3. This was evidence of some substantial progress in overcoming explosion hazards continued from the methods of past years and new hazards accompanying rapid mechanization in mines producing most of the total coal tonnage. The moderate reduction in explosions and in fatalities from 1941 to 1950 looks better when set against the rise in tonnage and man-shifts over the same period. The average number of fatalities from explosions over these 10 years was 86, compared with a yearly average of 102 for 1931–40. Figure 11 (p. 42) and table 7 show that open lights and smoking remained the leading causes of explosions, being charged as the source of ignition in 46 percent of the occurrences. Blasting and electric arcs each caused 24 percent and flame safety lamps 5 percent. The continued prevalence of ignitions from open lights or smoking becomes even less tolerable when compared with the increased use of electric cap lamps as shown on figure 12 (p. 44). Between 1940 and 1950 the percentage of underground men using electric cap lamps increased from 50 to 80. Most of these ignitions were from smoking. Figure 13 (p. 44) shows that the percentage of black blasting powder dropped from 40 to about 5

TABLE 10.—*Major explosions in United States coal mines, 1941–50*

Date	Name of mine	Location of mine	Killed
1941: January 22	Carswell	Kimball, W. Va	6
May 22	Panhandle No. 2	Bicknell, Ind	14
June 4	Docena	Adamsville, Ala	5
June 30	Kent No. 2	McIntyre, Pa	7
July 10	Acmar No. 6	Acmar, Ala	11
October 27	Daniel Boone	Daniel Boone, Ky	15
December 28	No. 47	Harco, Ill	8
1942: January 27	Wadge	Mount Harris, Colo	34
May 11	Peerless No. 2	Excelsior, Ark	6
May 12	Christopher No. 3	Osage, W. Va	56
May 18	Hitchman	Benwood, W. Va	5
July 9	Pursglove No. 2	Pursglove, W. Va	20
November 30	West Ky. No. 10	Wheatcroft, Ky	6
1943: February 27	Smith	Washoe, Mont	74
May 5	NuRex	La Follette, Tenn	10
May 11	Praco No. 10	Praco, Ala	12
August 28	Sayreton No. 2	Sayreton, Ala	28
September 16	3 Point	Three Point, Ky	12
September 24	Primrose Colliery [1]	Minersville, Pa	14
November 6	Nellis No. 3	Madison, W. Va	11
1944: March 24–25	Katherine No. 4	Lumberport, W. Va	16
July 28	Brilliant No. 2	Brilliant, N. Mex	6
1945: January 17	Bond Valley	Haileyville, Okla	9
March 14	Kennilworth	Kennilworth, Utah	7
May 9	No. 1	Sunnyside, Utah	23
December 26	Belva No. 1	Fourmile, Ky	25
1946: January 15	Havaco No. 9	Havaco, W. Va	15
April 18	Great Valley	McCoy, Va	12
1947: January 15	Nottingham [1]	Plymouth, Pa	15
March 25	No. 5	Centralia, Ill	111
April 10	Schooley [1]	Exeter, Pa	10
April 30	Spring Hill	Terre Haute, Ind	8
July 24	Old Ben No. 8	W. Frankfort, Ill	27
December 11	Franklin [1]	Wilkes-Barre, Pa	8
1948: February 8	Sun Excelsior	Excelsior, Ark	8
July 27	King	Princeton, Ind	13
July 30	Edgewater	Birmingham, Ala	11
1949: None.			
1950: None.			

[1] Anthracite.

percent of the total during this period, yet a fourth of the ignitions were from unsafe blasting. The use of dynamite in anthracite mines contributed heavily to ignitions of this class. Some explosions were also charged to misuse of permissibles. Table 10 lists 37 major explosion disasters between 1941 and 1948; none occurred in 1949 and 1950. Fatalities from these disasters totaled 678. Explosions and ignitions causing fewer than 5 deaths in a single occurrence are listed in table 11. The 213 minor explosions listed are those on which reports were made or received by the Bureau of Mines; in these explosions 156 were killed and 406 injured.

Reports published by the Bureau of Mines summed up the prevalent explosion hazards as demonstrated by each year's experience (*17*, *27*). In 1946, factors contributing to the explosions occurring from 1941 to 1945 were:

(1) The rapid increase in the use of electrical equipment at face regions where gas and dust are most likely to be found; (2) the increased demand for coal, with the desire to obtain maximum tonnage per machine at minimum cost, which in many mines has resulted in neglect of even rudimentary precautionary measures; (3) multiple-shift operation without provision of time for adequate maintenance of equipment, effective rock dusting, and testing for gas; (4) decrease in supervision owing to demands on supervisors for maximum tonnage and loss of competent supervisors to other employment: (5) lack of effective supervision, owing to numerous new conditions, some of them war-connected; (6) inability to obtain adequate equipment repair and replacement parts; (7) shortage of labor and inadequate training of coal-mine workers; and (8) failure of both miners and mining officials to show regard for safety in changing from hand-loading to mechanized methods.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1941: January 4	Royal	Royal, Utah	Dust; arc from shorted trolley wire.	K–1; I–1.
January 5	Primrose	Minersville, Pa	Gas; arc from blower fan	K–1; I–0.
February 1	No. 31	Lynch, Ky	Dust; bump and arc from mining machine.	K–0; I–3.
March 13	Revloc	Revloc, Pa	Gas; arc from trolley locomotive.	K–4; I–0.
May 9	Panhandle, No. 2	Bicknell, Ind	Gas; arc from mining machine	K–2; I–1.
June 9	Black Shale No. 3	Birmingham, Ala	Gas; carbide lamp	K–0; I–1.
June 14	Point Lick No. 4	Rensford, W. Va	Gas; arc from mining machine	K–2; I–I.
June 20	Rex	Eldorado, Ill	Gas; arc from electric drill	K–0; I–2.
June 27	Wilder No. 5	Wilder, Tenn	Dust; blown-out shot, black pellet powder.	K–0; I–4.
July 5	Blue Flame	Canon City, Colo	Gas; arc from blower fan	K–1; I–2.
July 22	Pagnotti No. 9	Hughestown, Pa	Gas; smoking	K–1; I–4.
August 28	New River	Capels, W. Va	Gas; arc from electric machine	K–1; I–1.
August 29	No. 9	Roslyn, Wash	Gas; arc from conveyor motor	K–0; I–5.
September 29	Harry E	Kingston, Pa	Gas; arc from electric drill	K–1; I–1.
October 9	Greenwood	Greenwood, Ark	Gas and dust; blown-out shot, black powder.	K–2; I–1.
October 11	Hetherington	Panama, Okla	Gas; defective safety lamp	K–1; I–0.
October 30	Hazelton shaft	Hazelton, Pa	Gas; smoking	K–2; I–0.
November 10	Davis No. 23	Thomas, W. Va	Gas; opened flame safety lamp	K–3; I–1.
December 8	Stephens	Manton, Ky	Gas; arc from locomotive, "nipping."	K–1; I–0.
December 30	Black Gem	Kentucky	Dust; blown-out shot, black powder.	K–1; I–0.
1942: February 11	Eddy Creek collery	Olyphant, Pa	Gas; arc from electric circuit	K–1; I–2.
April 29	Volpe No. 6	Volpe, Pa	Gas; arc from shorted electric circuit.	K–0; I–5.
June 1	Piedmont	Alabama	Gas and dust; open light	K–1; I–2.
June 7	Buck Creek No. 1	Panama, Okla	Gas and dust; opened flame safety lamp, 4 men in mine.	K–4; I–0.
June 20	New Hillside No. 2	Shelburn, Ind	Dust; blown-out shot, black powder.	K–0; I–6.
July 7	Exeter	Exeter, Pa	Gas; electric arc or smoking	K–0; I–7.
August 26	Heisley No. 3	Nanty Glo, Pa	Gas; arc from machine-cable nip.	K–1; I–0.
September 10	Packer No. 5	Girardville, Pa	Gas; flame safety lamp held in front of compressed-air hose.	K–0; I–8.
September 22	Little Creek	Pineville, Ky	Gas; arc from electric drill	K–0; I–3.
September 29	Dixie No. 2	Paris, Ark	Gas; open light	K–2; I–4.
October 3	Dixie Star	Alva, Ky	Gas and dust; arc from mining machine.	K–4; I–0.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1942: November 5	New River No. 11	Capels, W. Va	Gas; arc from trolley wire	K–0; I–2.
November 19	Stewart Elkhorn No. 2.	Carmen, Ky	Dust; open lights and black powder.	K–0; I–6.
November 22	Central Elkhorn	Estill, Ky	Gas; open light	K–0; I–0.
November 23	Alamo No. 2	Walsenburg, Colo	Gas; arc from electric drill	K–3; I–0.
December 6	Black Shale No. 3	Birmingham, Ala	Gas; open light	K–0; I–3.
December 17	Grant No. 3	Paris, Ark	Gas; open light worn by fire-boss.	K–0; I–4.
December 21	Richland	Warwood, W. Va	Gas and dust; electric arc	K–1; I–0.
December 28	McFarlin	Byesville, Ohio	Gas; open light	K–3; I–0.
1943: January 10	Belle Valley No. 1	Belle Valley, Ohio	Gas and dust; arc from power wires cut by rock fall.	K–3; I–0.
January 13	Lilly Meade	Ownesboro, Ky	Dust; blown-out shot, black powder.	K–0; I–3.
January 17	Renton No. 6	North Bessemer, Pa	Dust; blown-out shot, permissible explosive.	K–0; I–4.
January 18	Little Creek	Pineville, Ky	Gas; arc from electric motor	K–0; I–5.
January 31	Messina	Adamson, Okla	Gas; match, lighting fuse	K–0; I–1.
February 22	Putt Creek	Cuba, Ill	Gas; open light	K–0; I–2.
March 4	No. 34	McDowell County, W. Va.	Gas; electric arc	K–0; I–4.
March 13	Poplar Ridge	Sturgis, Ky	Gas; arc from loading-machine cable.	K–0; I–5.
April 8	Starr No. 3	Henryetta, Okla	Gas; open light; gas from floor, local.	K–4; I–10.
April 25	Keener No. 1	Bokoshe, Okla	Gas; open light; smoking or defective safety lamp, 3 in mine.	K–3; I–0.
April 27	Reeves No. 1	Hackett, Ark	Gas; arc from mining machine	K–0; I–1.
May 9	Superfuel	Paris, Ark	Gas; open light; methane released by heaving bottom.	K–3; I–0.
May 22	Sayreton No. 2	Sayreton, Ala	Gas; arc from electric drill	K–0; I–2.
May 29	Wolf Run	Bergholz, Ohio	Gas and dust; rock fall and short circuit of machine cable.	K–1; I–1.
June 9	Pursglove No. 15	Pursglove, W. Va	Gas; electric welding in air-shaft.	K–1; I–0.
June 16	DeeringNo. 2	Eldorado, Ill	Gas; arc from electric drill	K–1; I–2.
June 19	Revloc No. 1	Revloc, Pa	Gas; arc from mining machine	K–0; I–1.
June 29	Diamond No. 2	Boltz, Pa	Gas; open light; worked-out area.	K–0; I–0.
July 4	Peerless No. 2	Greenwood, Ark	Gas; smoking; 1 man killed by CO during recovery.	K–2; I–2.
July 6	Powhatan No. 1	Powhatan, Ala	Gas; arc from trolley locomotive.	K–1; I–6.
July 21	Industrial No. 53	Cokeburg, Pa	Gas; arc from trolley locomotive in airlock.	K–1; I–2.
July 28	Craig Valley No. 2	Haileyville, Okla	Gas; match used to light fuse	K–0; I–3.
September 20	Apex	Oak Creek, Colo	Dust; blasting; black powder shot on solid, wrecked mine.	K–1; I–0.
October 18	Nu-Rex	LaFollette, Tenn	Gas; relighting opened flame safety lamp.	K–1; I–0.
Do	Allison (surface)	Gallup, N. Mex	Dust; open flame; loading refuse bank with power shovel.	K–1; I–1.
October 24	Dixie No. 2	Paris, Ark	Gas; open light used by fire-boss to relight flame safety lamp.	K–1; I–0.
November 1	Daisy	Aquilar, Colo	Gas; gasoline engine driving fan after shutdown.	K–0; I–0.
November 23	Butte Valley No. 2	Butte Valley, Colo	Gas and dust; arc from electric drill.	K–3; I–0.
November 25	Sayreton No. 2	Sayreton, Ala	Gas; arc from trolley locomotive.	K–0; I–2.
December 12	Rockhill No. 5	Robertsdale, Pa	Gas; open light	K–0; I–0.
1944: January 7	Nottingham	Plymouth, Pa	Gas; smoking	K–1; I–0.
January 30	Buffalo	Moose Creek, Alaska	Gas; arc from powerline used in blasting from surface.	K–0; I–0.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1944: March 9	Nauvoo (surface)	Nauvoo, Ala	Dust; open flame; loading from refuse bank.	K–2; I–0.
November 18	Sixth Vein	Madisonville, Ky	Gas; smoking; idle day; ventilation cut off entry.	K–2; I–0.
May 11	Frederick	Valdex, Colo	Dust; open shots; blasting timbers.	K–0; I–7.
May 15	Coal Rain	Junedale, Pa	Gas; arc from electric drill	K–0; I–4.
May 27	Affinity slope	Affinity, W. Va	Gas; arc from trolley locomotive used by fireboss.	K–1; I–0.
June 23	Barr	Hackett, Ark	Gas and dust; arc from mining machine or smoking.	K–2; I–2.
June 26	Julian	Fritchton, Ind	Gas; smoking, machine men, room ahead of air.	K–0; I–2.
July 12	Continental	Raven Run, Pa	Gas; smoking	K–0; I–4.
August 7	Keener No. 3	Bokoshe, Okla	Gas; arc from electric switch for auxiliary fan.	K–1; I–0.
August 21	Cranberry	Hazleton, Pa	Gas; open shots; bulldozing to break large pieces.	K–1; I–0.
August 30	Jermyn Green	Jermyn, Pa	Gas; smoking	K–0; I–2.
September 5	Barton	Barton, Ohio	Gas; arc from mining machine.	K–0; I–3.
September 18	Nyota	Warrior, Ala	Gasoline; open light; spilled fuel for pump.	K–1; I–0.
September 18	Loomis	Nanticoke, Pa	Gas; arc from trolley locomotive.	K–0; I–5.
September 27	Templeton No. 4	Dugger, Ind	Gas; arc from electric drill	K–1; I–6.
October 11	Elmore No. 1	Birmingham, Ala	Gas; opened flame safety lamp	K–0; I–4.
October 17	McGregor No. 2	Slagle, W. Va	Gas; arc from mining machine, cut into old entry.	K–0; I–4.
October 19	Hazleton	Hazleton, Pa	Gas; smoking	K–1; I–?.
November 6	Elkhorn No. 4	Cromona, Ky	Dust; blown-out shot; black powder.	K–1; I–0.
November 7	McKay	Ravensdale, Wash	Gas; flame from fuse in firing shots.	K–0; I–0.
November 19	Black Bat	Madisonville, Ky	Dust; blown-out shot; black powder; fire followed.	K–0; I–0.
December 11	Norton No. 11	Norton, Va	Gas; arc from mining machine, after power off 15 min.	K–2; I–0.
December 15	Panther Creek No. 2	Springfield, Ill	Dust; windy shot, black powder.	K–1; I–?.
December 18	Mather	Mather, Pa	Gas; defective flame safety lamp and roof fall.	K–0; I–3.
1945: January 10	Prospect	Plainstwp, Pa	Gas; opened flame safety lamp	K–0; I–1.
January 13	Continental	Raven Run, Pa	Gas; arc from booster-fan motor.	K–0; I–0.
January 25	Regina	Prestonburg, Ky	Dust; blown-out shot, black powder.	K–3; I–0.
February 1	Mamouth Blue Gem	Gatliff, Ky	Gas; arc from trailing cable	K–0; I–0.
February 7	Cochran	Salina, Pa	Gas; arc from trolley locomotive.	K–2; I–0.
February 24	Porter Elkhorn No. 4	Garth, Ky	Dust; blown-out shot black powder.	K–0; I–1.
March 13	Victor	Virginia	Gas; arc from mining machine	K–0; I–2.
March 17	No. 10 tunnel	Pittston, Pa	Gas; arc from cable nip of electric drill.	K–1; I–?.
March 27	Huber	Johnstown, Pa	Gas; smoking	K–0; I–1.
May 8	Freeburn	Toler, Ky	Dust; blown-out shot	K–1; I–0.
May 14	Bradford	Dixiana, Ala	Gas, smoking	K–3; I–3.
June 8	No. 6	Reams, W. Va	Gas from bump; arc from trolley.	K–0; I–3.
June 28	Glen Rogers No. 2	Glen Rogers, W. Va	Gas from bump; arc; locomotive ran over trailing cable.	K–0; I–9.
July 10	Rosedale	Rosedale, Tenn	Dust; blown-out shots, overloaded; coal-dust stemming.	K–1; I–2.
July 23	St. Paul No. 2	Maidsville, W. Va	Gas; arc from trolley locomotive.	K–1; I–0.
August 2	Gary No. 2	Gary, W. Va	Gas; blown-out shot	K–0; I–1.
Do	Henry colliery	Plains, Pa	Gas; blasting or electricity?	K–3; I–3.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1945: October 2	Potts colliery	Locust Dale, Pa	Gas; blasting ignited feeder; accumulated gas set off.	K–1; I–?.
Nov. 20	Royalton No. 7	Royalton, Ill	Gas; arc from mining machine; cut into old borehole.	K–0; I–6.
Nov. 27	Lonesome Branch	Bartlick, Va	Gas; arc from cable-reel locomotive; door open.	K–1; I–1.
November 29	Blair City	Zebulon, Ky	Dust; blown-out shots, black powder; no one in mine.	K–0; I–0.
November 30	Prospect colliery	Plains Twp., Pa	Gas; arc from trolley locomotive.	K–0; I–4.
December 14	Champion	Wilkeson, Wash	Gas; open light; gas in chute	K–0; I–1.
December 17	Eddy Creek colliery	Olyphant, Pa	Gas; smoking	K–0; I–4.
1946: February 28	Washington	Erie, Colo	Gas; arc from cable nips	K–0; I–0.
March 5	Dalton No. 2	Pikeville, Ky	Dust; blown-out shot; black powder.	K–0; I–2.
May 13	Johnson	Black Diamond, Wash.	Gas; open light; gas in chute	K–0; I–1.
May 27	Richmond No. 1	St. Paul, Va	Gas; open light; mine idle; fan stopped.	K–0; I–0.
June 12	Guyan Eagle	Amherstdale, W. Va	Gas; arc from mining machine; fire followed.	K–0; I–3.
June 30	Gary No. 3	Gary, W. Va	Gas; smoking	K–0; I–3.
July 15	Zeth No. 2	Kearney, Pa	Dust	K–0; I–5.
July 25	Peabody No. 59	Springfield, Ill	Gas; smoking	K–0; I–2.
July 25	Saxton	Terre Haute, Ind	Gas; arc from trolley locomotive; leaking seals.	K–0; I–3.
Sept. 14	No. 34	McDowell Co., W. Va.	Gas; arc from nipping on haulageway.	K–0; I–2.
September 19	Great Valley	McCoy, Va	Gas; arc from battery locomotive.	K–1; I–4.
October 30	Elk-Big 4	Palmer, Wash	Gas; arc from electric drill	K–0; I–1.
November 14	Elmore No. 3	Birmingham, Ala	Gas and dust; fuse blasting, extended to surface.	K–2; I–0.
December 20	No. 8 colliery	Coaldale, Pa	Gas; blasting chute, dynamite.	K–1; I–3.
Do	Knickerbocker colliery.	Shenandoah, Pa	do	K–1; I–3.
1947: January 2	Panhandle No. 2	Bicknell, Ind	Gas; open light, open valve in seal.	K–2; I–0.
January 15	Tram	Tram, Ky	Dust; arc from drill cable set off open box of detonators and explosives.	K–0; I–4.
February 10	No. 34	McDowell County, W. Va.	Gas; arc from nipping	K–1; I–1.
March. 6	Kerns	Terre Haute, Ind	Dust; blown-out shots, black powder; shot firer.	K–1; I–0.
March 10	Pal Run	Road Fork, Ky	Dust; blown-out shots, black powder; man at portal.	K–1; I–0.
May 31	Panther No. 5	Marybill, W. Va	Gas; smoking; feeder at entry face.	K–0; I–2.
July 15	Louise	Coalmont, Pa	Dust; blown-out shot, pellet black powder.	K–0; I–3.
August. 14	New Orient	West Frankfort, Ill	Gas; arc from mining machine	K–3; I–2.
October 1	New Castle No. 2	New Castle, Ala	Gas; arc from mining machine cut into old room.	K–0; I–4.
October 13	Underwood colliery	Throop, Pa	Gas; smoking	K–2; I–0.
November. 18	Boncarbo	Burro Canyon, Colo	Gas; smoking; abandoned shaft.	K–0; I–2.
Do	Launder	Roseville, Ohio	Gas; open light; leakage into mine from surface pipeline.	K–1; I–0.
November 27	Christopher No. 6	Four States, W. Va	Gas; arc from cable cut with ax.	K–0; I–4.
December 2	Harm	South Hill, Ky	Dust; blown-out shot, black powder.	K–0; I–3.
Do	Lance colliery	Larksville, Pa	Gas; smoking or flame safety lamp.	K–0; I–7.
December 17	Nelson	Cedar City, Utah	Dust; blown-out shot, dynamite; 2 men at portal.	K–0; I–2.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1947: December 28	Buck Knob	Greenville, Ky	Dust; blown-out shot, black powder.	K–0; I–3.
1948: January 23	Rowe	Rowe, Va	Do	K–0; I–6.
January 24	Eccles, No. 5	Eccles, W. Va	Gas and dust; arc from lighting circuit; gas from pillar area.	K–0; I–0.
January 31	Maple Hill colliery	Shenandoah, Pa	Gas; mud-cap shot dynamite	K–2; I–5.
February 24	Hall No. 5	Lignon, Ky	Dust; blown-out shots, black powder.	K–0; I–5.
March 3	Easter Elkhorn No. 1	Water Gap, Ky	Dust; blown-out shots, black powder; men out.	K–0; I–0.
March 12	R & M	Dysart, Pa	Dust; blown-out shot, black powder.	K–0; I–2.
March 15	Wilson	Zebulon, Ky	Dust; open shot, permissible explosive.	K–1; I–1.
April 28	No. 9 colliery	Hughestown, Pa	Gas; smoking	K–2; I–5.
August 2	Bliss colliery	Nanticoke, Pa	Gas; arc from trolley locomotive.	K–0; I–2.
August 4	Browder	Browder, Ky	Gas; arc from trolley locomotive; gas from sealed area.	K–0; I–0.
August 14	Georges Creek No. 5	Lonaconing, Md	Gas and dust; cable-reel locomotive or smoking.	K–3; I–0.
August 20	Sterling No. 1	Bakerton, Pa	Gas and dust; arc from pump motor or trolley wire.	K–0; I–0.
August 24	Harmar	Harmarville, Pa	Gas and dust; arc from trolley locomotive.	K–2; I–1.
October 2	Lance colliery	Larksville, Pa	Gas; smoking or blasting face of crosscut.	K–0; I–2.
October 11	Dresser	Terre Haute, Ind	Gas; arc from trolley locomotive; power off; fan stopped 20 min.	K–0; I–2.
October 20	Dering No. 2	Eldorado, Ill	Gas; smoking; open door	K–0; I–6.
November 15	Kings	Princeton, Ind	Gas; blasting stopping; open shot, dynamite.	K–0; I–0.
November 17	Sun Excelsior	Excelsior, Ark	Gas and dust; smoking or arc from pump switch; 2 in mine.	K–2; I–0.
December 3	Brophy	Red Lodge, Mont	Dust; blown-out shot, black powder.	K–0; I–0.
December 6	Stotesbury No. 8	Stotesbury, W. Va	Gas; arc from defective permissible mining machine.	K–1; I–3.
December 8	Springdale	Logans Ferry, Pa	Gas; flame safety lamp; pocket in roof.	K–0; I–4.
December 13	Pond Creek	South Williamson, Ky.	Gas and dust; smoking; room face cut into old room.	K–1; I–4.
December 15	Black Diamond No. 1.	Hebbardsville, Ky	Dust; blown-out shots, black powder.	K–0; I–0.
Do	Coyer No. 2	Grove City, Pa	Gas; arc from mining machine; cut into gas well.	K–0; I–3.
December 21	Mead No. 3	East Gulf, W. Va	Gas and dust; arc from mining machine.	K–2; I–0.
December 23	Kelly's Creek No. 3	Ward, W. Va	Dust; unconfined rib shot, dynamite.	K–0; I–4.
1949: January 5	South Wilkes-Barre colliery.	Wilkes-Barre, Pa	Gas; arc from hoist control, underground hoist.	K–2; I–2.
January 7	Vanover	Calhoun, Ky	Gas; open light; machine cut into old gas well.	K–0; I–2.
February 14	Soisson slope	South Connellsville, Pa.	Gasoline; open light; gasoline-driven pump; fuel spilled.	K–0; I–2.
February 15	Boyd Excelsior	Excelsior, Ark	Gas; arc from mining-machine controller.	K–0; I–2.
March 31	Vanhouse No. 1	Sitka, Ky	Dust; blown-out shots, ignited dust and 2 boxes pellet powder.	K–3; I–1.
April 26	Nesquehoning colliery.	Nesquehoning, Pa	Gas; open shots, dynamite and permissible explosive.	K–0; I–5.
May 2	Huber colliery	Ashley, Pa	Gas; arc from hoist control or smoking.	K–1; I–0.

TABLE 11.—*Minor explosions in United States coal mines, 1941–50*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1949: May 18	Coaldale colliery No. 8.	Coaldale, Pa	Gas; open shot in breast	K–0; I–2.
May 21	Germantown colliery	Centralia, Pa	Gas; defective flame safety lamp at face.	K–0; I–2.
June 3	Blankenship & Ballard.	Whitewood, Va	Dust; black-powder shots blew through into crosscut.	K–0; I–3.
June 25	Mathies	Courtney, Pa	Dust; arc from trolley wire blown against water pipe; blast broke Airdox line.	K–0; I–1.
	Collier-Dunlap	Clarksville, Ark	Gas; arc from 2,300-v. cable cut by rock fall; mine idle; fan down.	K–0; I–0.
October 28	Barrett No. 1	Clintwood, Va	Dust; blown-out shots, black powder; 2 men in mine.	K–0; I–2.
November 16	Elkhorn	Belcroft, Ky	Dust; arc from firing line from trolley wire; blown-out shots raised dust.	K–3; I–1.
November 21	Nesquehoning colliery.	Nesquehoning, Pa	Gas; misuse of flame safety lamp in chute.	K–2; I–0.
1950: April 20	Imperial No. 8	Burnwell, W. Va	Dust; open shots, permissible explosive on slate fall.	K–0; I–4.
April 22	Acme	Enterprise, W. Va	Gas; arc from rock-dusting machine.	K–0; I–5.
May 5	Staunton No. 2	Williamson, Ill	Gas; open light or smoking	K–0; I–0.
August 9	Continental shaft	Centralia, Pa	Gas; arc from substation; ventilation door left open.	K–1; I–3.
August 27	Julian	Fritchton, Ind	Gas; arc from trolley; fan stopped.	K–0; I–2.
	New Alam No. 1	McCarr, Ky	Dust; open shot on slate on coal pile.	K–0; I–1.
September 5	Kings	Princeton, Ind	Dust; open shots on rock at room face, dynamite.	K–2; I–0.
September 9	Arkwright No. 1	Mona, W. Va	Gas; arc from trolley locomotive; roof fall broke seal.	K–0; I–3.
September 27	Lansford colliery No. 6.	Lansford, Pa	Gas; open shot in chute	K–0; I–3.
Do	do	do	Gas; smoking; gas from chute	K–0; I–1.
Do	Tamaqua colliery	Tamaqua, Pa	Gas; open shot in chute	K–0; I–4.
October 3	No. 6 colliery	Inkerman, Pa	Gas; smoking at face after blast.	K–0; I–1.
October 6	Coaldale colliery No. 8.	Coaldale, Pa	Gas; arc from trolley locomotive.	K–0; I–1.
October 20	Jonay	Sullivan, Ind	Gas; smoking	K–0; I–2.
October 30	Avondale colliery	Plymouth, Pa	Gas; arc from cable-reel locomotive.	K–4; I–0.
November 7	Ritter & Amburgey No. 1.	Littcarr, Ky	Dust; blown-out shots, black powder; no one in mine.	K–0; I–0.
November 15	Doceno	Adamsville, Ala	Gas; arc from trolley shoe; 2 men on locomotive.	K–0; I–2.
December 6	Kolen	Millerstown, Pa	Gas; open light; accumulation back of water dam.	K–1; I–0.

In 1950 improvement was noted (*17, p. 4*), and the following conclusions were drawn from conditions described in reports on explosions and mine inspections.

The factors on which emphasis is laid by the explosions that occurred during the past year are the need for closer attention to thorough ventilation, closer inspection for gas that may enter from inactive workings, and elimination of the use of black blasting powder underground. The maintenance of adequate rock dusting is stressed both by the life-saving control that was accomplished by this means and by the loss of life where rock dusting was omitted or inadequate. Coal dust caused or was involved in 5 explosions; 6 of the remaining explosions were in anthracite mines, the coal dust of which is not explosive. Thus, in the 8 explosions in bituminous-coal mines, coal dust was ignited in 62 percent of them. There is ample evidence that rock dusting saved many lives and prevented considerable loss of property during the year.

During 1949, 9 explosions were initiated by ignition of gas and 5 by ignition of coal dust. In 3 of the mines where gas was ignited, ventilation was inadequate; in 3 others the ventilating current was interrupted or disturbed, in 2 other mines the gas accumulated in workings adjacent to active areas and was moved into the active workings; in the other ignition, a gas well through the coal bed was cut into by a min-

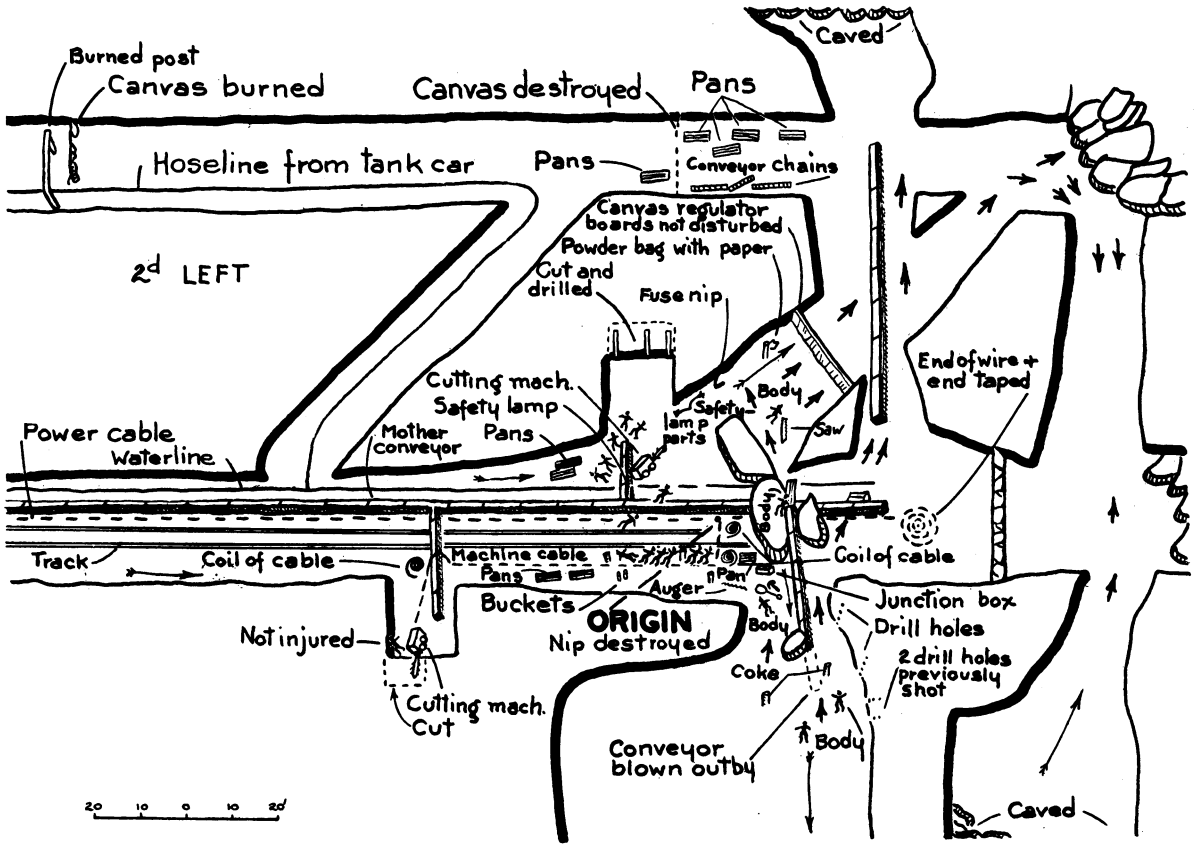

FIGURE 115.—Sketch of explosion area, Carswell mine, Kimball, W. Va., January 22, 1941.

ing machine. In six instances inspection was inadequate, and the hazard of gas was ignored or forgotten. Seven of the gas ignitions were in mines recognized as gassy, and the other 2 were in open-light mines; in 1 a gas well was cut into, as mentioned above, and in the other gasoline was spilled into a sump and ignited.

Of the 5 dust explosions, 3 were caused by blown-out shots or underburdened holes loaded with black blasting powder or dynamite. In another explosion, dust raised by a compressed-air line that was broken by blasting was ignited by an electric arc between the broken pipe and the trolley wire. Another explosion occurred when dust raised by blown-out shots was ignited by an arc from the firing line connected to the trolley wire. All of these explosions were primarily due to unsafe blasting practices.

DESCRIPTION OF MAJOR DISASTERS

January 22, 1941; Carswell Mine, Kimball, W. Va.; 6 Killed

(From Bureau of Mines report, by W. J. Fene and F. E. Griffith)

A localized gas and coal-dust explosion killed 4 men and injured 14 others about 4:30 a. m. Two of the injured died later. The 127 men in other sections were not aware of the explosion and were called out without difficulty. No appreciable property damage was done. One of the survivors in the affected section telephoned the dispatcher, who called the outside. A rescue party was sent in within half an hour, followed by an apparatus team and other officials. Most of the injured men were assembled and helped out of the smoke by the section foreman, also badly burned. Two mine officials found and removed two other victims, who were unable to walk. The four bodies were recovered by 10:00 a. m. without using apparatus.

An accumulation of methane occurred in room 36, 2 left, after a canvas check curtain and canvas regulator had been torn down on the preceding shift. An arc from the nips of a machine cable at the connection to the main power cable ignited the gas when it drifted out onto the entry (fig. 115).

This ignition was seen by survivors. The low temperature and pressure of the explosion burned some of the low-volatile coal dust in the vicinity but did not develop enough temperature and force to propagate flame through the coal dust. Rock dust that had been applied arrested the spread of the flame. The mine was classed as gassy, and fireboss inspections were made.

May 22, 1941; Panhandle No. 2 Mine, Bicknell, Ind.; 14 Killed

(From Bureau of Mines report, by W. H. Tomlinson)

The mine was opened by 2 shafts 330 feet in depth. Ventilation was produced by a blowing fan over 1 of the 3 compartments of the air and manway shaft, return air coming up the hoisting shaft. The ventilating current was not split, and air passed from aban-

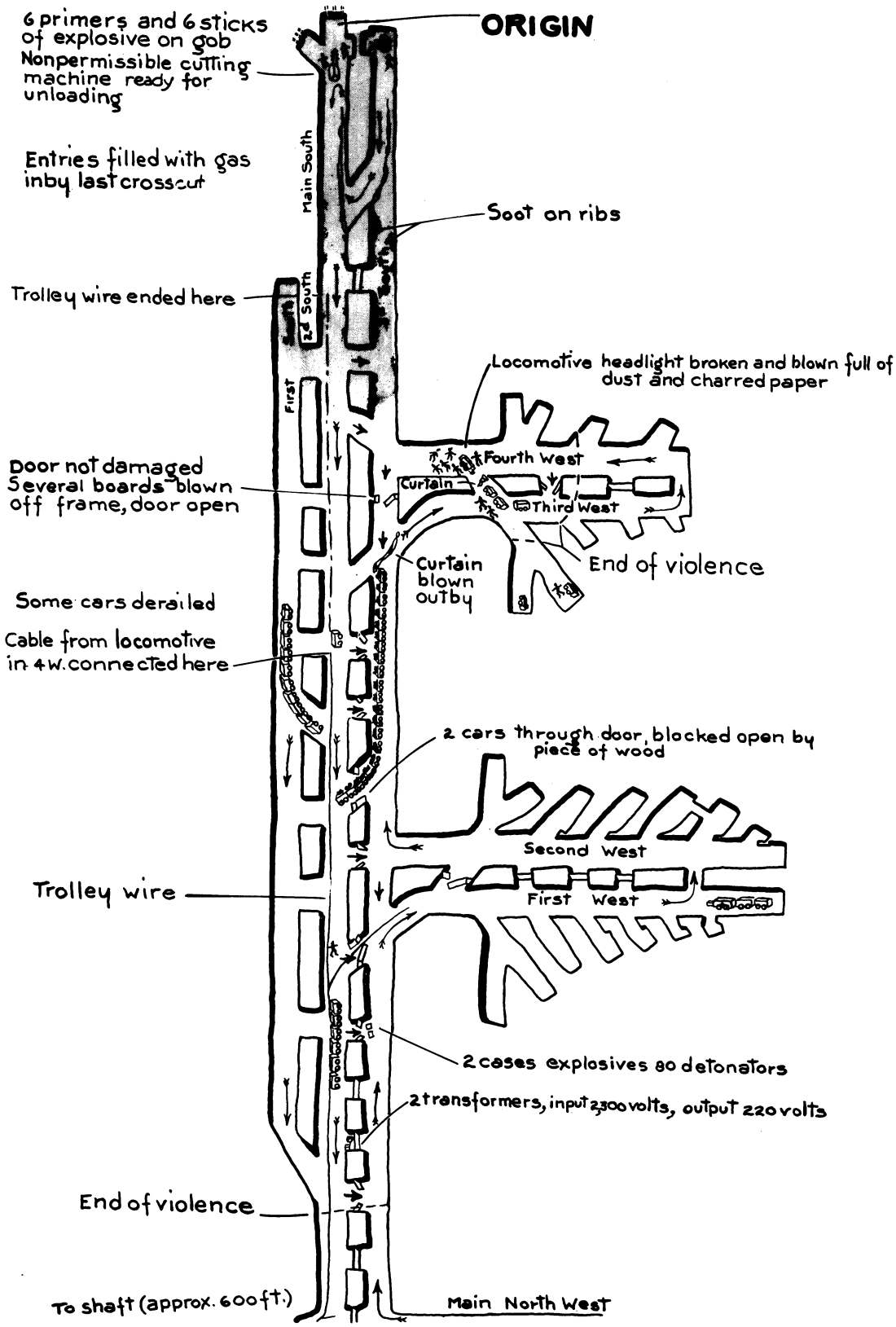

FIGURE 116.—Map of explosion area, Panhandle mine, Bicknell, Ind., May 22, 1941.

doned pillar sections to active faces. Pillars were not extracted. The mine was operated on a cooperative plan by 184 miners as shareholders. Coal was loaded by hand.

The night boss acted as fireboss on the night shift and was told by the mine foreman that doors had been left open and that the south entries were full of gas. The warning was ignored, and no further inspection was made. An explosion at about 10:00 p. m. killed 14 of the 31 men in the mine; the others escaped injury and left without assistance. A motorman at the junction with the main south entries felt a rush of air, and a heavy dust cloud passed swiftly by him. He tried to reach the shaft, but being in the return air he had to retreat into the main northwest section, where he notified the men (fig. 116).

The foreman and the superintendent had been notified by telephone and came into the mine. Officials from other mines, a rescue team, State and Federal officials arrived, and the recovery work was organized. Ventilation was concentrated into the affected section, and the bodies were recovered in about 10 hours. Gas masks and breathing apparatus were used in exploration. The explosion was moderate in violence, and while some coal dust was burned it did not propagate the flame.

Some rock dust had been applied in haulageways. The ventilation was inadequate; and although gas was frequently found, doors were left open for long periods. The accumulation in the south entry faces was ignited by an arc from the controller of an open-type cutting machine as it was being unloaded from its truck to cut these faces. Smoking was done by many of the men and could have been the igniting source. A similar explosion in this mine, killing 2 men, occurred 2 weeks earlier.

June 4, 1941; Docena Mine, Adamsville, Ala.; 5 Killed

(From Bureau of Mines report, by E. A. Anundsen)

A local explosion occurred at 11:20 a. m. while the day shift of 432 men was in the mine. A crew of 14 men was working in the faces of 1st northwest entry and aircourse. A crosscut at face of the entry was being driven toward the aircourse and was being drilled after undercutting when methane was ignited by the drill switch. Coal dust was raised, and the explosion traveled about 500 feet through the entry and the right and left aircourses, before it was stopped by rock dust and pools of water (fig. 117).

The men at the aircourse face were uninjured and escaped, the 3 men in the crosscut were killed, and 4 others in the entry were seriously injured; 2 died later. Nine others had lesser injuries. The section foreman rescued some of the victims and directed movement of uninjured men from the section. Help arrived, and all the injured men and the bodies were removed within 3 hours. Forces were light, and almost no damage was done to the workings. Methane accumulated because of lifting of curtains to move them and to load out rock from brushing as well as other interruptions preceding the ignition. The face boss was not familiar with the use of a flame safety lamp, and regular examinations were not made as the work progressed.

June 30, 1941; Kent No. 2 Mine, McIntyre, Pa.; 7 Killed

(From Bureau of Mines report, by G. W. Grove, E. J. Gleim, and J. W. Pero)

An explosion near the face of No. 44 room on 36 north off 7 right at about 9:30 a. m. resulted in the death of 7 men; 6 were killed outright, and 1 died the following day. Sixteen others were injured, 3 of them seriously burned. At the time 275 men were in the mine, 41 working in the affected section. Word of the explosion was telephoned to the surface and to officials in the mine. Eight men, who were unconscious from burns and afterdamp, were rescued and removed to fresh air. Help from outside arrived during the morning, and ventilation was restored in the section. Gas masks were used where needed. All bodies were removed by 5 p. m.

The fireboss had found gas in rooms 42 and 44 and had put up a danger sign at the entrance to 3 north section. The mine foreman and section foreman went into the active places in the section and finding them free of gas removed the danger sign and sent the men in to work. Rooms 42 and 44 were finished, and equipment was being taken out. A mining machine in room 44 was out of order and could not be moved. A mechanic and two helpers went in to find the trouble, and an arc from a set of test lights ignited the gas (fig. 118).

The rooms were ventilated by blower fans and tubing; and, as the fans were operated intermittently, the gas accumulated. The mine was rated nongassy. Although coal dust was burned locally, the force was weak, and the explosion was not propagated. Flame extended about 500 feet along 3 north entries each way from rooms 42 and 44. No rock dusting had been done in the section.

July 10, 1941; Acmar No. 6 Mine, Acmar, Ala.; 11 Killed

(From Bureau of Mines report, by E. A. Anundsen and C. E. Saxon)

Ignition of methane near the face of the 8th right entry about 5:00 p. m. resulted in a local gas and dust explosion that killed the 11 men working in the entry. Men in other sections of the mine were not affected. A concussion was felt on the slope, and dust and papers were raised in the air; shortly afterward smoke appeared, and the chainer called the surface. Power was cut off the mine, and the night foreman went down after calling for assistance. Three mine officials and 12 rescue men with oxygen breathing apparatus were in the mine by 6:00 p. m. Two crews with apparatus restored ventilation and recovered nine bodies by about 10:00 p. m. Two bodies were found under falls on July 11 and 12.

The night shift had gone in at 4:00 o'clock, and men in the 8th right heading were loading and raising cars from the 8th right aircourse through a slant. A hoist and cable were used to bring these cars up to the entry. An arc from the open switch controlling the hoist motor ignited gas. Methane accumulated because of interruptions to ventilation, such as opened doors and curtains, power failures that shut down the mine fan, and leakage through stoppings. Examinations for gas during the day shift did not show an accumulation.

The force of the explosion was confined to a distance of 600 feet from the face of the entry and 3 rooms within that area. Stoppings were blown out throughout the explosion zone. Coal dust was burned, but the pressure dropped where the rooms afforded a large expansion area and propagation stopped. Sprinkling was done but no rock dust was used in the summer months.

Figure 119 (p. 180) gives the details and conditions as observed by the investigators.

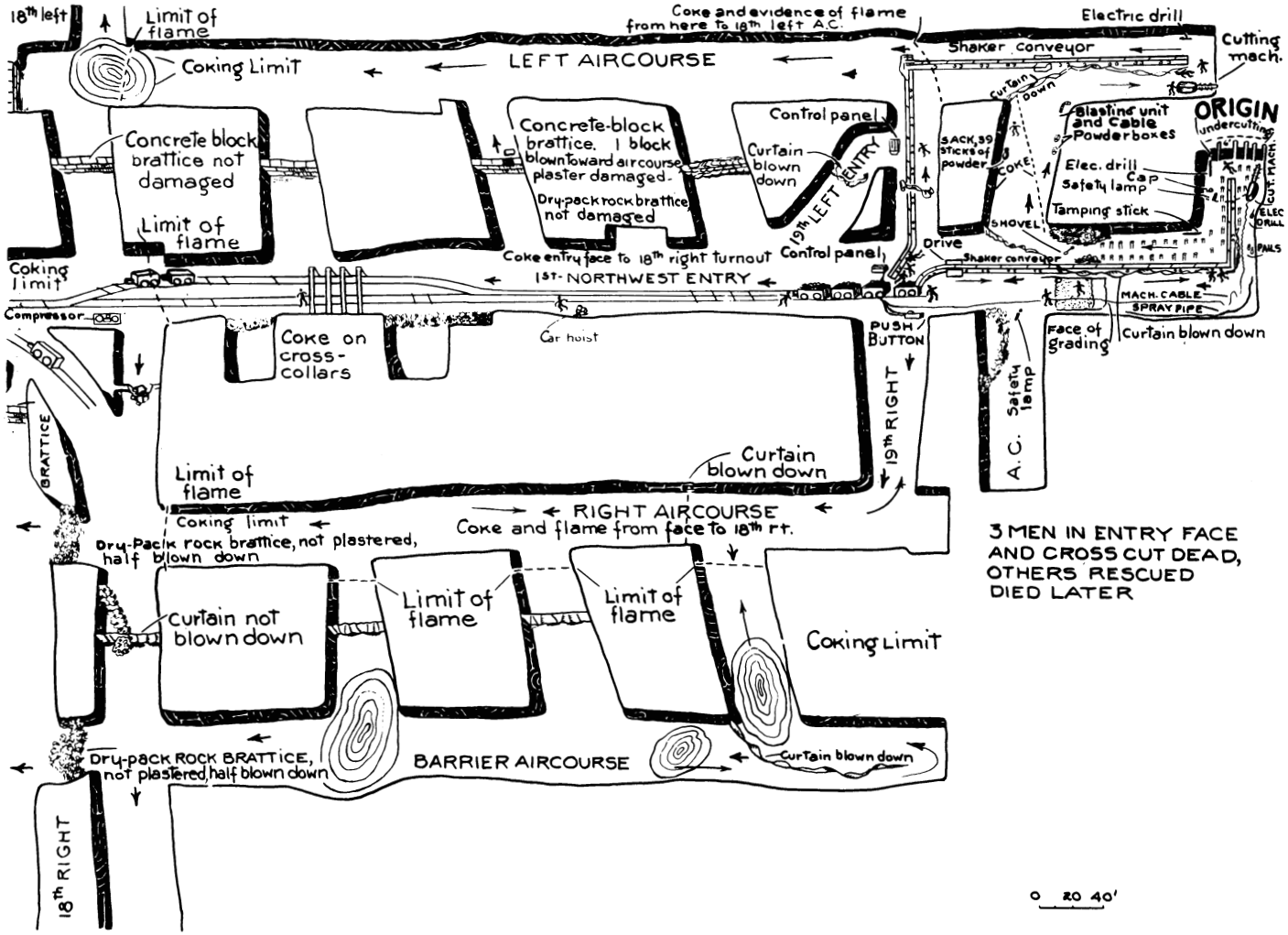

FIGURE 117.—Sketch of area at origin of explosion, Docena mine, Adamsville, Ala., June 4, 1941.

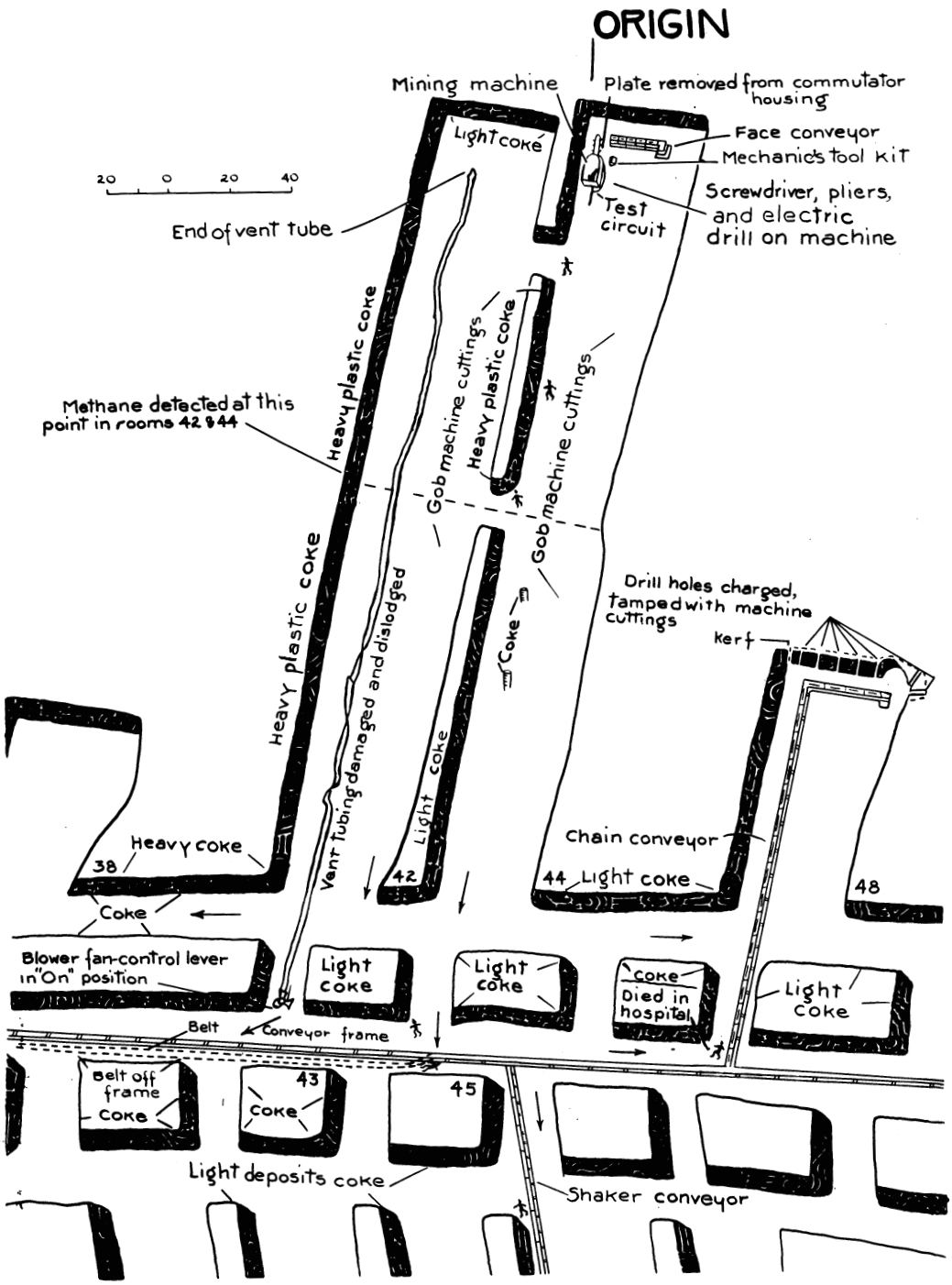

FIGURE 118.—Sketch of explosion area, Kent No. 2 mine, McIntyre, Pa., June 30, 1941.

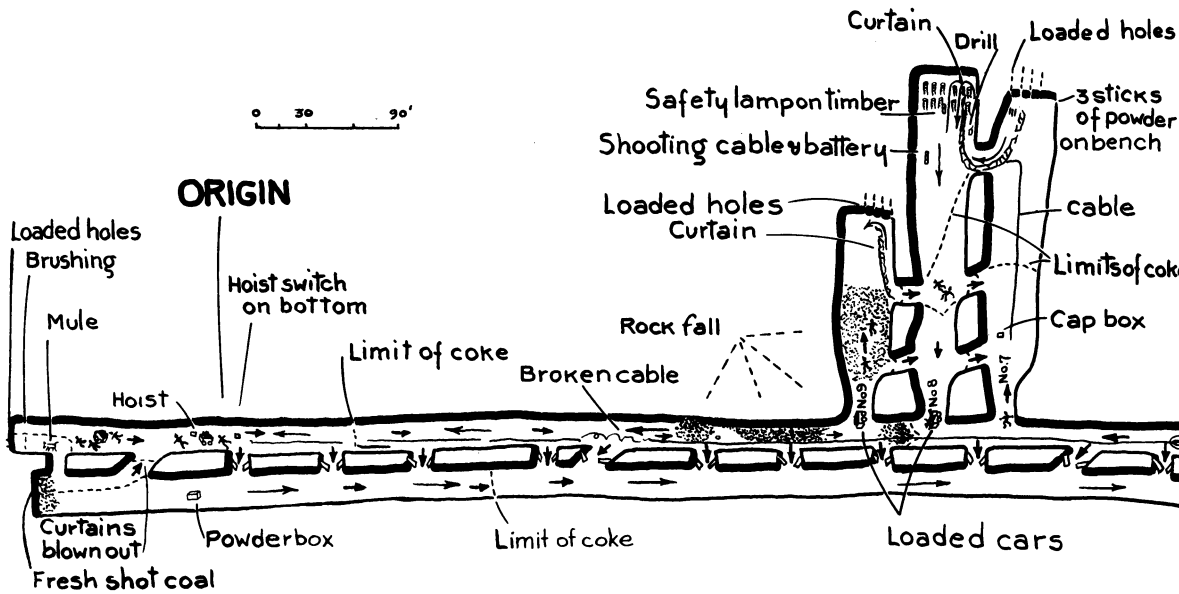

FIGURE 119.—Sketch of explosion area, Acmar No. 6 mine, Acmar, Ala., July 10, 1941.

October 27, 1941; Daniel Boone Mine, Daniel Boone, Ky.; 15 Killed

(From Bureau of Mines report, by C. A. Herbert and L. H. McGuire)

About 7:15 a. m. an explosion was felt on the surface, and explosion doors at the fan over the airshaft were blown open; they were closed, and ventilation was restored to the mine. The fan was operated blowing, so that recovery operations were carried on through that shaft. Three carpenters working at the airshaft bottom and 33 men from an unaffected section came out this way. A motorman and another man working near the slope bottom came up the slope before afterdamp made it impassable. Assistance was called, and rescue crews and leaders arrived during the day. Air was diverted to the explosion area and temporary ventilation restored. Gas masks were used in exploration. All bodies were removed within 18 hours through the main slope after the air was cleared. The explosion originated in a room parallel to the 7th north entry, and all 15 of the men in this section were killed.

Gas had accumulated at the room face while the mine was idle and the fan shut down. The blower fan used to ventilate the parallel room may not have been started much before the ignition occurred. The foreman had not inspected the place for gas, although he may have been on his way to do so. Some men used electric cap lamps, while others used open lights. However, ignition was caused by smoking. Coal dust was involved, but flame and force died out along the main entries after traveling through the 7 north and 7 south sections (fig. 120).

The force was weak, and little damage was done to the mine. Rock dust had been applied by hand, but no evidence of it could be seen after the explosion.

December 28, 1941; Peabody No. 47 Mine, Harco, Ill.; 8 Killed

(From Bureau of Mines report, by L. H. McGuire)

An explosion covering 1 section killed 8 men, who were in the affected section. Two others from that section were affected by carbon monoxide but escaped with 4 others, who were outside the explosion zone. The explosion occurred about 3:30 a. m. and was discovered by the engineer when he tried to put the circuit breaker back in at 3:35 a. m. A night foreman went down and found survivors on the way out and brought them to the surface. Help was called, and rescue teams and leaders were on hand by 8:00 o'clock. Air was advanced, using oxygen breathing apparatus, and the bodies were recovered by about 11:00 p. m., largely by apparatus crews.

A squeeze had developed on a panel in the affected section, and gas was released from the broken roof. A foreman and an mine examiner who left the section about 2:00 a. m. said no gas was detected. An incoming day examiner, riding a locomotive, reached the affected section on his rounds, where an arc from the trolley wheel ignited the gas. The explosion came out of 5th and 6th south with considerable violence and was propagated by coal dust over much of one section before dying out. Rock dust helped to limit the spread. Figures 121 and 122 show the extent and other details of the explosion.

January 27, 1942; Wadge Mine, Mount Harris, Colo.; 34 Killed

(From Bureau of Mines report, by E. A. Morgan and E. L. Christensen)

The night shift of 38 men was in the mine when the explosion in No. 3 room off the top entry above 17 north entry occurred at 9:40 p. m. All of the 34 men inby 14 north entry were killed. Four men in the 13 north entry escaped unhurt by way of the intake slope airway. They tried to telephone from the mine but could get no answer and so gave the alarm on reaching the surface. A party went down the intake air slope to erect stoppings at 15 north entry. Officials and men from other mines with rescue equipment arrived during the night. Ventilation was reestablished and 33 bodies were removed by the evening of January 28; the remaining body was found and removed the next evening. Gas masks were used in exploration.

The explosion traveled out the 17 and 18 north entries and up through rooms to 16 north entry, also

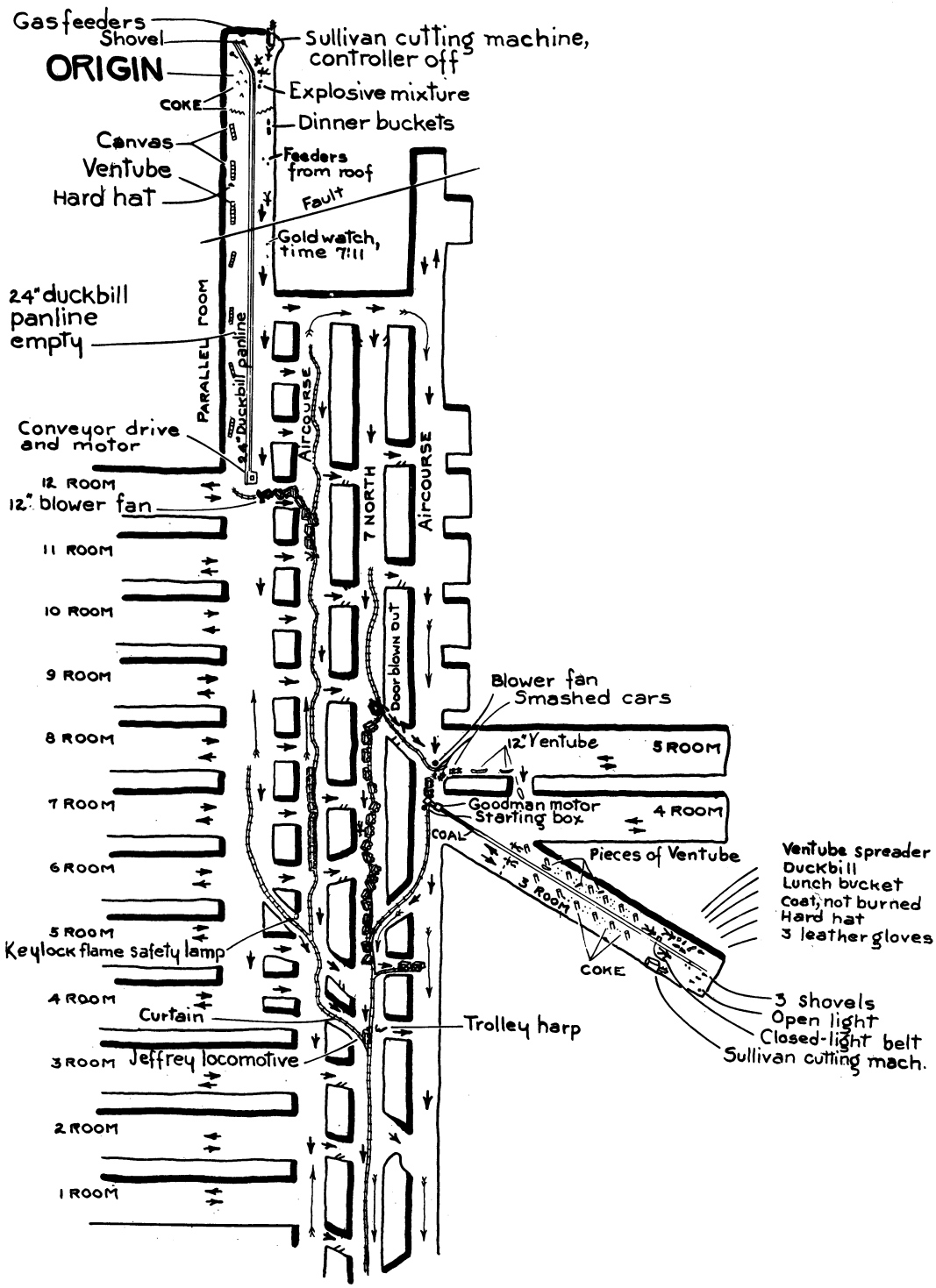

FIGURE 120.—Map of explosion area, Daniel Boone mine, Daniel Boone, Ky., October 27, 1941.

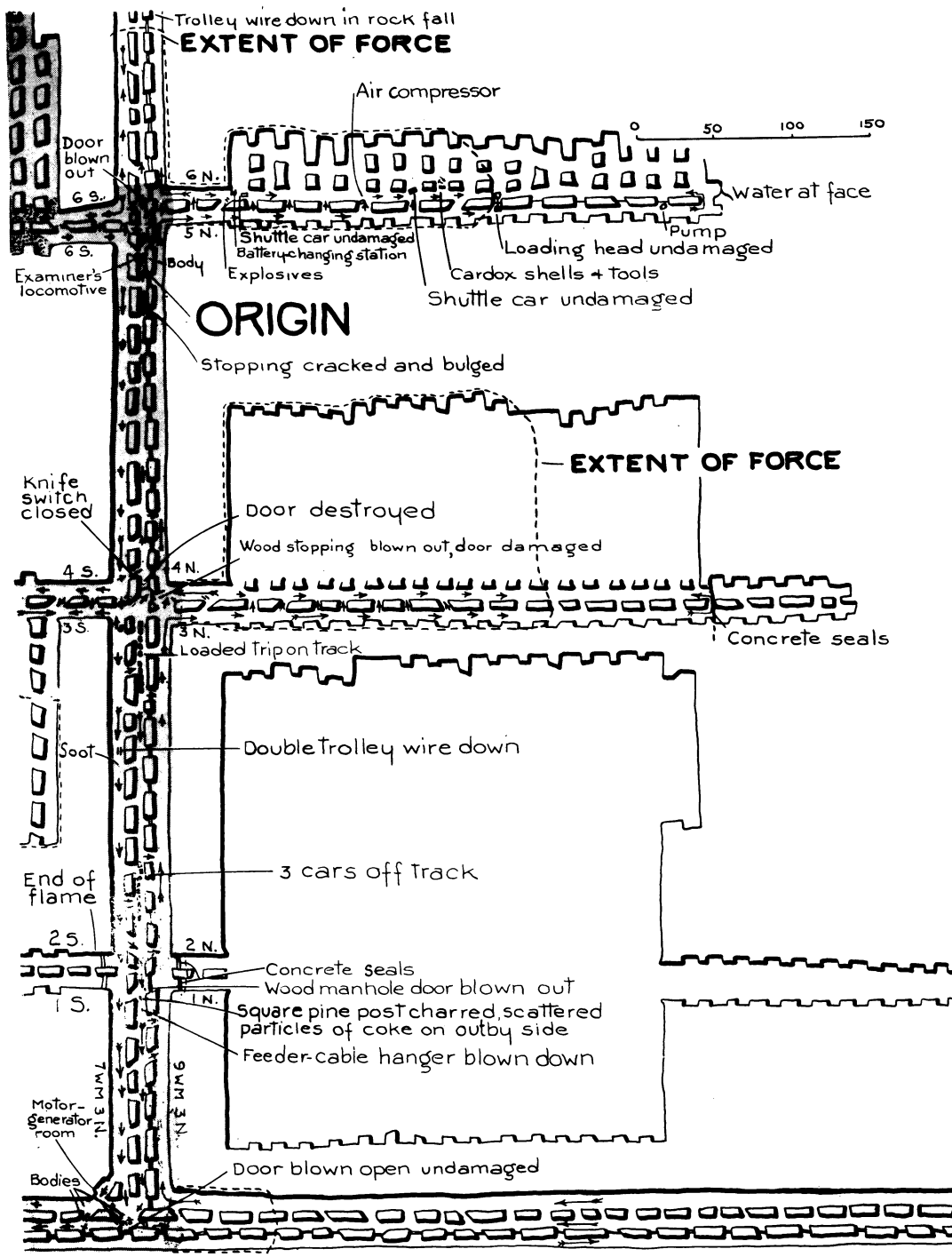

FIGURE 121.—Map of explosion area, Peabody No. 47 mine, Harco, Ill., December 28, 1941.

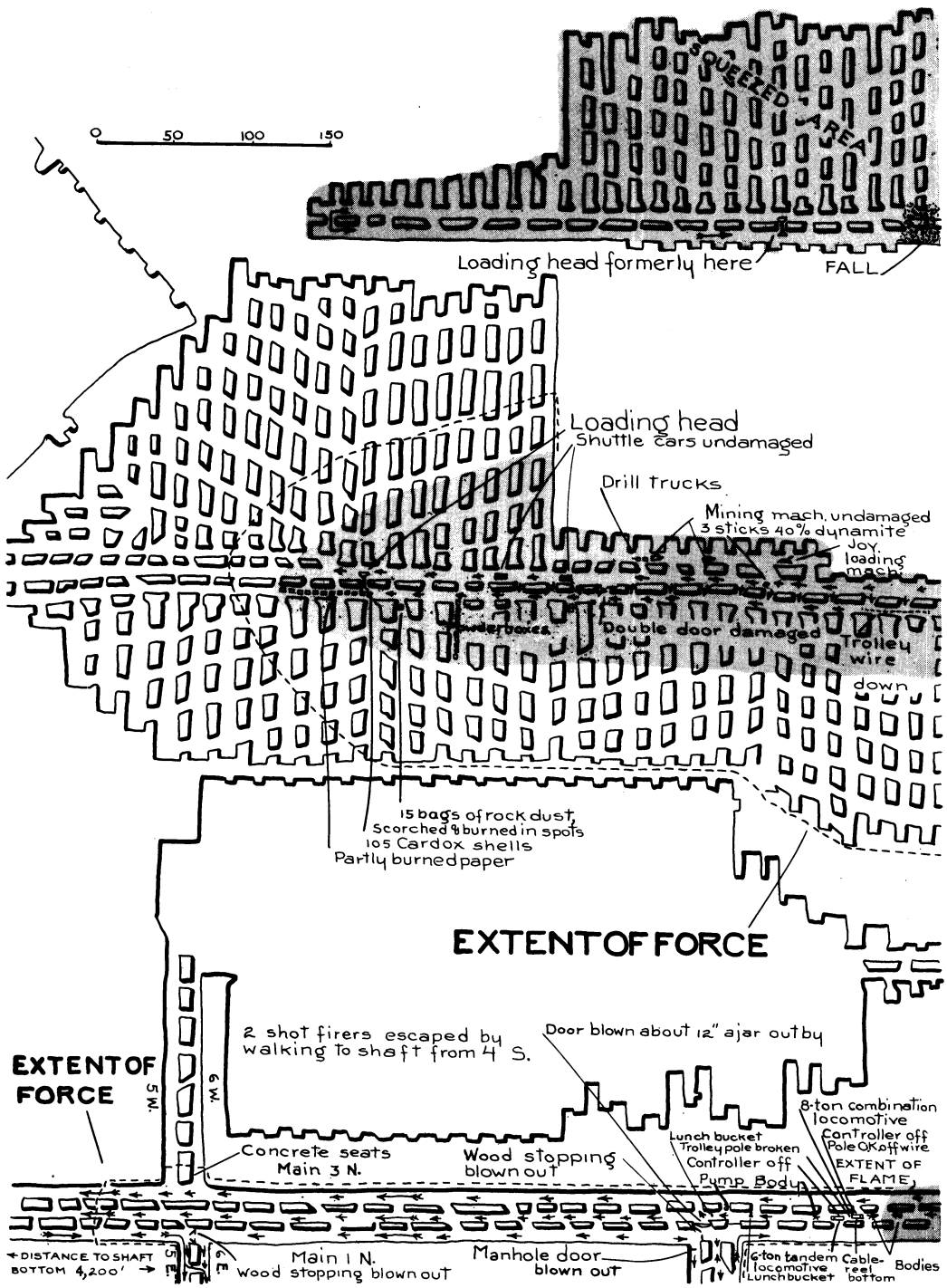

FIGURE 122.—Map of explosion area, Peabody No. 47 mine, Harco, Ill., December 28, 1941—Continued.

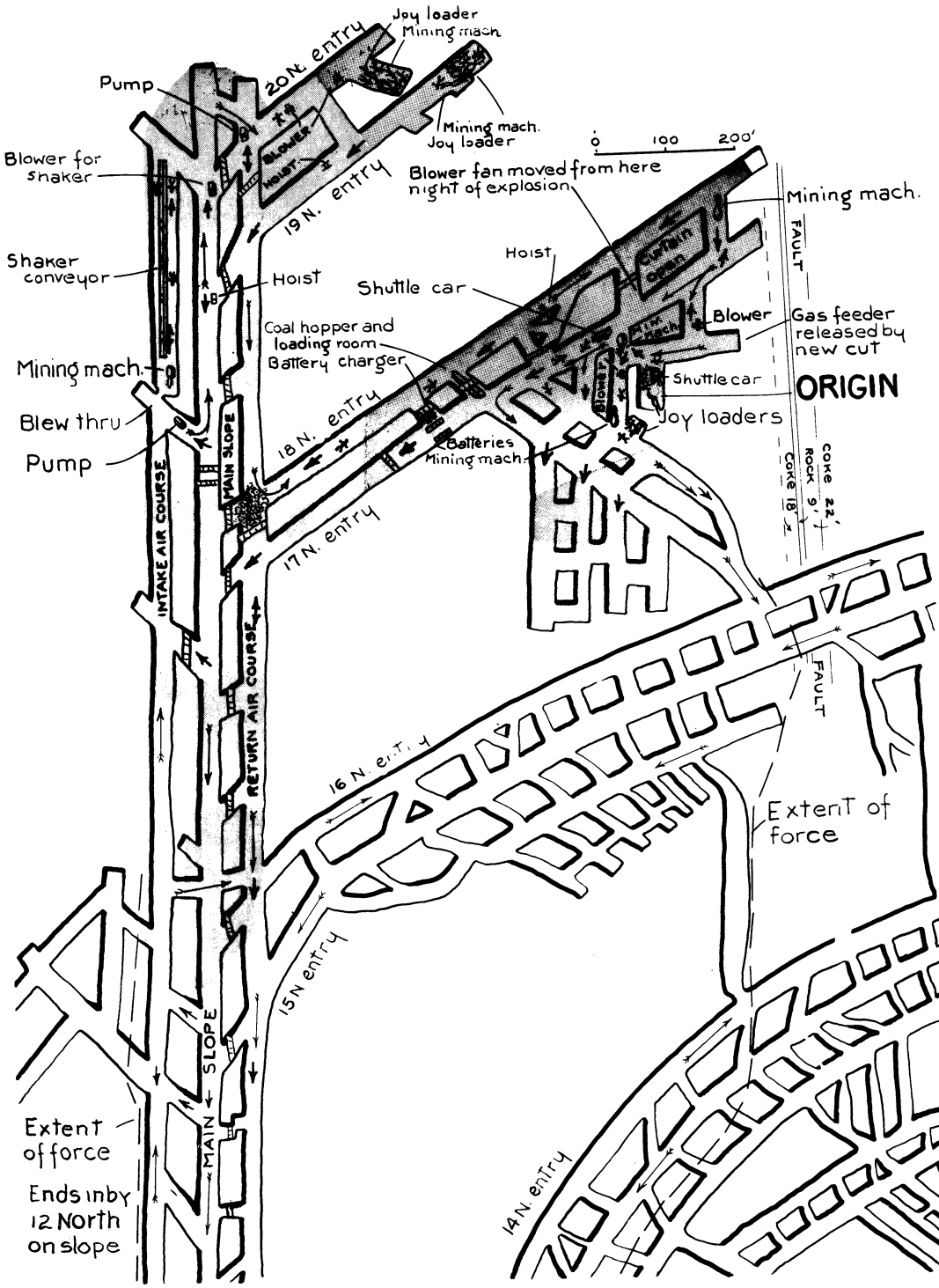

FIGURE 123.—Map of explosion area, Wadge mine, Mount Harris, Colo., January 27, 1942.

down the main and back slopes to the faces and into 19 and 20 north entries, where gas was again ignited. Forces up the slopes died out at 13 north entry and in the intake aircourse near 16 north. Coal dust helped to spread the explosion, and partial rock dusting may have helped to limit it.

A fireman and a shot firer were attempting to move an accumulation of gas in 17 top entry with a blower fan and tubing, when it was ignited by an arc from a loading machine or by wiring from the blower (fig. 123).

May 11, 1942; Peerless No. 2 Mine, Excelsior, Ark.; 6 Killed

(From Bureau of Mines report, by James Westfield)

The afternoon shift of 20 men was in the mine, when a mechanic and a fireboss on the slope about 6:30 p. m. noted that the air was sluggish and called the hoistman to go check the fan. The explosion occurred before he could reach the fan, which was operating normally. Fourteen men, including the fireboss and the mechanic, felt or heard the explosion and left for the outside, passing through dust and smoke on the slope. They found the body of a track layer on the slope under part of a door blown out from the entrance of 3 east entry. The bodies of 4 men in 4 east entry were recovered by 9:30 p. m. after ventilation was restored. A badly burned man was rescued but died the following day. No rescue equipment was used.

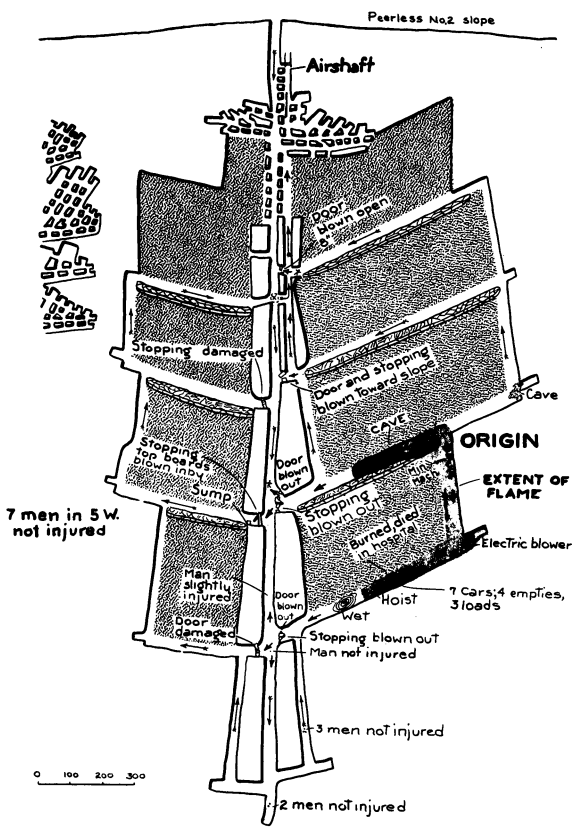

FIGURE 124.—Map of explosion area, Peerless No. 2 mine, Excelsior, Ark., May 11, 1942.

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The trackman removing rails under the door at 3 east entry latched the door open, short-circuiting the air in all working sections of the mine. Gas accumulated, and was ignited by one of the men smoking on 4 east longwall or by an arc from the controller of a mining machine. Coal dust was stirred up and burned. The explosion was stopped by water in 3 and 4 east entries (fig. 124).

May 12, 1942; Christopher No. 3 Mine, Osage, W. Va.; 56 Killed

(From Bureau of Mines report, by M. J. Ankeny, J. W. Pero, A. K. Bloom, and R. W. Stahl)

There were 117 men in the working sections of the mine, and 107 others were on an inbound man trip at about 2:25 p. m., when an explosion traversed the workings off 1½ right, killing 53 men in that area and 3 others who attempted to go out through smoke and afterdamp on the main haulage road. The men on the man-trip felt the concussion of the blast, and the air was immediately filled with dust. These men left the trip and started out. The mine power went off as circuit breakers opened in the surface substation, and the fan stopped.

The dispatcher on the main haulage road called the superintendent and told him of the explosion. He then helped get the men out of adjoining areas. Men were gathered at a place where a borehole connected to the surface but could not go out the main haulage road because of smoke and fumes. They started to put up a barricade, but a way was found through the left main return airways, free of smoke, while the fan was down; they went through some fumes and smoke but reached fresh air on the main haulageway near the upcast shaft. The fan was then started. Rescue crews then came into the explosion area, and apparatus crews explored the affected sections. Temporary ventilation was restored, and 45 bodies were removed by May 14. The remaining bodies under falls were recovered as the falls were loaded out, the last on May 23.

The explosion was caused by an arc in the control box of a cutting machine of permissible type on which the cover plates were not all in place or tight. The gas entered the area from an adjacent caved pillar area. The place was dry and dusty, and coal dust entered into the explosion. When the forces reached the entrance of 1½ right, they spread both ways, destroying an overcast, a regulator, and several concrete-block stoppings before dying out (fig. 125).

Haulage roads were rock-dusted but not the return airways or trackless entries. Water was not used to allay dust.

May 18, 1942; Hitchman Mine, Benwood, W. Va.; 5 Killed

(From Bureau of Mines report, by O. V. Simpson, K. N. Maize, and F. E. Griffith)

A coal-dust explosion in the haulage slope at about 1:52 a. m. killed five of the 13 men in the mine. The eight men were not aware of the explosion but started out when power and ventilation failed and the mine telephone was dead. They found and brought out two of the victims still living, but both died the next day.

A crew of five men was removing wooden and steel supports about 400 feet inby the portal, and when some of the supports were dislodged they fell on power cables paralleling the belt conveyor, causing an arc that ignited the dust cloud also raised by the falling material. The forces and flame extended out the portal and about 1,200 feet inby the origin before dying out because of expansion and less combustible dust mixtures on the floor (fig. 126, p. 187).

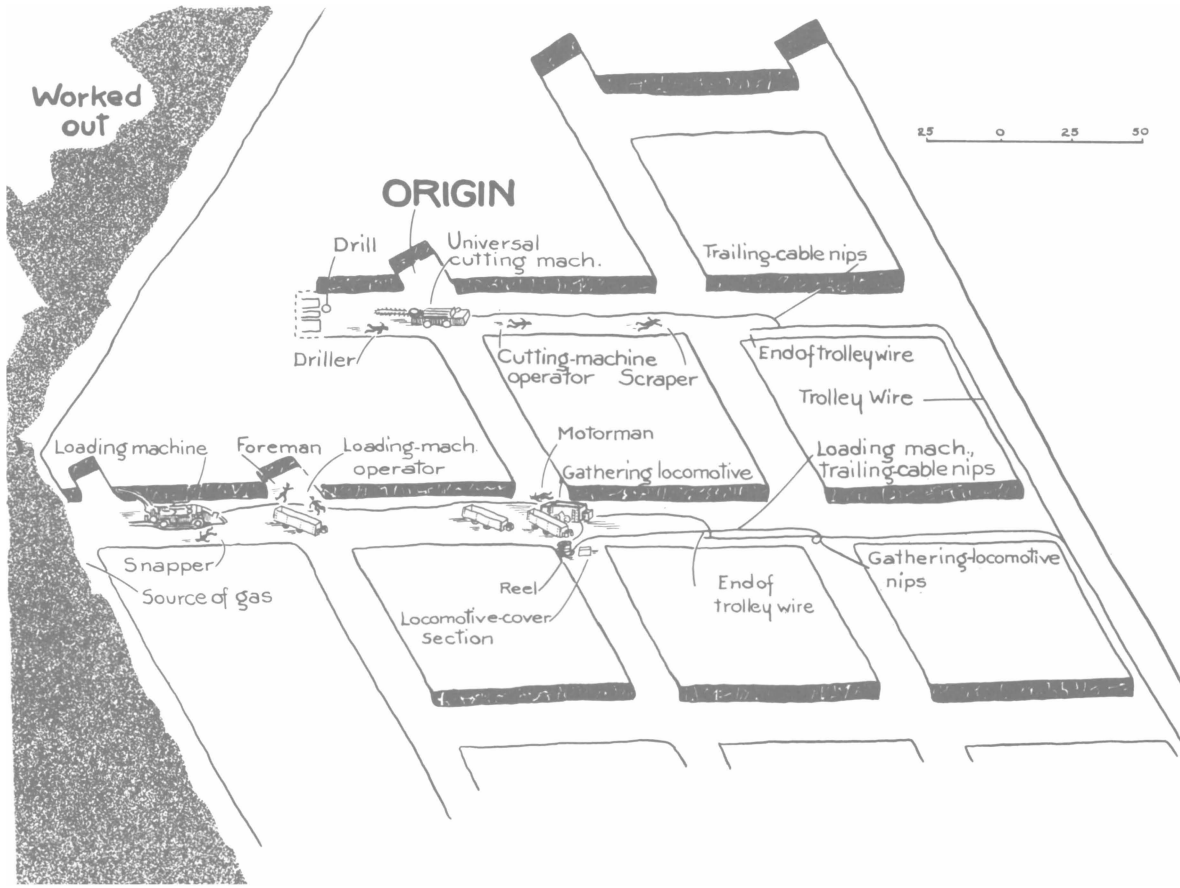

FIGURE 125.—Sketch of explosion area, mine No. 3, Osage, W. Va., May 12, 1942.

Gas-mask crews extinguished some small fires. The mine portal was wrecked, the tipple was set afire, and houses and mine structures were slightly damaged. Some rock dusting had been done, but the conveyor-belt section of the slope was heavy with coal dust.

July 9, 1942; Pursglove No. 2 Mine, Pursglove, W. Va.; 20 Killed

(From Bureau of Mines report, by F. E. Griffith, W. D. Walker, A. K. Bloom, and D. S. Kingery)

About 4:12 p. m., three minutes before start of the second shift, the night foreman at the junction of 20 north haulage entries on the main haulage entry felt a concussion and saw dust coming from the 20 north entries. He telephoned to the mine foreman on the surface and was told to open all power switches to inby workings, to get in touch with all other foremen in the mine, and to remove all of the men possible; 53 men escaped uninjured. A rescue party of officials from the surface joined the foremen underground, and a gas-mask crew started to explore 24 north. Later additional help arrived and ventilation was advanced into the affected area. Bodies of the 20 victims were removed by 4:30 p. m. July 10.

The explosion of gas and dust covered the 20 and 24 bleeder sections and entries and parts of the 15 west entries. The origin was reported to have been a fall of roof rock that threw up a cloud of dust and brought a 550-volt trolley wire down to the rail, causing an intense electric arc (fig. 127).

The air in this section had passed over pillared areas and abandoned workings and contained methane. Haulage entries were rock-dusted, but the working places were not.

November 30, 1942; West Kentucky No. 10 Mine, Wheatcroft, Ky.; 6 Killed

(From Bureau of Mines report, by L. H. McGuire)

The mine foreman and a crew were putting a trip of wrecked cars back on the main slope track when the explosion occurred about 8:30 a. m. The sound and rush of air were thought to be from a fall until some men came out from the affected 14 left entries. Assistant foremen were sent to bring men out of all sections except the left intake-air side. All 169 survivors were brought to the surface by 11:20 a. m., since the gases and smoke from the explosion were well diluted on the main hoisting slope, which was on return air. Officials from other mines arrived, and recovery work was quickly organized. Gas masks were used in exploration, and ventilation was restored. All bodies were removed by 4:00 p. m.

The explosion originated near the face of 14 left heading, where gas had accumulated when a door was left open, and curtains at another point were partly open. Ignition was caused by an arc from the controller of a locomotive or by smoking. Coal dust was stirred up and ignited. Some rock dusting had been done on the haulage but not in rooms or aircourses. The explosion was limited by expansion and by wet places in both the 13 left and 14 left entries (fig. 128, p. 189).

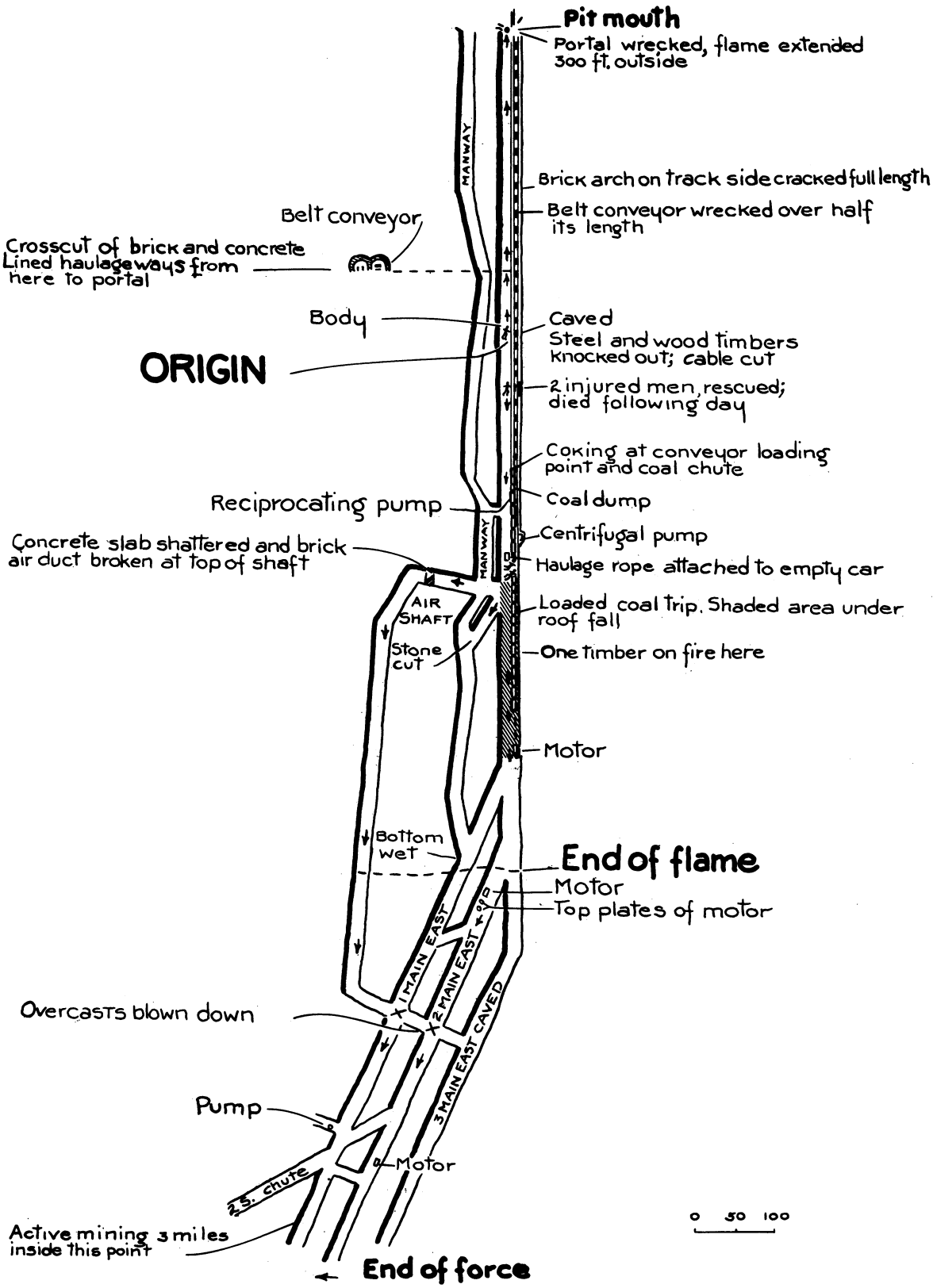

FIGURE 126.—Map of explosion area, Hitchman mine, Benwood, W. Va., May 18, 1942.

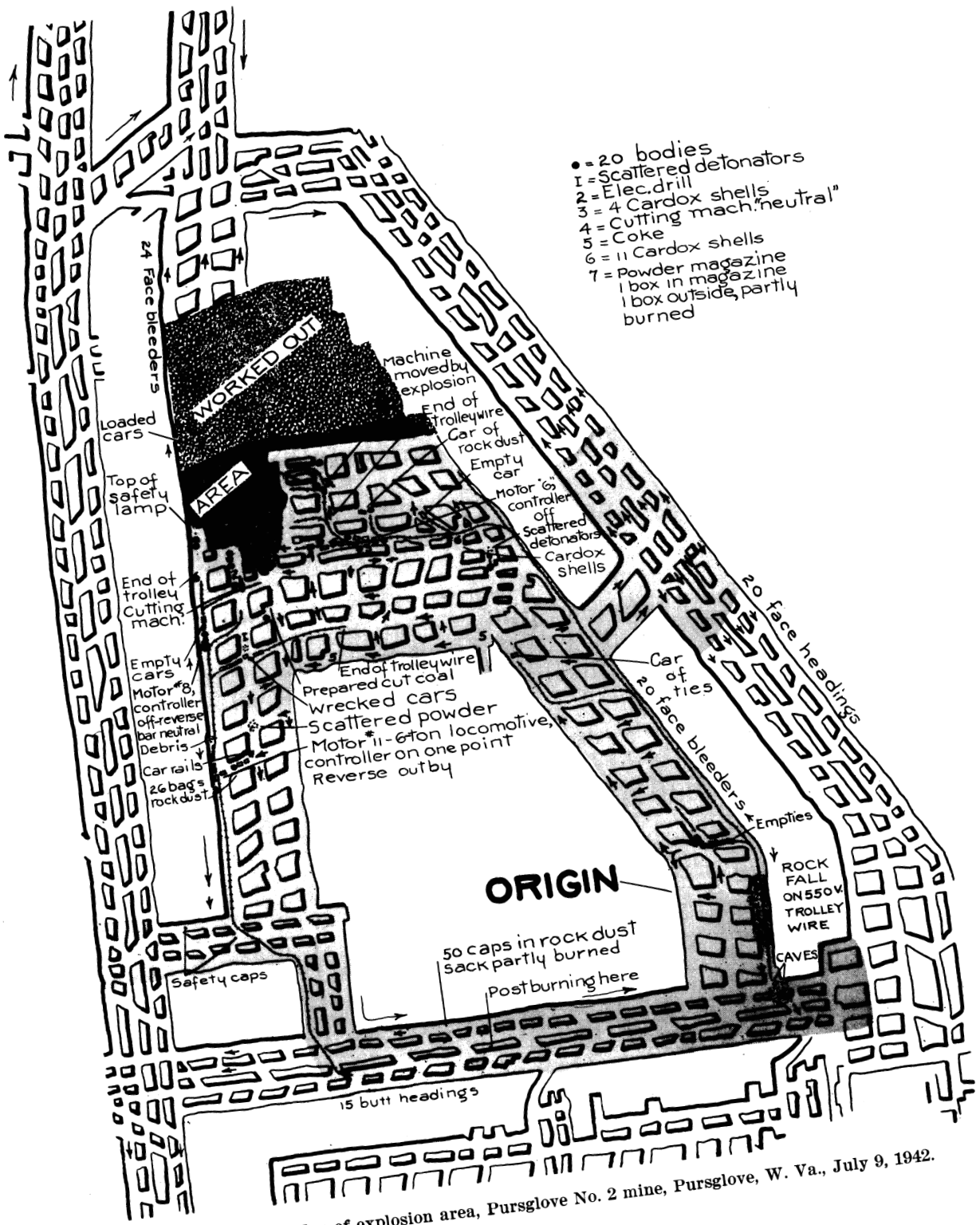

FIGURE 127.—Map of explosion area, Pursglove No. 2 mine, Pursglove, W. Va., July 9, 1942.

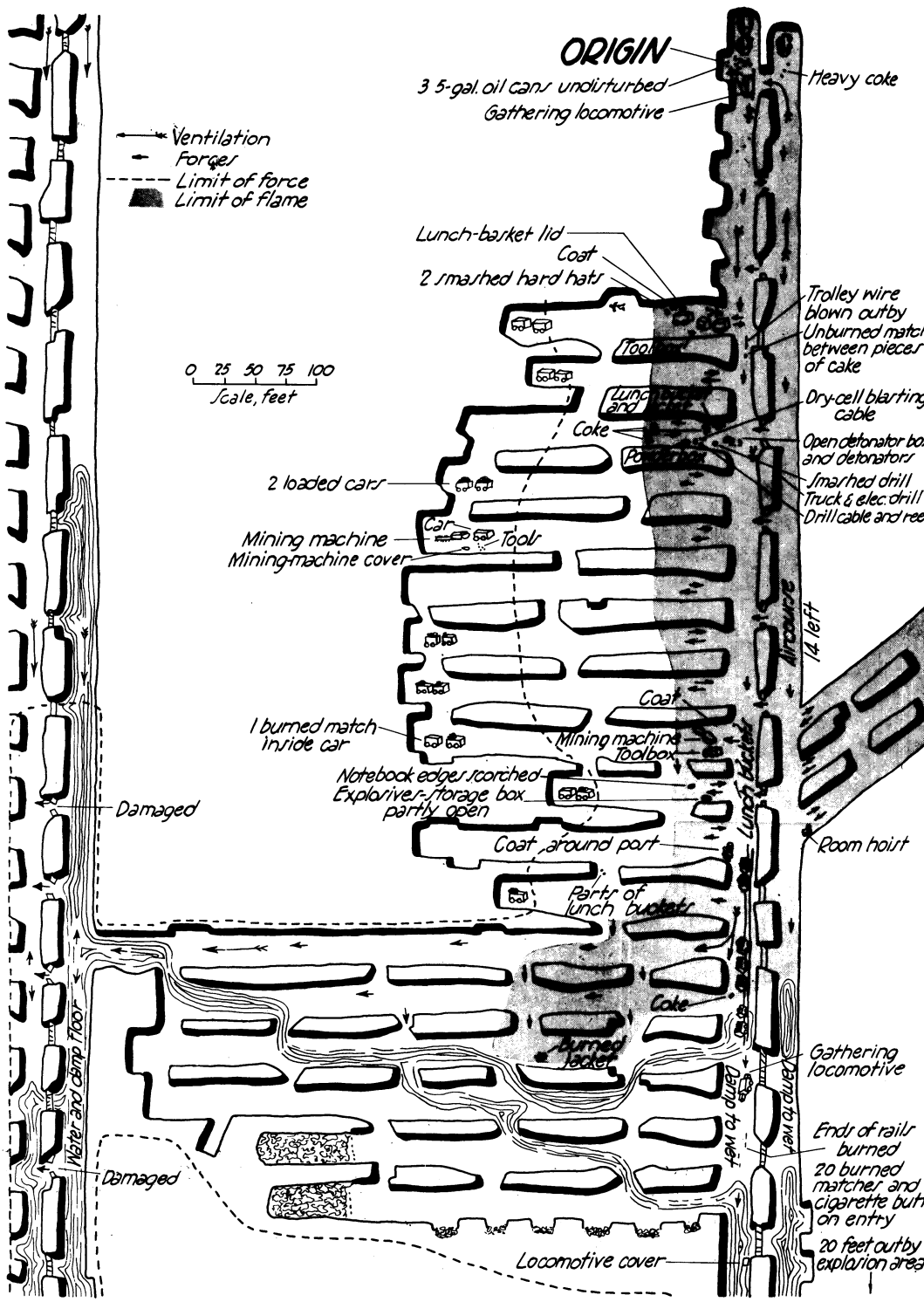

FIGURE 128.—Map of explosion area, West Kentucky No. 10 mine, Wheatcroft, Ky., November 30, 1942.

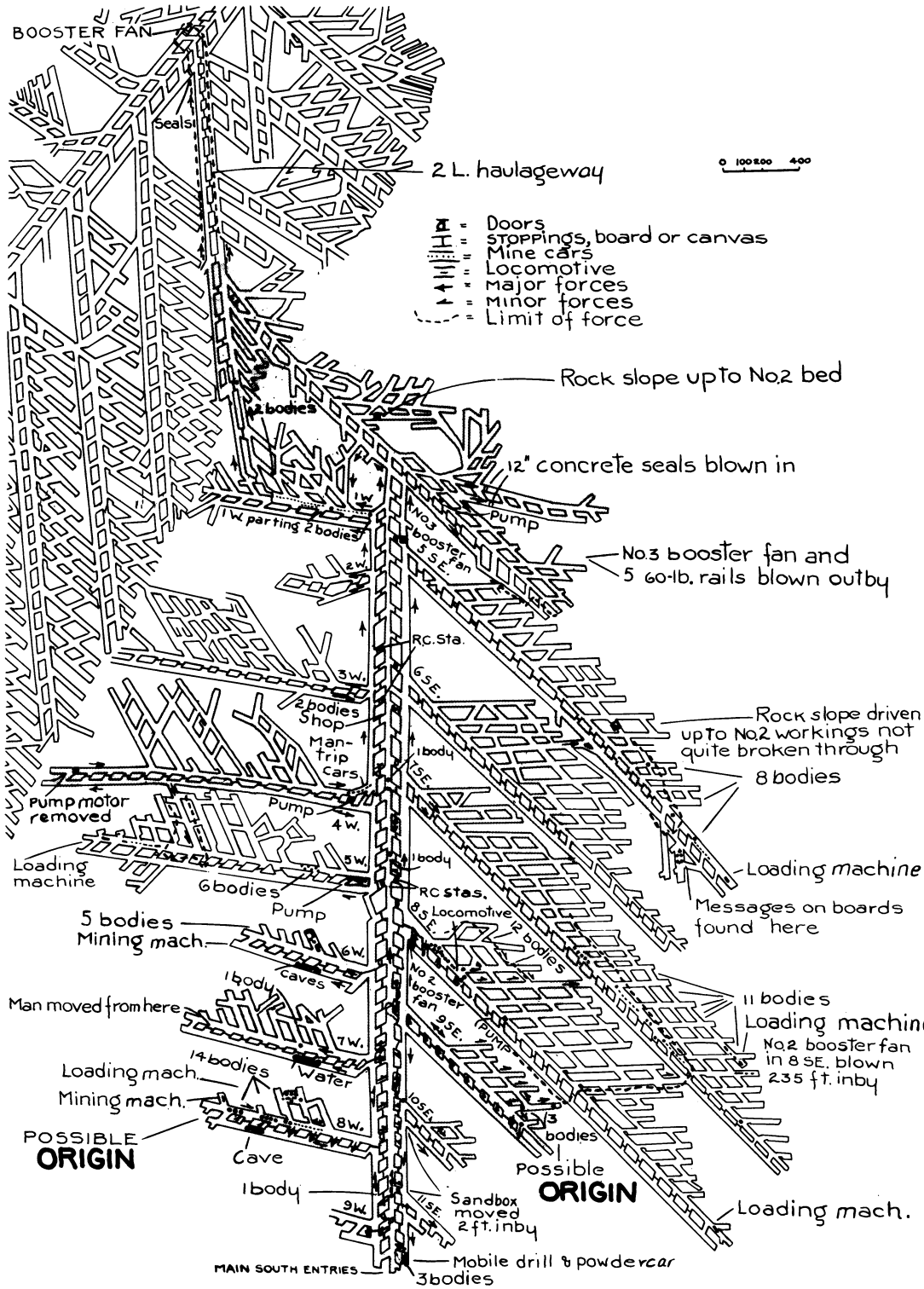

FIGURE 129.—Map of explosion area, Smith mine, Washoe, Mont., February 27, 1943.

February 27, 1943; Smith Mine, Washoe, Mont.; 74 Killed

(From Bureau of Mines report, by G. O. Arnold, M. C. McCall, and F. J. Bailey)

The old mine in No. 2 bed was opened by three slopes on the pitch of the coal bed. About 3,700 feet inside the portal a rock slope was driven down to the No. 3 bed and all work was in this bed. About 9:30 a. m. there were 77 men underground when the explosion happened; 74 died, and three others in the haulageway in No. 2 bed were rescued but were seriously affected by shock and gases. The explosion covered virtually all workings in No. 3 bed, although it did not reach the inby faces of some of the cross entries. Messages left by several men in one heading showed that they lived until some minutes after 11:00 a. m. Thirty of the men were killed instantly; the others moved varying distances after the explosion.

The hoistman at the top of the No. 3 slope felt a terrific wind and called the surface on the telephone before losing consciousness; soon after, gases and dust were noticed at the mine portal. Word was broadcast to other places by telephone and then by radio from Billings. The fan was not damaged, and by traveling 300 feet through return air on the haulageway a party was able to reach a door and get into the intake airway. They found three men unconscious on the slope and took them into the intake airway and revived them. Others found in this area were dead, although attempts were made to give artificial respiration.

Help arrived during the day, and recovery was organized. Ventilation was restored and the last body found and removed by 6:00 p. m. March 7. Forces were outby from the lower workings up the slopes and into cross entries; damage included the destruction of three booster fans, damage and destruction of locomotives and switch panels at rotary-converter stations, deranging of trolley and power wires, and destruction of all stoppings (wooden) and doors along the main entries and many inside the panels. Some timbers were blown out, resulting in several caves of roof material.

Gas was found by fireboss examinations in several working places almost daily and was brushed out or removed by hanging curtains. Some of the men used electric cap lamps, the others open lights. Electric equipment was open type, and fuse was used in firing shots. Smoking was practiced. No rock dusting had been done. The explosion originated by the ignition of an explosive mixture of gas by an open light in the face region of the mine. Dry coal dust was in turn ignited, and a general explosion traversed most of the mine. The details are shown in figure 129.

May 5, 1943; Nu Rex Mine, La Follette, Tenn.; 10 Killed

(From Bureau of Mines report, by R. W. Stahl and R. D. Bradford)

The first evidence of an unusual occurrence was about 1:10 p. m., when dust and flame issued from the slope portal momentarily. A few minutes later two men who had been working at the underground dump at the slope bottom came out severely burned on face and hands. The mine superintendent cut off the power from the mine and notified the State mine inspector and the Bureau of Mines, and help was called for. There were 33 men in the mine; 2 came out the slope, 3 were unaware of the disaster until found by a rescue party, 10 were killed, and 18 others were rescued from behind a barricade after being confined for 7 hours (*24, pp. 35–38*).

The explosion was restricted to the No. 2 main headings, which had been driven approximately 2,000 feet from the surface, although forces extended several hundred feet in 1 and 2 right entries off 2 main. A mechanic and 3 other men in 7 room, 2 right entry, felt the shock, followed by dust and smoke in the air. They tried to get to the main entry but ran into dense smoke and foul air and had to go back. The mechanic led them through 5 room to 1 right entry, where the air was clear. They met 14 men from 1 right, and the mechanic persuaded them to build a barricade and stay behind it. Three men explored 1 right toward the mains but were forced to return. The barricade was a board stopping sealed with pieces of vent tubing and brattice cloth. Four men from 2 right and 2 men from 1 right who had tried to get out to the surface were overcome on 2 main near 1 right. The bodies of four others were found near the face of 2 main close to the origin of the explosion. Rescue teams entered through the intake airway, extinguished a small fire, and restored ventilation by putting up brattice-cloth stoppings. Exploration was carried on by gas-mask crews. The bodies were removed by midnight. Damage consisted of the demolition of several wooden stoppings and two doors.

Gas in abandoned workings off 6 right, 1 main entry, was released when the angle room from the face of 2 main was cut through into an old room face. The map showing the location of the old workings was in error. Ignition was by an arc from the controller of the mining machine (fig. 130).

No tests for gas were made until near the end of the day shift. The mine was damp, and only a little coal dust was involved in the explosion until the dump at the slope bottom was reached. No rock dust had been used.

May 11, 1943; Praco No. 10 Mine, Praco, Ala.; 12 Killed

(From Bureau of Mines report, by H. N. Smith, C. E. Saxon, and Jas. B. Benson)

The third shift of 24 men was in the mine at about 4:10 a. m. when the control switch for the car hoist, 170 feet from the face of 22 north heading, was put in to start the hoist. An arc was created that ignited gas accumulated at the face from feeders while a door was left open. The mine was ventilated by one continuous air current. Five of the men in the explosion area escaped, although severely burned and injured; 2 died later. The remaining 10 employees in 22 north heading and aircourse were killed by violence, burns, and afterdamp. Nine men in other sections of the mine escaped uninjured (fig. 131).

The foreman was blown over but not injured; he sent word to the surface, as he could get no response on the telephone, and attempted to penetrate the affected area, found it impossible and gathered survivors, injured and uninjured. While further steps were being considered, a second explosion occurred, about 25 minutes later, and more violent than the first, but did not affect the workings where the men were. At 5:30 the hoisting engineer came on duty and answered the telephone. The man-trip was sent down, and the injured were removed. Help was sent down, and ventilation was restored by erecting canvas stoppings where 12 gob stoppings, a door, and 2 brattice-cloth stoppings had blown out. No respiratory equipment was used. All bodies were removed by 10:50 a. m. May 11. Coal dust was involved, but moisture and rock dust prevented further propagation of the explosion.

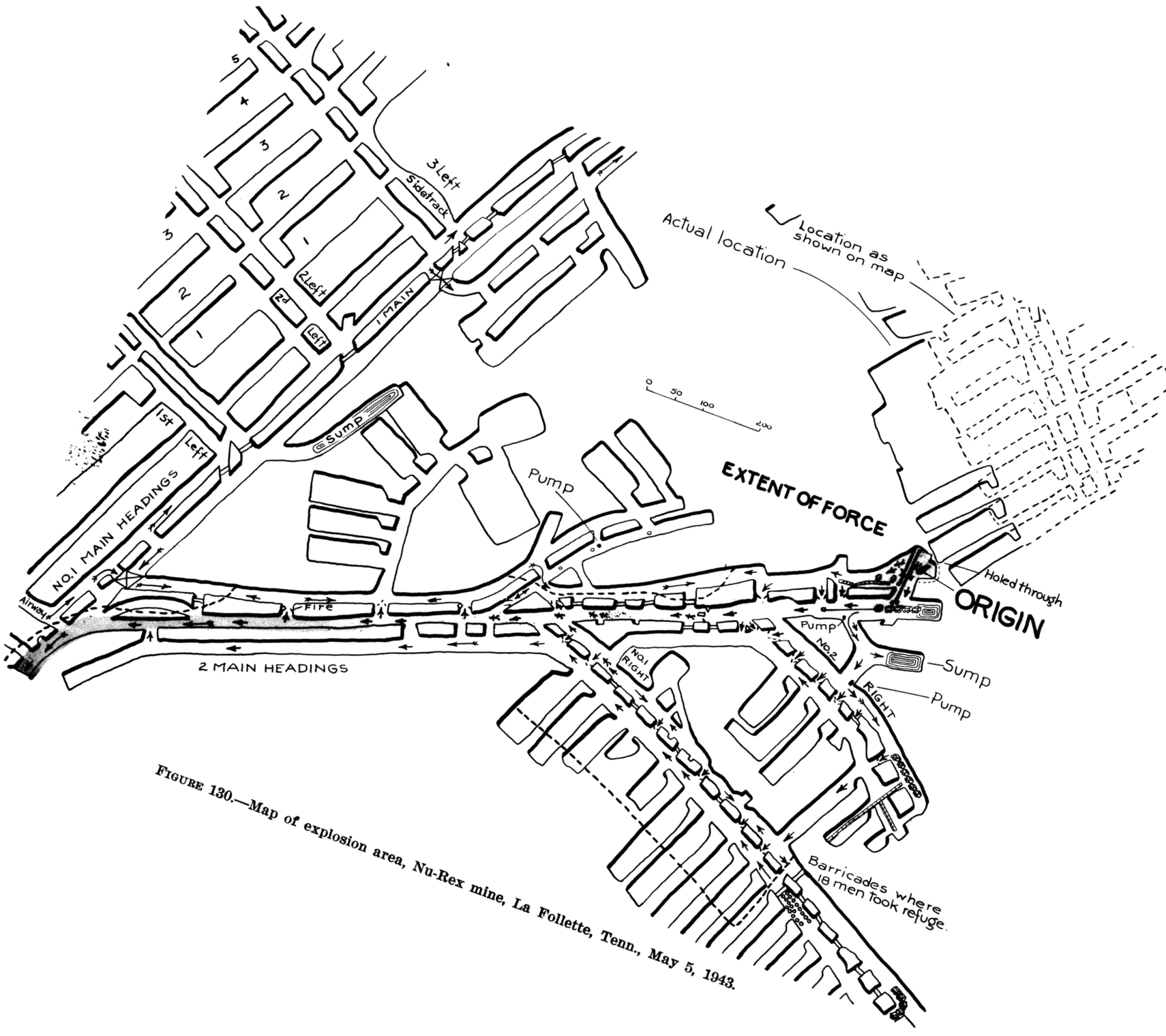

FIGURE 130.—Map of explosion area, Nu-Rex mine, La Follette, Tenn., May 5, 1943.

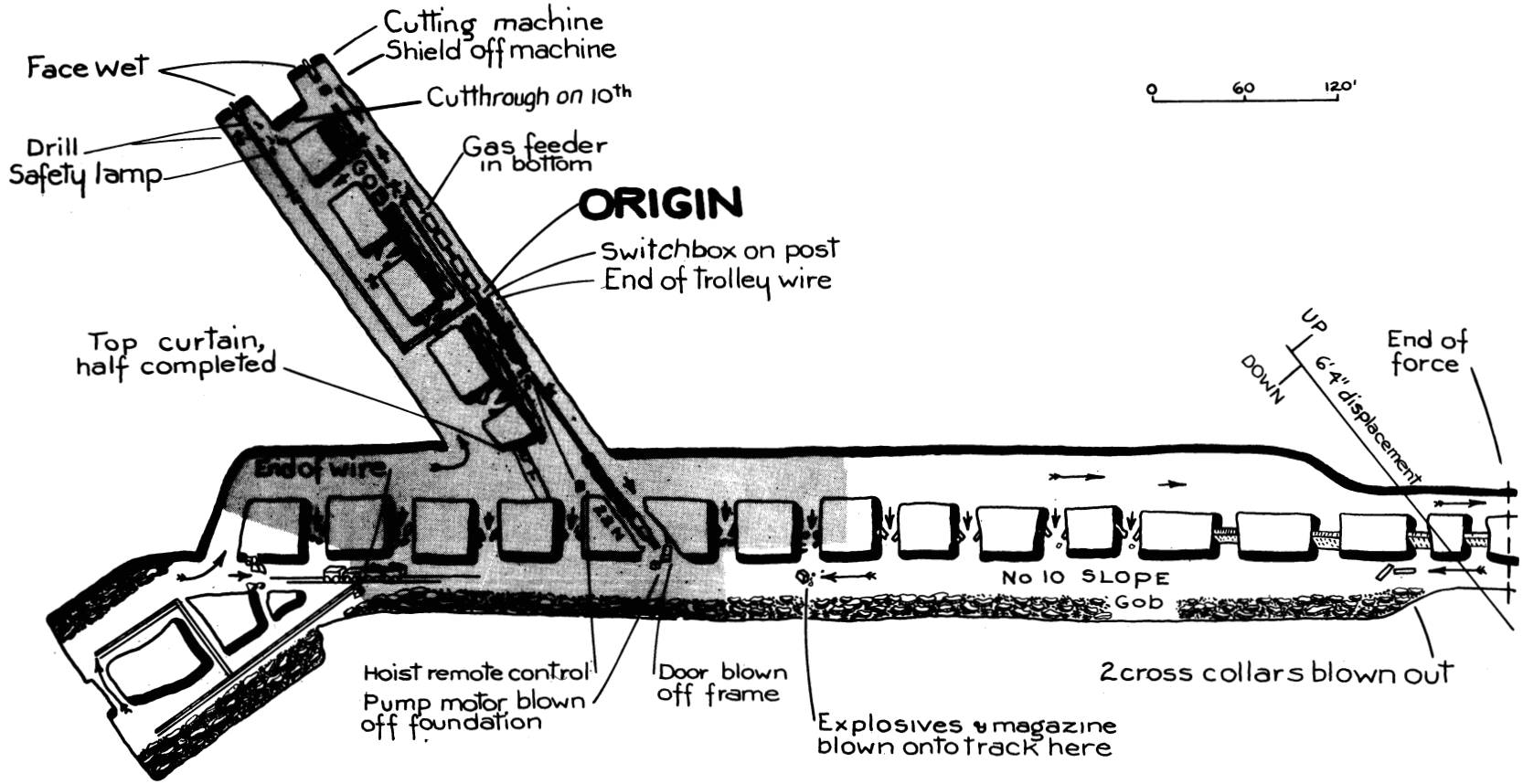

FIGURE 131.—Sketch of explosion area, Praco No. 10 mine, Praco, Ala., May 11, 1943.

August 28–29, 1943; Sayreton No. 2 Mine, Sayreton, Ala.; 28 Killed

(From Bureau of Mines report, by R. W. Stahl and Jas. B. Benson)

About 10:10 p. m., while 107 men were in the mine, an explosion in the 9 left and 9 left slope sections killed 14 of the 30 men in the affected area. Three escaped uninjured, 13 were injured, and 1 of this number died after rescue. The 77 men in the unaffected portion of the mine escaped. The haulage foreman at the entrance to 9 left saw a steel door pushed open by a rush of air, and shortly 3 burned survivors came out of 9 left. The foreman put the injured men on a slope trip and telephoned the surface to tell of the explosion and have the power cut off. The night mine foreman arrived and sent word to all sections to assemble the men at the lower chain yard for transportation to the surface. Some of the air was cut off 9 left entry to keep smoke and dust from spreading; 6 injured men were heard calling from the affected area and were taken to the slope.

The assistant mine superintendent arrived, and the section was explored; 14 bodies were seen, but no gas or fires were observed in the dust and smoke. Other mine officials, State inspectors, and Bureau of Mines representatives arrived, and the question of closing or opening the airlock doors to the affected section was discussed. By closing the doors that had been opened and erecting a brattice where a door had been blown out, the area would be ventilated for removal of the bodies. The doors were closed, and a party went in to explore the area again. About 15 minutes later a second explosion occurred, killing 2 of the 17 men in the party and burning and injuring the 15 others. Twelve of the injured died after being removed to a hospital, including the company safety engineer, a Bureau of Mines representative, the chief State mine inspector, and other mine and county officials.

The doors were opened to put fresh air where the victims were grouped. They were brought out; and another exploration party, equipped with gas masks, went into the area and extinguished several small fires with rock dust and water. A thorough examination was then made to see that all fires were out, and recovery of the bodies was begun. All bodies were removed by 7:30 a. m. August 29. Explosive concentrations of gas were encountered while the bodies were being removed, and one other small fire was found and extinguished by another exploration party at 2:00 p. m. August 29. Ventilation was then gradually restored.

The first explosion was ignited by an arc from the controller of a combination trolley and cable-reel locomotive. Methane from a caved area spread into open workings because of obstructed ventilation and was pushed out on the entry by roof falls in two rooms. The motorman operating the locomotive survived, though burned. Coal dust was involved; and, had not the surrounding territory been rock-dusted, plus the presence of water inby 11 left entry, a widespread explosion might have resulted. The second explosion originated in No. 7 room, 10 left entry, where a smoldering jacket was hanging on a post. Manipulation of the ventilation moved an explosive gas mixture over it and probably quickened the burning so that the gas was ignited, repeating the first explosion (figs. 132 and 133).

Damage to workings and equipment was minor; but the heat was intense, causing severe burning of most of the victims. Some rock dust had been applied in the explosion area but not enough to stop or control an explosion.

September 16, 1943; Three Point Mine, Three Point, Ky.; 12 Killed

(From Bureau of Mines report, by C. M. Keenan)

A local gas explosion at about 9:00 a. m. killed 12 of the more than 50 men in the workings off the No. 1 opening. All men working outby the point of origin escaped unaided; six men working in the face area of 12 left entry built a barricade of wooden ties covered with several thicknesses of vent tubing, but did not have to retreat behind the barricade, as the gases from the explosion were short-circuited outby the barricade where a door was broken by the blast.

The mainline locomotive crew felt the strong concussion and telephoned to the surface before coming out. Rescue assistance was called, and temporary brattices were built to sweep smoke and gases from the haulageway into the explosion area. The bodies found indicated that all men in new 1 right section were dead, so the rescue party continued toward 12 left 3,300 feet inside. At 10:00 p. m. when they had progressed 1,500 feet, footprints were seen in the dust, and 5 minutes later the lights of the 6 men were seen, and they were rescued by bringing fresh air through the polluted zone (*24, pp. 38, 39*) (fig. 134, p. 197).

Gas masks were used in exploration and in erecting some stoppings. Later, 1 right entry was cleared, and the bodies were removed by 9:00 a. m. September 17. Gas had accumulated at the face of idle 13 left entry and had seeped into a slant entry off 1 right, 12 left, when a drill hole and an undercut from a crosscut connected with the face of 13 left. An assistant foreman found that the air in the slant extinguished his flame safety lamp and withdrew from the crosscut with the men into the slant where he took the lamp apart and attempted to relight it with a match. Gas was ignited there (fig. 135, p. 198).

Dust was not involved, as the area was wet from water seeping from 13 left and rock dust had been applied on the haulage road. The force was moderate.

September 24, 1943; Primrose Colliery (Anthracite), Minersville, Pa.; 14 Killed

(From Bureau of Mines report, by L. L. Naus, R. M. Monteith, and C. F. Weber)

About 12:30 p. m. the mine foreman, the assistant foreman, and the contractor examined the working places and reported them free of gas for blasting. Another check was made in the return airway at 1:15 p. m. by the assistant foreman. At 1:30 p. m. he was at the discharge end of No. 1 west conveyor belt, instructing the electrician to install a light at No. 5 south conveyor, when the explosion threw him across the belt slope. He was uninjured and immediately called to the electrician to cut off the power and then telephoned to the mine foreman. He and others went into the affected area and helped injured men out to fresh air. After a short time they had to retreat because of the afterdamp.

Five men arrived from the surface with oxygen breathing apparatus and searched for other survivors. As only dead bodies remained, the rescuers withdrew until better ventilation was provided. Of the 31 men in the affected area, 14 were killed, 15 escaped, and 2 were rescued. The bodies were removed by 4:00 p. m. September 25, without using apparatus.

Gas was found in the section after ventilation was restored, and it was concluded that an explosive mixture had built up because of ineffective ventilation. The source of ignition was thought to be an arc from the switch of a conveyor motor in No. 2 west airway (fig. 136, p. 199).

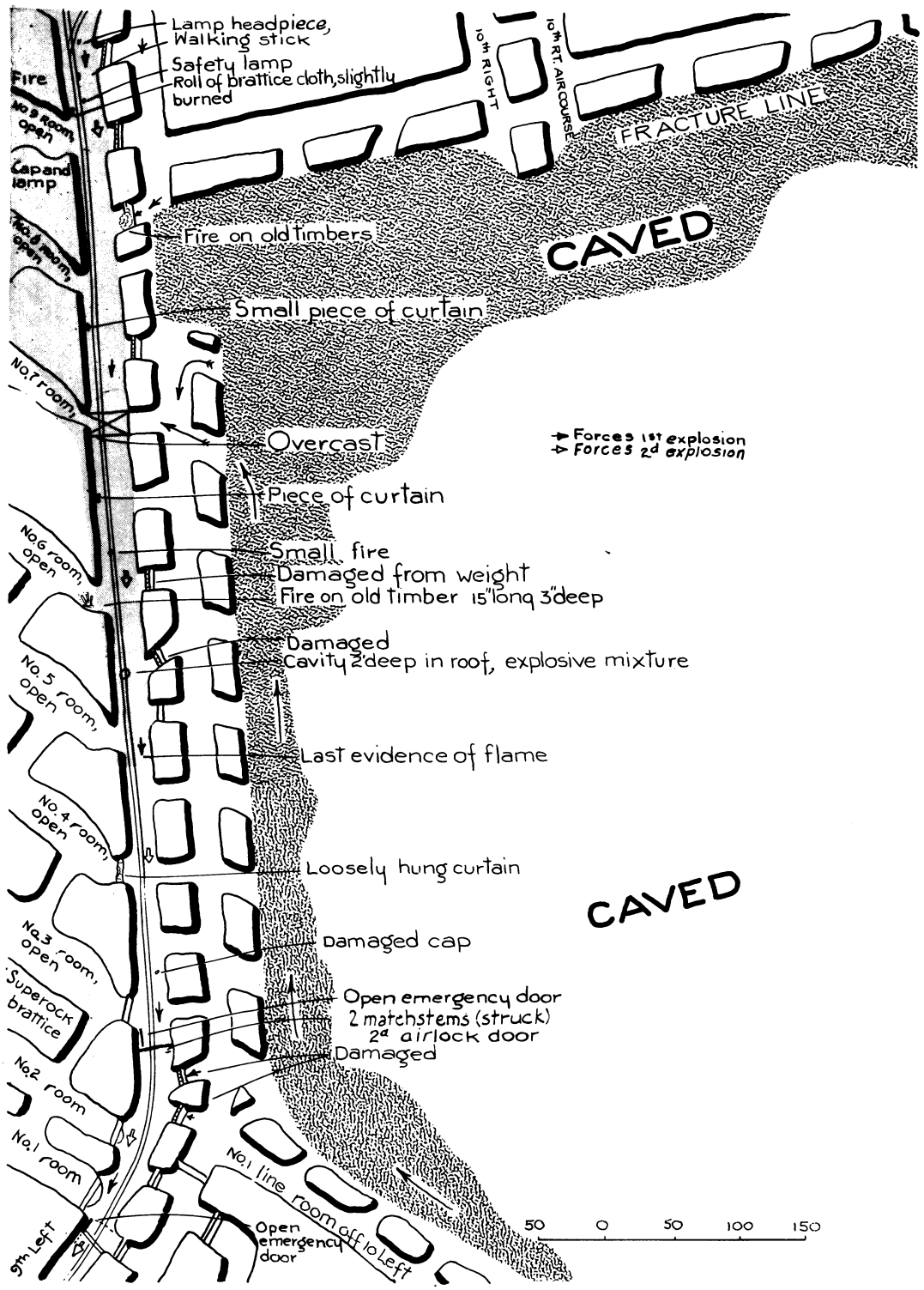

FIGURE 132.—Map of explosion area, Sayreton No. 2 mine, Sayreton, Ala., August 28–29, 1943. See also figure 133.

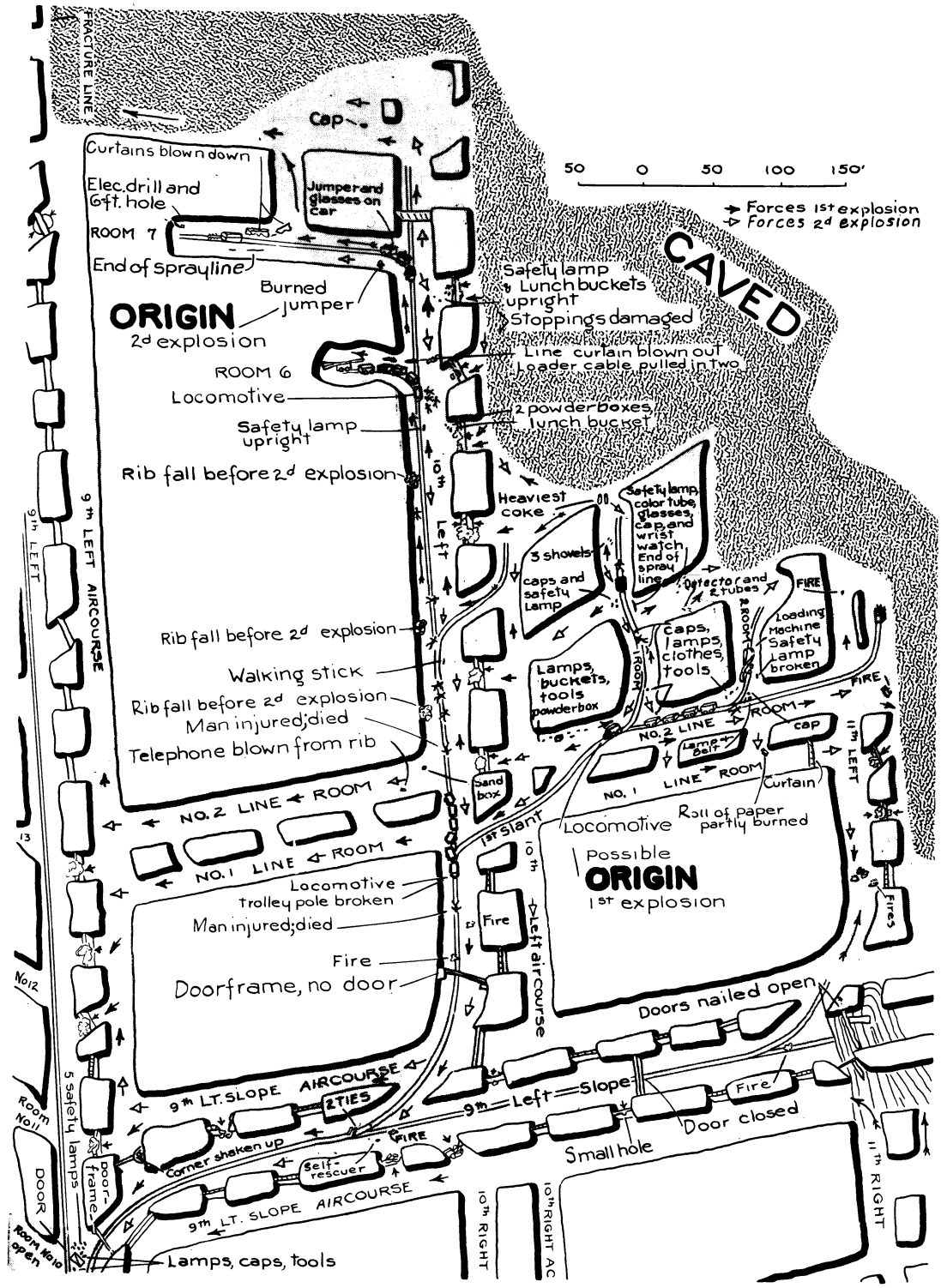

FIGURE 133.—Map of explosion area, Sayreton No. 2 mine, Sayreton, Ala., August 28–29, 1943—Continued.

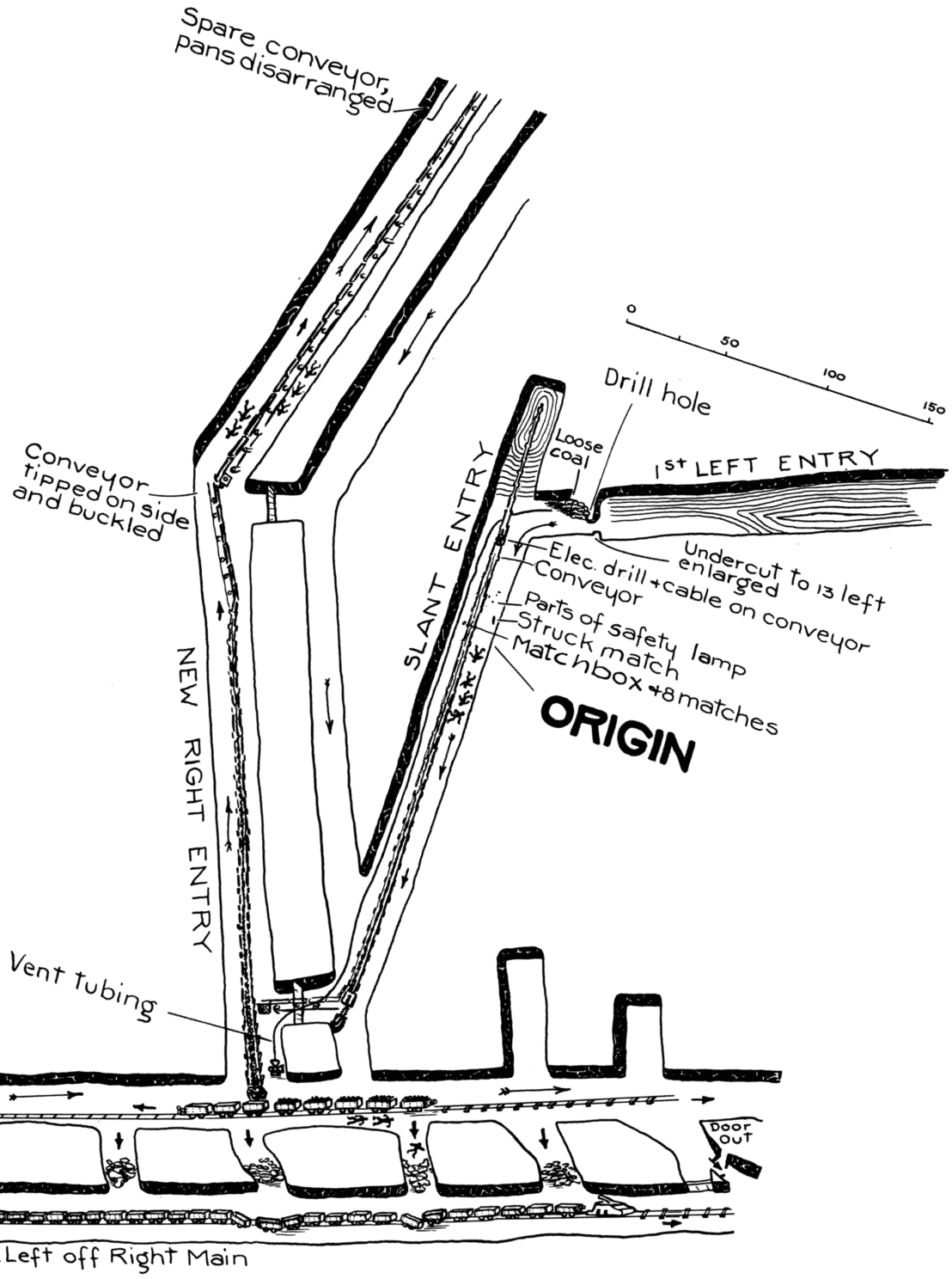

FIGURE 134.—Map of explosion area, Three Point mine, Three Point, Ky., September 16, 1943.

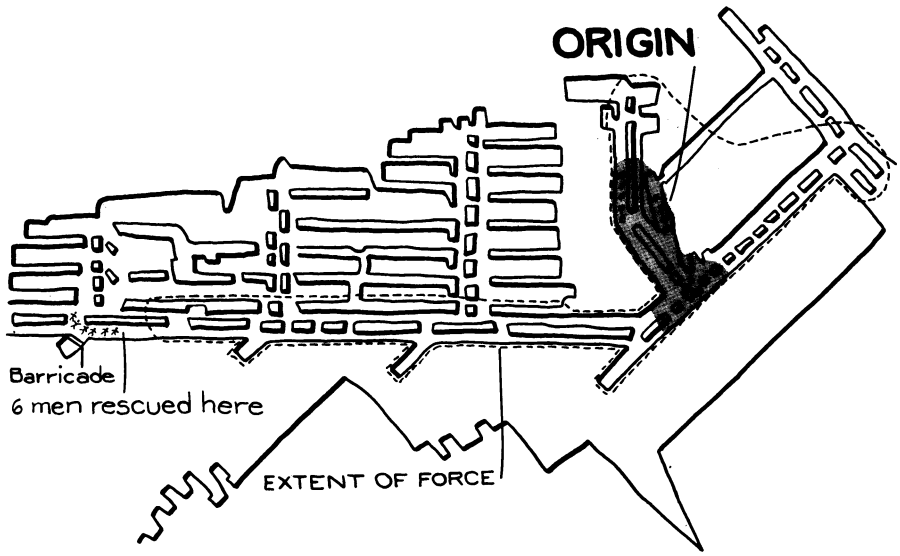

FIGURE 135.—Sketch of area at origin of explosion, Three Point mine, Three Point, Ky., September 16, 1943.

All the mine officials were charged by the State and were held responsible for violation of the mining laws on minimum ventilation requirements.

November 6, 1943; Nellis No. 3 Mine, Madison, W. Va.; 11 Killed

(From Bureau of Mines report, by E. H. Brown, F. J. Furin, and R. B. Jones)

About 7:00 p. m. the supply crew from section H at a door on 23 north entry felt a rush of air as it was on its way to the surface to change the flame safety lamp for the section foreman. His lamp had been extinguished when room 38 was cut through into the abandoned 25 north entry, and he was unable to relight it. The men attributed the rush of air to a heavy "slate" fall and continued on their way. A motor crew in neighboring section E noted the rush of air, and also thought a "slate" fall had occurred until a door was opened on 23 north while loaded and empty trips were being moved. Dense smoke was encountered when they opened the door. They left it open, uncoupled the locomotive, and headed for the surface.

The open door short-circuited the air going from section H to section E and saved the men in section E from the fumes and smoke. The haulage crew met the returning supply crew near the portal and notified the superintendent and the foreman. The 11 men in section E noticed smoke back of 2 doors and came out through return air to the entrance to 22 north, where the air was good, and proceeded to the outside. The superintendent, foreman, and a man from section E were able to reach section H by wearing gas masks. After passing through return air they found the air in the section clear. Two injured men were found and were treated and removed, other help having arrived. All bodies were removed by 1:40 a. m. November 7. Nine of the 11 men in section H were killed by violence, burns, and afterdamp, and the 2 injured men died several hours later in the hospital.

Methane from 25 north entry, abandoned since 1935, was ignited by nipping in moving the gathering locomotive. Coal dust was burned but did not propagate the explosion. Some rock dust had been applied by hand, but wetness and lack of force limited the spread. Most of these details are shown in figure 137.

March 24–25, 1944; Katherine No. 4 Mine, Lumberport, W. Va.; 16 Killed

(From Bureau of Mines report, by G. W. Grove, M. C. McCall, and W. D. Walker, Jr.)

Two mine fires occurred near the faces of the main north entries about 11:00 p. m. The mine workings consisted of these 5 main entries, driven about 3,100 feet from the portal, 5 No. 1 right dip entries driven 2,000 feet from the junction near the portal, and 5 No. 1 left entries driven about 800 feet off the No. 1 right dip entries. One of the fires, a minor one, was at the nip of a mining machine in the No. 5 entry, inby the third crosscut from the face. The other fire, which burned the fine coal and dust on the floor over a considerable area, resulted from a short circuit between the trolley wire and the return conductor, which were on hangers about 12 inches apart. Contact between the wires was caused by jerking or pulling the nips of a cable-reel locomotive attached at the second crosscut from the face in the No. 2 entry. The fire gained headway while the crews were eating lunch elsewhere, and attempts to approach it failed when it was discovered.

The men were removed from the mine, and a crew of 12 men was organized by the night foreman to combat the fire. The superintendent and the general mine foreman also went into the mine. While the superintendent and 6 of the fire-fighting crew were outside loading supplies, 2 other men joined the supply crew. The superintendent was at the telephone when the supply trip went back into the mine, and when he approached the portal at 1:03 a. m. an explosion occurred that traversed the entire mine and flame extended 300 feet or more outside the portal, setting 2 automobiles on fire. The forces destroyed the masonry of the mine portals and the fan duct. They damaged and moved the fan and damaged mine shops and offices. Some small debris was blown one-fourth mile. In the mine, bent track rails, bent hangers, dislodged timbers, and coke deposits indicated that the explosion traveled the No. 1 main entry and expanded across the other four entries and toward the portals. The superintendent was blown into the repair shop and under a loading machine, but he was not injured.

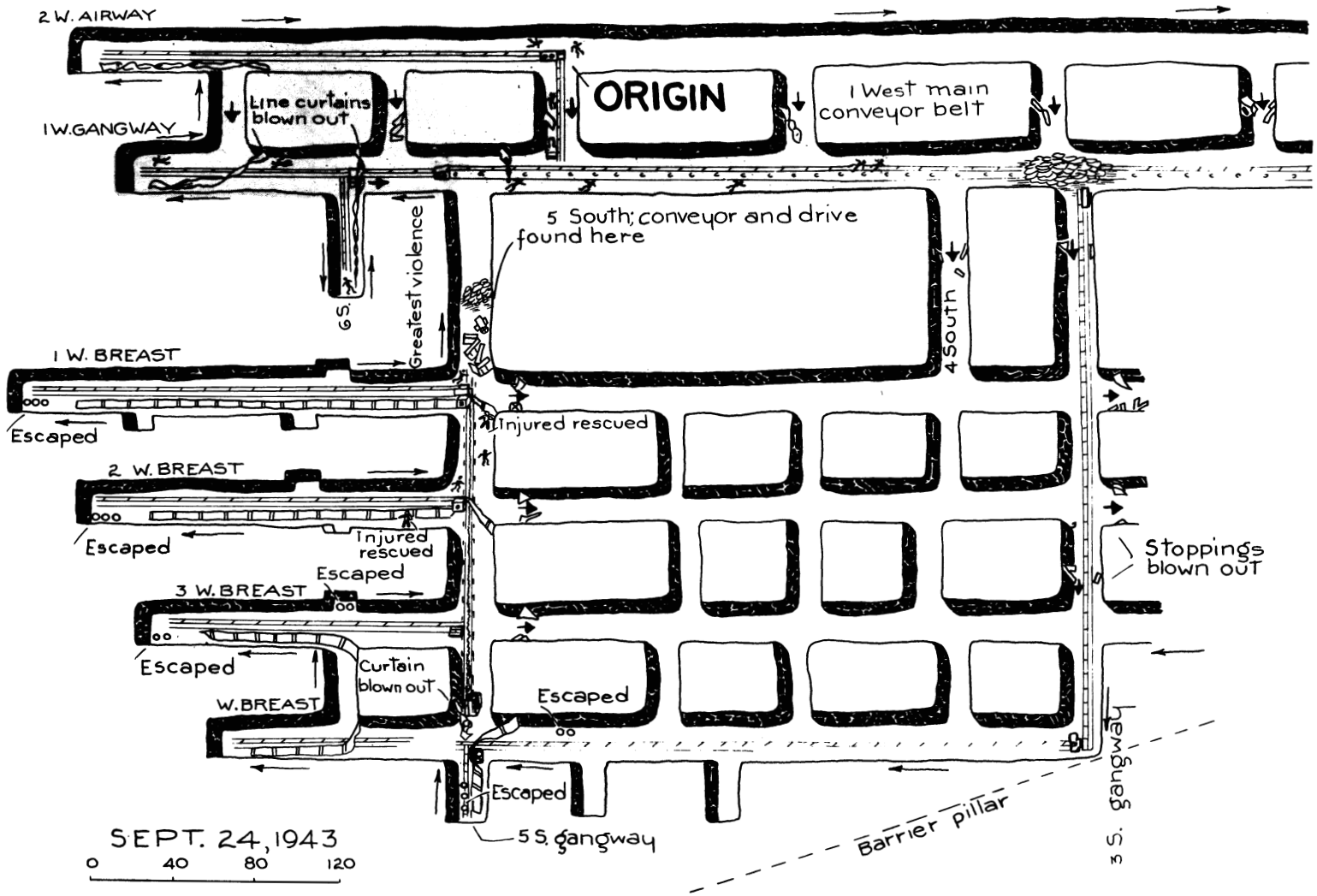

FIGURE 136.—Map of explosion area, Primrose mine, Minersville, Pa., September 24, 1943.

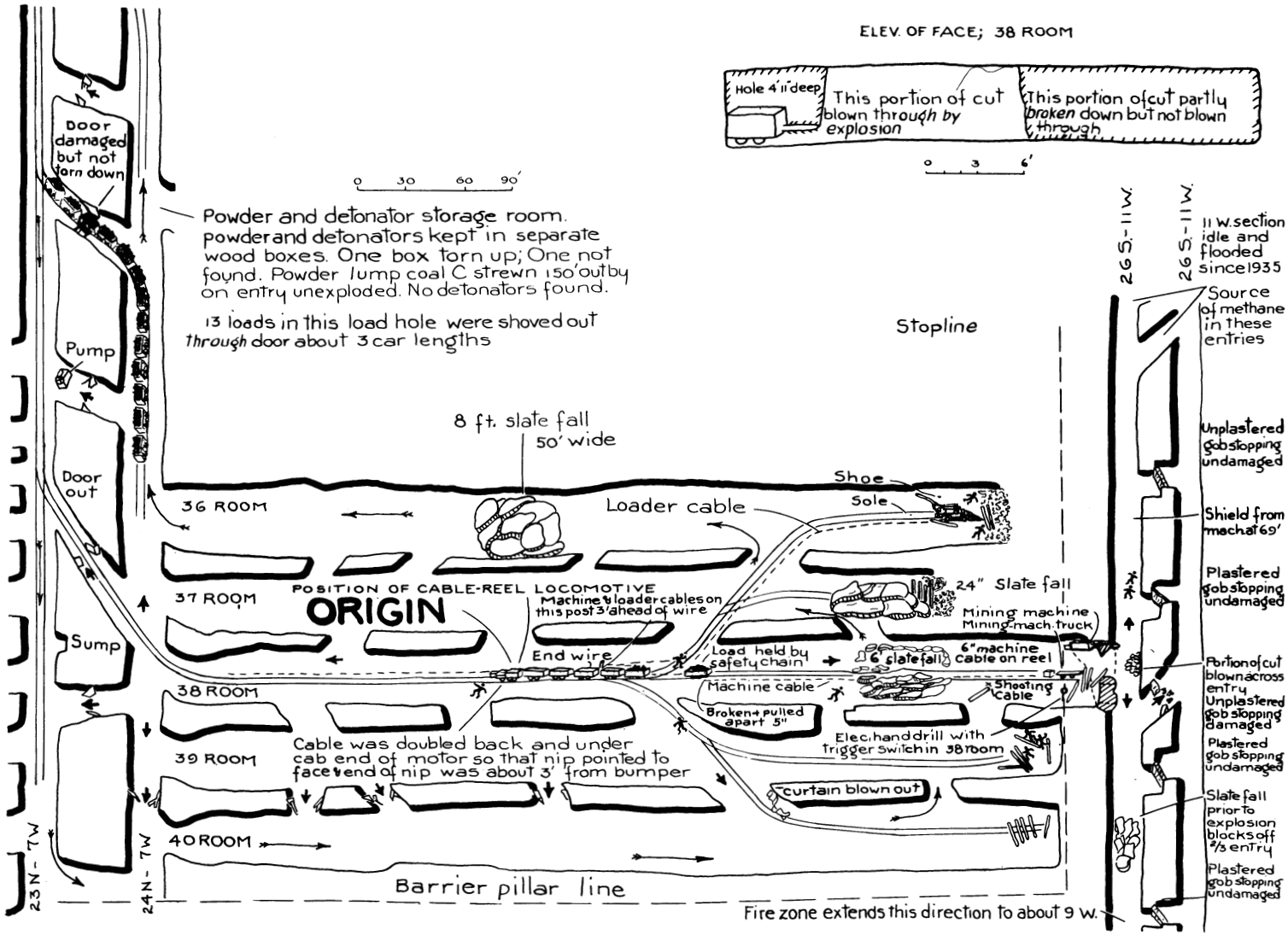

FIGURE 137.—Sketch of explosion area, Nellis No. 3 mine, Nellis, W. Va., November 6, 1943.

Surface breaks over the No. 1 right dip entries about 1,200 feet from the main entries were made by the force of the explosion. Rescue leaders and crews arrived during the day. A mine rescue team under oxygen entered the mine about 7:30 p. m. to inspect locations for seals. Members of the fresh-air-base crew and the reserve apparatus crew were overcome by carbon monoxide at a base 50 feet outside the mine portal. It was decided to seal the mine at the drift portals. As a preliminary step the breaks over the No. 1 right dip entries were covered with earth, using a power shovel and a bulldozer. This was completed by midnight, and the temporary seals were finished by 2:15 a. m. March 26.

A second explosion at 4:00 a. m. blew out the seals and again broke the surface over the No. 1 right dip entries. Repair of these breaks again delayed erection of temporary seals until noon.

A third explosion occurred at 1:35 p. m., with six men in the drifts erecting the seals. Flame did not extend to the drift portals, but air pressure broke the frames of the seals. The crew completed the seals by 2:50 a. m. Permanent seals were installed March 28. Water from a small creek was run into the mine through the surface breaks over the right dip entries to make a water seal. On August 1 the seals were removed, and the mine was explored. The 16 bodies were removed August 2 and 3. A canvas in No. 21 crosscut between No. 2 and No. 3 entries was found propped open permitting accumulation of methane and fire fumes in the entry faces (fig. 138).

The mine was rated not gassy by the State, and coal dust had not been cleared from the workings as required by law. Rock dust had been applied over the loose coal and dust but was not adequate to protect against ignition of the dust.

July 28, 1944; Brilliant No. 2 Mine, Brilliant, N. Mex.; 6 Killed

(From Bureau of Mines report, by L. L. Naus, E. A. Morgan, and H. L. Scott)

About 11:00 a. m. the superintendent visited two men working on an overcast about 1,040 feet from the face of No. 5 south entry. A few minutes later he was with the assistant mine foreman in No. 7 east entry when the explosion was felt. They called the surface by telephone, and recovery operations were started immediately. Canvas was used to replace broken cinder-block stoppings and doors. Bodies of the 2 men at the overcast and of 2 electricians, a timberman, and a track layer were recovered in less than 3 hours. The first 2 bodies were at the overcast, and the 4 others were near a storage-battery locomotive at the top of a rise about 820 feet inby.

A stopping in the crosscut where the overcast was being erected had been removed that day, short circuiting the ventilation in No. 5 south entry and aircourse. Gas accumulated and was ignited by an arc from the controller of the locomotive when it was moved to the "off" position. The force of the explosion extended from the faces of the entry and aircourse to about 300 feet outby the overcast (fig. 139). Rock dust had been applied, and coal dust was not involved.

January 17, 1945, Bond Valley Mine, Haileyville, Okla.; 9 Killed

(From Bureau of Mines report, by R. D. Bradford and R. L. Ellis)

Nine men were working underground. At 1:00 o'clock six had left the working faces in the 6 east entry, the counter entry, and the longwall face above to eat lunch while the machine crew and the shot firer stayed to prepare more coal for loading. The machine crew cut about 30 feet on the longwall, which did not require blasting, and went down to eat. The shot firer loaded 1 hole in the lower side of the haulage-entry face and 1 hole in the upper side of the counter entry. He lit the fuses of both shots and had joined the other men on the entry when the explosion occurred at about 1:24 p. m. The explosion traveled from the entry face to the slope and up the slope to the surface, gathering force as it progressed. All stoppings between the intake and return airways were blown out; the concrete overcast at the month of 4 east was destroyed; all roof supports along the main slope and the return airway were blown out, causing extensive caves of roof; 40 feet of the slope portal was blown out, and the wooden air duct and fanhouse were blown apart (fig. 140). Help was called by the surface men, and officials of State and Federal agencies and other mines arrived to work with volunteer rescue men from other mines. Ventilation on the slope was restored for about 900 feet after teemporary repairs were made to the fanhouse and air duct. At that point the concentration of carbon monoxide became so high it was necessary to return to the surface. Additional repairs were made to the air duct and fanhouse, and time was allowed for the air to clear.

At 9:00 p. m. a party returned to the slope and noted a burning crossbar near the mouth of 6 east. This was extinguished with water by two men wearing gas masks, after which ventilation was restored to the face of 6 east. The bodies of the 9 men and a mule were found about 200 feet outby the face. All were removed by 9:00 a. m. January 18. The explosion was originated by the shot in the 6 east counter face, which blew out. Both of the shots were on the solid and were heavily loaded, probably with both 40-percent dynamite and a permissible explosive. Coal dust was ignited, and the thick deposits of dry coal dust on the slope and haulageways propagated the explosion (fig. 141, p. 204). No rock dusting had been done.

The mine was rated gassy, but apparently methane played a minor part in this explosion. Blasting off the solid when other men than the shot firer were in the mine was a violation of the Oklahoma mining law. A committee of the State legislature investigated this explosion and reported that there had been gross negligence by the operators. Seven of the 13 men working at the mine were the partners forming the cooperative company that leased the mine.

March 14, 1945; Kenilworth Mine, Kenilworth, Utah; 7 Killed

(From Bureau of Mines report, by W. B. Odendahl)

At 1:15 p. m. 16 men were working in No. 5 panel on the 3d east entry off No. 2 slope, when a severe bounce occurred in the pillar that was being mined next to the caved area. Although all of the electrical equipment in the panel was idle, the flying coal pulled the trailing cable of a loading machine with such force that it was severed and short-circuited on the edge of the pipe conduit entering the machine. An arc was formed that ignited the coal dust and methane in the air as a result of the bounce. Flame filled most of the area and burned 12 of the men severely. A shot firer just outside the flame was knocked down but not injured, and three timbermen also beyond the flame were not affected. The shot firer cut off power from the section and telephoned to the dispatcher for assistance. The injured men were given first aid and removed to the hospital. All men were sent out from other sections. Later seven of the injured died.

The coal thrown from 1 side of the pillar filled a crosscut to a depth above the tops of the cars, 50 inches high. A section of the pillar 60 by 40 feet had been thrown out to a depth of 6 inches below the roof. Sur-

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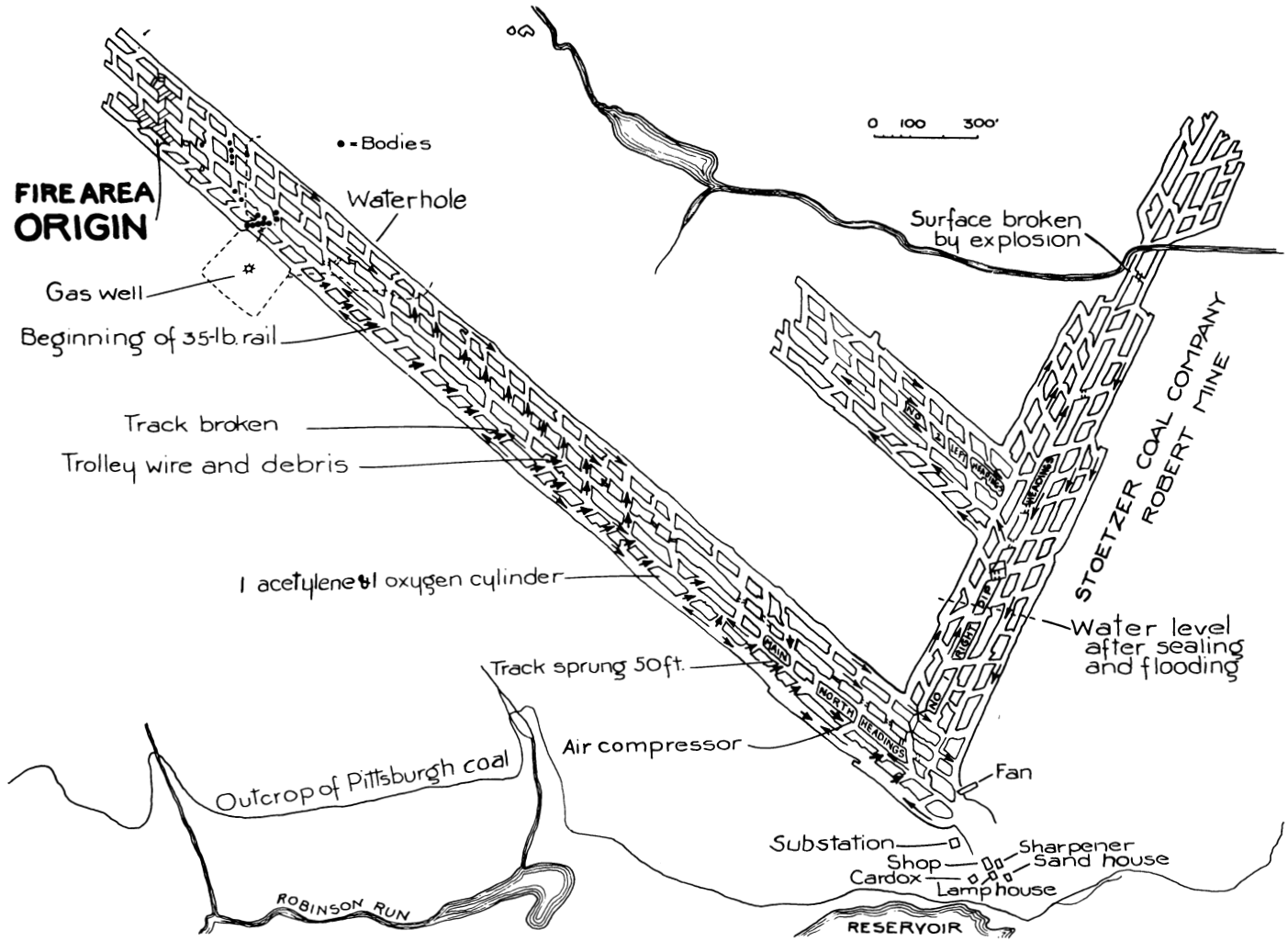

FIGURE 138.—Map of explosion area, Katherine No. 4 mine, Lumberport, W. Va., March 24, 1944. Flame and force extended over entire mine and 300 feet from portal.

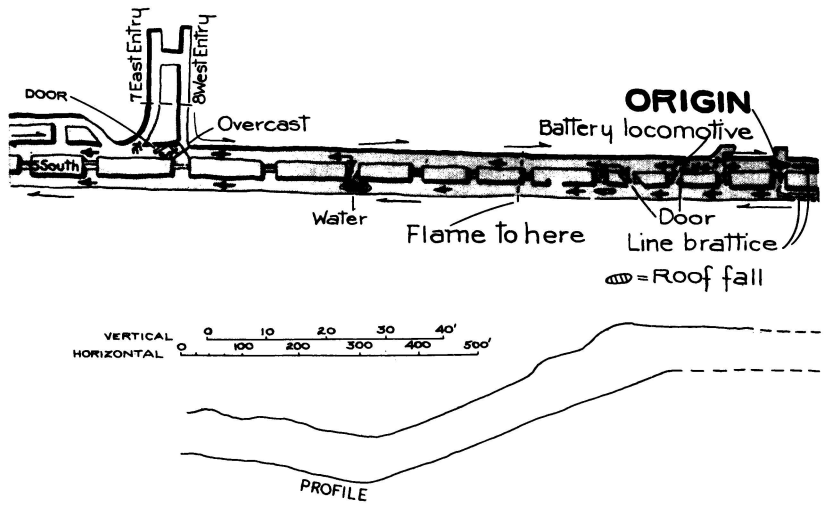

FIGURE 139.—Map of explosion area, Brilliant No. 2 mine, Brilliant, N. Mex., July 28, 1944.

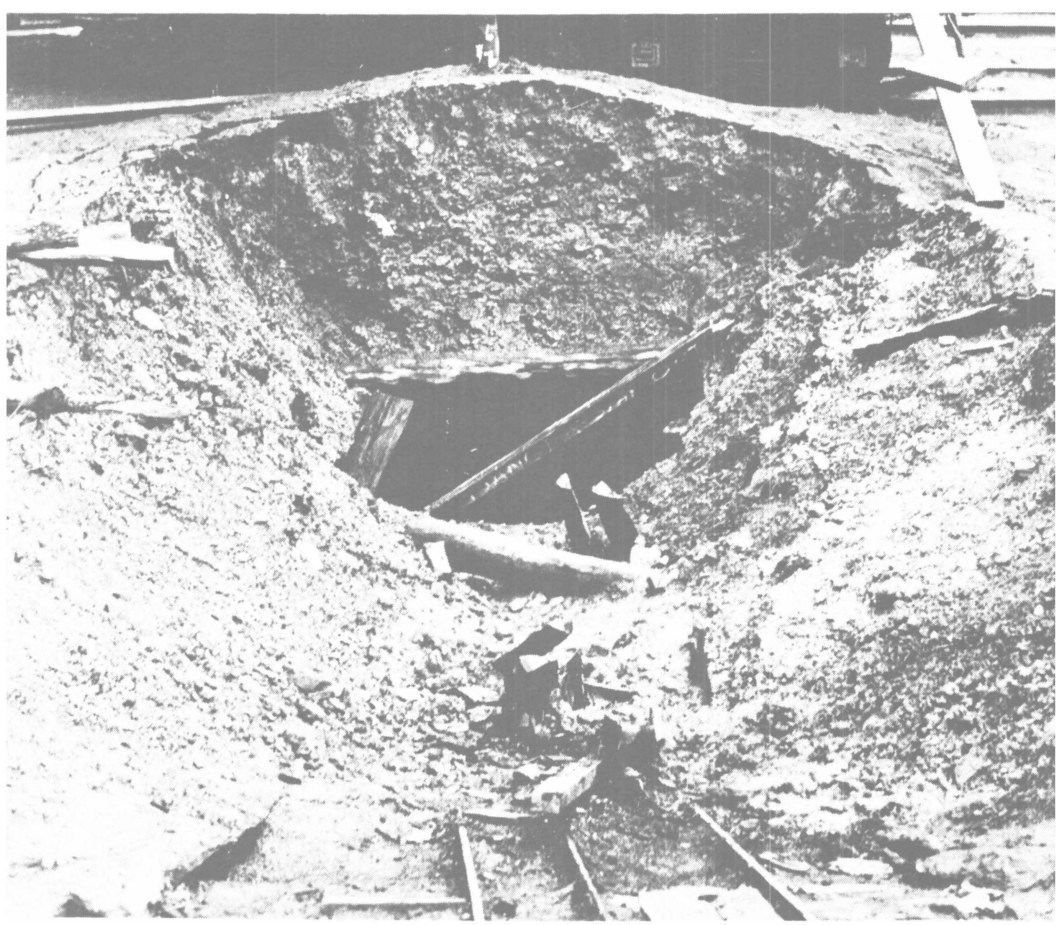

FIGURE 140.—Slope portal of Bond Valley mine, Haileyville, Okla., after explosion, January 17, 1945.

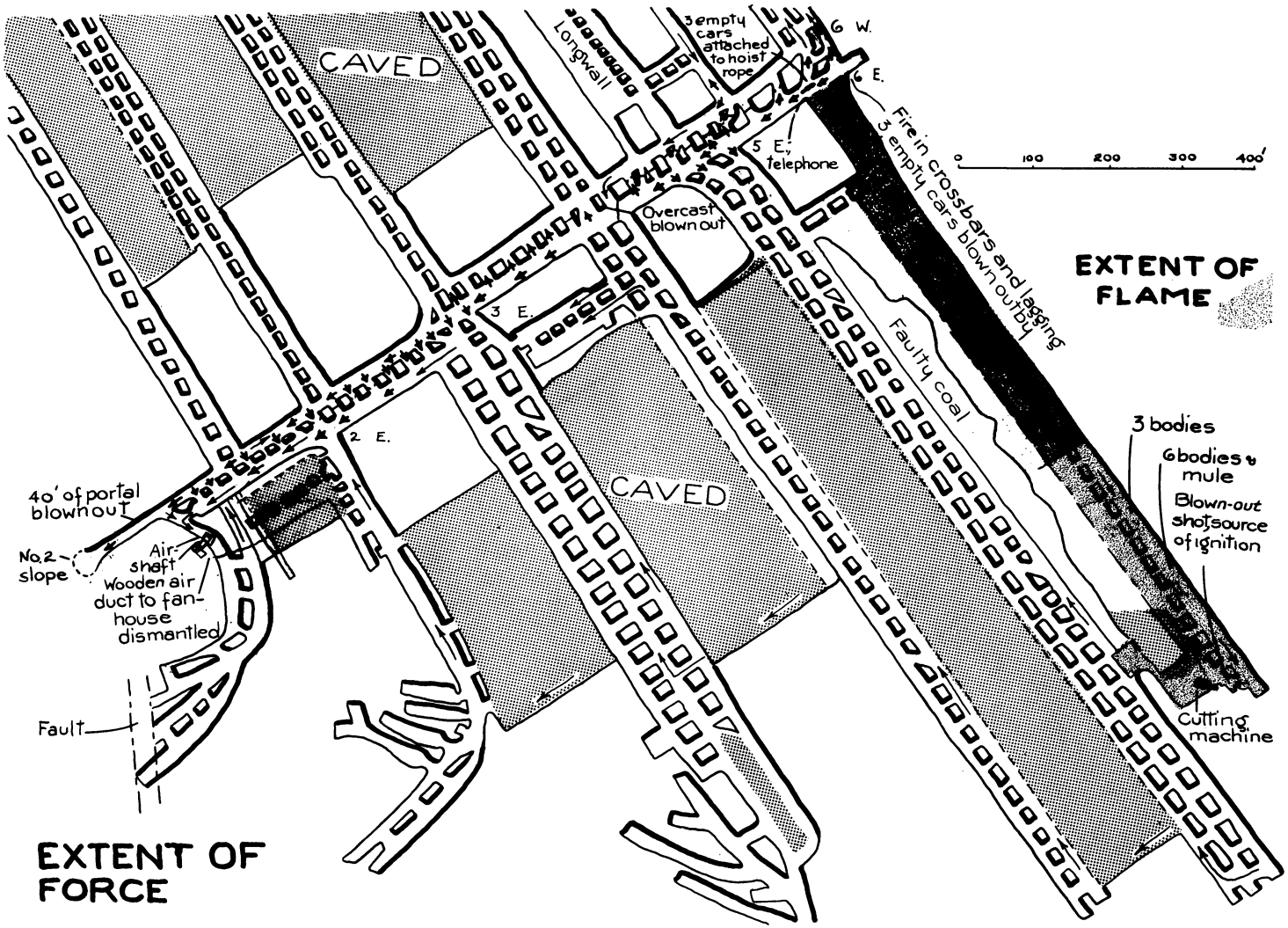

FIGURE 141.—Map of explosion area, Bond Valley mine, Haileyville, Okla., January 17, 1945.

vivors stated that the flame lasted 10 seconds or longer. The well-rock-dusted condition of the mine confined the explosion to the immediate area (fig. 142). As a precaution a method was devised later for grounding cables and fog nozzles were used to allay dust. Water saturation of pillars was also adopted.

May 9, 1945; Sunnyside No. 1 Mine, Sunnyside, Utah; 23 Killed

(From Bureau of Mines report, by R. D. Reeder and J. H. Bird)

At 3:12 p. m. an explosion killed 23 of the 85 men in the mine, and 7 were hospitalized; the other 55 escaped unassisted. The day-shift employees were preparing to leave their places when the mine foreman on the main haulageway at 1 dip felt a heavy concussion. He telephoned the surface and cut off the power from 1 dip and 2 dip sections at the circuit breakers near 1 dip hoist. He went to 2 dip and through dust and smoke to 1 right parting, finding several men, some alive and some dead. He came back to the haulageway and organized a small rescue party and led them down the dip to 1 right. The air had cleared somewhat, and they were able to revive 7 of the 11 men found. The injured were removed to a hospital. All of the 11 had been overcome by carbon monoxide and were not burned.

Rescue crews and leaders arrived and restored ventilation in the affected area and removed 19 bodies by the morning of May 10. Much of the work was done by oxygen-breathing-apparatus crews. Flame and violence were confined to part of 1 right and 2 left and 3 left entries off 2 dip. Doors, stoppings, and overcasts were destroyed, and timbers were dislodged. Gas had accumulated in the 3 left back entry from feeders uncovered by blasting earlier in the day. A line curtain had been put up to clear this face, but the curtain was found pinned up 2 or 3 times that morning. Other curtains and doors in the section were also opened and left open without regard for the effect on ventilation. The point of ignition was probably in the 3 left back entry near the leeast crosscut. The source of ignition may have been a carelessly handled flame safety lamp, an arc from the motor or switch at a pump, or smoking (fig. 143). Coal dust was raised and ignited, but the explosion was localized by rock dust that had been applied 4 days earlier.

December 26, 1945; Belva No. 1 Mine, Fourmile, Ky.; 25 Killed

(From Bureau of Mines report, by M. J. Ankeny, M. C. McCall, and C H. Dodge)

The mine power failed for a few minutes about 7:10 a. m., soon after the last man-trip entered the portal. On reaching 5 left off 9 right, 6 cars were placed in the 3 working places before the locomotive crew felt the explosion about 8:20 a. m. After gathering the other seven men in 5 left they started toward 9 right entry but were stopped by dense smoke at 1 left off 5 left. They then went back to 5 left and walked around to find a suitable place to stay. They entered 2 left off 5 left and stayed until about 4 o'clock that afternoon, when they made a futile attempt to find a way out through breathable air but found all openings into 4 left caved. They came back to 2 left off 5 left with difficulty, where they remained until about 9 o'clock on the morning of December 27, when they started out 5 left. They entered 9 right and walked nearly to 4 left, where the leader collapsed. Although the smoke had disappeared, the air still contained carbon monoxide and was low in oxygen. Two of the party dragged the man back until he was able to crawl, and all retreated to 2 left off 5 left. On their way they placed boards in 5 left with chalk-marked directions to their location in 2 left. About 11:30 a. m. they took an old door that had been torn off its hinges and pushed it over the opening to the room in which they took refuge. It kept out much of the smoke that was then entering. At times they felt considerable heat, but air kept coming in from some place on the aircourse. The changes in temperature and atmosphere were caused by the flaring up of fresh fires and their extinguishment and changes in ventilation made by rescue crews as they progressed against terrific hazards.

An electrician on the surface saw smoke and dust rolling out of the haulage portal at 8:20 a. m. He reported this to the superintendent and tried to close the circuit breaker in the substation, but it would not stay closed. The breaker had opened before the dust and smoke appeared. The superintendent notified State, Federal, and other mine officials who arrived during the day. The main fan continued to run, although the casing was moved inward about 3 inches by the detonation wave, but the stoppings between the haulageway and the intake airway were destroyed or damaged. The caved old workings used as the intake airway could not be traveled, so the fan was reversed at 12:30 p. m., and work was started on rebuilding stoppings with the few men available. An exploration party traveled about 2,000 feet of the main haulageway and extinguished several small fires.

During the recovery work at least 22 fires were found and extinguished. In order to obtain enough air to clear the smoke from the haulageway beyond 7 left, tight wooden stoppings had to be built in about 50 outby crosscuts. Gas-mask crews explored the caved workings and put out fires. While ventilation was being restored on the straight main haulageway inby 9 right, an exploration of 9 right was made for 1,000 feet before encountering heavy afterdamp. Caved airways prevented exploration from the straight mains and greatly reduced the air flow. An exploration party in 9 right on December 28 found footprints at 4 left and noted chalkmarked boards, indicating that men were in 1 left off 5 left. The door over the room entrance was moved, and the unconscious men were found about 1:30 p. m. The advance party, without gas masks, became distressed, and some were unable to walk. Help was summoned, and the ventilation was changed to put fresh air into 5 left and then into 9 right. One of the 9 men was dead; the 8 survivors were given oxygen and other treatment in the mine and removed to a hospital; 1 died the second day, another after several months, and the other 6 men lived.

Attempts to force air into 6 left and explorations by oxygen breathing apparatus, and gas-mask crews were halted when a fire about 2,000 feet from the portal destroyed a stopping. The fire was extinguished and the stopping rebuilt. Gas-mask crews reached the entrance to 6 left section, but ventilation was inadequate to clear the afterdamp and methane encountered. It was evident that no victims could be alive in the section and that the situation had become too dangerous for further recovery work because of gas and fires. The mine was sealed at the drift mouth on January 3, 1946.

On August 5, 1948, the seals were removed, and the fan was operated. Falls were cleared and stoppings repaired. By October 21, 20 bodies were found and removed, making a total of 25 dead of 31 men who were in the mine (fig. 144, p. 208). The explosion was not violent, except in the 6 left aircourse off 9 right. At this location, a blower fan, a conveyor-drive unit and loading head, and the wiring and controls were moved violently and damaged by the forces. Elsewhere all but 3 stoppings between the main intake and return airways were destroyed and several doors were smashed.

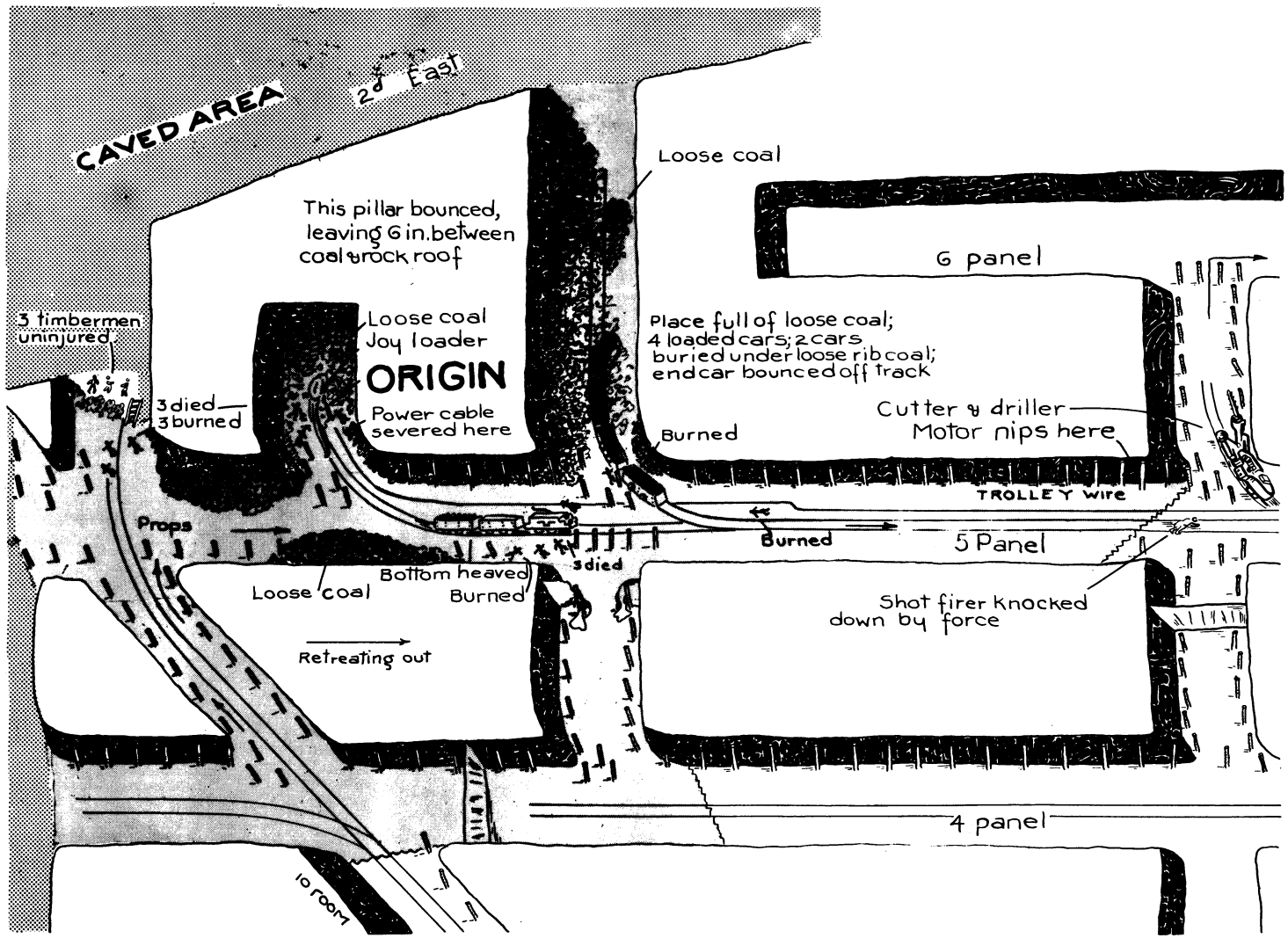

FIGURE 142.—Sketch of explosion area, Kenilworth mine, Kenilworth, Utah, March 14, 1945.

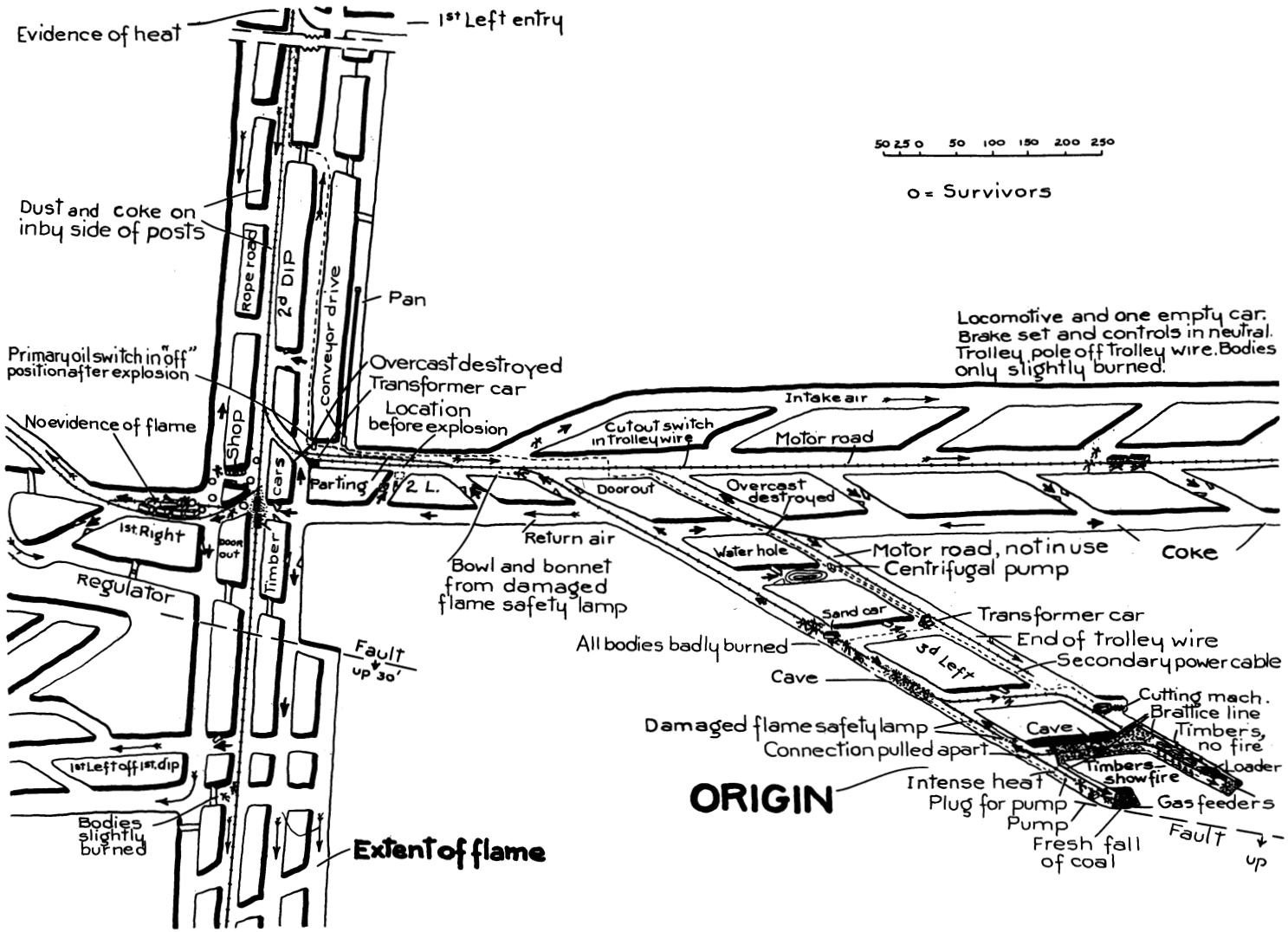

FIGURE 143.—Map of explosion area, Sunnyside No. 1 mine, Sunnyside, Utah, May 9, 1945.

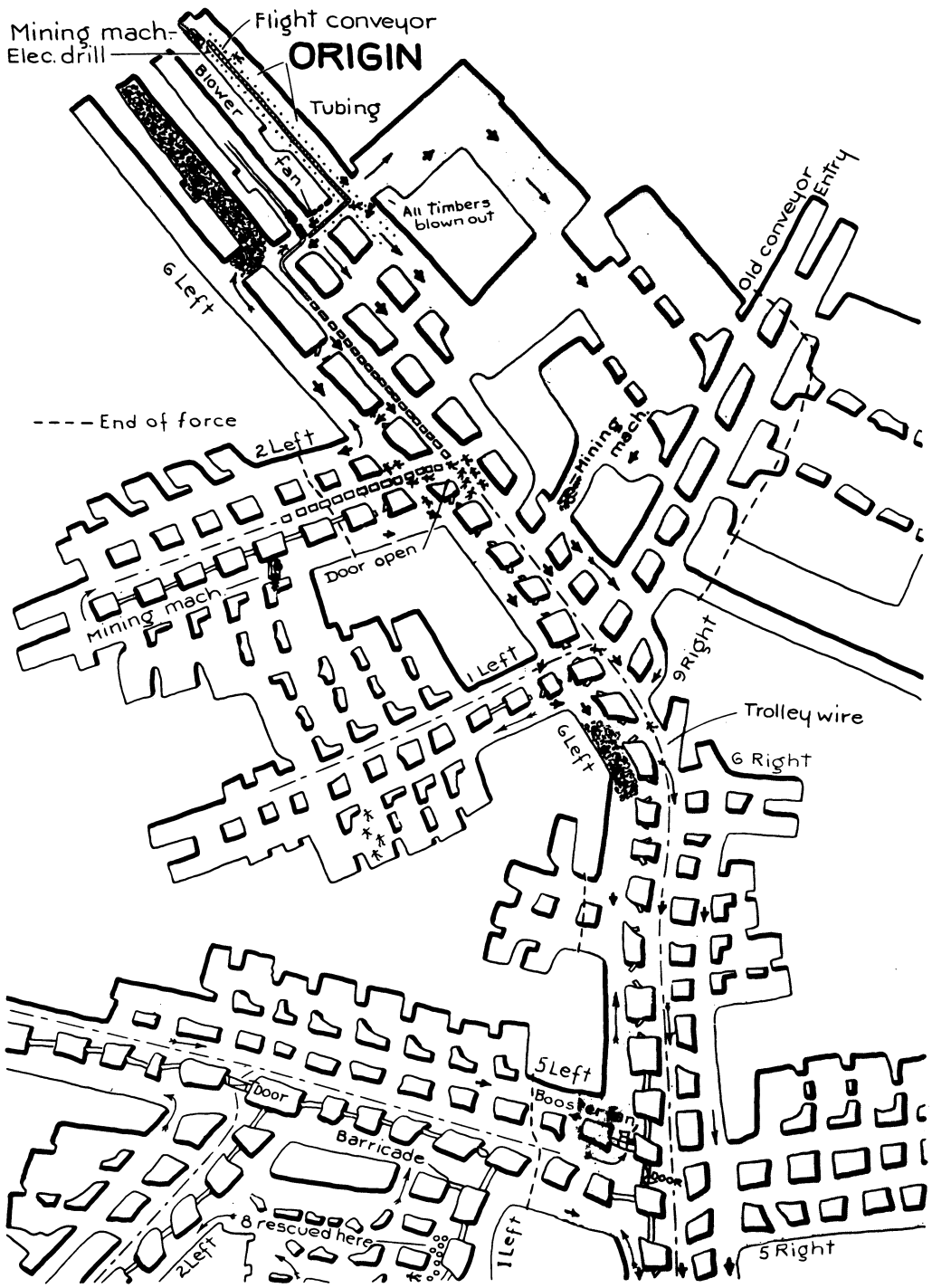

FIGURE 144.—Map of explosion area, Belva No. 1 mine, Four Mile, Ky., December 26, 1945.

Flame traversed the open entries from the face of 6 left to the portal. A blower fan in the right aircourse of 6 left entries supplied air to the face through tubing but was placed so that air was recirculated. The fan was operated only while men were at the face. A gas feeder was noted in this face on the last working day, 64 hours before the explosion. No inspection had been made before the explosion. Gas accumulated in this working place was ignited by a man lighting a cigarette or by an arc from the motor of the blower fan (fig. 145). Smoking was practiced without restriction, and all electric equipment except the cap lamps was open type. Dust propagated the explosion. The mine was dry and dusty and was not rock-dusted.

January 15, 1946; Havaco No. 9 Mine, Havaco, W. Va.; 15 Killed

(From Bureau of Mines report, by M. J. Ankeny, J. L. Gilley, and John Zeleskey)

The explosion occurred at 9:35 a. m. when the only official on the surface was the outside foreman in the foreman's office. The forces coming from the main hoisting shaft demolished the concrete mine office and waiting station; the shops and the supply, bath, and lamp houses were damaged; the headframe and tipple were bent and partly demolished (fig. 146). Other surface buildings were also destroyed or damaged.

The outside foreman and other surface employees were severely injured.

The store manager called the telephone operator in Welch and asked her to notify the State mine inspector and general office of the company. The news was broadcast by radio, and officials and mine rescue men responded. The company safety director arrived shortly after the explosion and went down the escapeway and intake airshaft, meeting survivors on their way up. He found the weigh office at the shaft bottom destroyed and a number of injured men. He went into the main dip haulageway where there were other injured men, but as the air was clearing rapidly and men could travel the haulageway safely he came back and directed removal of survivors and treatment of the injured. Help arrived promptly, and the workings were explored and three fires extinguished. All men and bodies were out of the mine by 4:00 p. m.

Loose rock over the empty branch track about 640 feet west of the hoisting shaft had been blasted by placing 4 cartridges of 40-percent dynamite between the loose slab and the main roof and firing the shot. Fine coal dust about the bottom and up the shaft to the tipple was ignited, causing much flame and violence (fig. 147, p. 212). Of the 270 men in the mine, 234 escaped unaided, 24 were injured and were rescued, 12 were killed and 3 of the injured died later in the hospital. Twelve surface employees were seriously injured. The mine was dry to wet and had been partly rock-dusted.

April 18, 1946; Great Valley Mine, McCoy, Va.; 12 Killed

(From Bureau of Mines report, by M. J. Ankeny, and H. E. Sanford)

The general manager was in the main haulageway at 10:45 a. m. when the explosion occurred. He felt the concussion and went to the surface to summon help. The mine foreman in 14 east felt the shock and went to find where it came from. He found smoke and gases blocking his way into 16 east and returned to the main haulageway to organize a crew to restore ventilation and to send the other men out. Additional men and supplies were sent in about noon. After damaged overcasts and stoppings along the main haulageway and 16 east haulageway were repaired, an injured survivor was found and taken to a hospital, where he died a few hours later. Eleven bodies were recovered by 6:00 p. m.

The explosion originated in a crosscut near the face of 16 east, and flame extended only a few hundred feet. The forces destroyed stoppings and doors and damaged an overcast at the mouth of 2 east 4,700 feet from the origin. Gas released from a fault in the face of the crosscut by a shot or partly accumulated there was ignited by an arc from the controller of a storage-battery locomotive in 16 east near the crosscut. Coal dust was not ignited as the coal is semianthracite. Details are shown on figure 148 (p. 213).

January 15, 1947; Nottingham Colliery (Anthracite), Plymouth, Pa.; 15 Killed

(From Bureau of Mines report, by C. H. Weber, R. W. Stahl, and H. A. Schrecengost)

The night-shift crew drilled and blasted two holes in the face of chamber 49 off road No. 30 airway. These shots broke an opening into the face of chamber No. 3 off No. 10 tunnel, south rise gangway. The abandoned No. 10 tunnel workings were inaccessible, and methane had collected in the chambers. This methane pulled into chamber 49 and the adjoining places. At about 4:45 p. m. an explosion killed 15 of the 22 men in the section; 3 were injured, and 4 escaped unharmed. Flame spread through chambers 45 to 52 and the gangway and airway from chamber 44 to the faces. Equipment and workings were damaged heavily near the entrance to chamber 49, the force diminishing in all directions from this point. The injured men made their way out and notified the fireboss and other officials. Two men made short trips with oxygen breathing apparatus to see that there were no fires before ventilation was restored. Thirteen bodies were recovered by midnight, and the 2 others were found under falls and removed by January 21.

The maps given to the foremen were in error, as they showed a distance of about 50 feet between the faces of the chambers on the day before the explosion. It was found that chamber 3 had been driven 40 feet farther than was shown on the map (fig. 149, p. 214). The source of ignition was an arc from electric equipment or possibly smoking.

March 25, 1947; Centralia No. 5 Mine, Centralia, Ill.; 111 Killed

(From Bureau of Mines report, by M. J. Ankeny, W. A. Gallagher, F. J. Smith, Frank Perz, and J. S. Malesky)

At 3:26 p. m. the assistant mine superintendent was in the powerplant when the fuse in the fan power circuit blew out. Knowing that something had happened in the mine, he telephoned to the district mine inspector and had the mine office call the State mine rescue station; calls were also made to bring other State rescue teams. He went down the shaft and found dust and smoke at the bottom. With the mine manager he organized rescue attempts by the men at hand to bring out survivors. As assistance arrived from outside, rescue teams were sent in to bring out survivors, explore ahead of fresh-air crews, and locate bodies. All stoppings and doors inby 15 north 1 west and the stoppings between 20 and 21 north off 4 west were destroyed (fig. 150).

The stoppings were replaced by temporary seals, and the last body was recovered by 5:30 a. m. March 30. At the time of the explosion 142 men were in the mine. Of these, 65 were killed by burns and violence and 45 by afterdamp. Eight men were rescued but 1 of these died from the effects of afterdamp. The other 24

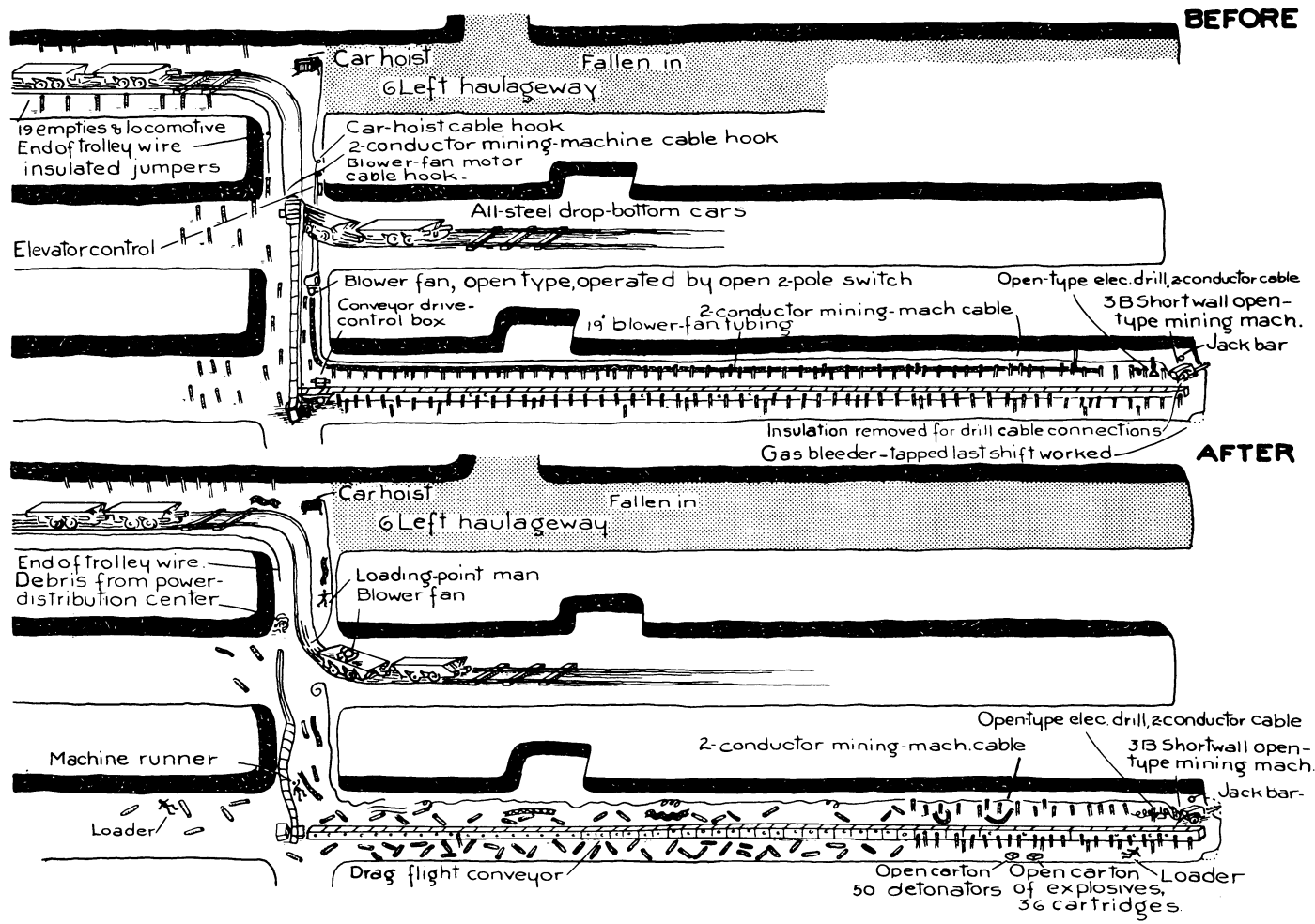

FIGURE 145.—Sketch of origin of explosion, Belva No. 1 mine, Four Mile, Ky., December 26, 1945.

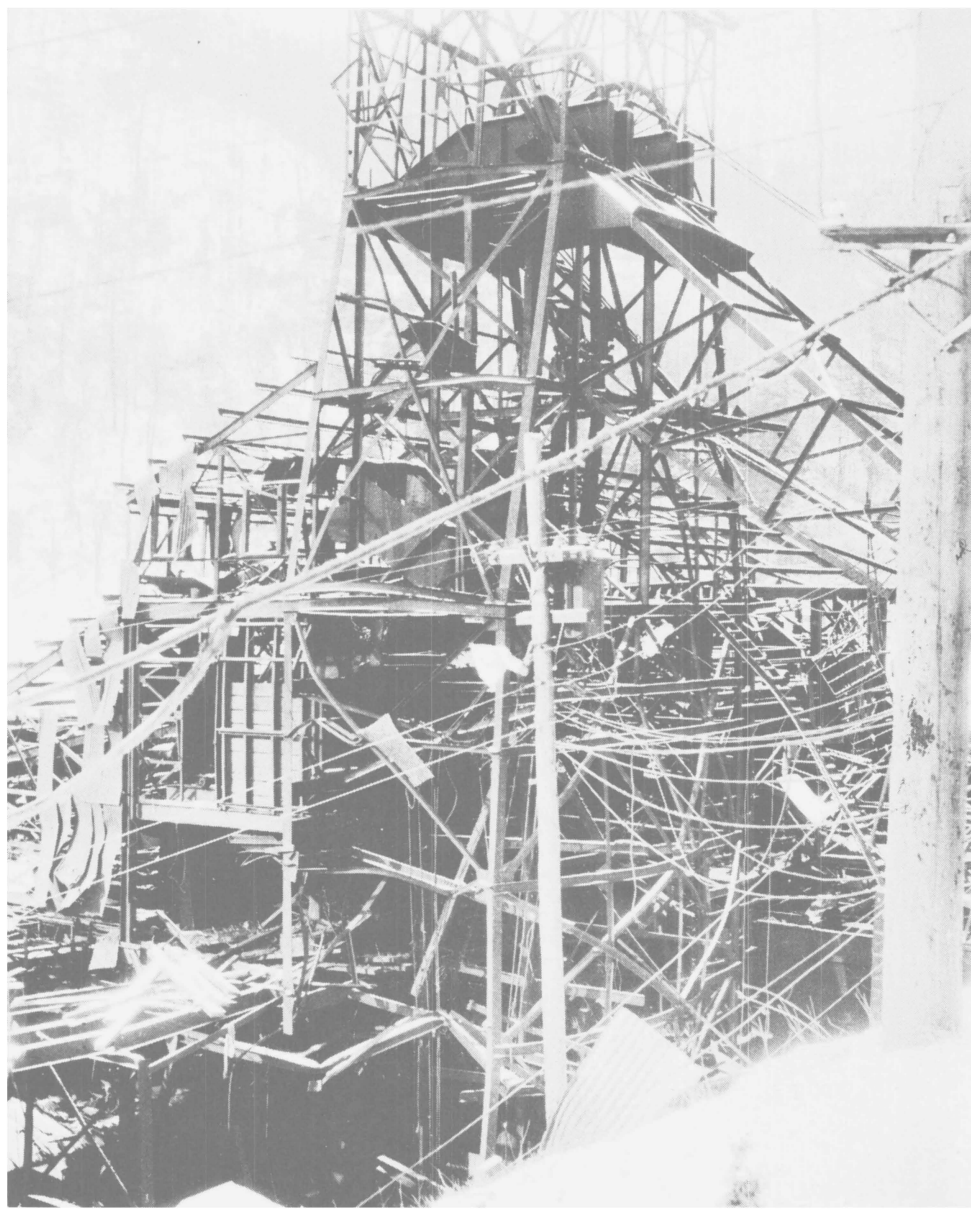

FIGURE 146.—Tipple and headframe, Havaco No. 9 mine explosion, Havaco, W. Va., January 15, 1946.

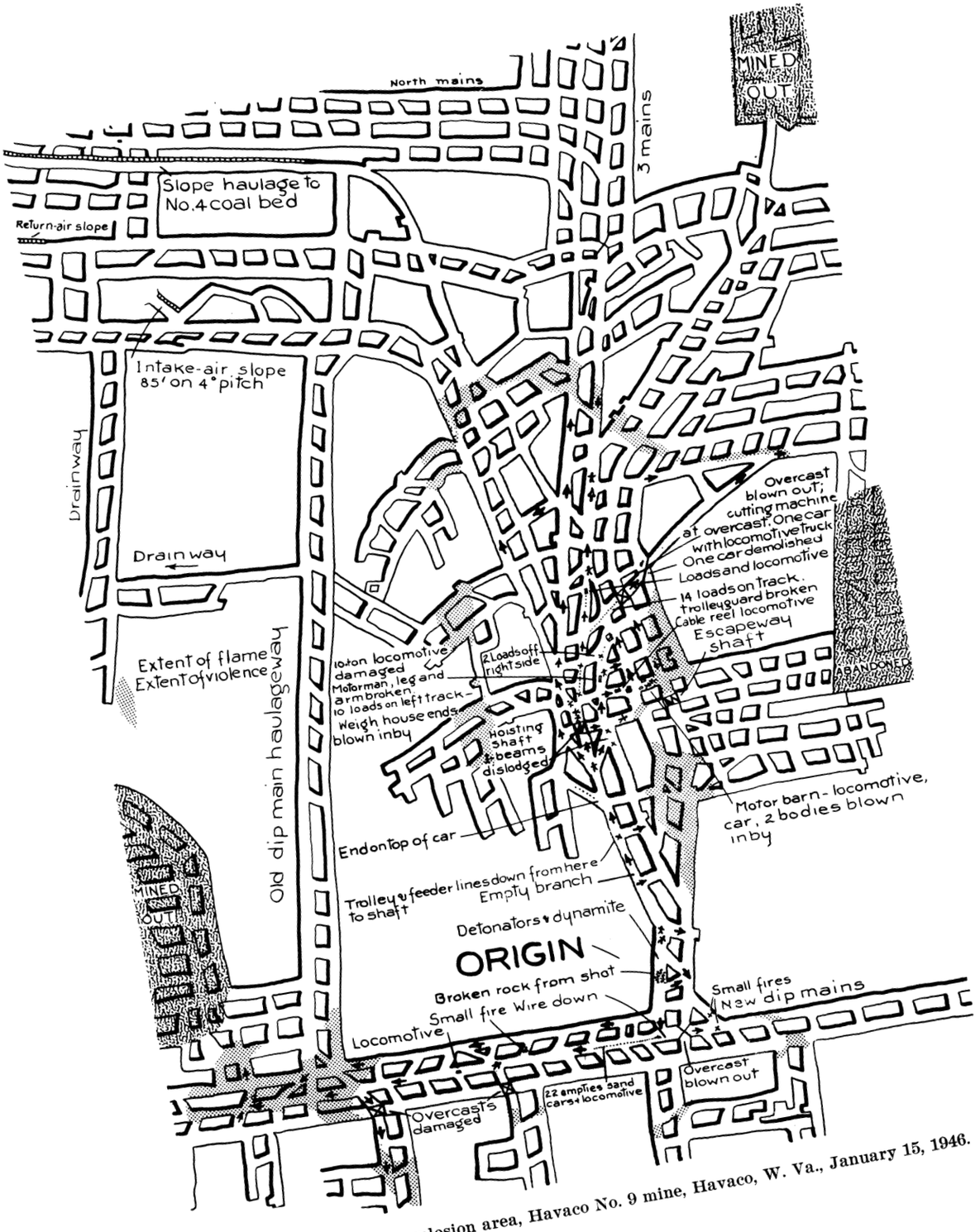

FIGURE 147.—Map of explosion area, Havaco No. 9 mine, Havaco, W. Va., January 15, 1946.

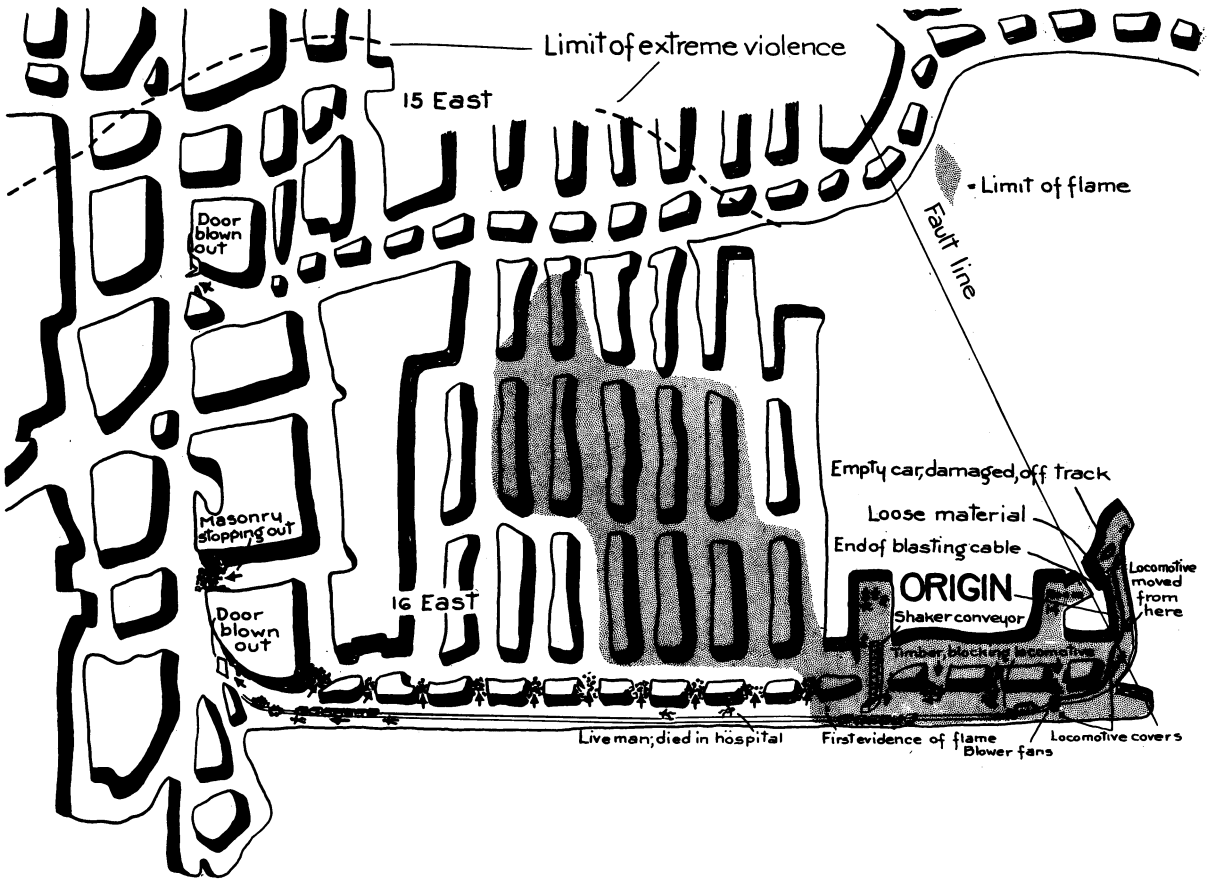

FIGURE 148.—Map of explosion area, Great Valley mine, McCoy, Va., April 18, 1946.

escaped unaided. The explosion probably originated at the face of 1 west and spread north and south through the first openings to the right and left (fig. 151, p. 216).

An underburdened shot or a blown-out shot stemmed with coal dust ignited dust, and the explosion was propagated by coal dust through workings to the north, south, and east from the junction of 1 west. Four of the 6 working sections were affected by the flame and violence of the explosion. The two remaining sections were affected only by the afterdamp resulting from the combustion of coal dust. Forces were extremely violent in some portions, while in others the velocity of the explosion was so slow that there was little evidence of its direction. Flame extended from the face of 1 west and the adjacent workings to a point about 800 feet from the faces of 1 and 2 west. Flame also traversed the 20, 21, and 22 north entries off 4 west, the active rooms off 20 and 22 north and other rooms and parts of 17, 18, 19 north.

The explosion was localized and confined when it reached the rock-dusted zones on the entries. It traveled through all the active rooms and some abandoned rooms, none of which had been treated with rock dust, but it failed to propagate through old workings that were partly caved and in some parts filled with incombustible roof rash brought there from open entries by means of shuttle cars. Large areas of open workings gave relief of pressure.

The mine was exceedingly dry and dusty, and heavy deposits of coal dust were present along the roadways and on the roof, ribs, and timbers in working places and entries. Very little effort had been made to load out excessive dust, and water had not been used to allay the dust at its source. Rock dust had been applied on active haulage entries but was not maintained close enough to the faces and was not applied in rooms. In active entries rock dusting terminated from 500 to 1,000 feet from the faces. Permissible explosives were used in blasting, fired by fuse and detonators. Carbide lamps were used to light the fuse. The holes were stemmed with coal cuttings and some clay. Pairs of drillers drilled and charged shot holes during the shift. Six holes, 2½ inches in diameter and 8 feet deep, were drilled in entries or crosscuts. Bottom holes were 3 feet from the floor and top holes 2½ feet higher. Fuse was trimmed to obtain the desired order of firing. Charges were from 1 to 2 pounds. Shots were fired near the end of the working shift when the other employees were at the man-trips or en route to them.

At the time of the explosion most of the men were at the man-trips on the entries waiting for the shot firers to complete lighting the shots so that the shot firers could ride to the shaft bottoms on the man-trips. The dusty conditions of the mine and the blasting procedures were contrary to the State mining law and to the Federal Mine Safety Code under which the mine was being operated by the Coal Mines Administrator (*41; 61, pp. 4–11*).

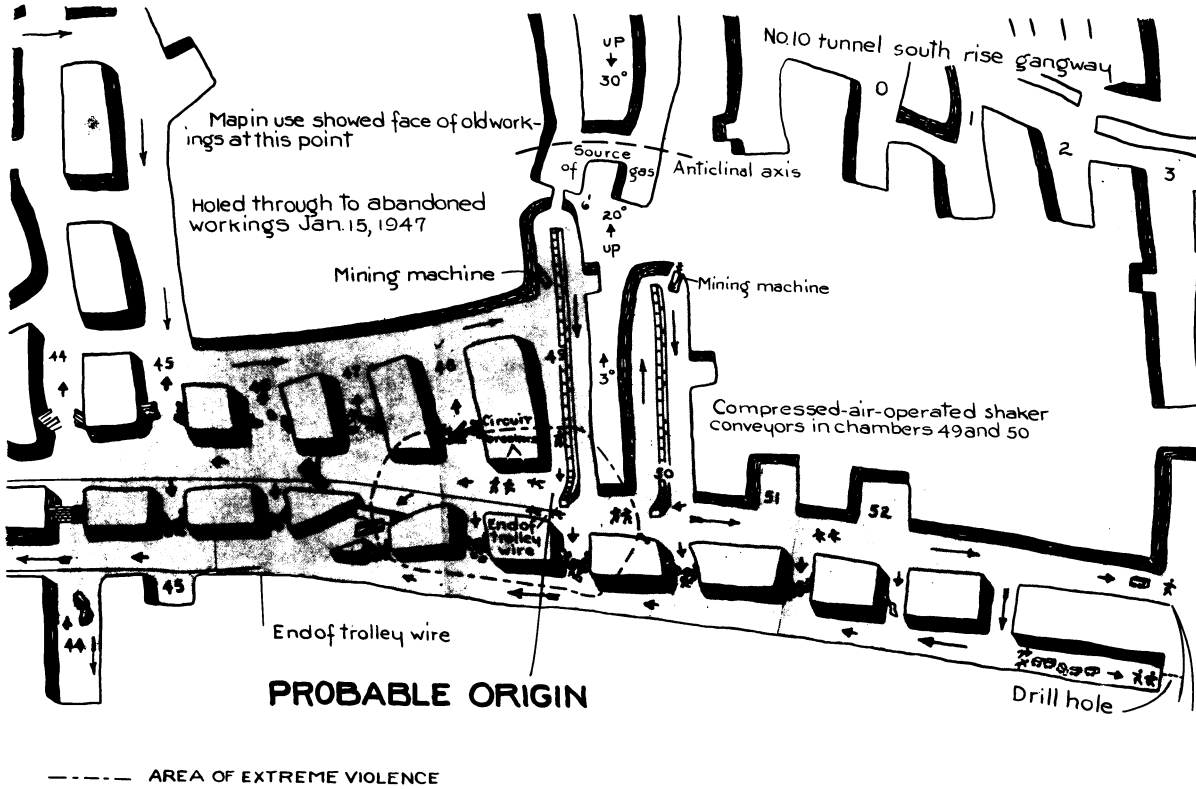

FIGURE 149.—Map of explosion area, Nottingham Colliery, Plymouth, Pa., January 15, 1947.

April 10, 1947; Schooley Shaft (Anthracite), Exeter, Pa.; 10 Killed

(From Bureau of Mines report, by E. H. McCleary, C. F. Weber, W. S. Eltringham, and B. L. Curry)

The day shift of the working force in the Marcy vein (17 men) entered the mine at the usual time, and some had reached their working places and started to work when the explosion occurred at 7:05 a. m. Preshift examinations were not always made, and the men sometimes were not checked in at the shaft bottom. The superintendent was near the surface landing of the shaft, and he saw dust, smoke, and debris blown up the shaft. The headframe and the cages were not damaged, so he went down after telling the clerk to call the State mine inspectors and other assistance. He met the mine foreman and other men at upper landings, and they were lowered to the Marcy landing. A survivor walked out of the explosion area, but they were unable to enter the contaminated air. After opening a door to the Ewen colliery to get more air they proceeded and found dead and injured men and three more survivors walking out. Rescue teams arrived and were sent in, as the afterdamp prevented further exploration. Ventilation was restored, and the dead and injured were removed by 11:30 a. m. Nine were killed or died shortly after reaching the hospital; 1 injured man died 3 days later.

Ventilation was weak, and methane issued from crevices in the floor in finished workings. It also filtered through cinder-block stoppings into the haulageway where it was ignited by an arc from a hoist or by smoking (fig. 152, p. 217).

April 30, 1947; Kerns Mine, Terre Haute, Ind.; 8 Killed

(From Bureau of Mines report, by M. J. Ankeny, W. A. Gallagher, L. W. Kelly, and J. S. Malesky)

On March 6, 1947, a local coal-dust explosion in the mine resulted in the death of the shot firer, who was the only man in the mine, firing shots off shift, as was then the practice. On March 21, the Coal Mines Administrator acted on the Bureau of Mines report on this explosion and ordered the operating manager of the Kerns mine to conform to the Federal Mine Safety Code, particularly with the section relating to requirements under which blasting with black powder was permitted.

On April 3, 1947, the Administrator's order closing 518 coal mines was issued, in which the Kerns mine was included. On April 7 the operating manager arranged with the district and local union officials to permit men to work in the mine to drive a new aircourse entry through old workings and to perform other work necessary to bring about compliance with the Code. This was done with the sanction of the Administrator and the Bureau. Only the men needed for such work were to be allowed in the mine, and any blasting was to be done by a shot firer after all other men were out of the mine.

On April 9 work on these improvements was started, and some rock dust was applied by hand to the haulageways during the next 3 weeks. In addition to the work necessary to comply with the Code, four loaders and a driver were put to work driving entries and producing coal in 1 and 2 main south entries and 1

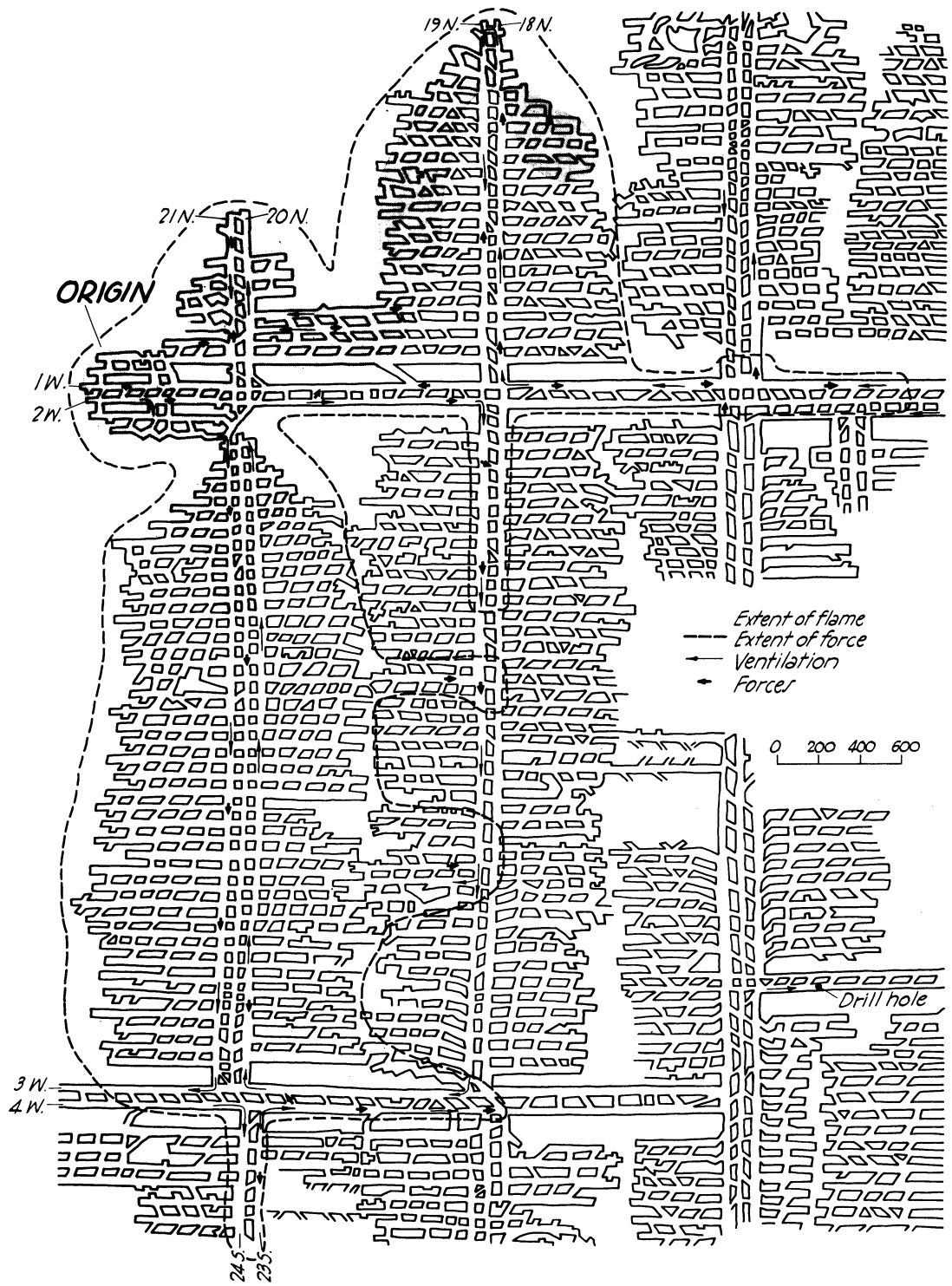

FIGURE 150.—Map of explosion area, Centralia No. 5 mine, Centralia, Ill., March 25, 1947.

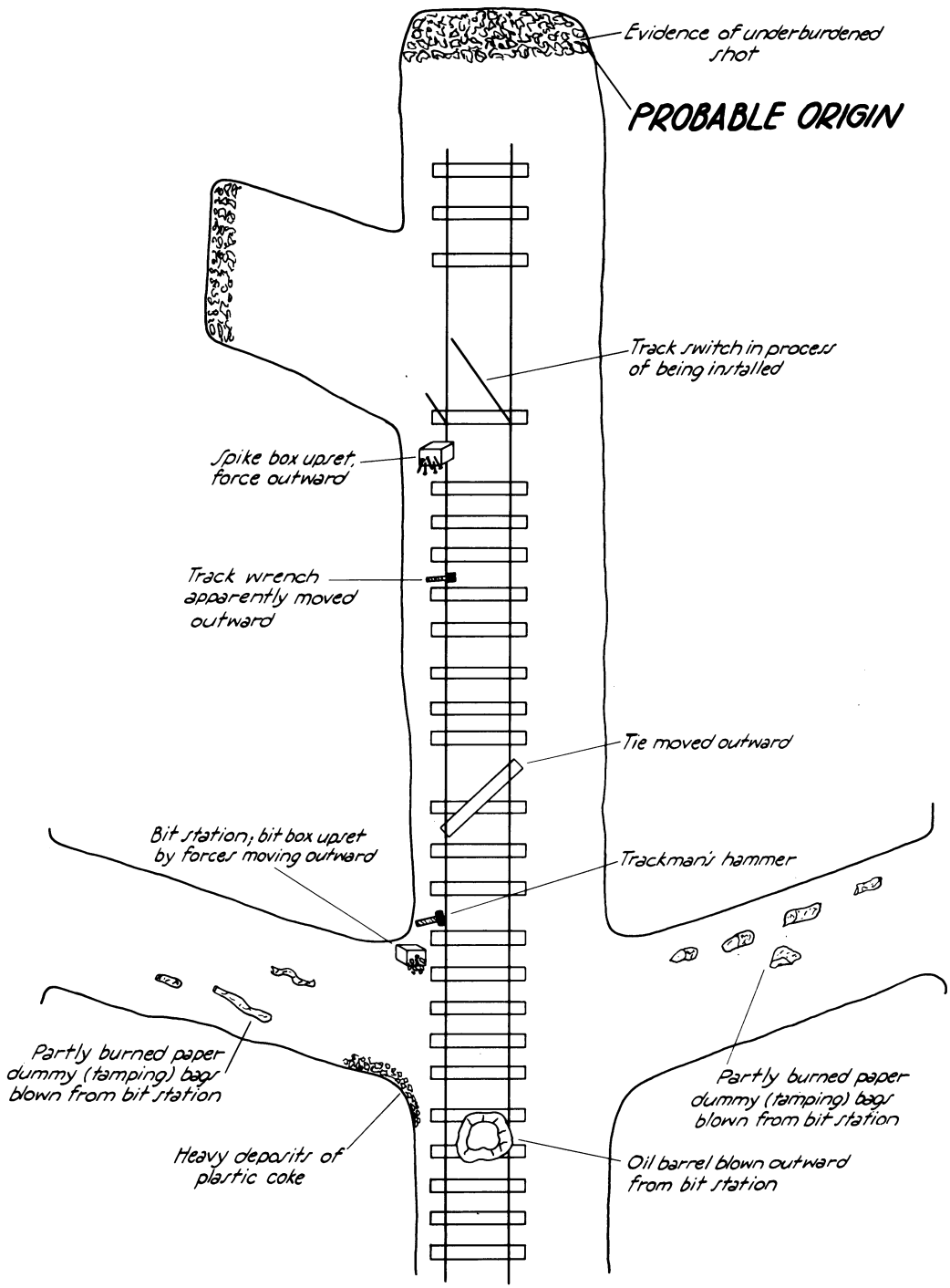

FIGURE 151.—Sketch of Centralia No. 5 mine; evidence of explosion near face of 1 west.

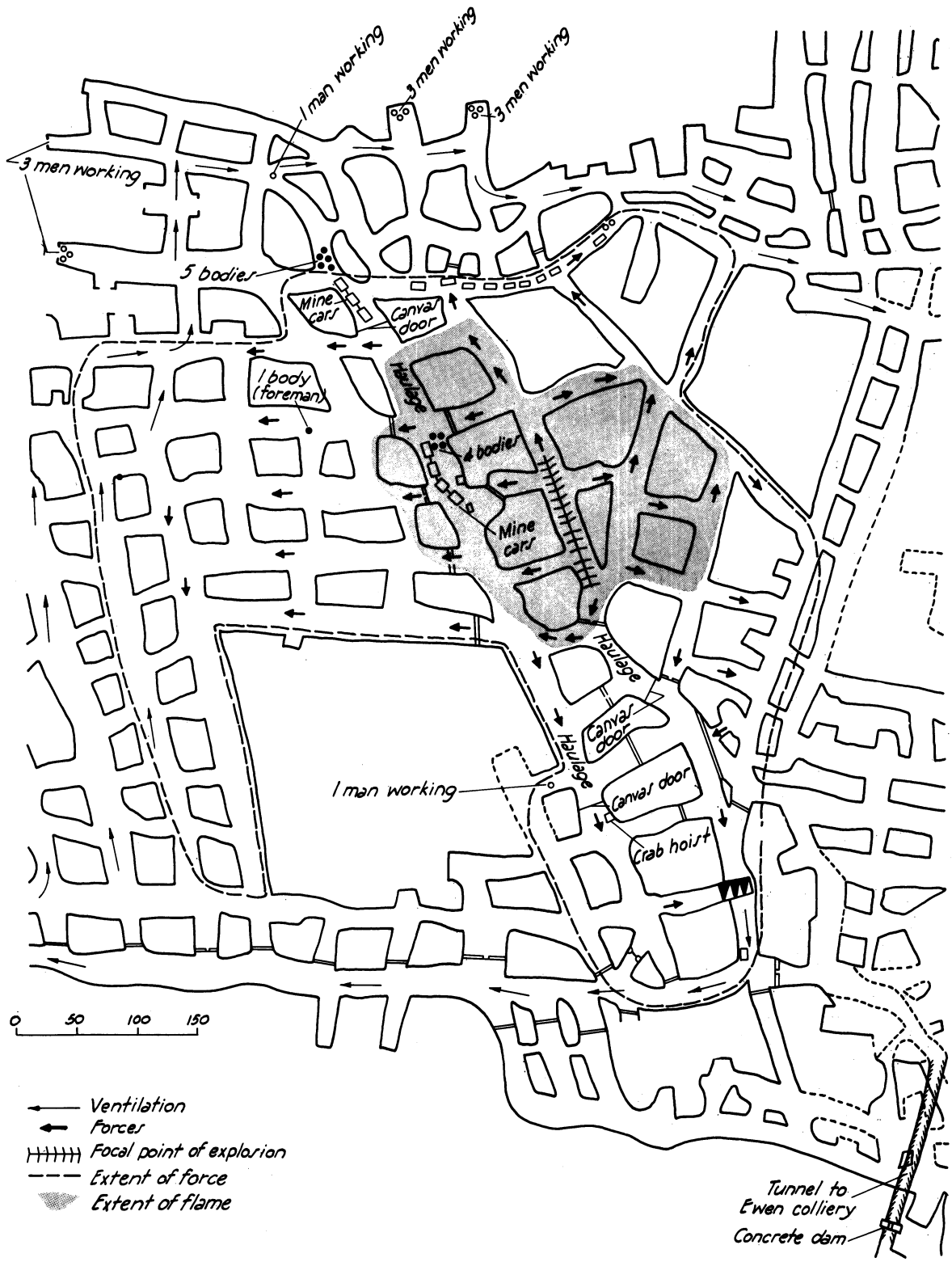

FIGURE 152.—Map of explosion area, Schooley shaft section, Schooley colliery, Exeter, Pa., April 10, 1947.

and 2 east entries off 2 main south, and shots were fired by miners at the end of the shift while the shift was still in the mine. This work was done surreptitiously and in violation of the order and the agreement.

On the day of the explosion 6 men were doing the agreed work to correct dangerous conditions, and 4 men were producing coal without relation to improvement of safety conditions. At 2:47 p. m. three men near the shaft bottom heard the explosion and felt a pressure of considerable force. They came to the surface and State officials were notified. Help was called, and as men arrived work was started to restore ventilation. Intake air entered the fanshaft, and haulage roads were on return air. Temporary brattices were erected working through the intake aircourse. The 8 bodies were all found within a space of 200 feet along the new aircourse entry, and all bodies were removed about midnight. Because of a fire later found to be in two stoppings in the 1 and 2 west entries off the main south, the mine was sealed on the surface at the shafts by 5:00 a. m. May 5. The seals were opened on August 5, 1947, and an investigation was made of all the working places. The origin of the explosion was at the face of No. 1 main south entry, where the last of three shots had blown out, igniting coal dust.

The shots on the solid were overloaded with black powder and were stemmed with mixed coal dust and clay. The explosion caused only moderate damage. The stoppings from 1 and 2 east entries to the shaft bottom were damaged or blown out, and two doors in 1 and 2 main south entries were damaged (fig. 153).

July 24, 1947; Old Ben No. 8 Mine, West Frankfort, Ill.; 27 Killed

(From Bureau of Mines report, by W. A. Gallagher, W. R. Chick, H. C. Brumbaugh, and T. C. Higgins)

The mine was working normally, and the mine examiners reported all places to be in safe working condition. At 12:35 p. m. the trapper at the 11 east on the main south noticed smoke and dust coming from 13 and 14 east. He cut off power from that section and called the mine manager at the shaft bottom by telephone. Mine officials and the State inspectors, and the Benton and Herrin mine rescue stations and the Bureau of Mines were notified. Mine officials went in to 13 east and found 4 men burned and dazed and 1 dead. These men were removed to the surface promptly. Working from the intake airway in 14 east, canvas brattices were erected in crosscuts where stoppings and doors had been demolished. Twenty-five other bodies were found and removed by 11:30 p. m., the remainder of the 30 men that were at work in the section. One of the injured men died in the hospital.

As the area was squeezing and a fire was smoldering, the equipment was removed, and seals were placed at the entrance to 13 and 14 east the next day. Only a small part of the 13 and 14 east section was affected by the flame and violence of the explosion. The afterdamp passed directly into the main return and did not affect other working sections. The forces were violent in some portions of the explosion area but diminished rapidly owing to expansion into abandoned workings. Recent liberal applications of rock dust limited spread of the explosion.

Pillars were being extracted, and a large area inby the seat of the explosion was worked out and abandoned. The area was squeezing and was not ventilated. The explosion was caused when methane, accumulated in the abandoned area, was forced out on the cross entry and was ignited by an arc from a gathering locomotive or by smoking (fig. 154). The local ventilation may have been disturbed by one of the single doors being left open. The workings were dry and dusty and coal dust entered into the explosion inby the rock-dusted zones on the entries. Bags of rock dust were suspended in the airways outby the active working area. A few were tripped, but the dust fell to the floor without being dispersed and did not help to limit the propagation.

December 11, 1947; Franklin Colliery (Anthracite), Wilkes-Barre, Pa.; 8 Killed

(From Bureau of Mines report, by C. F. Weber, D. M. Hart, and W. S. Eltringham)

Two explosions about a minute apart occurred in the Ross vein workings in the No. 9 slope section at approximately 11:10 a. m. The section foreman and the fireboss were leaving adjacent workings when they heard a heavy rumbling, and the air became filled with dust. They went into the affected section, where they first saw the body of the slope footman and a fire at the bottom of the slope. They got wrenches and disconnected the waterline, connected hose, and put out the fire. They went on and met a miner's helper who had escaped uninjured and then found other dead and injured men.

Meanwhile, word had been telephoned to the surface, and help had come into the mine. The dead and injured were brought out, and other small fires extinguished by men using oxygen breathing apparatus. One body was not found until after midnight, because of falling roof on the gangway that had to be cleared and timbered. Of the 9 men in the explosion area, 5 were killed instantly, 3 died later in a hospital, and 1 escaped uninjured. Eleven workers in nearby workings also escaped unharmed. Brattices, stoppings, and doors along road 859 and in the old workings were destroyed or damaged, and timbers were blown out causing roof falls.

A large accumulation of methane existed in the old workings in the return of road 859. The coal had pinched out at a fault at the faces of eight chambers off the return road, and they were abandoned. The main ventilating door was latched open, causing a short circuit of the ventilation, but did not bring the gas into the places where men were working. A rush of coal occurred in chamber 4 shortly before the explosion. Methane was liberated, which spread into chamber 5 because, with the open door, the air current was reversed. When the miner operated the controls of a conveyer, an arc ignited the gas. The disturbance caused by this explosion brought gas from the large accumulation inby No. 22 chamber into contact with a fire set by the initial explosion, resulting in a second severe explosion (fig. 155, p. 221).

February 8, 1948; Sun Excelsior Mine, Excelsior, Ark.; 8 Killed

(From Bureau of Mines report, by R. D. Bradford, A. A. Sinicrope, M. T. Fuller, and B. L. Curry)

Near 3:30 p. m. the night foreman and two men were in a trip of cars being lowered down the slope. When they were about 300 feet from the portal, the explosion threw them around in the cars. The hoist engineer stopped the trip, because the force of the explosion closed the signal circuit. Following a short reversal of air flow, the ventilation resumed a normal course down the slope, and 1 man went outside to summon aid while the other 2 continued down the slope on foot. They advanced slowly, pausing occasionally to patch up damaged stoppings, and reached 6 west overcast where the intake air was short-circuited and the contaminated atmosphere prevented further progress. Three concrete-block stoppings were demolished. A rescue party arrived a short time later, without gas masks or breathing apparatus, so advance was

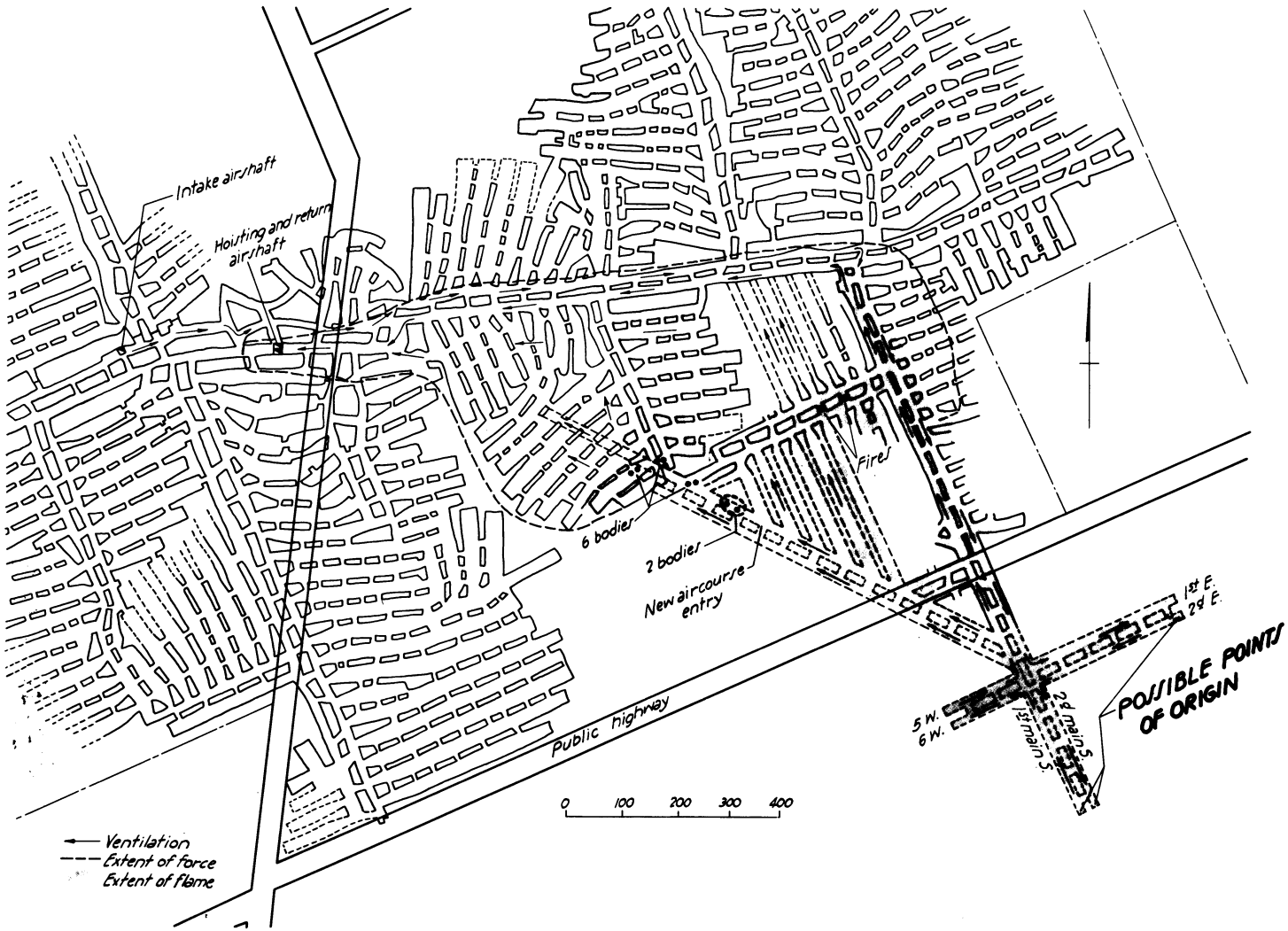

FIGURE 153.—Map of explosion area, Kerns mine, Terre Haute, Ind., April 30, 1947.

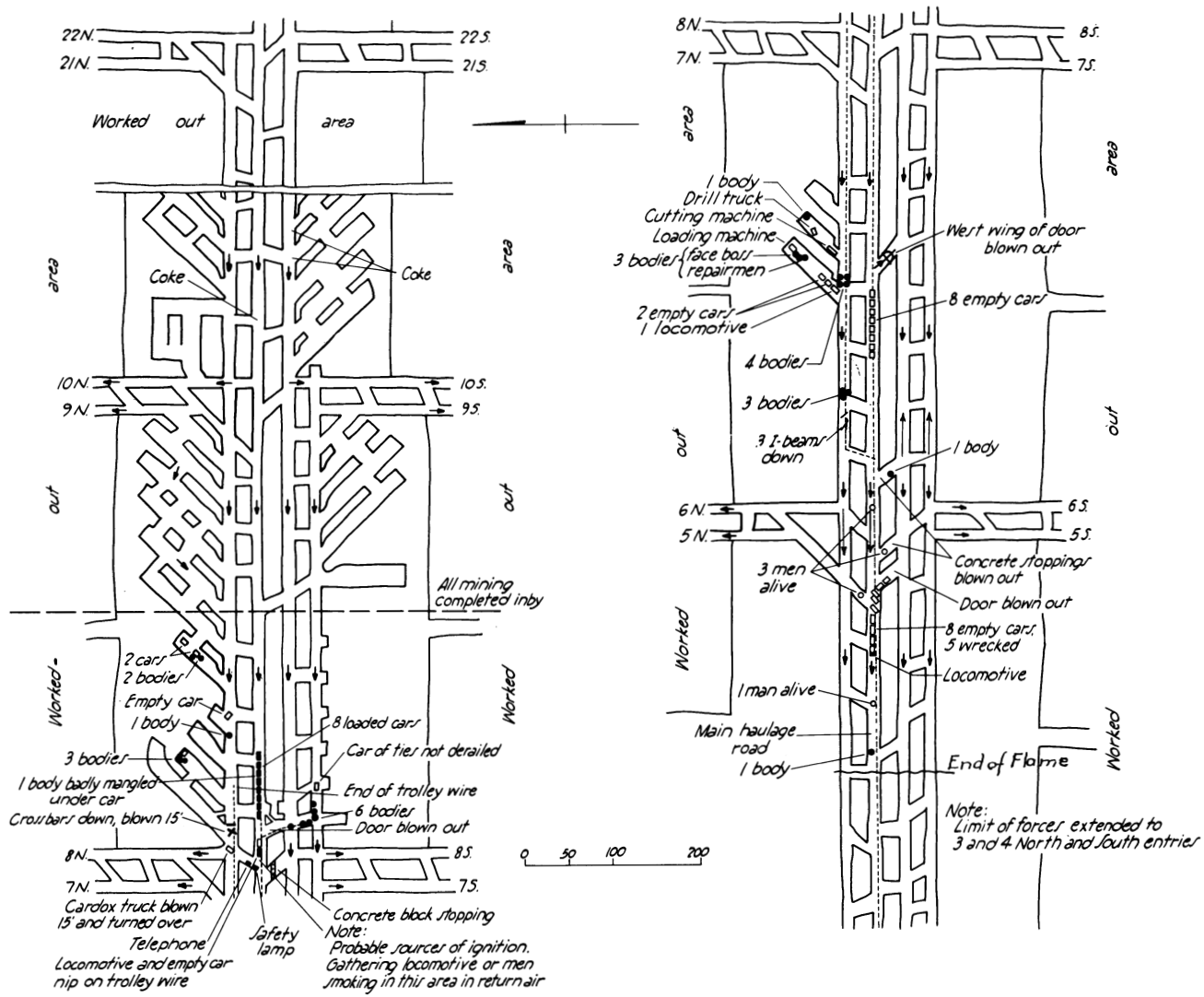

FIGURE 154.—Map of explosion area, Old Ben No. 8 mine, West Frankfort, Ill., July 24, 1947.

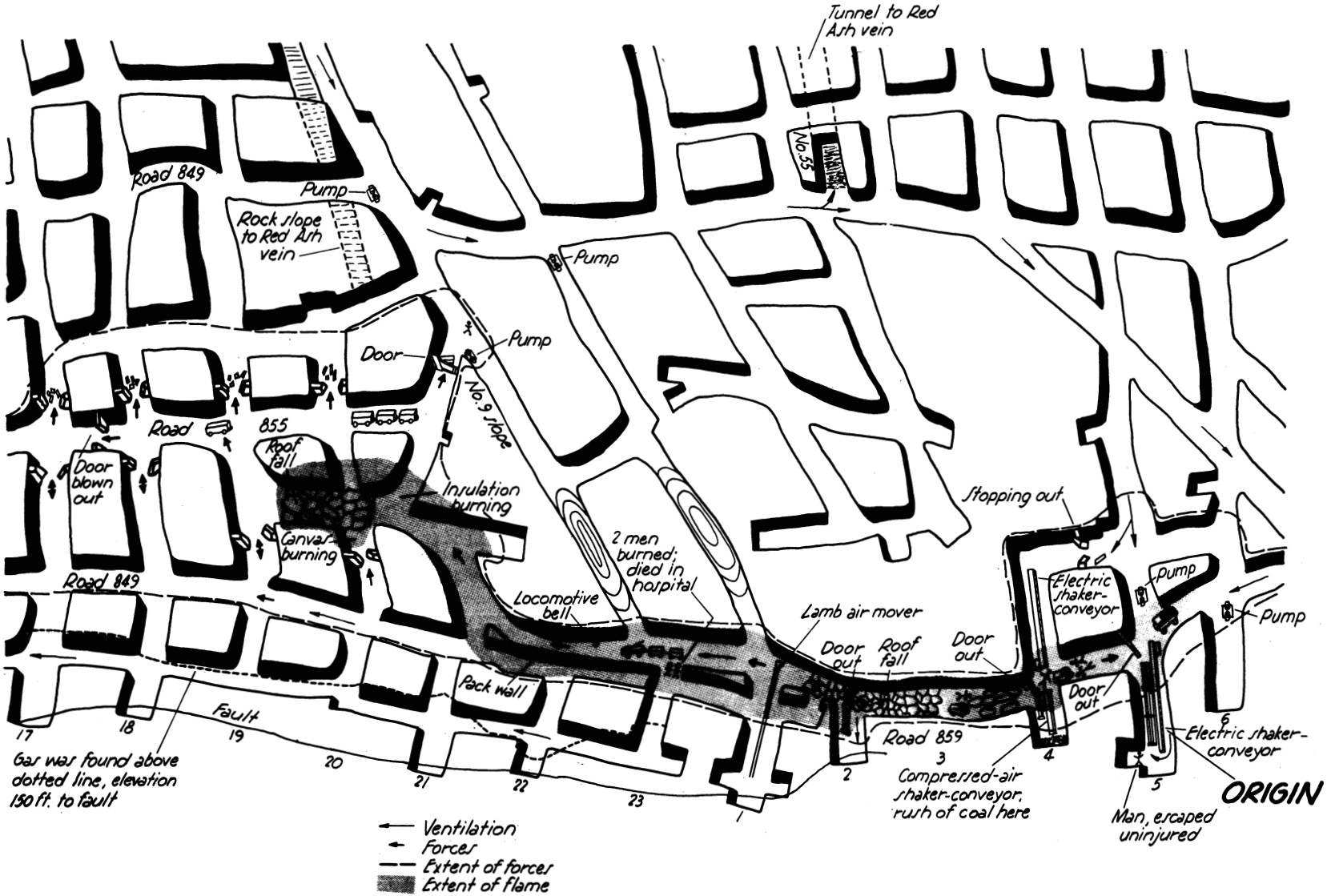

FIGURE 155.—Map of explosion area, road 859, Franklin colliery, Wilkes-Barre, Pa., December 11, 1947.

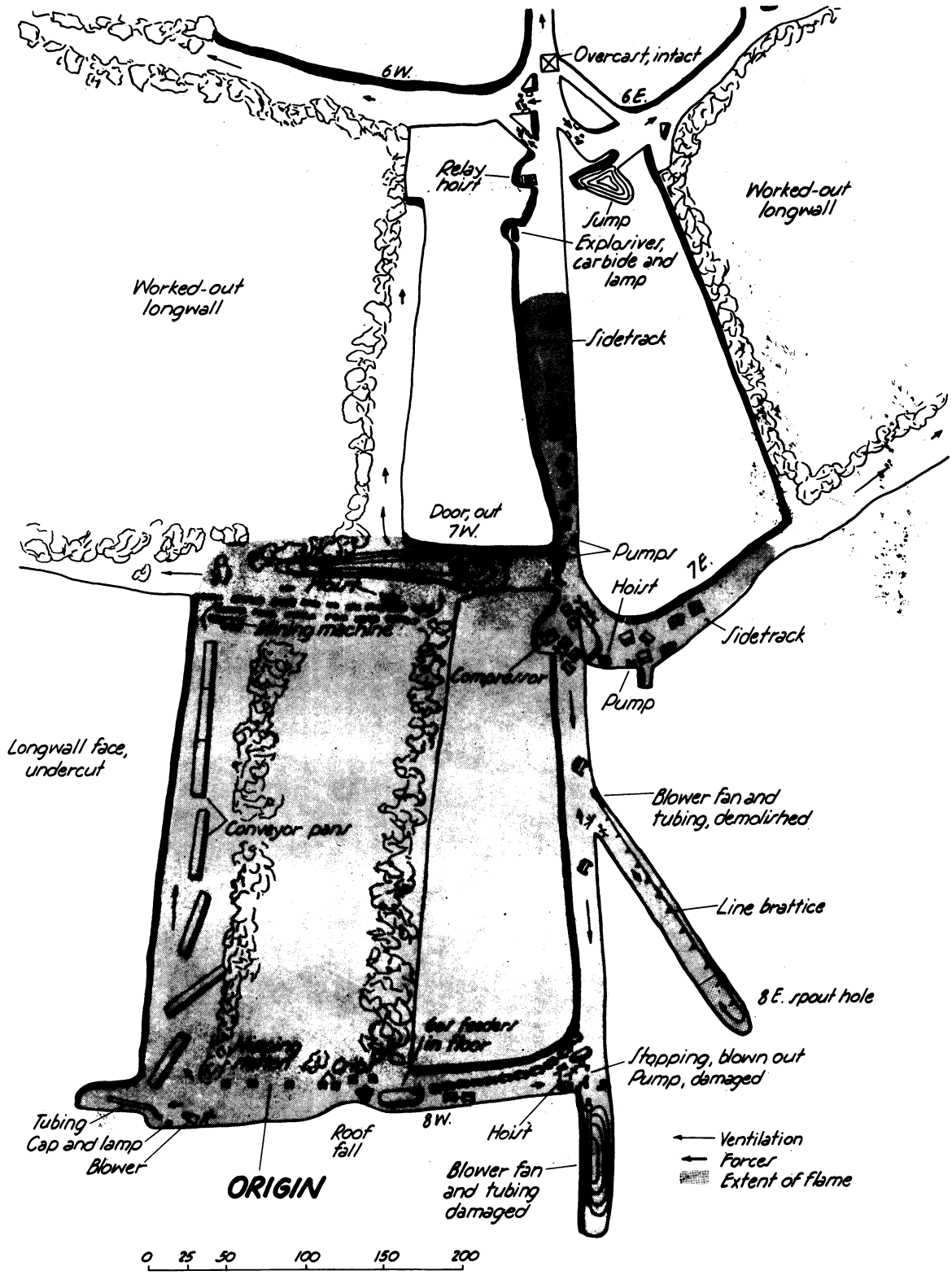

FIGURE 156.—Sketch of explosion area, Sun Excelsior mine, Excelsior, Ark., February 8, 1948.

made by erecting brattice-cloth stoppings. The bodies of 8 men were found and recovered by 8:30 p. m. These were the only men underground besides the three men on the slope at the time of the explosion.

The explosion was violent for 2,000 feet from the face of the slope and was especially destructive from the face to the junction at 7 east. Flame traversed the 8 west section, the 7 west return airway, and the 8 east spouthole, also about 200 feet of 7 east and the main slope to between 6 and 7 west.

Heaving action of the floor at 8 west sidetrack probably released methane into an area that was poorly ventilated. Ignition may have been due either to an arc from a nipping station, an arc from the wiring or motor of a blower fan, or by smoking, which was a common practice. No preshift or onshift examinations for gas were made on the day of the explosion. Coal dust entered into the explosion, but water on the slope and in 7 east and rock dust applied several months before as far as 7 west helped to limit the propagation (fig. 156).

July 27, 1948; Kings Mine, Princeton, Ind.; 13 Killed

(From Bureau of Mines report, by James Westfield, F. J. Smith, J. S. Malesky, J. A. McCune, G. W. Colbert, and C. M. Dovidas)

The mine had been idle from July 14 to July 27 to seal 1 and 2 west off the main north, 3 west, where water and methane were excessive. A squeeze developed in 1 and 2 east, and this section was also sealed inby the No. 8 crosscut. The mine examiner's report for that morning showed the mine to be free from gas accumulations. An overall inspection on the preceding 2 days by a group of inspectors and officials had reported it safe. The company safety inspector had been in the 1 and 2 east section just before 1:00 p. m., but he had not tested for gas or inspected the seals.

The mine foreman entered the section about 10 minutes before 1 o'clock, when the section foreman and men in 5 and 6 east section felt the explosion. When the section foreman encountered smoke and fumes near 3 and 4 east, he told his men to return to their section and prepare to put up barricades. He went on to 1 and 2 east and telephoned to the shaft bottom to call for help. Word was sent to the deputy mine inspector and to the rescue stations at Bicknell and Terre Haute and to the Federal Bureau of Mines at Vincennes.

Mine officials entered and immediately started restoring ventilation by placing canvas stoppings where wooden doors and stoppings had been demolished. No gas masks or breathing apparatus was used. Two men suffering from burns and afterdamp were found and taken outside. All of the injured men and bodies were taken out by 4:30 p. m. that day. Twelve men were killed outright, and 1 of 3 injured died on the way to the hospital. The other 160 men in the mine escaped without injury.

Ventilation in the 1 and 2 east section had been short-circuited for some time before the explosion. A trip of cars blocked a door open; a door was being erected at another place, and a shuttle car was standing under a check curtain. Methane leaked from behind the seals and moved out over a drill truck on 2 east entry at No. 5 crosscut. An arc from the drill truck probably ignited the gas, and coal dust was stirred up and propagated the explosion (fig. 157). Rock dust applied in entries and rooms prevented a widespread explosion. Smoking was also a possible source of ignition, as several of the victims carried matches, lighters, and smoking materials.

July 30, 1948; Edgewater Mine, Birmingham, Ala.; 11 Killed

(From Bureau of Mines report, by M. C. McCall, H. N. Smith, and A. Guthrie)

At the time of the explosion, 9:00 a. m., 310 men were in the mine, and 4 men were in a rock slope driven from the surface to make an escapeway for new development. It had connected to the mine, and the opening was being enlarged. Three concrete-block stoppings had been erected to enclose the foot of the escapeway to prevent it from becoming an intake when it connected with the inactive 11 south entries. Two days before the connection was made, it was found that the connection would be outside of the sealed area, so 2 more seals were erected. Two or three blocks were left out of the top of each seal for ventilation of the sealed area and to protect the seals against concussion from blasting in the escapeway.

On the morning of the explosion a ventilation inspector found an increased flow of air in 1 west off 11 south slope and an increase in methane concentration from 0.35 to 0.60 percent. The direction of air flow in 11 south was neutralized by the connection to the escapeway. Seventeen men were working in the 11 south slope—2 men scaling roof on 11 south between 2 and 3 west, 2 men traveling toward the slope face at 6 west, 4 men removing one of the unneeded seals in 2 right aircourse outby the foot of the escapeway, 1 man at the pump control room, 4 men in the pump room and 4 working at the foot of the escapeway (fig. 158). The concussion of the explosion was felt in areas near 11 south slope and calls were made to the underground car distributor, who advised the mine office on the surface.

Company, State, and Federal Bureau of Mines offices were notified, and assistance arrived promptly. The 4 men from the foot of the escapeway and 6 others from the vicinity came out through the escapeway. Eight of these men were burned, and 5 of them died in hospitals. Men from other parts of the mine came out through the man-and-material slope. Rescue teams wearing oxygen breathing apparatus explored the explosion area and extinguished three small fires. The new escapeway was closed off, and temporary brattices were erected to clear smoke and gases from the 11 south slope workings. One injured man and 6 bodies were recovered by about 9:00 p. m.

The explosion blew out stoppings, blew the blower-fan tubing out at the portal of the new escapeway, and blew open the explosion doors of the 10 south fan. Flame extended through much of the explosion area and for about 150 feet from the portal of the escapeway (fig. 159). Methane accumulated in 11 south slope entries because of the short circuiting of air through the new escapeway.

The source of ignition appeared to be near the seal that was being removed where a flame safety lamp was found with a hole in the glass chimney, believed to have been caused before the explosion. Coal dust entered into the explosion, but propagation was arrested by rock dusting and by expansion. The ventilation inspector and assistant foreman were checking the ventilation and testing for methane near 6 west, when they were killed by the explosion. The area was inspected by a fireboss on the day before and reported free of standing gas. However that was before the hole into the escapeway was enlarged. No regular inspection was made the day of the explosion.

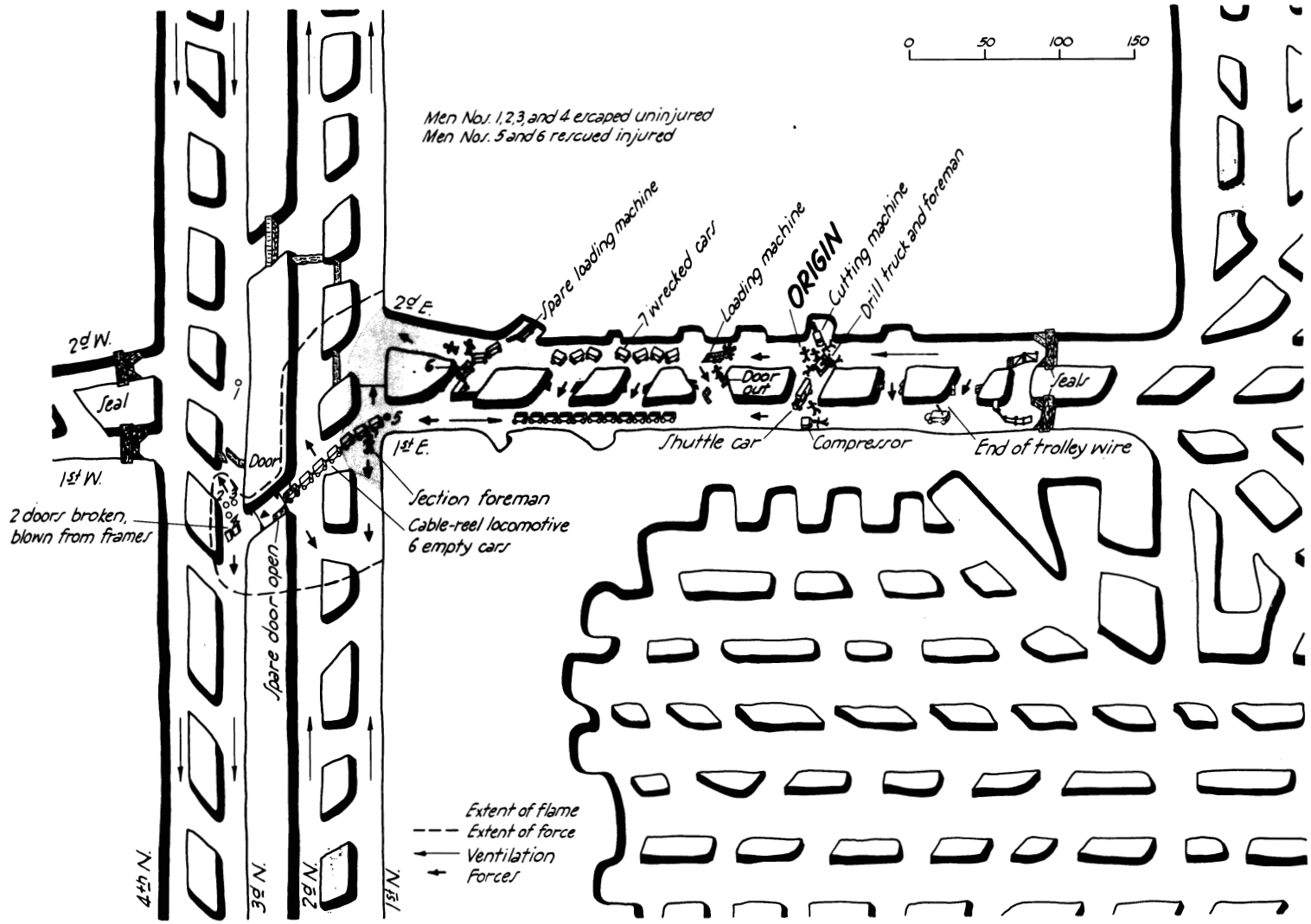

FIGURE 157.—Map of explosion area, Kings mine, Princeton, Ind., July 27, 1948.

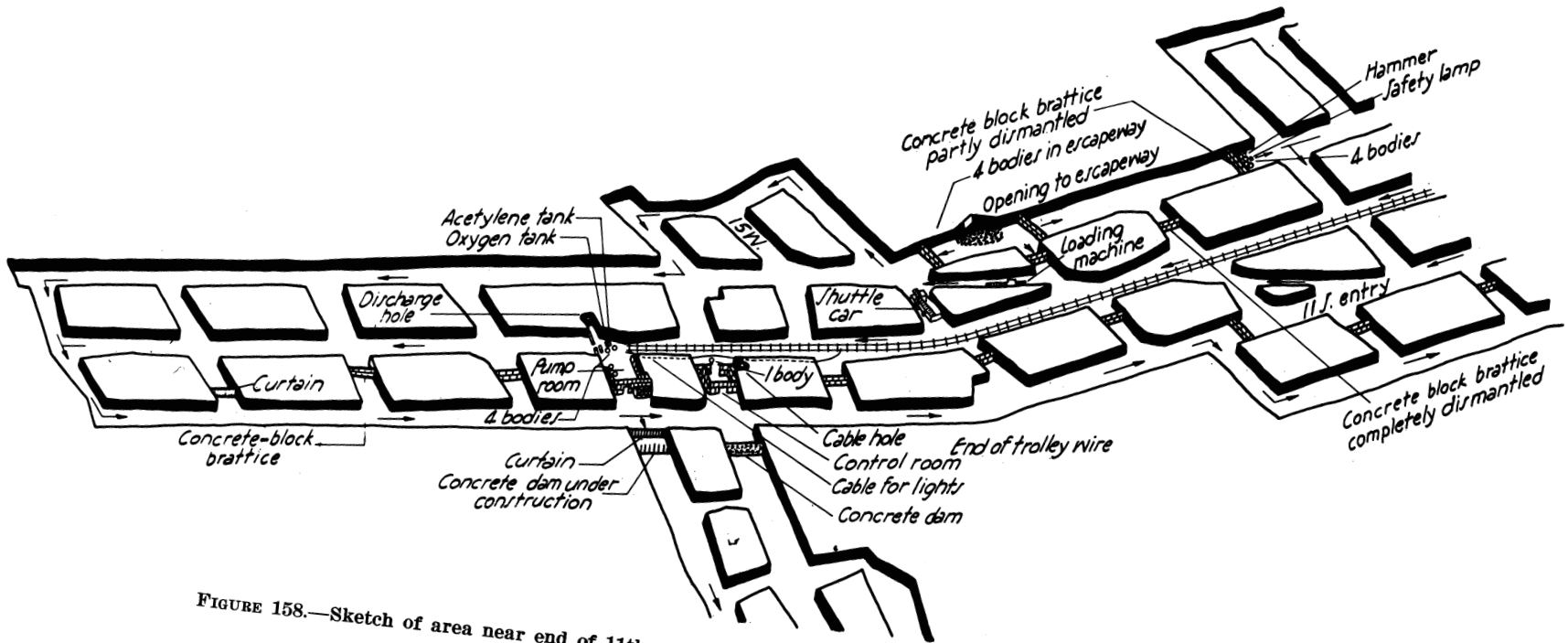

FIGURE 158.—Sketch of area near end of 11th south entry before explosion, Edgewater mine, Birmingham, Ala., July 30, 1948.

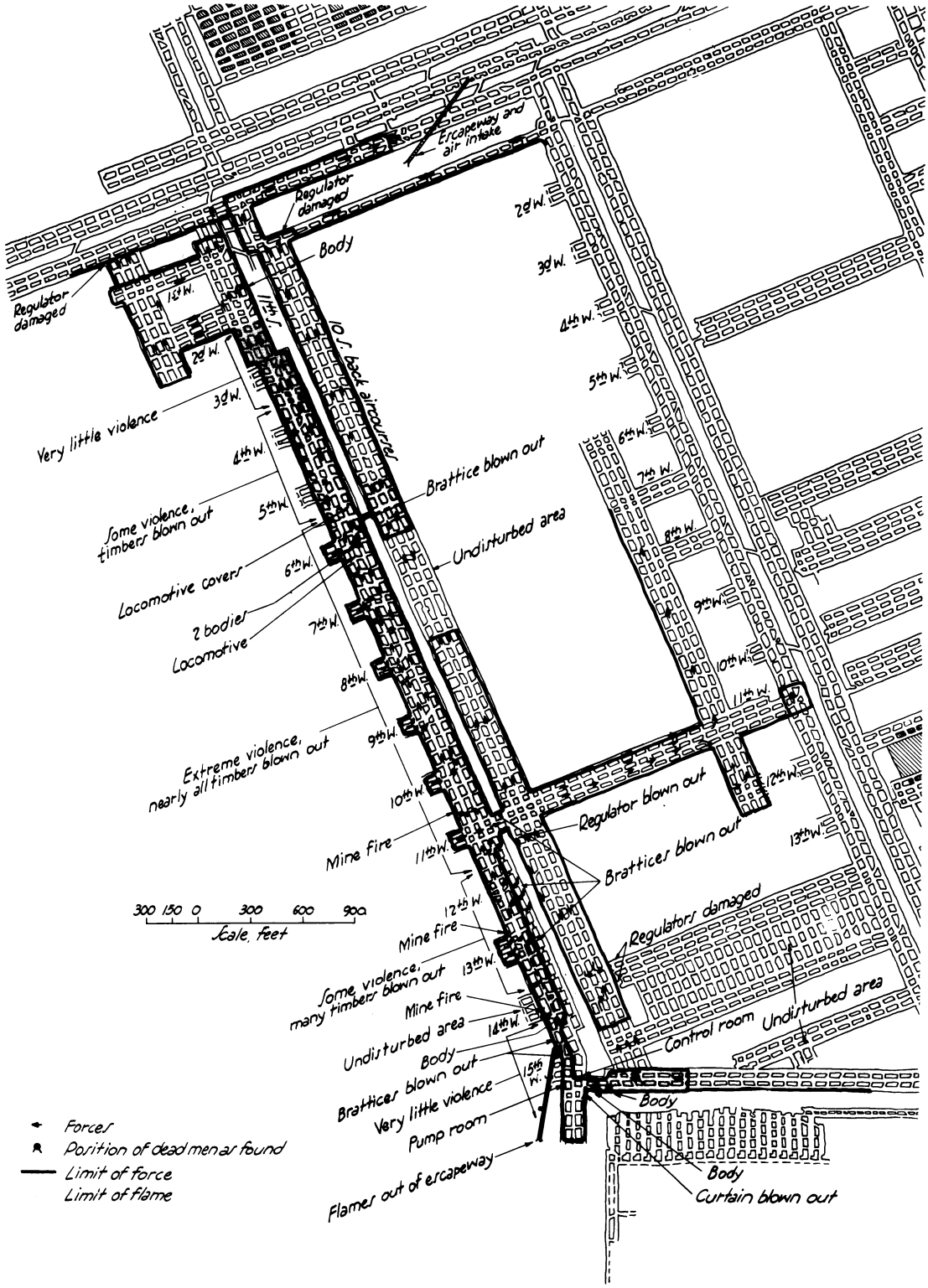

FIGURE 159.—Map of 11th south entry, Edgewater mine, Birmingham, Ala., July 30, 1948.

METHODS AND PROGRESS IN CONTROLLING AND PREVENTING EXPLOSIONS

PREVENTIVE PRACTICES IN 1941

Coal-mining practices that permitted or prevented mine explosions were discussed in 1941 by R. D. Currie, an engineer with long experience in coal-mine safety. In his address before the Mine Inspectors' Institute of America he remarked that violent gas or dust explosions are much more difficult to produce than they are to prevent. The right combinations of accumulations of gas and dust, a potent source of ignition, and a group of victims unaware or unheeding the danger would be extremely difficult to set up in an ordinarily well managed mine.

The fact that 6 disastrous explosions took almost 300 lives in 1940 is an indication that, in hundreds of other combinations of conditions, 1 or more of the necessary factors was not present, so that an explosion was prevented, either by forethought or otherwise. He observed that, with some exceptions, mining men and the management of mining companies had agreed to the premise that positive ventilation is a necessary function of coal-mine operations, based on compulsion, a desire for greater efficiency, safety, or some combination of these.

In theory, suitable quantities and velocities of fresh air coursed to every section and face of mines will prevent the formation of explosive methane-air mixtures. In practice few, if any, ventilating systems meet these requirements. Unventilated dead ends are driven, line brattices are neglected or torn down and not replaced promptly, and doors are built singly and left open where more positive means should be employed to direct air currents. Falls or other obstructions disrupt the flow of air, or power failures cause interruptions. Flame safety lamps are often carried by men unskilled in their use, and only infrequent tests are made. Use of more accurate devices for determining methane is not common. Flame safety lamps are sometimes used improperly or are opened in explosive atmospheres.

Permissible mine equipment is used in many gassy mines, but often nonpermissible equipment is used along with it. Permissible explosives are employed for blasting coal in many gassy and dusty mines where nonpermissible explosives are used for blasting rock. Black blasting powder continues to be used in mines that are gassy and dusty. Smoking in closed-light mines is still a cause of gas ignitions.

Major defenses against explosions are water and wetting of coal dust, rock-dust applications, the coursing of only pure intake air on travelways and haulageways, and regular frequent inspections of all parts of mines to find and forestall accumulations of methane. The methods needed to prevent mine explosions are neither difficult nor costly. Those companies making a sincere effort to prevent explosions by using all available means should be supported in their efforts, while the hundreds of companies who make no effort to prevent explosions should be brought into line by stringent legislation and inspection.

FEDERAL COAL-MINE INSPECTION

PUBLIC LAW 49

Those thoughts and recommendations were in the minds of many inside and outside of the coal-mining industry as the list of disasters and dead continued to grow in 1940 and 1941. Bills for Federal inspection of coal mines had been introduced in earlier years but had not been acted on. Through the efforts of John L. Lewis, president of the United Mine Workers of America, and with the support of the administration then in office, the 77th Congress enacted the Coal Mines Inspection and Investigation Act, Public Law 49 (*58*). By this law, the Secretary of the Interior, acting through the Federal Bureau of Mines, was empowered to make inspections and investigations of health and safety conditions in coal mines and to publish reports concerning them. Annual reports of the information gathered and recommendations for additional safety measures were required to be made to the Congress. No authority was given to enforce safety standards.

INSPECTION PROCEDURE

A Coal-Mine-Inspection Branch was established in the Health and Safety Division of the Bureau of Mines, and an initial staff of 107 inspectors was employed and trained. The first inspections were made in December 1941. Reports of the conditions and hazards found in each mine, with recommendations for correcting or safeguarding against dangers, were sent to the mine owners, national and local Union offices, and State authorities. Copies were kept for public inspection, and short summaries were sent to newspapers in the area in which the mine was operating (*4, pp. 19–28; 62, pp. 420, 421*). Publicity given to hazards existing in the mine and to the action or lack of action on recommended corrections did not bring about any sudden change in attitude toward explosion hazards, mainly because clearly recognizable imminent hazards of explosions were not easily defined and when found were corrected to some degree. The potential ex-

plosion hazards were numerous and constantly reported. Corrections were temporary or inadequate, because the need for better measures was accepted in theory but not in general practice.

INSPECTION STANDARDS

The inspection standards used by Federal coal-mine inspectors in making recommnedations for preventing explosions included these provisions (*4, pp. 87–134*) :

Aircourses and accessible falls should be traveled at least once each week by a certified mine official, who should leave his initials and the date; if the aircourse is in such condition in any part or parts that it cannot be traveled, the defective condition or conditions should be remedied promptly.

Entrance to dangerous places should be fenced off, and a suitable danger sign placed.

A statement of all dangerous conditions should be recorded daily in a book signed and dated by the mine foreman, and countersigned by the superintendent.

Each working place should be inspected for safety by a certified official at least twice each working shift and at such more frequent periods as seem necessary and practicable. He should leave at or near the face of each place examined his initials and date.

When approaching abandoned workings which cannot be inspected or workings filled with water or gas, boreholes should be kept at least 20 feet in advance of the face, and similar 45° angle holes 25 feet deep in each side.

Permissible electric cap lamps should be carried by all underground employees.

At least two permissible flame safety lamps should be kept in proper working condition at every coal mine, and at least two persons should be kept well informed as to the safe maintenance, testing, and use of flame safety lamps.

Idle or abandoned sections of the mine should be inspected for gas and other dangerous conditions by the foreman or fireboss immediately before other employees are permitted to enter these sections.

Strict compliance with mining laws and company safety standards should be demanded of all employees.

A mine should be classed as gassy when methane or other combustible gas can be detected in amounts of as much as 0.25 percent or more by frequent, systematic search.

If the air of a working place contains more than 1 percent of flammable gas, the place should be considered hazardous and to require improved ventilation immediately; if it contains more than 2 percent (slightly less than ½-inch cap on a testing or low flame), the workers should be withdrawn until ventilation has been improved.

If the air immediately returning from a split that ventilates any group of active workings contains more than ½ percent of flammable gas, as determined by chemical analyses in duplicate or by other recognized means of accurate detection, the workings of that split shall be considered hazardous and require improved ventilation. If this air contains more than 1½ percent of the flammable gas, the workers should be withdrawn until ventilation has been improved.

All entries, rooms, panels, or sections that cannot be kept well ventilated throughout and regularly inspected, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, should be sealed by strong, fireproof stoppings and provided with some means of bleeding off the gas into the return.

Breakthroughs should be made not more than 80 feet apart.

A split ventilation system utilizing air crossings should be used instead of doors for conducting ventilation in all main passageways. Where doors are used in connection with coursing the air in any one split or if used in lieu of a split ventilation system they should be:

(*a*) Installed in pairs to form air locks or, where this is not feasible, tight check curtains, well maintained, should be hung in connection with single doors.
(*b*) Self-closing.
(*c*) Not provided with latches or other devices to hold them open.

Places should not be worked on an air current that has passed through abandoned workings or pillar lines that cannot be inspected regularly. It is hazardous to work in places using air currents from partly caved workings.

Changes in ventilation affecting the mine as a whole or splits thereof should be made when the mine is idle and with no men in the mine other than those engaged in changing the ventilation.

Should the main fan fail or stop for 5 minutes or more in a gassy mine (gassy mine being defined by Bureau of Mines Safety Decision 33) the men should be withdrawn immediately from the mine. After the fan has been started the mine should be examined thoroughly for gas and any gas found should be removed before the men reenter. The same procedure should be followed in a section of a gassy mine if it is ventilated by a booster fan and there has been more than momentary stoppage of such fan.

All coal mines classed as nongassy should be carefully inspected for methane at least once a month.

"Enough firebosses should be employed in gassy mines; they should:

(*a*) Begin examination of the mine not more than 3 hours before each shift enters the mine.
(*b*) Examine every working place, all places adjacent to live workings, every roadway and travelway, every unfenced road to abandoned workings, and all accessible falls in the mine for explosive gas and other hazards.
(*c*) Leave at or very close to the face of each place examined their initials and the date.
(*d*) Place a danger signal across the entrance to every place where explosive gas can be detected by a flame safety lamp or where other danger is found.
(*e*) Report to the foreman any dangers found before the men enter the mine.
(*f*) Record the result of this inspection in a book kept on the surface for that purpose.
(*g*) Indicate on a bulletin board near the mine entrance the places where gas was found or other dangerous conditions were observed.

No electrically driven permissible equipment should be taken into or operated in any place if methane can be found by a flame safety lamp or permissible methane detector in amount of more than 2.00 percent in the general air of the place. Such test for methane should be made not nearer than 4 feet from the face and 10 inches from the roof.

No electrically driven machine operating in face regions in a gassy mine should run more than 30 minutes without an examination for gas being made; in very gassy places or those in disturbed strata, such as during a squeeze, the gas examinations should be spaced not more than 15 minutes apart.

Haulage and hoisting openings and main haulageways should be kept on intake air.

Smoking should not be permitted in any mine.

Search of employees for smoking material, matches, and other lighting devices should be made frequently

and in a manner to assure that such articles are not being carried into the mine.

Accumulations of gas should be removed under the direct supervision of a foreman or other competent official, and men should not work and nonpermissible electrical equipment should not be operated on the return of the split while gas is being removed.

When electric power has been off a mine or section for 4 hours or more, the mine or section should be examined for gas, and if gas is detected the power should not be turned on again until the gas has been removed. However, this is not intended to bar operation of a single unit such as a pump on a properly fused branch line if examination has been made with flame safety lamp and no gas is found at pump surroundings.

Only permissible explosives or permissible blasting devices should be used, and these should be used in a permissible manner as follows:

(*a*) Not more than 1½ pounds in any one shot.
(*b*) Fired only with electric detonators of proper strength.
(*c*) Fired with a permissible shot-firing device.
(*d*) Not fired on the solid.
(*e*) Stemmed with incombustible material.

Shots should be charged and fired by certified shot firers, other certified officials, or authorized persons.

If the coal is cut, boreholes should not be drilled until after the undercut, topcut, or shear is made.

Boreholes should be drilled at least 6 inches less than the depth of the cut or shear.

Boreholes should be cleaned properly before the charge is placed in the hole.

Shot firers should refuse to charge or fire improperly placed holes.

Dependent shots or shots having insufficient or excessive burden should not be fired.

Shots should not be fired from the power or signal circuit while any men are in the mine.

A shot should not be fired when more than 1 percent of methane is known to be present.

Examination for gas should be made before and after firing a shot or simultaneous shots in a gassy mine.

Adobe (mudcap) or other open, unconfined shots should not be fired in any bituminous or lignite coal mine.

In anthracite mines adobe or other open, unconfined shots may be fired to start running of coal in chutes but only if it is not possible to start the coal running otherwise and there is no gas or fire hazard. Permissible explosives only should be used in such shots.

Air in which nonpermissible mining equipment and electrical wiring is used should not contain more than ½ of 1 percent methane as determined by analysis or other recognized means of accurate detection of methane. In addition, such equipment and wiring should not be used in air from areas that might liberate dangerous explosive gas. Also if methane can be found in excess of 2 percent in holes in the roof of any working place by analysis or by methane indicator (flame safety lamp or electrical indicator) nonpermissible electrical equipment should not be taken into or operated in the working place until the pocket of gas has been removed by additional ventilation.

Permissible equipment should be maintained in good state of repair and in permissible condition, as determined by a rigid examination each week by a person well informed in the safe use of electricity underground and in the maintenance of equipment; a record should be kept of the defects found and how they were remedied. Repairs should not be made, nor the electrical parts opened at or near the face, while the power is on the machine or cable.

Coal dust should not be permitted to accumulate on roadways, along conveyor lines, and on gob, rib, roof, or timbers.

Water or wetting solutions should be used for allaying coal dust:

(*a*) On the cutter bar or cutting chain of mining machines, or sprayed on the dust as it emerges from the kerf.
(*b*) Before and after blasting.
(*c*) On the coal pile before and during loading, if handloading into car or on conveyor is done.
(*d*) On the coal pile before and during loading, if loading by "duckbill" or scraper.
(*e*) On mobile loading machines.
(*f*) At the unloading head of conveyors or scrapers.
(*g*) On loaded and empty trips.
(*h*) In the face region and back to the last application of rock dust.
(*i*) At underground dumps.

All coal mines, except anthracite mines (whether in wet or dry condition), should be kept thoroughly rock-dusted, in all open, unsealed places to at least within 40 feet of the face. The dust should be distributed upon the top, bottom, and sides.

Loose coal and coal dust should be cleaned up before applying rock dust.

Rock dust should be applied and maintained in such quantity that the incombustible content will not be less than 65 percent.

ACCEPTANCE OF RECOMMENDATIONS

The inspection reports showed wide variation between the recommended standards and operating practices and conditions, although in a few mines there was a reasonable approach to these safety standards. Since they were for recommendation only and not to be enforced, they were uncompromising in many respects, as for instance, the banishment of black powder. Voluntary correction of dangerous conditions and practices by conscientious operators when reports brought them to attention started an improvement that was counteracted by stepped-up production and decreased manpower brought on by World War II.

The total fatalities from explosions in the 5 years 1941–45 were 549 compared with 620 in 1936–40, while production was increased about 30 percent. Progress was being made in improving safety in the mines, but mine safety was not keeping pace with the concepts of safety in other industries; moreover, the explosion disasters were not being prevented or reduced, as was possible and expected. Tight standards of control against factors causing explosions were not generally followed because the need for them was acknowledged only after repeated disasters. The Annual Report of the Director of the Bureau of Mines for the fiscal year 1943 contained the following statements:

> The numerous safety improvements made voluntarily by officials and workers in coal mines were among the concrete results of the Federal coal-mine inspection program. * * * Ventilating improvements made as a result of Bureau of Mines inspections have, the Bureau believes, prevented some mine explosions.

The report for the fiscal year 1944 stated:

The accident-frequency rate in coal mines reinspected by Bureau representatives has declined approximately 6 percent, and it is significant that only one major explosion and one major fire disaster occurred during the first 6 months of 1944 when fatality rates reached their lowest ebb in coal-mining annals. This record was achieved in the face of numerous handicaps: Increase in the average age of mine workers from 32 to 45, employment of inexperienced men to replace those lost to war plants and the armed forces, a greater effort by workers resulting in physical and mental fatigue, and a shortage of new equipment.

The report for the fiscal year 1945 included the following statements:

Bureau of Mines representatives made 3,163 inspections and reports on coal mines producing approximately 91 percent of the Nation's total annual output. The reports on these safety surveys, most of which were reinspections, demonstrated an increasing acceptance of the Federal safety recommendations by the coal-mining industry, for hundreds of proposed improvements had been made in the mines since the previous inspections.

COAL MINES ADMINISTRATION

In May 1946, after strikes closed many of the bituminous-coal mines, they were put under control of the Federal Government by Executive Order 9728 (*62, p. 361*). The order of seizure directed the Secretary of the Interior to take possession of mines affected by the strike and to operate them under the existing management. The Krug-Lewis agreement of May 29, 1946, entered into by the Secretary of the Interior acting as Coal Mines Administrator and the United Mine Workers of America, contained certain provisions designed to improve safety conditions and practices in the mines involved (*62, p. 422*).

This concept of safety regulation by contract supplemented regulation by State statute. It called for issuance of a reasonable code of standards and rules flexible enough to be applicable to all coal-mining conditions encountered in the United States and for the inspection of mines by coal-mine inspectors of the Federal Government for the purpose of finding and reporting upon lack of compliance with the Code. It placed on management and workers responsibility to comply with the code and authorized safety committees of miners to inspect mines and to report unsafe conditions to the management. It authorized safety committees to recommend to the management the removal of workmen from places of imminent danger and required the management to carry out such reasonable recommendations as the committee might suggest. It authorized the Coal Mines Administration to remove the workmen upon report of imminent danger by an inspector.

A Coal Mines Administrator was appointed, and a staff was organized, mainly from Navy personnel. John E. Jones, an experienced coal-mine safety engineer, was retained as safety engineer for the Administration.

FEDERAL MINE SAFETY CODE

As provided by the agreement, the Director of the Bureau of Mines, after consultation with a committee consisting of 2 representatives of the United Mine Workers of America, 2 representatives from the mine operators, and the safety engineer for the Administration issued the Federal Mine Safety Code for Bituminous-Coal and Lignite Mines of the United States, dated July 24, 1946.

The primary responsibility of the Coal Mines Administrator was to maintain the output of coal at a high level of production; on the other hand, under the agreement, his obligation was to put a reasonable safety code into effect. The Code was intended to obtain as great a measure of safety as possible without jeopardizing the production of coal. For these reasons the requirements of the Code were not as severe or inclusive as the safety standards employed by the Bureau of Mines in its procedures under the Coal-Mine Inspection Act of 1941. The power of enforcement was vested in the Administrator and not in the inspectors of the Bureau of Mines, whose responsibility was to make inspections and to report to the Administrator violations of the code and any imminent dangers.

The requirements of the Code regarding explosion hazards were (*3, pp. 13–72*):

Permissible explosives were to be used, except that mines using black blasting powder could continue to do so with certain restrictions.

When the main fan failed or stopped, power must be cut off the mine, and the men withdrawn from face regions. If ventilation was restored in a reasonable time, gas examinations must be made before men return. If the ventilation was not restored in a reasonable time all underground employees must be removed from gassy mines.

Booster and auxiliary fans could not be installed, but their use might be continued in mines already using them. Removal of methane accumulations by blower fans was prohibited, and other restrictions were specified.

Volume, quality, and coursing of air to working faces were prescribed.

Preshift and onshift examinations for methane were obligatory.

Changes in ventilation that might affect the safety of the men were to be made when the mine was idle and with no men in the mine except those changing the ventilation.

Air from any split should not contain more than 1.0 percent methane; if 1.5 percent methane was found, men had to be withdrawn and power cut off until the condition was corrected.

When the methane content of air at a working face exceeded 1 percent the condition had to be corrected promptly.

Doors on haulage roads were to be in pairs; single

doors had to be attended. Doors had to be kept closed except when equipment was passing through.

Abandoned workings had to be sealed or ventilated.

Air from abandoned sections of pillar lines in gassy mines could not be used to ventilate live workings, but mines unable to comply might continue to operate until new development permitted a change.

Mine officials in gassy mines had to carry flame safety lamps and make tests for methane.

Fireboss examinations had to be made of idle or abandoned sections immediately before men were permitted to enter such places. Coal dust could not be permitted to accumulate excessively, and water or other means must be used to allay dust raised by mining operations.

Rock dust had to be applied to all workings except locations too wet or too high in incombustible content to propagate an explosion. Rock dusting had to be done to within 80 feet of the faces of rooms and entries.

Barriers or bags of rock dust might be used, pending tests at the Experimental Mine.

After the date of the Code all new electric equipment in gassy mines had to be of a permissible type, except that nonpermissible equipment being used could be continued in use.

No electric equipment could be taken into or operated in working places in gassy mines where 1.0 percent or more methane could be detected, and frequent inspections for methane had to be made while such equipment was in operation.

All persons underground in gassy mines had to use only permissible electric lamps for illumination. Mines using open lights could continue until permissible lights can be supplied.

Making arcs, sparks, or flames intentionally was prohibited in gassy mines, as was the carrying of matches or other flame-making devices.

Other provisions were in harmony with the standards recommended by the Bureau of Mines. Some concerned only minor hazards.

The Code was a compromise between the recommended standards and current practices and conditions. Even so, immediate and complete enforcement was not intended, since new equipment would have to be obtained and extensive changes made in many mines to conform with the Code requirements. It was considered that serious risks were taken care of by the authority given the Administrator to close mines where imminent danger was found and reported by the inspectors and by the wording of the agreement that required mine management to remove men from mines or parts of mines reported dangerous by a mine safety committee. Such areas were to be kept closed unless the Coal Mines Administrator determined that the safety committee had acted unreasonably or that dangerous conditions were corrected.

CHANGES IN STANDARDS FOLLOWING THE CENTRALIA MINE DISASTER

Events proved that recognition of an imminent hazard was less certain than had been assumed. Explosions and ignitions were few and caused only eight deaths in bituminous-coal mines after the Code was adopted until the Centralia No. 5 mine disaster on March 25, 1947. The investigation and hearings on the failure to correct the hazards that combined to cause that explosion showed that the program of gradual compliance with Code requirements would not protect miners against explosions and that the procedures set up for detecting imminent danger were not effective in eliminating explosion hazards (*62, p. 302*).

Although miners had complained of the dust hazards in the mine and the State and Federal inspectors had reported that serious hazards existed, the risk of an explosion was not considered imminent, and the mine was not shut down by the State or by the action of the miners' safety committee, or by the Coal Mines Administration.

Blasting practice was reported as a violation of the Code but not as an imminent danger. Before this disaster, failure to rock-dust adequately and violation of the requirements prescribed for use of permissible explosives were not recognized as imminent dangers, although some explosions had occurred from those causes (*62, p. 390*). Because of the infrequency of major disasters from such a combination of causes, it had not been customary to regard dry, dusty conditions in mines as constituting an imminent danger of such magnitude as to warrant the withdrawal of men, particularly if the mine did not liberate methane.

The error became apparent immediately, and the Bureau of Mines at once reviewed the mine-inspection reports and found 518 mines with deficient explosion protection. The Coal Mines Administration ordered those mines closed until the Union safety committee and the management agreed they were free from hazards or until the Federal inspector was satisfied after a reinspection.

The names of 162 other mines not in Government possession were also sent to State governors, with recommendations for correction of explosion dangers. A hurried period of rerock-dusting, ventilation improvement, and changes in blasting practices brought a temporary improvement in safety conditions in the mines, but this was not maintained. The mines under seizure were returned to the operators on June 30, 1947, and Government control ended.

IMPROVEMENTS EFFECTED UNDER THE CODE

The Federal Mine Safety Code for Bituminous-Coal and Lignite Mines continued to be the basis for Federal inspections. Under the wage agreements between the Union and the operators, compliance was stipulated in mines covered by the agreement. A similar set of standards was included in the wage agreements for anthracite mines.

The annual report of the Bureau of Mines for fiscal year 1948 states that inspection reports showed ventilation improved in 1,330 mines, permissible explosives replaced black blasting powder in 160 mines, 349 mines were rock-dusted for the first time, and 824 partly rock-dusted mines were brought up to standard; smoking was discontinued in 215 mines; permissible electric cap lamps replaced open lights in 168 mines; and preshift examinations for gas and other hazards were instituted in 541 mines.

The congressional committee that investigated the Centralia explosion disaster continued to receive information on the safety conditions and rate of improvement of accident prevention in bituminous-coal mines. Under Public Law 328, approved August 4, 1947, the Director of the Bureau of Mines made four quarterly reports on the progress shown by Federal inspections.

The continued improvement shown by these reports was not enough to prevent numerous explosions during 1947 and through July 1948. There were 7 major explosion disasters and 20 or more minor explosions from April 1947 to July 1948. The inspections, the checkbacks, and the emphasis on elimination of explosion hazards showed results in 1949 and 1950, when no major disasters occurred. There were 15 minor explosions, causing 11 deaths, in 1949 and 18 explosions, causing 8 deaths in 1950; 10 of the 19 deaths were in anthracite mines.

EDUCATION IN SAFETY STANDARDS

The coal-mine-inspection program of the Bureau of Mines was as much education of mine operating officials, mine inspectors, and mine workers as it was inspection and recommendation. The Federal inspectors were engaged in finding the hazards and reporting violations of the Code and remedies prescribed in the Code to company, State, and Union officials and then attempting to persuade company officials to take action.

Equally great tasks were the training and education of officials and mine workers in the safety standards set up in the Code and the practices necessary to comply with them. The standards had to be explained and reasons given for their adoption. Accident-prevention courses for mine officials and mine-safety committeemen were carried on in all districts, and there was gradual improvement in the attitude toward a stricter program of eliminating the factors generally responsible for explosions.

The habits of many years of tolerance of lower standards were not quickly broken, and absence of serious disasters did not emphasize any urgent need for drastic changes. Mine management cooperated in the educational work, and training of committeemen and other miners had the support of Union and management. After the disaster at Centralia, Ill., the United Mine Workers built up a Safety Department to organize and promote training of mine-safety committeemen.

REVISION OF STATE MINING LAWS

One effect of Federal inspection was to induce more frequent and more careful State inspection in States where this function had become lax and perfunctory. The State mine inspectors sometimes could enforce compliance with the Code provisions where their authority or the State mining law was equal to the standards involved. In many States the laws did not require greater protection than had been in effect before the Code was established.

To remedy these defects, revised mine-safety laws were introduced in several coal-mining States, and some were enacted. The revision usually was sponsored by the United Mine Workers of America, and Bureau of Mines representatives cooperated with State representatives in drafting codes to conform with the Federal Mine Safety Code. Some State mine-inspection departments were allotted more men and funds.

SUMMARY OF IMPROVEMENTS UNDER FEDERAL INSPECTION

A summary of the work and accomplishments of Federal inspection written in 1951 gives figures on improvements noted in mine-inspection reports for the years 1941–51 (*16*, *p. 4*). Major improvements affecting explosion hazards were: The use of black powder was discontinued in 1,037 mines; new main fans were installed at 2,010 mines; auxiliary blower fans with tubing were removed from 473 mines; preshift examinations for gas and other dangers were begun in 1,688 mines; the use of water to allay dust was initiated in 867 mines; 1,407 mines were rock-dusted for the first time: second openings were provided in 660 mines; smoking was discontinued in 1,186 mines; and the use of open lights was discontinued in 1,049 mines.

These figures do not picture the actual situation throughout all the mines in regard to these and other explosion hazards, but they do indicate the great strides in 10 years in modernizing the coal mines to prevent explosion.

Credit for the improvement cannot be ascribed rightfully to the efforts of any one group or agency, but Federal activities under Public Law 49 were a potent influence in bringing needed attention to safety and health in coal mines. The combined efforts of management,

labor, State inspection agencies, manufacturers of mining equipment, coal operators' associations, the Federal Bureau of Mines, and other agencies interested in mine safety brought about the improvements.

The number of underground employees in coal mines using electric cap lamps was greatest in 1948, as shown in figure 12 (p. 44); 87 percent were thus equipped, compared with about 53 percent in 1941. This percentage declined between 1948 and 1950, when it dropped to 80 percent. The reason for the decline is that fewer men were employed in the large closed-light mines in proportion to the overall employment.

In 1941, as is shown in figure 13 (p. 44), about 43 percent of coal-mine explosives used were permissible, and 33 percent were black powder; 24 percent were nonpermissible high explosives, mostly used in open-pit mines. In 1950 permissible explosives comprised 38 percent, black powder 6 percent, and high explosives 56 percent. More strip mines were operated in 1950, and more of the underground production was being mined by use of Cardox and compressed-air devices not considered as explosives. By 1950 about 92 percent of the underground production was machine cut or mined.

Figure 112 (p. 164) shows the influence of increased strip mining on the percentage of mines using rock dust. In 1941 about 10 percent of the mines, representing 57 percent of total production, were using rock dust; in 1950 about 30 percent of the mines were applying rock dust, and these mines produced about 85 percent of the coal. A small decrease from the figures for rock-dusted mines in 1949 is due to the greater production from strip mines.

Better practices in ventilation, testing for methane, and dust allaying were described in hundreds of inspection reports of 1950 (*18*) in contrast to those found in the first reports of 1941 and 1942. With this change in conditions, there was also a change in attitude. Mine officials, State authorities, and Union representatives gave prompt attention to deficiencies reported.

Although these things did prevent many explosions in 1949 and 1950 that undoubtedly would have occurred under earlier methods, more needed to be done to eliminate lurking dangers from substandard methods and practices tolerated or overlooked. Two educational activities that still had to be continued were mine rescue training (fig. 160) to cope with emergencies that might occur despite all precautions and demonstrations of dust explosions (fig. 161) to induce more wholehearted attention to rock dusting.

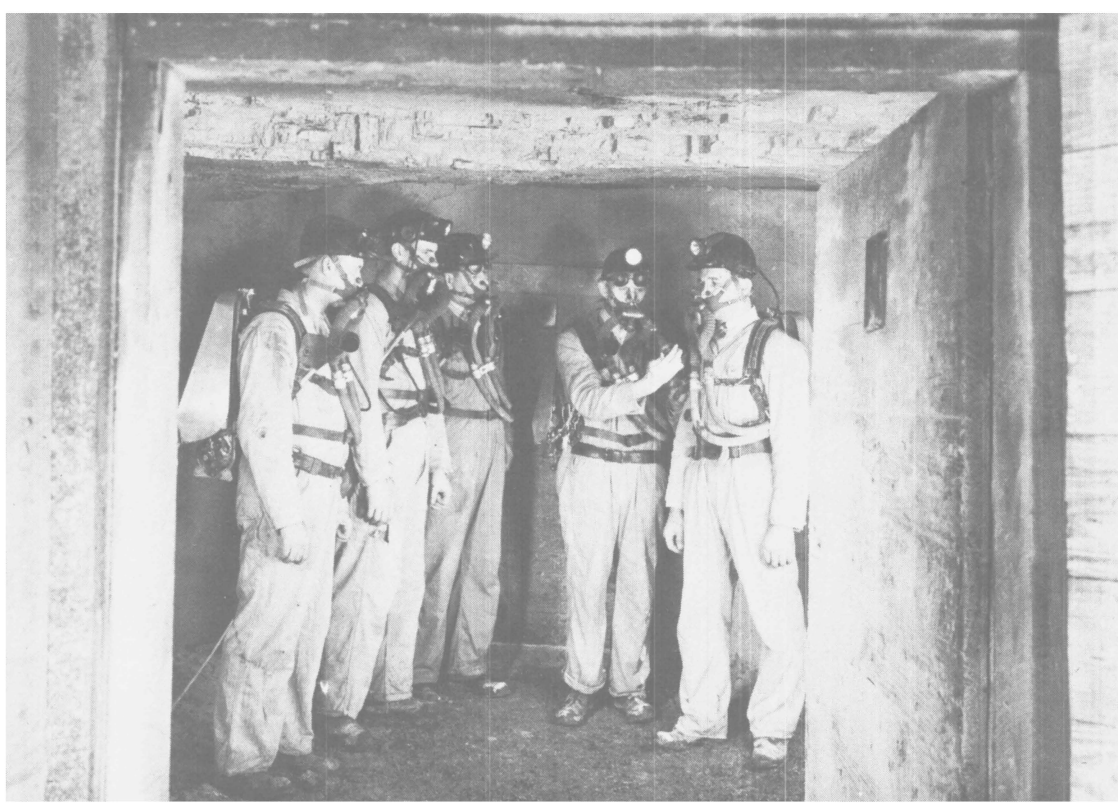

FIGURE 160.—Rescue crew at fresh-air base, 1945.

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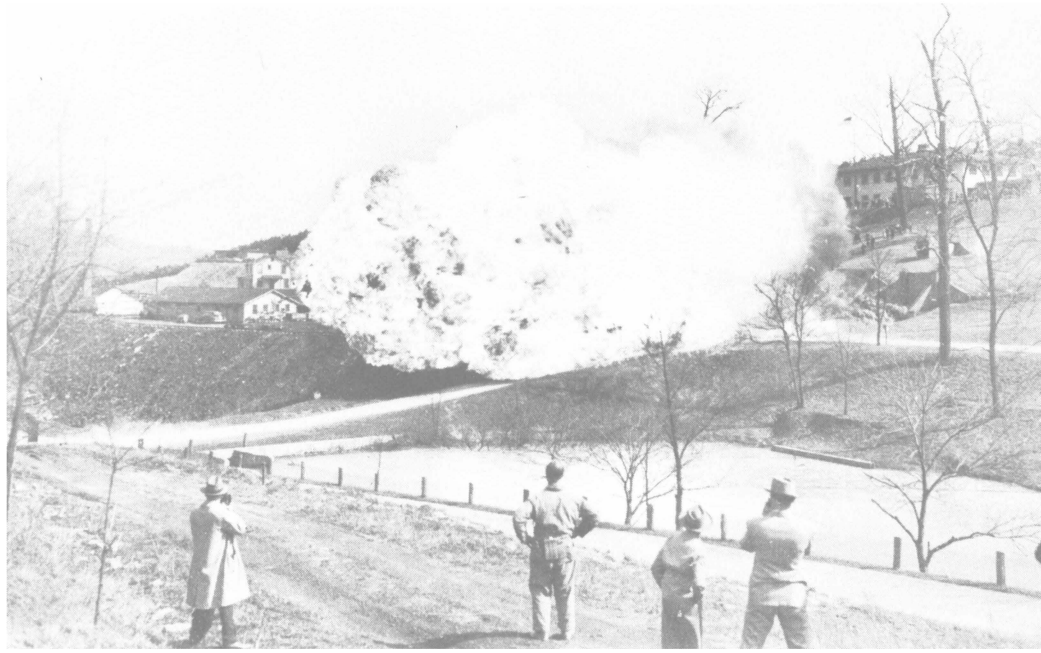

FIGURE 161.—Explosion demonstration, Federal Bureau of Mines Experimental Mine, 1950.

1951–56

HAZARDS AND OCCURRENCE OF EXPLOSIONS

The annual fatalities from coal-mine explosions for 1951–56 have been: 1951—163, 1952—15, 1953—14, 1954—19, 1955—4, and 1956—11. In 1951 the Orient No. 2 mine explosion caused 119 deaths, and 4 other major disasters added 38 more. In 1952, 1 major disaster caused 6 deaths, and in 1953 another caused 5. The Jamison No. 9 mine explosion in 1954 killed 16 men.

The record in 1951 was extremely bad, and measures were put into effect that helped to control explosions and ignitions for the following years. The measures were taken under a Federal law making Federal coal-mine inspectors responsible for ordering withdrawal of men from mines or parts of certain mines found to be imminently dangerous. Authority was also given to require compliance with specific provisions of the Federal law within a stated time (*59*).

The causes of all reported explosions in 1951 were: 10 ignitions of gas or dust by electric arc, resulting in 132 deaths; 3 ignitions of gas and dust by blasting, causing 14 deaths; and 10 instances of gas being ignited by open lights or smoking, causing 17 deaths.

In the major explosions resulting in more than five deaths each the causes, as later described, were:

Orient No. 2 mine, gas from a caved area ignited by an arc from open-type machine, propagated by dust.

United Gas No. 1 mine, open shots on a rock fall ignited dust in an area unprotected by rock dust.

Bunker mine, gas forced out of a pillar area by a fall was ignited by a cable-reel locomotive.

Burning Springs No. 1 mine, gas from an abandoned area was circulated to an active face and ignited by an arc from a faulty cable splice or by smoking.

Buttonwood mine, gas accumulated when a brattice was removed during the shift ignited by smoking or by a defective flame safety lamp.

These explosions and those of a minor type emphasized the need for more careful attention to thorough ventilation, closer inspection for gas that might enter from inactive places, and safeguards for blasting open shots. The dust explosions and explosions from gas and dust made it clear that rock dusting was substandard in many mines (*12, p. 3*).

In 1952 and 1953 similar failures in protec-

tion were revealed. The major explosion at Carpentertown mine was ignited by an arc from a trolley locomotive when gas from a squeezed area came out onto a haulageway; at the O'Brien mine blown-out shots of black powder ignited dust.

Of the minor explosions, 21 were from electric arcs, 15 were from blasting, and 15 were from open flames, such as smoking, misused flame safety lamps, and open lights. Forty-four were gas ignitions only, 6 were from dust, and 1 was from gas and dust. Gas accumulated because auxiliary fans were shut down, because face ventilation was neglected, or because regular ventilation was allowed to be interrupted.

Dust explosions in 1952 occurred in dry and dusty workings where holes were shot on the solid, where dust on a haulageway was ignited by a stalled locomotive, and where dependent shots blew out. Ignitions from open lights virtually ceased, but smoking and other uses of open flames continued as sources. Unsafe blasting practices caused a fourth of the ignitions, mainly in anthracite mines, but several occurred in bituminous-coal mines. Electric arcs were the source of ignition in about 42 percent of all explosions in the 4 years. Use of electric equipment in almost every operation in the mines makes this hazard ever-present and necessitates the removal of gas and coal dust from all active working places.

In 12 of a total of 76 ignitions in 1951, 1952, and 1953, rock dusting was not done or was inadequate, so that the explosion was not prevented or confined to a small area.

The explosion in the Jamison No. 9 mine in 1954 demonstrated again the danger of the lurking hazards of incomplete rock dusting, accumulations of methane in inadequately ventilated places, and the firing of insufficiently confined charges of permissible explosives in the presence of gas and dust. Although more than average amounts of rock dust were used in this mine, the distribution did not give the protection that was assumed to exist. The minor explosions reported in 1954, 1955, and 1956 showed that the leading hazards of the 3 preceding years were continuing in various degrees and that some hitherto infrequent sources of ignition were causing numerous ignitions.

For the 3 years, 35 (40 percent) were attributed to electric arcs, 19 (23 percent) were caused by blasting, 15 (17 percent) were from open flames or smoking, and 14 (16 percent) were charged to sparks from the bits of modern cutting or drilling machines striking rock or impurities in the coal, although electric arcs or sparks may have caused some of them. One ignition was charged to misuse of a flame safety lamp and three to smoldering fires. Seventy were ignitions of gas, 4 of dust, and 13 of gas and dust. Gas accumulated in roof cavities and at faces after shooting or because ventilation was poorly maintained or inadequate. Dust was ignited where sprays were shut off at a loading chute, where both permissible and nonpermissible explosives were used in underburdened or dependent shots, and where oxygen was used to blow dust from a motor in the presence of highly heated material.

Ignitions from open lights reappeared in very small mines, and five ignitions were charged to smoking, also in small mines. Open shots, mainly in anthracite mines, caused 6 ignitions; underburdened shots or exposed charges caused 12 more. Ignitions by electric arcs remained at 40 percent—sound evidence that gas and equipment capable of producing arcs are not being kept apart. The hazard from electric equipment has not been effectively reduced by the measures taken since 1950. Three of the ignitions involving dust became widespread because of inadequate rock dusting. Since only these instances were reported, it seems probable that generally improved rock-dusting practices helped to localize some ignitions.

TABLE 12.—*Major explosions in United States coal mines, 1951–56*

Date	Name of mine	Location of mine	Killed
1951: January 18	Burning Springs	Kermit, W. Va	11
March 29	Buttonwood	Wilkes-Barre, Pa	5
October 15	Bunker	Cassville, W. Va	10
October 31	United Gas No. 1	United, W. Va	12
December 21	Orient No. 2	West Frankfort, Ill	119
1952: February 2	Carpentertown	Carpentertown, Pa	6
1953: March 30	O'Brien	Lovilia, Iowa	5
1954: November 13	Jamison No. 9	Farmington, W. Va.	16
1955	None		
1956	None		

TABLE 13.—*Minor explosions in United States coal mines, 1951–56*

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1951: January 10	Stotesbury No. 8	Stotesbury, W. Va.	Gas; arc from mining machine at face.	K–0; I–3.
January 18	Sunny Ridge	Silt, Colo.	Dust; arc from power line or firing line; 12 holes on solid.	K–0; I–0.
March 26	No. 34	McDowell Co., W. Va.	Gas; arc from cable-reel locomotive.	K–1; I–2.
May 7	Enoco	Bruceville, Ind.	Gas; machine-man smoking at face.	K–0; I–2.
May 17	Green Valley	Terre Haute, Ind.	Gas; smoking; door open	K–0; I–5.
June 5	Coaldale colliery No. 8.	Coaldale, Pa.	Gas; open shots in battery	K–1; I–1.
June 21	Red Ash shaft	Exeter, Pa.	Gas; smoking; ventilation deranged by blasting.	K–0; I–2.
June 24	Boyd Excelsior	Excelsior, Ark.	Gas; smoking; longwall; small accumulation.	K–0; I–3.
June 25	Valley Camp No. 5	Elm Grove, W. Va.	Gas; arc from trolley-wire hanger; accumulation behind gunite.	K–0; I–2.
July 26	Midland No. 1	Midland, Ark.	Gas and dust; smoking at room face; after cut.	K–0; I–6.
August 13	Weston colliery No. 2.	Shenandoah, Pa.	Gas; heavy blasting in breast; no local ventilation.	K–1; I–1.
September 13	Long No. 4	Haysi, Va.	Gas; open light over roof fall	K–0; I–0.
Do	Bunker	Cassville, W. Va.	Gas; arc from electric drill in unventilated chute.	K–0; I–3.
November 11	Borderland No. 1 and Alma.	Pike County, Ky.	Dust; blowtorch in bin at headhouse.	K–1; I–0.
November 14	Bethlehem No. 101	Century, W. Va.	Gas; smoking; gas from feeder ignited at face of heading.	K–0; I–0.
November 22	Boyd-Excelsior	Excelsior, Ark.	Gas; arc from mining machine on longwall.	K–0; I–1.
December 10	Kessler-Angelo	Llewellyn, Pa.	Gas; arc from pump switch or motor, slope bottom.	K–2; I–0.
December 26	Crucible	Crucible, Pa.	Gas; arc from locomotive cable nips.	K–0; I–4.
1952: January 3	Premium	Premium, Ky.	Dust; arc from stalled locomotive.	K–0; I–1.
January 5	Glendora No. 28	Sullivan, Ind.	Gas; cutting torch; gas from idle shaft.	K–0; I–2.
January 7	Sunny Ridge	Silt, Colo.	Dust; blown-out shots, permissible explosive; arc from firing line.	K–0; I–0.
January 22	Seaboard No. 5	Seaboard, Va.	Dust; blown-out shots, black powder.	K–0; I–2.
February 25	Seaboard No. 9	do.	do.	K–0; I–3.
March 21	Joanne	Rachel, W. Va.	Gas; defective flame safety lamp; line brattice down.	K–0; I–0.
March 24	Acosta-Gray No. 3	Gray, Pa.	Gas; arc from mining machine; line brattice down.	K–0; I–4.
April 15	Dresser	Terre Haute, Ind.	Gas; arc from electric drill; line brattice down.	K–0; I–1.
April 18	Sunnyside No. 1	Sunnyside, Utah	Gas; arc from trolley shoe	K–0; I–2.
May 9	do.	do.	do.	K–0; I–0.
May 12	Alaska No. 1	Beelick Knob, W. Va.	Gas and dust; smoking or arc from cable splice; mine idle 4 days.	K–1; I–0.
May 23	Pursglove No. 15	Pursglove, W. Va.	Gas; arc from light wire; fan off; 5 men in new shaft.	K–0; I–5.
May 25	Barr No. 1	Dixonville, Pa.	Gas; arc from switch after power failure.	K–0; I–1.
May 26	Kenilworth	Kenilworth, Utah	Dust; arc from firing wires; 9 holes shot on solid.	K–0; I–0.
June 17	Peabody No. 43	Taylorville, Ill.	Gas; defective flame safety lamp.	K–0; I–1.
June 23	Fies	Madisonville, Ky.	Gas; undetermined (friction, arc, or smoking?)	K–0; I–0.
June 26	Olga No. 2	Caretta, W. Va.	Gas; arc from light wires; fan off 1 hour; 5 men in new shaft.	K–4; I–1.

TABLE 13.—*Minor explosions in United States coal mines, 1951–56*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1952: June 27	Lansford Colliery	Lansford, Pa	Gas; open shots in chute	K–4; I–1.
Do	Continental shaft	Centralia, Pa	Gas; open shot in draw hole	K–0; I–3.
July 1	Stankiewicz slope	Shamokin, Pa	Gas; smoking	K–0; I–3.
September 15	Diamond No. 2	Charles, Pa	Gas; arc from trolley wheel	K–0; I–1.
October 7	Bethlehem No. 53	Cokeburg, Pa	Gas; arc from machine-cable short circuit.	K–0; I–2.
October 21	Potts colliery	Locustdale, Pa	Gas; open shot in chute	K–0; I–4.
October 23	Lance colliery	Larksville, Pa	Gas; smoking; poor ventilation in chamber.	K–0; I–2.
November 12	No. 34	McDowell Co., W. Va.	Gas; arc from nip; cable-reel locomotive.	K–0; I–1.
December 9	Maple Hill colliery	Shenandoah, Pa	Gas; smoking in rock hole; compressed-air ventilation.	K–0; I–2.
1953: January 16	Loomis colliery	Nanticoke, Pa	Gas; flame safety lamp in front of compressed-air hose.	K–1; I–2.
January 29	Packer No. 5 colliery	Girardville, Pa	Gas; heavy charges permissible explosives in long holes.	K–0; I–3.
February 20	Fry Farm	Universal, Pa	Gasoline; open light; fumes from leak in pipeline.	K–0; I–1.
February 25	Ellena	Pleasant Valley, Pa	Gasoline; arc from mining machine; leak from surface pipeline.	K–0; I–2.
March 6	Jamison No. 22	Marion County, W. Va.	Gas; arc from light circuit in new shaft.	K–3; I–0.
March 10	Germantown colliery	Centralia, Pa	Gas; open shot in chute; dynamite.	K–0; I–2.
March 12	Chiefton No. 2	Dola, W. Va	Gas; arc from mining machine and roof bolt.	K–0; I–0.
March 30	Elkfoot No. 4	Biggs, Ky	Dust; blown-out shot; dynamite and permissible explosive; men out.	K–0; I–0.
April 28	Lancashire No. 15	Bakertown, Pa	Gas; Colmol bits cut into sandstone roof.	K–0; I–2.
May 1	Vesta No. 5	Vestaburg, Pa	Gas; underburdened rock shot; permissible explosives.	K–0; I–0.
May 5	Richardson No. 3	Colson, Ky	Gas; open light; pocket in roof near face—small.	K–0; I–0.
May 12	Biscontini No. 58 Slope.	Nanticoke, Pa	Gas; blasting on solid; ventilation blocked; tests not made.	K–2; I–1.
May 29	Dodson colliery No. 6.	Lansford, Pa	Gas; multiple shots on solid; ventilation weak.	K–2; I–2.
June 3	Pocahontas No. 33	McDowell Co., W. Va.	Gas; arc from trolley locomotive; fireboss in idle mine.	K–1; I–0.
June 4	Peach Mountain slope.	Phoenix Park, Pa	Gas; arc from electric drill air recirculated; 4 in mine.	K–0; I–4.
June 12	Potts colliery	Locustdale, Pa	Gas; open shot in rock hole; permissible explosives.	K–0; I–2.
June 22	Pursglove No. 15	Pursglove, W. Va	Gas; arc from short circuit in cable; ventilation curtain raised.	K–0; I–3.
July 30	Magnolia	Madisonville, Ky	Gas; arc from trolley(?) pocket in roof cavity.	K–0; I–1.
August 12	Storrs colliery	Dickson City, Pa	Gas; smoking; line brattice down overnight.	K–0; I–1.
August 14	Tracy slope	Port Carbon, Pa	Gas; 2 shots in breast ignited gas.	K–0; I–7.
August 26	Russian No. 1 slope	Minersville, Pa	Gas; smoking at face of chute	K–0; I–1.
September 9	Z & B No. 1 slope	Phoenix Park, Pa	Gas; open light at face of chute.	K–0; I–2.
October 3	Tri–K	Terre Haute, Ind	Gas; arc from loading machine	K–0; I–0.
October 30	Peabody No. 14	DuQuoin, Ill	Gas; arc from trolley wheel; gas from seal; 4 foremen in mine.	K–0; I–2.
November 4	Pursglove No. 15	Pursglove, W. Va	Gas; overheated splice in cable; waiting room at shaft bottom.	K–0; I–1.
December 13	No. 10	Thorpe, W. Va	Gas; arc from trolley wheel; high place in roof.	K–0; I–2.

TABLE 13.—*Minor explosions in United States coal mines, 1951–56*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1954: January 7	Oriole	Madisonville, Ky	Gas; small accumulation over broken coal; probably smoking.	K–0; I–1.
January 13	New River No. 11	Capels, W. Va	Gas; ignited by cutting bits striking rock.	K–0; I–0.
February 9	IHI No. 3	Rifle, Colo	Gas; feeder ignited by arc from electric drill.	K–0; I–2.
February 17	Bunker	Cassville, W. Va	Gas and dust; underburdened shot, permissible explosives.	K–0; I–1.
February 18	Joanne	Rachel, W. Va	Gas; feeders ignited by roof-bolt drill, electric arc.	K–0; I–0.
April 6	Havaco No. 9	Havaco, W. Va	Gas from idle entries; cable nip on entry.	K–0; I–3.
April 9	Williams slope	Minersville, Pa	Gas; poor ventilation, 1 opening; carbide light.	K–0; I–1.
April 14	Coaldale No. 8	Coaldale, Pa	Gas; unconfined shake shot in chute, permissible explosives.	K–0; I–2.
April 27	Springdale	Logans Ferry, Pa	Gas in roof cavity; arc from trolley shoe.	K–0; I–0.
April 28	Storrs No. 2 shaft	Dickson City, Pa	Gas at face; poor ventilation, not reported; smoking or arc from drill.	K–0; I–4.
May 4	Enoco	Bruceville, Ind	Gas; sparks from continuous miner bits and roof rock.	K–0; I–4.
May 6	do	do	do	K–0; I–1.
May 12	Gaston No. 2	Alpoco, W. Va	Gas from old workings; arc from locomotive	K–1; I–6.
May 25	Palmer No. 10	Franklin, Wash	Gas; electric drill	K–0; I–2.
May 28	Cheruka Rock slope	Branchdale, Pa	Gas; poor ventilation; smoking or arc.	K–0; I–3.
June 8	Carbon No. 5	Carbon, Okla	Gas from kerf; arc from machine.	K–0; I–0.
July 16	Fies	Madisonville, Ky	Gas; sparks from machine bits.	K–0; I–0.
August 24	Germantown colliery	Centralia, Pa	Gas; unconfined shake shot in chute, permissible explosives.	K–1; I–0.
August 27	Lucerne No. 3	Lucerne Mine, Pa	Gas and dust; ventilation and rock dust inadequate; fireboss on trolley locomotive.	K–1; I–0.
September 28	Buttonwood colliery	Wilkes-Barre, Pa	Gas; poor ventilation, tests not made; 2 exposed shots, permissible explosives.	K–0; I–8.
November 3	Bethlehem No. 32	Revloc, Pa	Gas; no line brattice; short circuit in trailing cable.	K–0; I–0.
November 17	Bird No. 3	Johnstown, Pa	Gas; underburdened shot, permissible explosives.	K–0; I–0.
November 30	Yocum Darby	Evarts, Ky	Gas in crosscut face; blasting from 250-v. circuit, arc firing cable and rail; nongassy.	K–0; I–2.
December 13	Katchmar and Machita slope.	Buck Run, Pa	Gas; poor ventilation; struck match to light cigarette.	K–0; I–3.
1955: January 18	Mathies	Courtney, Pa	Gas from drill hole ignited by friction sparks of drill starting new hole.	K–0; I–0.
January 28	Wyoming	Wyoming, W. Va	Gas; poor ventilation and inspection; arc, defective permissible type machine.	K–2; I–5.
February 14	Kenilworth	Kenilworth, Utah	Dust; loading without sprays; arc from car wheel.	K–0; I–0.
February 25	No. 2	Gary, W. Va	Gas in roof cavity in crosscut; underburdened shot, permissible explosives.	K–0; I–0.
March 14	Loomis colliery	Nanticoke, Pa	Gas in kerf; sparks from cutter bits.	K–0; I–0.
March 18	Vesta No. 5	Vestaburg, Pa	Gas after rock shots; 1 hole underburdened permissible explosives.	K–0; I–0.

TABLE 13.—*Minor explosions in United States coal mines, 1951–56*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1955: April 25	No. 2 Lykens vein slope.	Burnside, Pa	Gas in chute; match used to light cigar.	K–1; I–1.
April 25	No. 9 vein, south dip S 1	Trevorton, Pa	Gas; poor ventilation and tests; blasting exposed permissible explosives.	K–0; I–2.
May 25	Coiltown	Nebo, Ky	Gas in face; curtain torn down; lighting cigarette with lighter.	K–0; I–2.
June 9	South Wilkes-Barre colliery.	Wilkes-Barre, Pa	Gas in blasted coal face ignited by permissible explosives.	K–0; I–0.
June 17	Vesta No. 5	Vestaburg, Pa	Gas in kerf; sparks from machine bits and draw slate.	K–0; I–0.
June 18	South Wilkes-Barre colliery.	Wilkes-Barre, Pa	Gas; face of air chute; poor ventilation; arc from open-type drill.	K–0; I–0.
June 18	No. 2 Lykens Valley slope.	Mount Pleasant, Pa	Gas; poor ventilation in chute face; arc from open-type drill.	K–0; I–1.
July 23	Kehler No. 2 slope	Valley View, Pa	Gas; poor ventilation; arc from drill.	K–0; I–2.
August 23	Ten Mile	Dola, W. Va	Gas; insufficient ventilation; arc, cutter bar and roof bolt.	K–0; I–0.
August 29	Saginaw No. 1	St. Clairsville, Ohio	Gas; leakage from seals of old entries; arc from trolley shoe.	K–0; I–2.
October 22	Hickory drift No. 2	Rausch Creek, Pa	Gas; poor ventilation; arc from drill.	K–0; I–3.
November 8	Nelms	Nelms, Ohio	Gas in shear cut; sparks from cutter bits and rock.	K–0; I–0.
November 30	Pursglove No. 15	Pursglove, W. Va	Gas in faces; curtain pinned up; arc, bare headlight wire, continuous miner.	K–0; I–5.
December 9	Maysville No. 1 slope.	Kulpmont, Pa	Gas from blasted face; open-shot permissible explosives on rock.	K–1; I–1.
December 19	W. and W. No. 3	Westernport, Md	Gas; poor ventilation; match lighting a cigarette.	K–0; I–0.
1956: January 4	Peach Mountain slope.	Pottsville, Pa	Gas; no line brattice or tests; arc from electric drill.	K–0; I–2.
February 3	McCurtain	McCurtain, Okla	Gas; ignited by rekindled mine fire.	K–0; I–0.
February 14	Alexander No. 2	Moore's Junction, Ohio.	Carbide gas and pellet powder in 2 cans ignited by open lights.	K–0; I–2.
February 21	Pikeview	Pikeview, Colo	Gas in fire area ignited by fire	K–0; I–0.
February 24	Clyde	Fredericktown, Pa	Gas in roof cavity at face ignited by shot; permissible explosives.	K–0; I–0.
February 28	Cedar Grove	Maylene, Ala	Gas; poor ventilation; open-flame carbide light.	K–0; I–0.
March 2	Vesta No. 5	Vestaburg, Pa	Gas in kerf ignited by friction sparks from cutter chain.	K–0; I–0.
March 14	S and J	Forestville, Pa	Gas; poor ventilation; smoking.	K–0; I–2.
March 20	Vesta No. 5	Vestaburg, Pa	Gas in kerf; friction sparks from cutter bar.	K–0; I–0.
March 21	Thompson Creek No. 1.	Carbondale, Colo	Gas; poor face ventilation; arc from electric drill.	K–0; I–2.
March 22	Osage No. 3	Osage, W. Va	Gas ignited by sparks from cutter bits of continuous miner.	K–0; I–0.
April 3, 4	Green Valley	Terre Haute, Ind	Gas in kerf; 6 ignitions from arcs or sparks from cutter bars.	K–0; I–0.
April 6	Compass No. 3	Dola, W. Va	Gas; poor ventilation; loading-machine cable shorted.	K–0; I–0.
April 12	Ebensburg No. 1	Colver, Pa	Gas; poor ventilation; arc from trailing cable.	K–0; I–0.

TABLE 13.—*Minor explosions in United States coal mines, 1951–56*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1956: April 13	Valley Camp No. 3	Triadelphia, W. Va.	Gas at face of chute; line brattice out; flame-safety lamp.	K–0; I–1.
April 24	Compass No. 3	Dola, W. Va.	Gas feeder; sparks from cutter bits and sulfur ball.	K–0; I–0.
May 21	Vesta No. 5	Vestaburg, Pa.	Gas; roof cavity in air lock; arc from locomotive.	K–0; I–1.
May 31	Praco	Praco, Ala.	Gas; inadequate ventilation and testing; arc from trolley locomotive.	K–2; I–0.
June 9	Lansford Nos. 4 and 6.	Lansford, Pa.	Gas in a battery; unconfined shot, permissible explosives.	K–0 I–5.
July 12	Pond Creek	South Williamson, Ky.	Gas; poor ventilation; arc from nip of mine jeep.	K–1; I–1.
July 14	Aldrich shaft	America, Ala.	Gas from abandoned shaft ignited by lightning.	K–0; I–0.
July 17	Darby No. 1	Closplint, Ky.	Gas at entry face; no testing; open-flame carbide lamps.	K–0; I–0.
July 19	Valley Camp No. 3	Triadelphia, W. Va.	Gas in shear; cutter bits, sparks while water off.	K–0; I–0.
August 31	Allen	Stonewall, Colo.	Gas from caved area; ignited at pillar by underburdened shots.	K–0; I–0.
September 18	Bunker	Cassville, W. Va.	Gas at face; arc from nip, loading-machine trailing cable.	K–0; I–0.
October 8	Compass No. 3	Dola, W. Va.	Gas in roof cavity; arc from roof-bolting machine.	K–0; I–0.
October 20	Lancashire No. 15	Bakerton, Pa.	Gas in roof cavity; defective curtain; arc from trolley of locomotive.	K–0; I–1.
October 22	Arthur (Auger mine)	Lost Creek, W. Va.	Gas and dust in auger hole ignited by friction sparks; blew out.	K–0; I–4.
October 23	DeKoven	DeKoven, Ky.	Dust from shot of gelatin dynamite on overhanging rib.	K–0; I–1.
October 25	Green Valley	Terre Haute, Ind.	Gas from blasted cut of coal; arc from nips of shooting cable.	K–0; I–0.
November 2	Lancashire No. 20	Carrolltown, Pa.	Dust; blowing out motor with oxygen ignited by incipient fire.	K–0; I–3.
Do	Bunker	Cassville, W. Va.	Gas over fall; open shots permissible explosives.	K–0; I–1.
November 7	Truesdale colliery	Nanticoke, Pa.	Gas from below seal in shaft; cutting torch used above seal.	K–4; I–0.
November 28	Buck Mountain slope	Branchdale, Pa.	Gas; poor ventilation; open-flame carbide lamps.	K–0; I–0.
November 29	Hickory Spring	Sparta, Tenn.	Carbide; fuse; blasting caps in carbide can; open light.	K–0; I–1.
December 6	Marianna No. 58	Marianna, Pa.	Gas at face; blasting with permissible explosives.	K–0; I–0.
December 14	Shannopin	Bobtown, Pa.	Gas in roof cavity; arc from trailing-cable anchor and roof bolt.	K–0; I–0.
December 20	Baltimore colliery	Wilkes-Barre, Pa.	Gas from roof in chamber; installing signal button caused arc.	K–0; I–2.
Do	Deerfield	Corel, W. Va.	Gas in roof cavity; arc from locomotive trolley.	K–1; I–0.
December 21	Vulcan No. 3	New Castle, Colo.	Gas from drill holes accumulated at face; arc from open-type drill.	K–0; I–2.
December 26	Trail Mountain No. 2	Orangeville, Utah	Dust; 2 shots—1 blown out at face, violent to portal, permissible explosives.	K–3; I–0.

DESCRIPTION OF MAJOR DISASTERS

January 18, 1951; Burning Springs No. 1 Mine, Kermit, W. Va.; 11 Killed

(From Bureau of Mines report, by E. E. Quenon, J. J. Whalen, O. W. Harris, and H. B. Lynch)

A unit crew of 13 men was working in the 3 entries off 7 main entry. About 12:00 noon a motorman delivering a trip of empty cars near this section noted smoke and dust on the haulageway and quickly notified the outside mine office. The superintendent immediately went underground, while calls were made to State and Federal mine inspectors. The superintendent organized a rescue crew and went to the affected section. They found the section foreman and the loading-boom operator both alive but injured and sent them to the surface.

Heat and smoke prevented further exploration, so eight temporary stoppings were put up to replace those blown out in the 7 main entry. This restored ventilation to No. 3 entry, where five bodies were found and recovered. Inspectors and mine officials arrived and made an exploration of the remaining working places in the area, recovering six other bodies. Breathing apparatus or gas masks were not used.

The explosion was local, and there was little flame or violence. Men from other sections were not affected. A watch stopped at 11:51 a. m. indicated the time of the explosion. Recovery was completed by about 7:00 p. m. The damage consisted of stoppings blown out, powder boxes demolished, and about 75 percent of the timbers blown out. The No. 3 room had cut into abandoned workings earlier that morning. Methane was carried into the active workings and was ignited near the face of No. 1 room off No. 3 entry by smoking or by an arc from a poorly made splice on the trailing cable of a loading machine. Coal dust was ignited, but spread of the explosion was limited by rock dusting that was maintained to within 80 feet of the faces (fig. 162).

March 29, 1951; Buttonwood Colliery (Anthracite), Wilkes-Barre, Pa.; 5 Killed

(From Bureau of Mines report, by F. E. Griffith, N. M. Benson, F. Retsel, and G. W. Culverhouse)

An explosion at about 10 a. m. in the No. 33 tunnel, east Abbott gangway workings of the No. 6 plane section, killed 2 of the 17 men in the affected area and critically injured 4 others. Three of these died later in a hospital. Three others were slightly affected. The other 8 men assisted in rescuing the injured men and recovering the 2 bodies. The 576 men working elsewhere continued the shift undisturbed.

The fireboss had made a preshift examination of the section and pegged the men into the section. He told the section foreman that everything was all right. The section foreman sent the fireboss to "measure" in No. 10 tunnel, while he went elsewhere in the section to "measure." He was told about 10 a. m. that something was wrong in No. 33 tunnel and went there immediately. The mine office was informed by telephone, and officials were sent to take charge.

The fireboss had measured the gangway, the airway, and chambers outby No. 19 chute to No. 11 chamber when the explosion occurred. The survivors, except 2 critically injured, came out unassisted and carried or supported the other 2. Ventilation was reestablished, and the two bodies were removed within a few hours.

Property damage consisted of the destruction of stoppings in the airway and headings between chambers from No. 7 to No. 12. The workmen in No. 11 chamber had removed some boards from a wooden line brattice being used to ventilate the face and had put them on a new cross brattice they were building below the last open crosscut to No. 10 chamber. This short-circuited the air from the face, permitting gas to accumulate where a gas feeder was known to exist. When the miner raised his safety lamp to check the air the explosion occurred. Tests of the lamp did not result in any failures and defects were not found. No other source of ignition was found (fig. 163).

October 15, 1951; Bunker Mine, Cassville, W. Va.; 10 Killed

(From Bureau of Mines, by T. J. McDonald, R. E. Riley, and F. D. Baker)

The A west section consisted of 4 parallel entries driven 1,725 feet from the 6 south entries to the boundary. Pillaring had been started at the boundary and completed over an area 600 feet deep and 700 feet wide. A fireboss examination was made before the start of the shift; and no unusual conditions were reported, nor was methane reported in the A west section.

The mine had been idle Saturday and Sunday, until four working crews went in at 12:15 a. m. Monday. Ten of the 40 men were in A west. A helper on the mining machine in the section was injured and was sent to the surface about 2:00 a. m. He stated that a pillar fall was hanging, and the section foreman had remained with the mining machine during the time it was operating in 16 chute making continuous tests for gas. As his was the only flame safety lamp in the section, tests were not being made where the loading machine and open-type locomotive were operating.

At 6:35 a. m. the section foreman telephoned to the shift foreman, reporting that the section was free of gas, but that the roof along the pillar line was working and a fall was expected. At about 6:45 a. m. the B west section foreman called and said his section was filling with smoke. The shift foreman told him to bring his men out and went to investigate. As B west was on the intake side of the ventilation from A west the smoke cleared quickly and the men could go out 6 south. The shift foreman and a man from B west found smoke, heat, and damaged stoppings inby B west on 6 south. A locomotive was on fire, which they put out.

The outside mine office was called, and officials came underground and started recovery. Temporary stoppings were put up, and all bodies were recovered by 1:30 p. m. Breathing apparatus was not used. It was evident from the location of the bodies that the men were moving outby from where they would be during normal operations when the explosion happened.

It originated in the vicinity of the loading machine and the locomotive and probably was ignited by an arc from the locomotive when gas from the pillared area was forced over the equipment by a large fall (fig. 164.). Dust entered into the explosion but not as a major factor. Rock dusting to within 70 feet of the faces prevented spread of the forces and flame. It was evident that methane had been present in the unventilated pillared area. No means was provided to bleed this methane into the return air without passing it through active workings.

October 31, 1951; United Gas No. 1 Mine, United, W. Va.; 12 Killed

(From Bureau of Mines report, by E. E. Quenon, F. J. Furin, and J. H. Blanton)

The explosion occurred on the third or maintenance shift during which coal was not produced. At the time, 1:35 a. m., 16 men were in the mine. A repair-

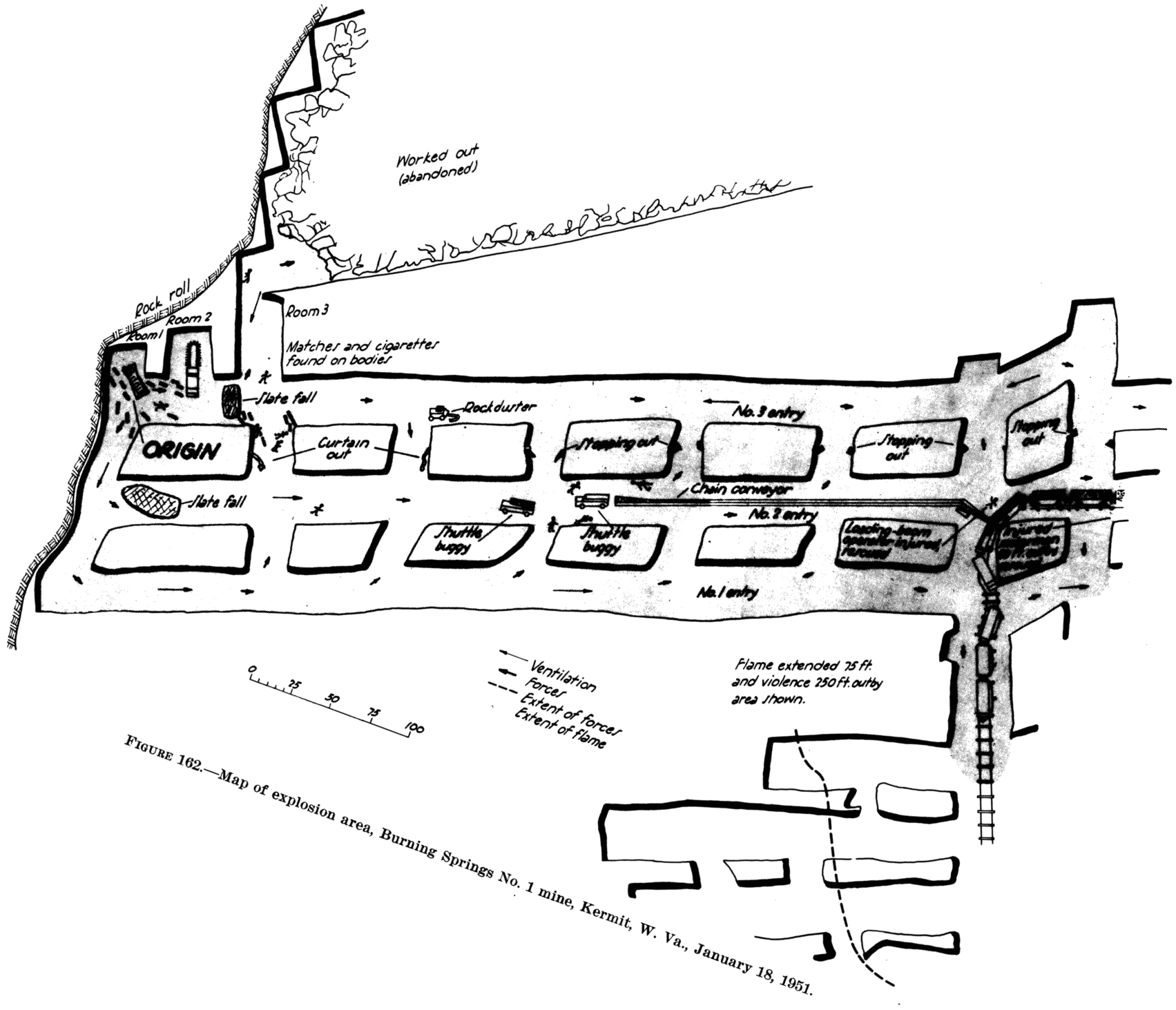

FIGURE 162.—Map of explosion area, Burning Springs No. 1 mine, Kermit, W. Va., January 18, 1951.

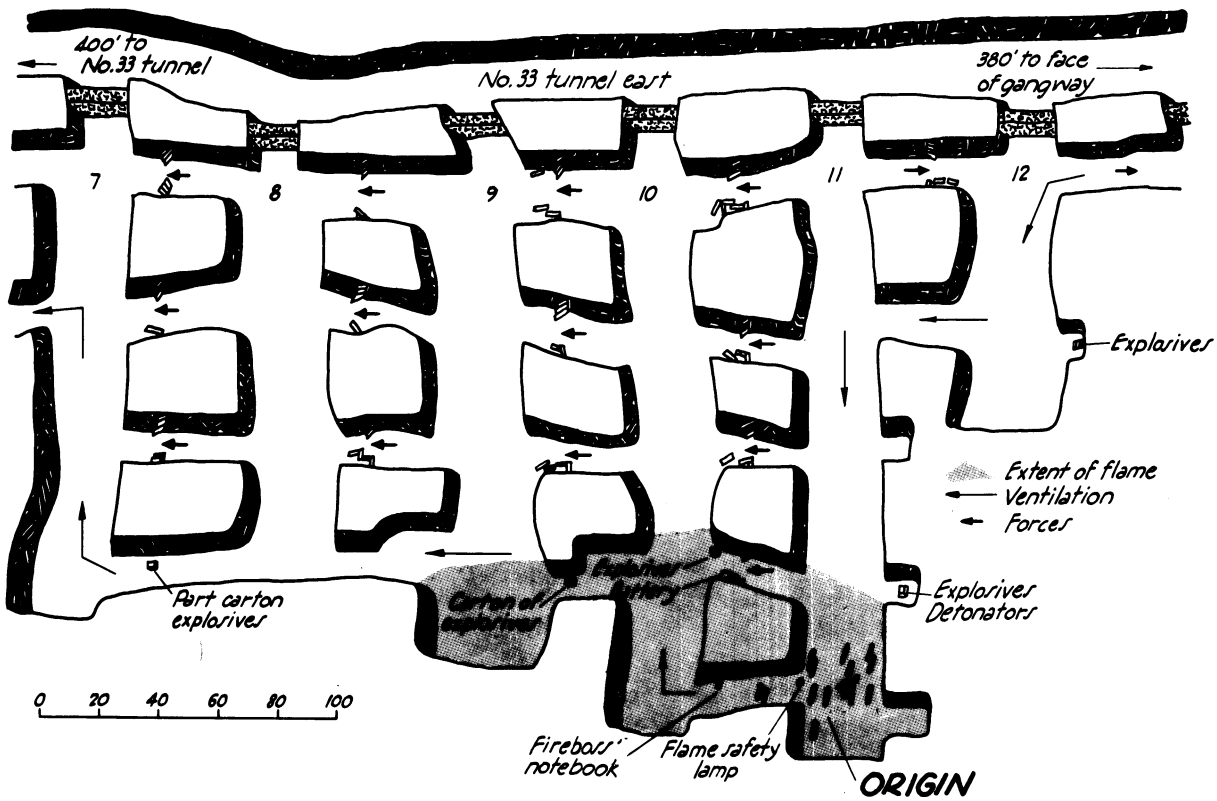

FIGURE 163.—Map of explosion area, Buttonwood colliery, Wilkes-Barre, Pa., March 29, 1951.

man on his way outside for a replacement part for a shuttle car was about 500 feet from the drift portal when he was blown off his feet and rolled along the floor. He could not see in the dust but groped his way out along the belt conveyor. On reaching the surface he found the fan stopped and the explosion door on the fanhouse open. He closed the door and started the fan, then notified the mine officials who came to the mine and went in.

Three other survivors were delivering supplies in 3½ left when they felt the force and heat. Heavy dust made it difficult to breathe. They retreated to a butt off and waited for the air to clear. After several attempts they were able to reach the north main entry and proceeded to 2½ left where they met the mine foreman and chief electrician coming in. These three men remained and assisted in the recovery work. Rescue men came to the mine, and temporary stoppings were erected. A crew equipped with Chemox breathing apparatus explored the explosion area to find out if there were any living men or fires.

Recovery was slow because of falls, loose roof, and the many blown-out stoppings and overcasts. About 35 temporary stoppings were constructed. Removal of the 12 bodies was completed by 4:45 p. m. of the day of the explosion. Property damage was extensive to face equipment, conveyor belts, stoppings, overcasts, timbers, and trolley wires. The forces radiated from the faces of the 3 left entries; the disturbance was negligible for the first 200 feet but increased in violence toward the north mains where the forces were greatest. They diminished toward the surface but damaged 2 automobiles parked near the pressure-relief doors of the fan. Flame extended from the faces of 3 left to a distance of 1,700 feet outby.

The second shift section foreman and a crew of 3 men had "doubled back" to take down loose roof at the last crosscut on No. 3 entry 3 left. A piece of rock 30 feet by 19 feet by 1 foot was taken down and was broken up by firing 12 or more open charges of permissible explosives on it. The blasting cable was connected to the fuse compartment of a loading machine, using 250-volt direct current. Coal dust was raised and was ignited by arcs from the firing circuit (fig. 165).

The explosion was propagated by coal dust in the face regions and along the shuttle-car roadways. The rock-dust applications were 110 to 150 feet from the entry faces and were inadequate throughout the 3 left section. A rock-dusting machine and crew were waiting in 2½ left to apply more dust when the roof rock was removed. Methane was not found in the mine and was not involved.

December 21, 1951; Orient No. 2 Mine, West Frankfort, Ill.; 119 Killed

(From Bureau of Mines report, by M. J. Ankeny, J. Westfield, W. H. Tomlinson, F. J. Smith, W. R. Chick, and C. L. South)

The night shift entered the mine at the No. 4 shaft and the man-trips left the shaft bottom about 6:25 p. m., reaching the working sections about 20 to 30 minutes later. About 7:40 p. m. the explosion caused the death of 118 of the men in the mine; 4 were rescued (1 of whom died), and 133 escaped uninjured

The night mine manager was on the surface at the No. 4 shaft when power went off in the mine and on the surface and smoke and dust came up the shaft. When the power came on in about 5 minutes he went to the shaft bottom and changed doors to put the stairway compartment of the upcast shaft in intake air. He warned all the sections on the south side of the mine by telephone to bring the men to the surface immediately but could not reach any of the north

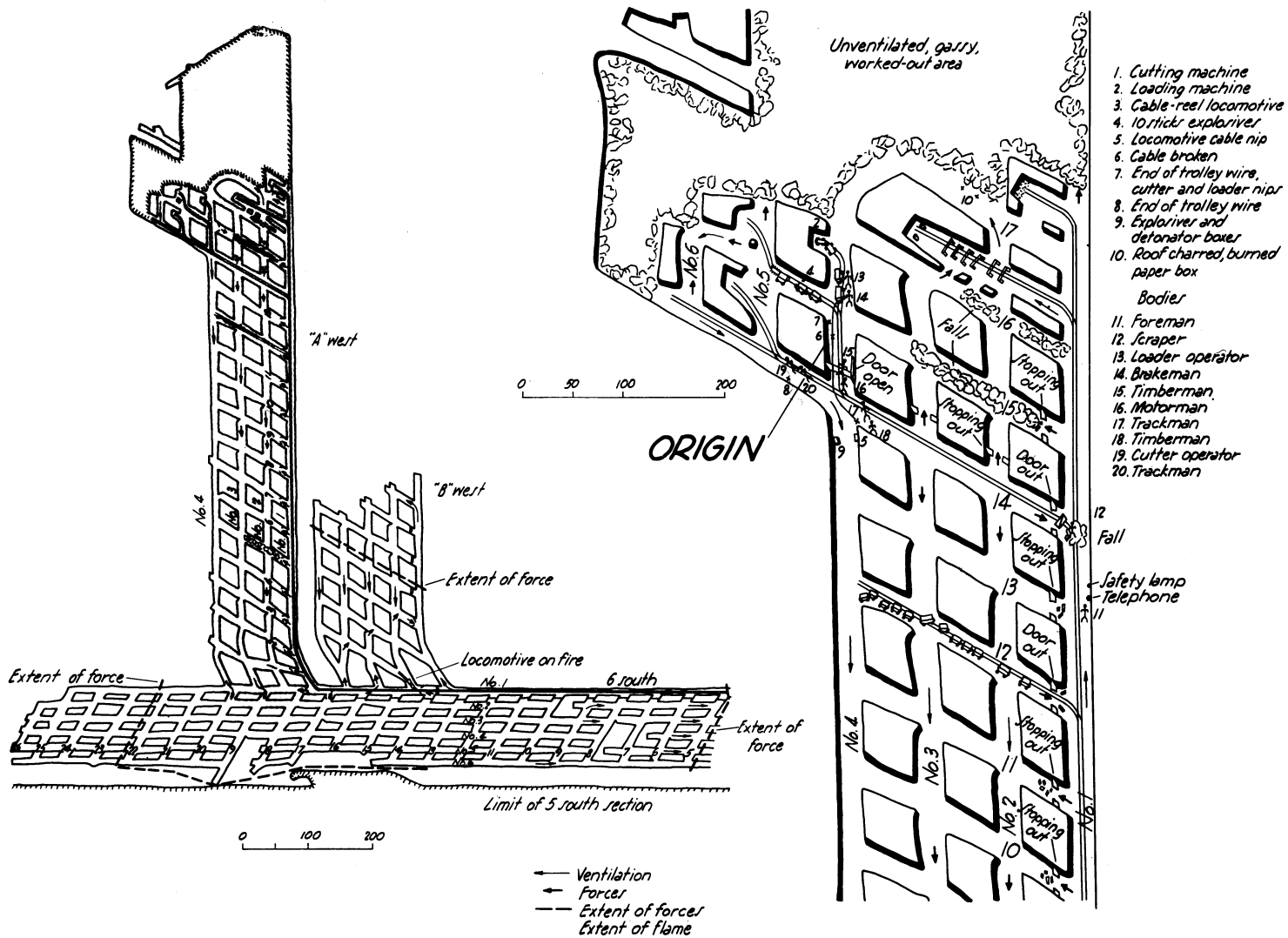

FIGURE 164.—Map of explosion area, Bunker mine, Cassville, W. Va., October 15, 1951.

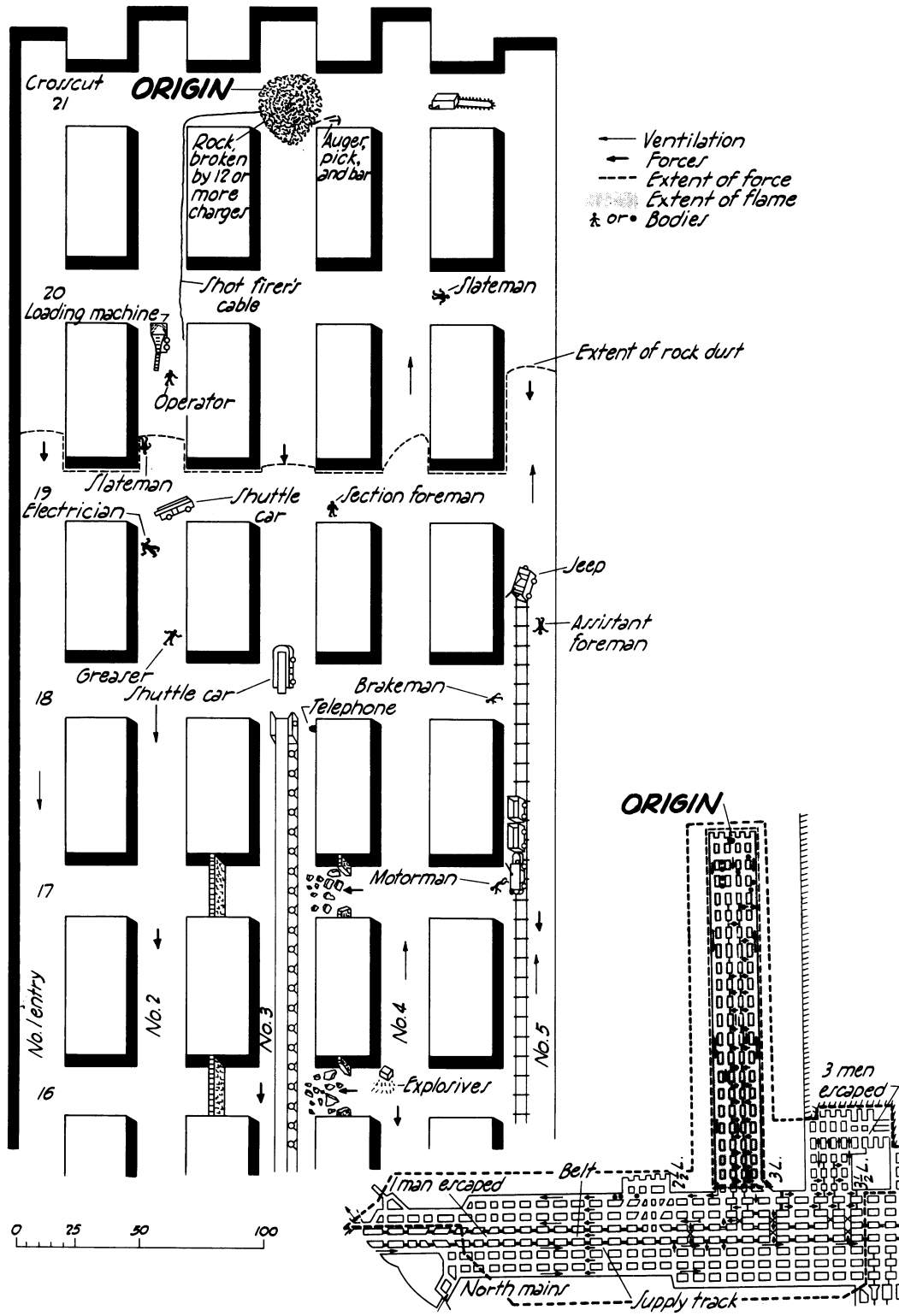

FIGURE 165.—Sketch of 3 left, origin of explosion, United Gas No. 1 mine, United, W. Va., October 31, 1951.

sections except the 11 and 12 north, 23 west northwest. He then called the company officials on the surface.

Rescue work was started, and three injured men were carried out of the new main north entries. One of these men died. Ten men in 1 north 25 west north erected a single canvas barricade across the entrance to No. 1 entry but did not otherwise shut off the openings to the place in which they took refuge. Nine were dead when found; but one was rescued alive at 5:40 a. m., December 24, and recovered.

A large force of rescue workers, crews, and leaders came to the mine and the operations were fully organized. Explorations were made by apparatus crews, and ventilation was restored by erecting temporary stoppings. Some bodies were removed by apparatus crews, all being brought out by 2:00 p. m. December 26. The ventilation in the explosion area was completely destroyed, in that almost all stoppings and doors were demolished as was one main overcast. Wires and air lines were blown down, and haulage equipment was damaged. Flame traversed the explosion area except the outer parts of new main north and main north entries (fig. 166).

The mine was gassy and methane was known to be in abandoned panels and sections of panels termed "old ends." These areas were open to air currents which were used to ventilate active workings, and haulage roads were also on return air. Attention was called to this hazard in Federal mine inspection reports, the last having a date July 31, 1951, which cited the following violation of the Federal Mine Safety Code.

Methane was detected in numerous abandoned entries (termed old ends) by means of a permissible flame safety lamp. The ventilation was short-circuited at No. 1 room in these abandoned entries generally. Trolley locomotives were being operated 150 to 300 feet outby the old ends.

All working sections affected by the explosion were ventilated by air that had passed by the entrances to abandoned workings. Three of these old ends were caving just previous to the explosion, releasing gas. A gas watchman was assigned to watch one of these places on the day shift. At the time of the explosion a trip of empty cars was standing in the main ventilating door in the 3 and 4 south at 27 east north west. This took air pressure off the abandoned 3 and 4 south entries and let gas come out onto the active workings where it was ignited, probably by an arc from electrical equipment near the junction of 3 south off 27 east north west and No. 3 stub entry off 3 south. Ignition may also have been from smoking. The flame was propagated by coal dust and by gas from other worked out and abandoned areas. Accumulations of coal dust principally along the roadways were not removed or rendered inert by the application of enough rock dust. Watering methods were inadequate.

February 2, 1952; Carpentertown Mine, Carpentertown, Pa.; 6 Killed

(From Bureau of Mines report, by W. D. Walker, G. M. Smith, F. E. Riley, and J. H. Dumire)

A fireboss examined the mine before the third shift entered, and later checks by section foremen between 11 p. m. and 1 a. m. did not show any methane in the mine. Twenty men were working in the 6 butt 1 right section, which included an area that was squeezing and from which equipment and rails had been removed on preceding shifts. At 1:15 a. m. a trolley locomotive brought empty cars into the section and then started out with a trip of 11 loaded cars. At 1:45 a. m. as the locomotive came out of No. 20 room an explosion occurred. The time was marked by a momentary increase of pressure on the fan chart from 3.0 to 3.8 inches of water gage.

The section foreman about 1,200 feet away felt the wind, and the air was filled with dust but no flame. He went to a telephone at No. 12 room and called outside for assistance. A pumper near No. 20 room was knocked into a ditch. He waited, then came out with four other survivors through the dust. Traveling by way of the intake aircourse they reached No. 12 room. The mine foreman arrived and organized rescue crews. Five men were found alive and removed, but one died on the way out. Four bodies were found.

Outside rescue men and crews came to the mine, and the last body was found and removed at noon. Four other men in the section who were outside the flame area escaped unaided. Methane was released in increasing quantity from the broken roof and floor strata in the squeeze area. An accumulation was carried to the haulage road where it was ignited by an arc from the locomotive (fig. 167). Flames extended down the borehole heading about 550 feet to water and about 750 feet outby the locomotive. The damage to the mine was minor; a few doors, and stoppings were damaged and timbers were dislodged. Dust entered into the explosion to a minor degree. The workings were damp or wet, and little dust was present. The investigation involved representatives of the company, the State Department of Mines, the Federal Bureau of Mines, the United Mine Workers of America, the United States Senate Committee on Labor and Public Welfare, and the company's insurance carrier. Considerable argument arose over the Federal inspectors' earlier classification of the mine as gassy on the strength of one air sample showing 0.25 percent methane in a place where a line curtain had been partly torn down. The State classed the mine nongassy.

March 30, 1953; O'Brien Mine, Lovilia, Iowa; 5 Killed

(From Bureau of Mines report, by R. Capps, W. B. Dalrymple, E. W. Felegy, J. A. O'Connor, R. O. Pynnonen, and H. F. Weaver)

The mine crew of 15 men had completed the single shift, and all but 2 had left the mine before 4 p. m. The foreman and another man remained underground to fire the shots that were drilled and charged during the shift. The holes in the faces of 13 rooms off 9 and 10 west entries and in the face of 7 east off the back entry were charged with black pellet powder and fired with fuse. Fine coal and clay were used for stemming. All holes except the 2 in No. 1 room off 10 west and 3 in 7 east entry had been fired when the explosion occurred and killed both men.

The force of the explosion spread throughout the 9 and 10 west entries and rooms and extended 700 feet along the main entries outby that section. A check curtain and four gob stoppings outby 9 west were demolished as was a door between 7 and 8 west entries. Ten empty mine cars in the main entry were piled so that they blocked the entry. Timbers were knocked out in the main and back entries, so that roof falls blocked the entries. No evidence of the explosion was noted on the surface. Three of the men on the surface saw smoke coming up the slope; and as the shot firers usually came up ahead of the powder smoke they went down the airshaft to look for them and found the entries blocked by falls. They came out and telephoned for help. A volunteer party of townsmen went down to the slope at 5:15 p. m., found the bodies, and brought them out before 6 p. m. Three officials from another mine, the owner of the O'Brien mine, and an employee went underground later to see what had happened.

Two of the men began to get worried about the air after examining a few places and started outside;

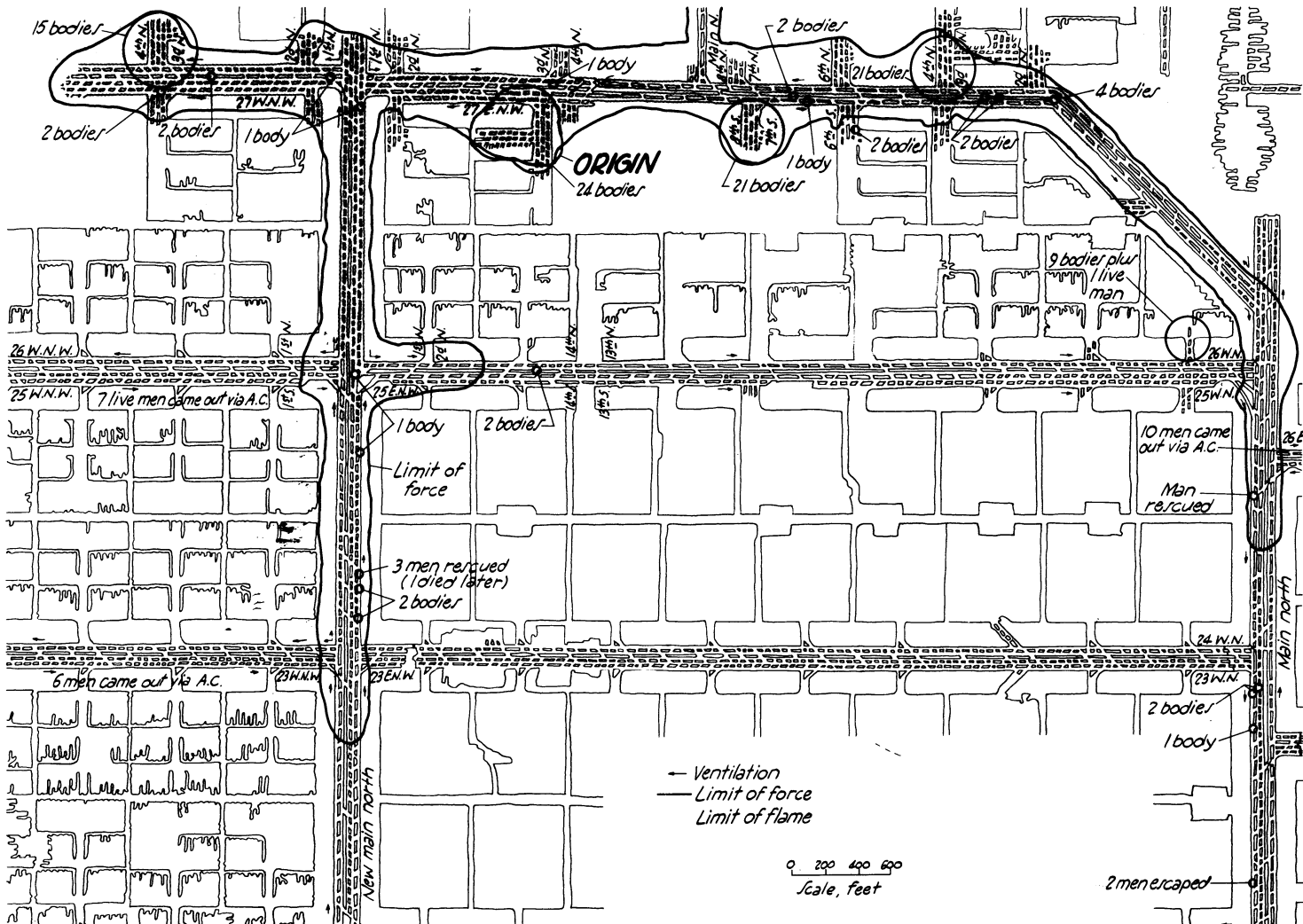

FIGURE 166.—Map of explosion area, Orient No. 2 mine, West Frankfort, Ill., December 21, 1951.

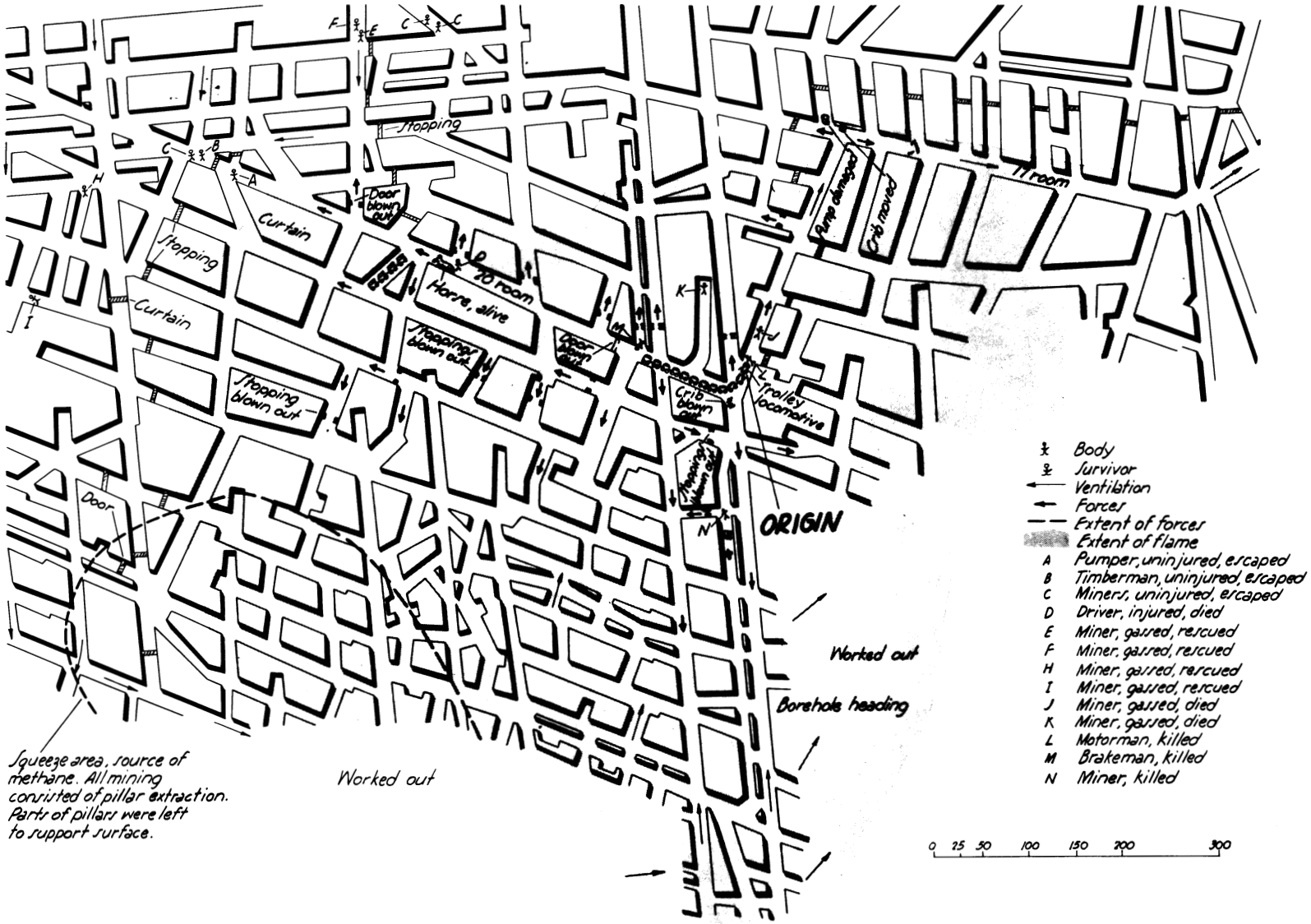

FIGURE 167.—Map of explosion area, Carpentertown mine, Carpentertown, Pa., February 2, 1952.

looking back they saw one of the others in trouble and tried to help him but were almost overcome themselves before leaving. When they reached the surface, Federal inspectors who had arrived organized rescue operations and entered the mine to restore ventilation by putting up brattice cloth stoppings. Falls were cleared to permit passage, and the three bodies were found and removed. Two town firemen with Chemox apparatus recovered one of the bodies.

Dust from blasting was ignited by two blown-out pellet black-powder shots off the solid in No. 4 room 10 west. Spread of the explosion was limited by dust from the fire-clay bottom, expansion, and wet entries (fig. 168). Explosion hazards in the mine were found during a Federal inspection October 9, 1952, and a notice was issued to the owner to correct them. After some correspondence regarding the owner's intention to reduce the number of underground employees to 14, a State district court order was obtained on January 19, 1953, restraining the Federal inspectors from enforcing the Federal Coal Mine Safety Act at this and the neighboring mine. The restraining order was dissolved March 27, and notice of this action reached the Bureau office on March 31, 1953. The act required that the use of black blasting powder be discontinued before January 16, 1953.

November 13, 1954; Jamison No. 9 Mine, Farmington, W. Va.; 16 Killed

(From Bureau of Mines report, by W. R. Park, W. D. Walker, Jr., J. J. Dougherty, and M. L. Davis)

The mine was idle on the day shift that Saturday, except for men doing supervisory work, general ventilation inspections, maintenance, rock dusting, surveying, pumping, and work to straighten a pillar line. Fireboss examinations had been made before and after 7:00 a. m., and conditions were found normal. Twenty-four men had entered the mine. The assistant foreman and three section foremen traveled in pairs by electrically operated jeeps to all active sections, measuring air currents and testing methane concentrations with W–8 methane testers in return air currents and making fireboss examinations of all working sections except 4 left off 2 north, in which another section foreman was working. They had returned to the surface by 1:45 p. m.

The mine foreman traveled throughout much of the mine by jeep, examined and made tests for gas in most of the normally active sections, and returned to the surface by 1:00 p. m. Two mining engineers finished their work and returned to the surface. Two mechanics had completed burning and welding near the car dump and the foot of the slope and were waiting for a ride up the slope when the explosion occurred about 1:45 p. m.

The electric lights flickered, and then a strong rush of air and rock dust engulfed them, but they did not smell smoke. Just then the man-car was ready to take them out, and they managed to get on and give the signal to hoist. After riding about 20 feet the mine electric circuit was deenergized by the electrical engineer. They then walked out the slope. The section foreman and four men who were completing a pillar lift in 4 left off 2 north section were blasting when the explosion occurred. They moved very little as their bodies were found within 60 feet of the firing station in positions showing that they were moving outby but were killed in their tracks.

Two mechanics repairing face equipment in 2 left section off 1 south were joined by a maintenance foreman. These men had completed their duties and were on a locomotive and a jeep in 2 left haulageway starting for the manshaft when the explosion occurred. They were uninjured, but the jeep was derailed. After procuring self-rescuers and two gas masks from the section "dinner hole" they started on foot for the manshaft. Forces of the subsequent explosions obliterated much evidence of their travel, but parts of self-rescuers found in 1 south near main west indicate that they were there before returning to 2 left where their bodies were found in a crosscut one block outby the "dinner hole". They had not used the gas masks or attempted to erect a barricade, but each had used 2 or 3 self-rescuers. Seven unused self-rescuers were lying nearby. The bodies were together on a canvas and partly covered with blankets.

It was assumed that they may have lived for between 1 and 2 hours after the explosion. They could not have escaped or been rescued, as they were more than 4 miles from the only means of egress, and the intervening area was filled with smoke and other noxious products of the explosion and fires. Two other mechanics had repaired face equipment in 4 left off C face mains. They were in a locomotive and had almost reached the underground shop near the manshaft when they were killed by the explosion. Their bodies were found under the huge fall in the fire area.

A pumper coming toward the manshaft on a jeep was killed when about 600 feet from the shaft. His body was also under the fall in the straight entry west. The other 4 underground victims distributed rock dust in 3 north and main west sections; these men were walking to the shaft bottom and were within 400 feet of the manshaft when killed by the explosion. A lampman in the building at the top of the manshaft was also killed by falling debris. The headframe from this shaft was blown over the building (fig. 169).

The violent explosion carried through the mine to the surface, demolishing the elevator assembly and causing extensive damage to the office, wash, lamp, and supply building at the top of the manshaft. Figure 170 shows the top of the shaft after it was cleared and a temporary hoist put in service. The No. 2 fan was damaged but the No. 1 fan was not and continued running.

Recovery operations were organized following prompt arrival of men and equipment from the Federal Bureau of Mines, the West Virginia Department of Mines, and other mines. Entrance was made by the slope about 2½ miles from the manshaft in intake air provided by the No. 1 fan. A rescue team found a trace of carbon monoxide on the old haulageway near main north, and at the time methane and carbon monoxide were building up in the return air at No. 1 fan.

Rescue crews were pulled out of the mine because it was feared that fires existed and that high methane concentrations were in the areas where ventilation was destroyed, making secondary explosions possible at any moment. The last crew returned to the surface at 8:40 p. m., and a second explosion occurred about 10:30 p. m., sending flame and smoke from the No. 2 shaft 100 feet in the air. About 11:00 p. m. smoke and fumes came out of the slope by which the teams had entered. The No. 1 fan was then shut down.

A conference of officials decided that the mine must be sealed. The sealing was completed at 1:30 a. m., November 15. At 4:10 a. m. the seal on the No. 2 fanshaft was blown off, and 5 minutes later the seal on the manshaft was ruptured. Resealing was made difficult by pressures, heat, and smoke coming from the No. 2 fanshaft but was completed by 2:00 p. m. November 17, after installing a pressure-release valve in the seal of the No. 2 fanshaft; it was closed at 9:45 a. m., November 18.

The seals placed at the 5 mine openings (4 shafts and a slope) were quickly effective; an air sample on November 18 showed the oxygen content to be 8.4 percent. By December 15, 1954, the oxygen content had dropped to 2.2 percent. The carbon monoxide content

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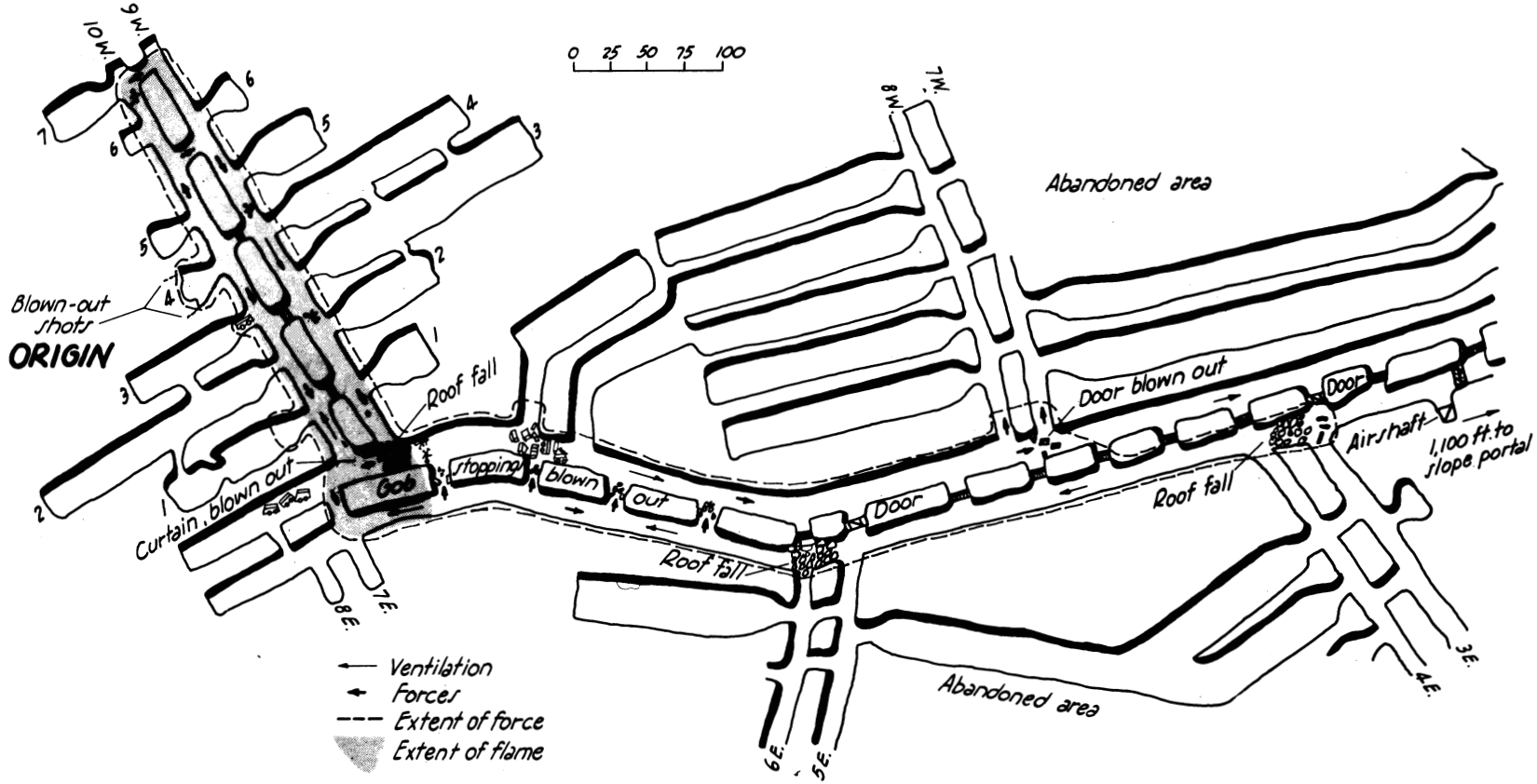

FIGURE 168.—Map of explosion area, O'Brien mine, Lovilla, Iowa, March 30, 1953.

FIGURE 169.—Headframe from manshaft, blown from other side of building on right, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

of the mine atmosphere decreased rapidly from 1.5 percent on November 18 to 0.01 percent February 1, 1955, and carbon monoxide was not found after March 1, 1955. Methane gradually increased from 4.3 percent November 16 to 9.7 percent November 18, 22.0 percent December 1, and 67.5 percent March 10, 1955.

When it was decided that conditions were favorable for reopening, a borehole was drilled from the surface to C face main entries between Nos. 1 and 2 fans to permit the collection of mine-atmosphere samples in advance of recovery work. By January 1956, after months of difficult and dangerous work because of large rock falls and rekindled fire, the mine was cleared and reventilated, except for 4 right off 3 north section and the main north and 10 right entries. A fire area was sealed underground and later reopened and hot material loaded out. Figure 171 shows one of the seals placed to control this fire, and figure 172 shows the remains of masonry and equipment. Coal was produced from a few recovered sections during the last half of 1955, while recovery was proceeding in other areas. Gas masks, oxygen breathing apparatus, and other equipment were provided and used in initial explorations and to a small extent in reopening after fires were controlled and in some of the recovery work.

The evidence found showed that the explosion originated in No. 7 pillar place of 4 left off 2 north entries, when two or more charges of explosives were fired in an explosive mixture of methane and air; either the flame of the explosives or an electric arc produced by short-circuiting the blasting wires was the igniting agent.

Figure 173 is a sketch of the conditions found when the caved area was cleared into No. 7 pillar after the mine was reopened. Coal dust raised by blasting entered into the explosion immediately. In 2 north section the explosion was propagated by methane from the pillared area west of 2 north entries and also by coal dust; propagation throughout the greater part of the rest of the mine was by coal dust, perhaps aided by methane that may have accumulated over extensive falls in the airways. The coal in the pillar remnants being blasted was possibly crushed and broken so that the charges may not have had enough burden to confine the flame of the explosive; the holes were fired simultaneously with electric power from the 275-volt mine circuit. The blasting-cable ends were brought in contact with nails driven into the shuttle-car trailing cable (see fig. 174, p. 254).

The initial explosion was propagated throughout a great part of the mine and forces extended to the surface through the slope, manshaft, and No. 2 fanshaft openings. The extent of the forces and flame is outlined on the map (fig. 175, p. 255). The explosions caused extensive damage underground and on the surface. Concrete linings in the shafts spalled and were cracked. The No. 2 fan housing was destroyed, and the elevator, guides, hoisting equipment, and housing were destroyed or damaged, as was the combination building adjoining. The underground ventilation system was almost completely disrupted; 600 permanent stoppings, 28 overcasts, and many regulators were demolished. Workings and equipment were so damaged by the explosions and fires that many openings and units had to be abandoned and replaced.

Figure 176 and 177 (p. 256) are views of relatively moderate damage to equipment. Extensive falls occurred where supports were knocked or burned out and where fire burned the roof coal.

Permissible explosives were used for blasting, coal faces were cut and sheared, and incombustible material was used for stemming. Gas tests were reported made before and after blasting. Pillar stumps were blasted with long or short holes gaged to the size and firmness of the stump. The holes might be charged with 2 to 12 cartridges; and, although company safety rules required that only 1 shot be fired at a time and multiple-blasting units were not provided, at times several shots in pillar stumps were fired simultaneously in series by means of power obtained from the 275-volt mine elec-

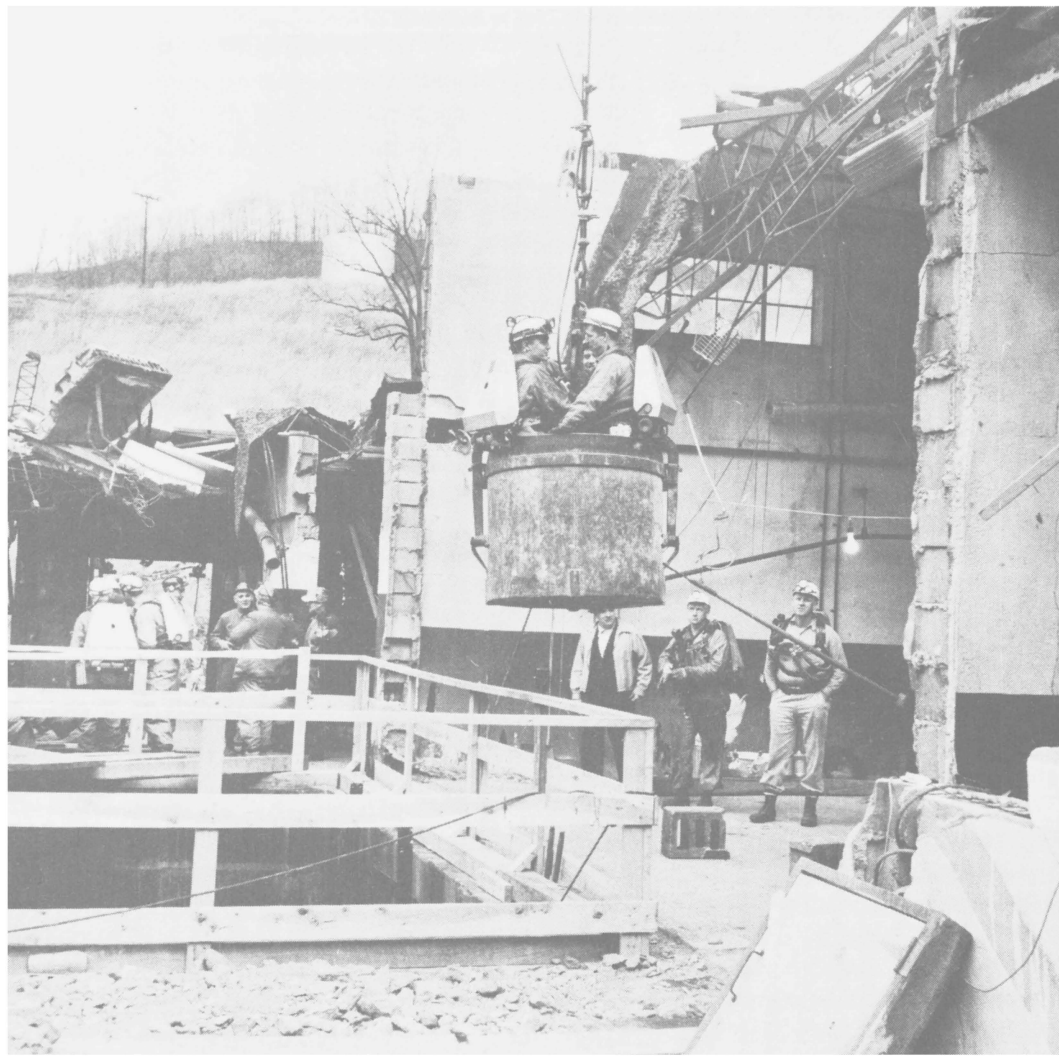

FIGURE 170.—Recovery crews at top of wrecked manshaft, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

tric circuit. Frequently tests for gas were not or could not be made safely close to the point of blasting.

Ventilation was induced by 2 axial-flow fans, operated exhausting and circulating approximately 347,800 cubic feet of air a minute through the mine. Overcasts, stoppings, and regulators were substantially constructed. Doors were used only at the man-trip station at the foot of the manshaft and on the supply track near the slope bottom. Check curtains and line brattices were installed in the face regions; but the check curtains were rolled up and tied in place to facilitate shuttle-car haulage, and the ends of line brattice were found to be 15 to 50 feet from the faces of some working places. Reportedly line brattice was not used in pillar lifts, except when gas was encountered.

Each working section was ventilated by a separate split of air. According to measurements made by the general assistant mine foreman within an hour before the explosion, 47,232 cubic feet of air a minute was entering 2 north entries just outby 3 left entries. The volumes entering 4 left entries and passing through the 2 north regulators inby 4 left were not measured. Air volumes measured in the 4 left returns totaled 36,332 cubic feet a minute; and, if the quantity of air passing through the 2 north regulator was 3,000 to 5,000 cubic feet a minute, only a small volume of air could have passed through the 4 left gob area toward the worked-out 3 left section.

Since a bleeder opening was not provided and the entries between the worked-out sections and the 2 north returns were not closed, an air current did not pass through the vast gob area on the west side of 2 north entries; and, at best, only the east edge of this area was ventilated. Tests of the air at the edge of the gob area made before and after the explosion indicated that it was filled with methane or above the explosive limits.

The greater part of the mine surfaces was dry. Water sprays were mounted on mining machines to allay dust; water was used when needed to allay dust during loading and unloading of shuttle cars and at the rotary dump near the slope bottom. Shuttle-car road-

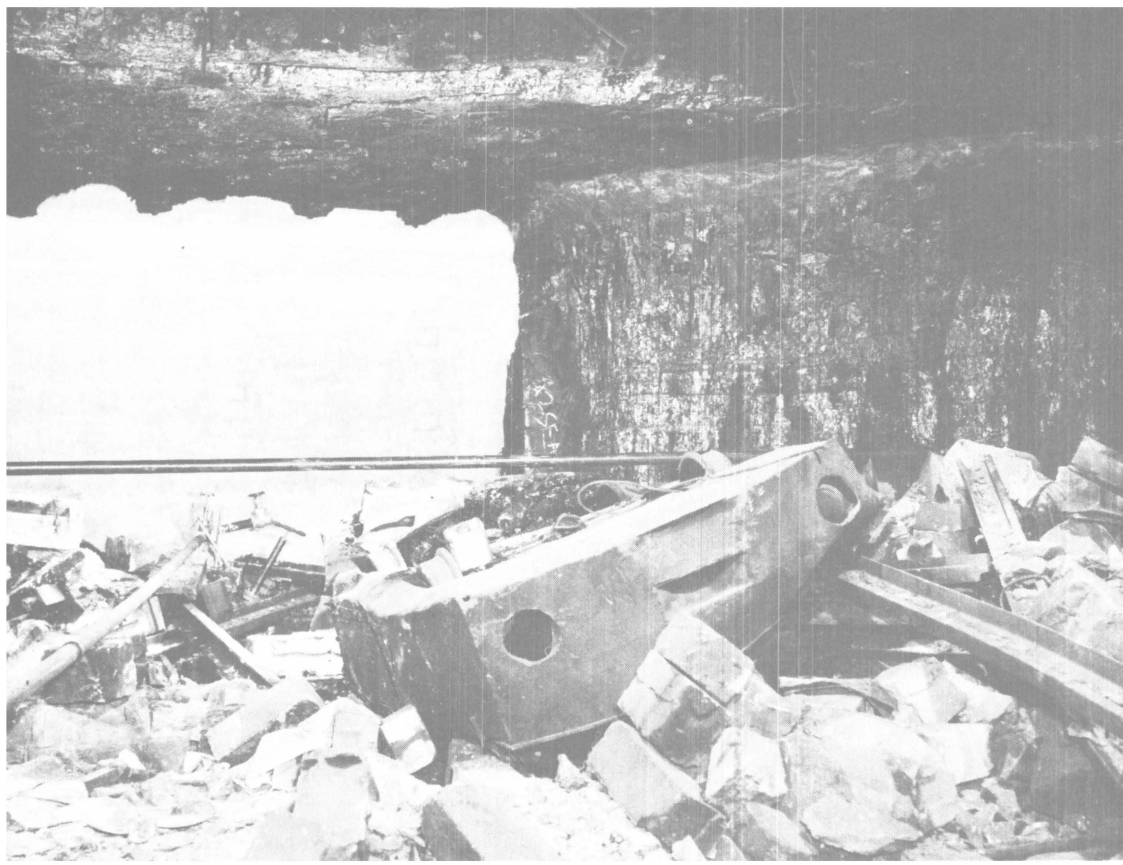

FIGURE 171.—Fire seal and debris after explosion, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

FIGURE 172.—Wrecked man-trip station; carbon dioxide piped through seal into fire area after explosion, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

ways were wetted down occasionally. Dangerous accumulations of loose coal and coal dust were reported during inspections and were removed.

Rock dust was applied to within 40 feet of working faces, using small, high-pressure distributors in active sections and larger machines on off shifts for generalized rock dusting. As the working sections were advanced, the floor in the return airways was covered with a layer of rock dust 1 to several inches deep. Parts of back entries and parallel entries had been rock-dusted recently by hand, and heavy blanket layers were placed on the floor at some locations in such areas. Rock dust amounting to 6.1 pounds per ton of coal produced was applied in 1954 and in the 4 preceding years. This rate was above the average for West Virginia mines and probably above the national average.

The amount of rock dust applied, the high incombustible content of the dust samples collected, the reasonably dust-free condition and good state of rock dusting on haulageways, as well as the blanket rock dusting in advancing back entries and in parts of older black and parallel entries, led company officials and employees and other interested officials to believe the mine was well rock-dusted. If this quantity of rock dust had been evenly distributed, it would have provided good protection in the area mined in 1954, if the area had been reasonably free of fine coal and dust.

The investigation, however, revealed certain deficiencies. A high proportion of the rock dust was used in blanket covering of the floor of back entries, leaving only a relatively small amount for re-rock-dusting old entries and for newly developed workings. This resulted in inadequate protection for some workings. Even in heavily blanketed entries, the coal

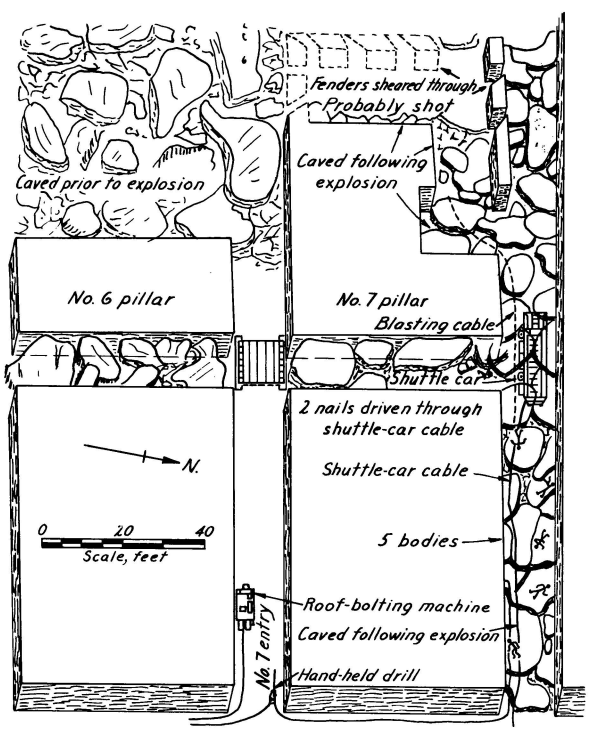

FIGURE 173.—Origin of explosion, pillar section 4 left, 2 north, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

FIGURE 174.—Battery end of blasting cable and part of shuttle-car trailing cable, showing nails through cable, used for firing shots in No. 7 pillar place, Jamison No. 9 mine, Farmington, W. Va.

dust on the ribs and roof must also be neutralized by adequate application of rock dust thereon.

In 4 active sections, beyond propagation of the explosion, the incombustible content of the floor dust in blanket-rock-dusted back entries exceeded 67 percent; in haulage entries it was close to 65 percent; but in parallel intake entries it was low—less than 60 percent. Since only 64 of the 340 samples taken in back and parallel entries throughout the mine contained more than the required percentage of incombustible material, it was concluded that these entries were not rock-dusted adequately before the explosion. Haulageways in general were well rock-dusted.

Loose coal and dust had been left along the ribs, especially in pillar sections, and in many places rock dust covered the loose coal and coal dust. Enough rock dust had not been applied on the roof and ribs at several places in advancing entries, notwithstanding the large amount of rock dust on the floor. At many places in the parallel and older back entries there was little evidence of rock dust having been applied, even though other parts of these entries were

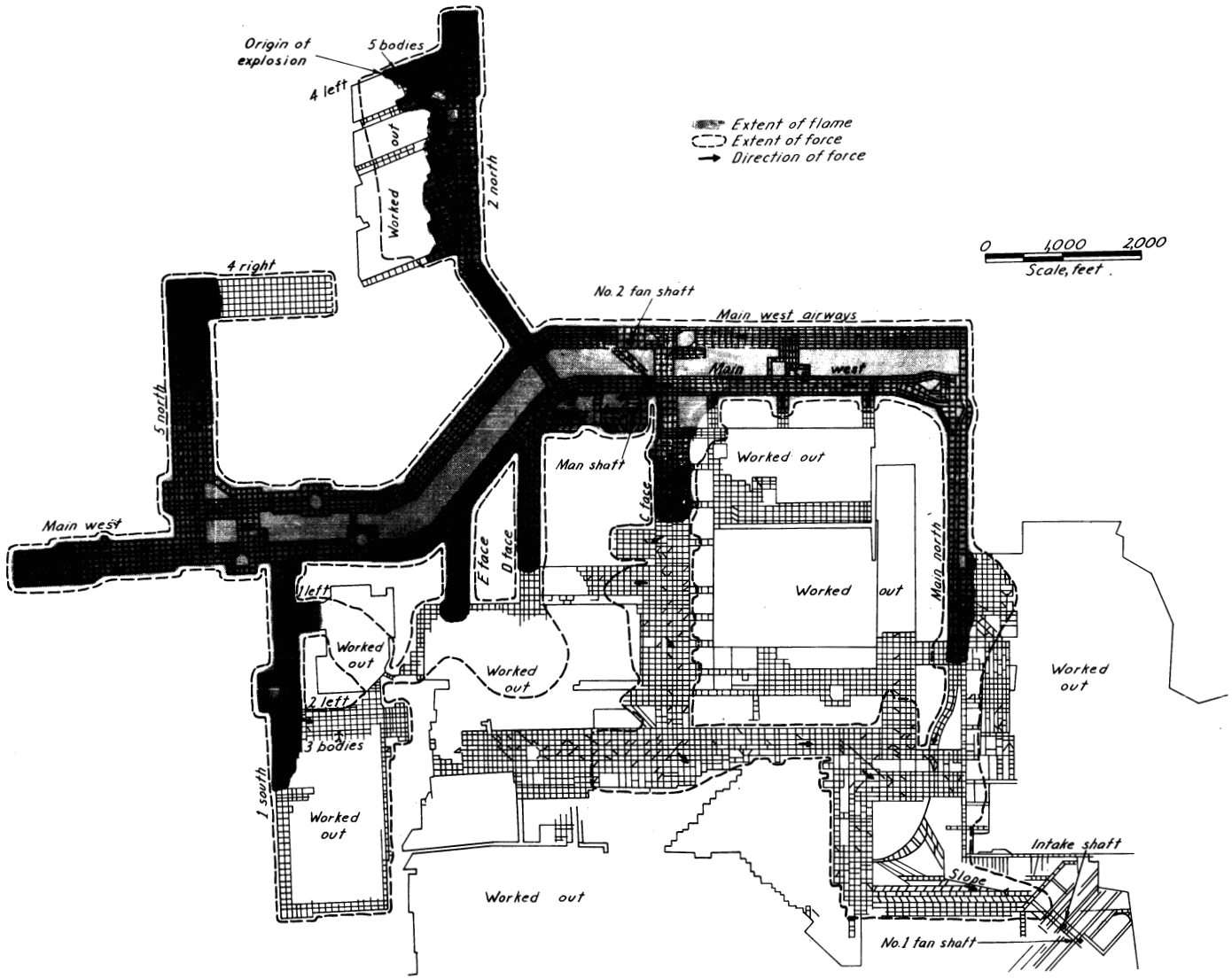

FIGURE 175.—Map of explosion area, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

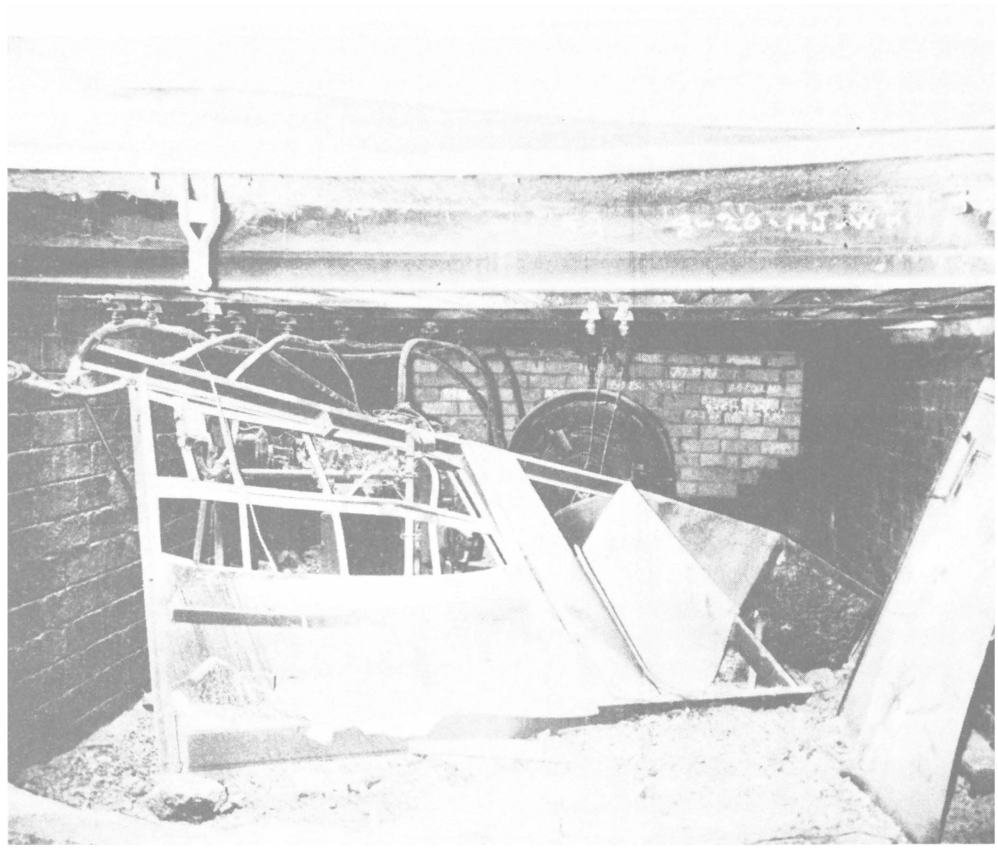

FIGURE 176.—Part of underground shop after explosion, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

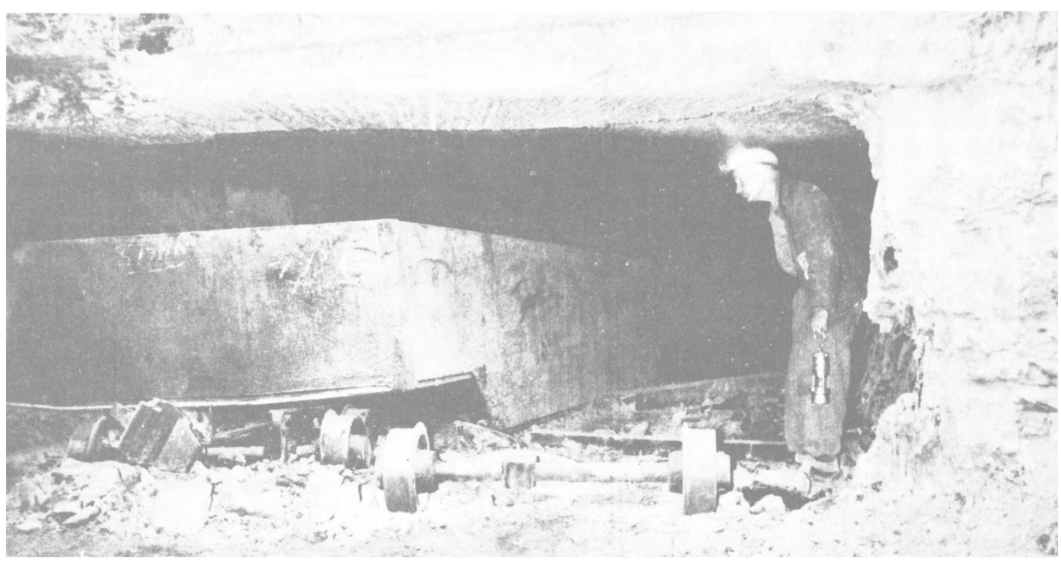

FIGURE 177.—Car blown into crosscut from trip of empty cars on track in foreground, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

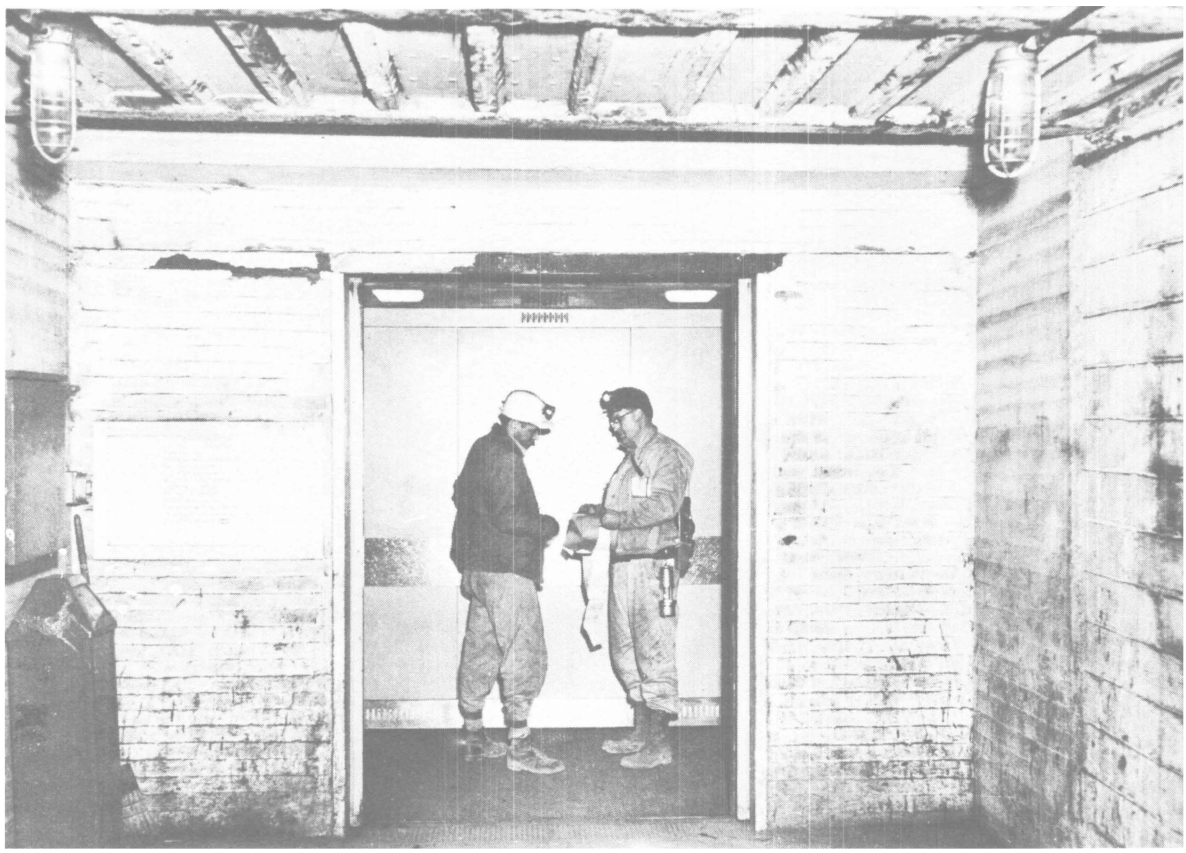

FIGURE 178.—Elevator and man-trip station at bottom of manshaft before explosion, Jamison No. 9 mine, Farmington, W. Va., November 13, 1954.

blanket-rock-dusted. The mine dust in the greater part of the parallel and older back entries did not contain enough incombustible material to prevent propagation of an explosion.

Surface and underground inspections revealed that gas and oil lines over the property did not contribute to the explosions and that coal pillars left to protect oil or gas wells were adequate and intact, with no evidence of emission or seepage. The change in barometric pressure was too slight to have been a factor as were the changes in normal fan pressure.

Although gas had been detected in the 2 north pillar section, the records of the fireboss examinations listed no unusual condition observed during either of the two shifts before the explosion. Section foremen and employees acknowledged that they knew some of the hazardous practices contributing to this disaster were dangerous and that such practices were not permitted or used when high company officials or State or Federal inspectors were present.

The mine had been reputed to be a model of safety, and the management of the mine had put into effect many safety rules and practices that were in advance of those usually ordered. Nevertheless, it became evident that other hazardous conditions and practices were not clearly recognized or were tolerated as minor dangers by employees, supervisors, or inspectors.

Figure 178 shows the excellent provision for safety and convenience at the bottom of the manshaft, and the condition of this station after it was cleared for recovery work is shown in figure 179.

METHODS AND PROGRESS IN CONTROLLING AND PREVENTING EXPLOSIONS

THE FEDERAL COAL MINE SAFETY ACT

The Burning Springs explosion in January 1951 and the Buttonwood explosion in March broke the longest disaster-free period in the history of American coal mining. Both were caused by ignition of undetected gas accumulations in working places. Despite the improvements accomplished in reducing explosion hazards since Federal inspection of coal mines was begun, 6 major explosion disasters occurred between January 18, 1951, and February 2, 1952. The Orient No. 2 disaster on December 21, 1951, which killed 119, brought action in Congress on bills that had been pending to give enforcement powers to Federal coal-mine inspectors. Because these bills, as originally drawn up, gave complete regulatory power to the Federal agency, whereas it had always belonged to the States, the bills had not been enacted, although

FIGURE 179.—Bottom of manshaft during recovery operations, Jamison No. 9 mine, Farmington, W. Va.

hearings had been held and one had passed the Senate. A bill was drawn up to grant enforcement powers for safety measures to prevent major mine disasters (*60*) and became law on July 16, 1952, as Public Law 552 (82d Congress, 2d session), known as the Federal Coal-Mine Safety Act, amending Public Law 49 (77th Congress). This act applies only to those mines employing 15 or more men regularly underground.

PROVISIONS OF THE ACT

The Federal Coal Mine Safety Act incorporates, as Title I, the Coal Mine Inspection and Investigation Act of May 7, 1941 (Public Law 49, 77th Congress), which gave the Federal inspectors authority to enter and inspect mines but no power to enforce their recommendations. Title II of the new act contains the "teeth"; Federal inspectors are empowered to require compliance with the mine safety provisions, or certain penalties may be invoked. However, the act is designed primarily to prevent major disasters from explosions, fires, inundation, and man-trip or man-hoist accidents. It does not cover the ordinary day-to-day types of hazards, which the Congress specifically reserved to the jurisdiction of the State mining departments.

The act specified that the Director of the Bureau of Mines shall cooperate with official mine-inspection agencies of the various States; the procedure that State agencies must follow to qualify for joint inspections by State and Federal inspectors is stated explicitly.

A State agency with complete authority to carry out the plan must first be designated; an adequate and competent staff of State inspectors must be assured; the State agency must give assurance that it will assign inspectors to make

joint inspections; and the Director of the Bureau of Mines must be assured that the State agency will make such reports to him as he may from time to time require. When these requirements are met, a formal agreement is executed. Subsequent inspections then are made jointly by Federal and State inspectors.

If a Federal inspector finds a hazard that he believes may cause a mine explosion, mine fire, mine inundation, or man-trip or man-hoist accident before the hazard can be eliminated, he is required first to determine the extent of the area where such danger exists and then to order, in writing, the operator or his representative to remove all persons from the danger area, except those necessary to eliminate the hazard and such other persons as are specified in the act. The Federal inspector must give a detailed description of the hazard involved and must clearly describe the area from which persons must be withdrawn and debarred.

When a Federal inspector finds a hazard that eventually may lead to a disaster if not corrected, but not of such a kind that a disaster may occur before the danger can be eliminated, a different procedure is followed. In such instances the inspector must give a detailed description of the hazard involved and must be specific in describing the extent of the danger area. Moreover, he does not order the operator to withdraw and debar persons from the danger area. He must, however, determine a reasonable time that would be required to eliminate the danger and must issue a notice of finding accordingly. In a notice of finding, the inspector specifies the time within which the danger must be abated. This time may be extended if an inspector deems it proper and necessary. If, however, the operator fails to comply with a notice of finding as originally issued or extended, the inspector is authorized to issue an order for the operator to withdraw the men from the affected area.

An operator has recourse when he feels that an order issued by a Federal inspector is unjustified. The act provides for a series of appeals whereby the operator may have such order reviewed by the Director of the Bureau of Mines, by the Federal Coal Mine Safety Board of Review created specifically for that purpose, and ultimately by the Federal courts. The order remains in effect, however, while any review proceedings are pending, unless the reviewing authority specifically grants some temporary modification.

The mine-safety provisions included by the act are stated specifically.

The term "gassy mine" is defined, and the law directs each operator of such a mine to operate it under the rules governing gassy mines. A gassy mine is one that the State inspection agency has considered gassy before passage of the act or that has been operated knowingly as a gassy mine before the act. A mine is also rated gassy under the act if a Bureau of Mines representative finds that methane has been ignited in that mine, or if he finds 0.25 percent of more of methane in open workings and at a point not less than 12 inches from the roof, face, or rib.

The longest and most explicit portion of the mine-safety provisions of the Federal Coal Mine Safety Act deals with ventilation. This part of the act is designed to prevent mine disasters resulting from accumulations of flammable and noxious gases in underground workings.

The provisions covering ventilation prescribe the quality of air that must be provided in active working places. The law specifies that all underground working places in a mine shall be ventilated by a current of air containing not less than 19.5 percent of oxygen, not more than 0.5 percent of carbon dioxide, and no harmful quantities of other noxious or poisonous gases. It also prescribes the quantity of air required in the ventilating current as follows:

> The volume and velocity of the current of air shall be sufficient to dilute so as to render harmless, and to carry away, flammable or harmful gases.

It then goes on to prescribe a minimum of 6,000 cubic feet of air a minute in the last open crosscut in any pair or set of entries and entering the intake end of pillar lines.

With respect to the ventilation of coal mines, the law recognizes that in pillar workings the coal may be extracted from an area so extensive that it may not be possible to measure the velocity of the air at any one point. In such instances the requirement is that the air current should at least have perceptible movement.

When unusual quantities of gas are found in coal mines, the law specifies procedures for diluting the gas to make it harmless and for discharging it safely to the surface. When prescribed limits of methane in the mine atmosphere are reached, the law specifies withdrawal of workmen, restrictions on use of electric power, and other safeguards. The law prohibits reusing the air from abandoned workings and pillar lines in gassy mines in active face areas, but it recognizes and allows for the fact that some coal mines and parts thereof may have been developed before its enactment and that immediate compliance with all the provisions would be impossible. To permit such mines to operate, the law gives the mine owner time to revise his mining system so that full compliance eventually will be possible.

The Federal Coal-Mine Safety Act provides that all coal mines be examined for hazards be-

fore persons other than the examiners are permitted to enter. Gassy mines must be examined within 4 hours immediately preceding the beginning of each coal-producing shift. Nongassy mines must be examined at least once each day during which coal is produced; such examination must begin within 4 hours immediately preceding the beginning of the first coal-producing shift.

The examinations include tests for gas; inspection of roof, face, and rib conditions; and observation to see that the ventilating currents are traveling in their proper courses and in normal volumes. If the examiner finds a dangerous condition, he is required to post a danger sign at each approach to the dangerous area. The place is then closed to all but specified persons, including those authorized to enter for eliminating the danger.

The persons charged with the responsibility for making these examinations must be well qualified for their duties. In States that provide for the certification of coal-mine examiners, only certified persons are permitted to make preshift examinations in gassy mines. In States that do not provide for such certification, the examiner must be deemed by the operator to be qualified to perform these duties.

Other examinations for danger, including tests for gas in gassy mines, must be made throughout the various coal-producing shifts.

Some exemptions are provided in the subsection on ventilation, particularly with respect to systems of ventilation that were in effect before the effective date of the act. In mines where haulage roads are ventilated by air that had passed through active workings and through and by abandoned workings, the exemptions permit mining companies to continue this system of ventilation until it can be changed to conform with the law.

The strongest provisions in the Federal Coal-Mine Safety Act are those pertaining to removal of excessive accumulations of coal dust and application of rock dust to mine surfaces.

The act prohibits accumulation of dangerous quantities of dust in a bituminous-coal mine and requires the coal-mine operator to use water or water mixed with a wetting agent to allay the coal dust where it is produced, to prevent coal dust from being carried about by the air currents and scattered through the mine.

The law requires application of enough rock dust so that the combined coal dust and rock dust will contain a minimum of 65 percent of incombustible material. The law specifies further the places where rock dust must be applied as follows:

> All underground mines, except those mines or areas of mines in which the dust is too wet or too high in incombustible content to propagate an explosion, shall be rock-dusted to within forty feet of all faces, and, if open crosscuts near such faces are less than forty feet therefrom, such crosscuts shall be rock-dusted.

The act includes considerable detail regarding the use of electric equipment in gassy mines. This phase begins with the statement,

> All electric face equipment used in a gassy mine shall be permissible, except that electric face equipment may be used in a gassy mine even though such equipment is not permissible if, before the effective date of this section or the date such mine became a gassy mine, whichever is later, the operator of such mine owned such equipment, or owned the right to use such equipment, or had ordered such equipment.

The purpose of the first exception in this part of the act is to permit the operator of a gassy mine to operate such nonpermissible equipment as he owned, had the right to use, or had ordered before July 16, 1952. The words "owned the right to use" are intended to include instances in which the operator may not have been the owner of nonpermissible equipment but may have had the legal right to use it as a lessee or a holder under a conditional sales agreement or any other legal agreement.

It is the spirit and intent of the law that all newly purchased electric equipment installed in gassy coal mines shall be permissible.

Junction or distribution boxes used for making multiple power connections in working places must be permissible, except that, like other units of electric equipment, a mine owner may continue to use such nonpermissible junction or distribution boxes as he owned before passage of the act or the date on which the mine is classed as gassy, whichever is later.

The act requires that explosion-tested, cable-reel locomotives used in gassy mines must be equipped with two-conductor trailing cables. The purpose of this requirement is that, when the current to operate such locomotives is being transmitted through trailing cables, the steel rails on which such locomotives run shall not be used as one of the conductors to complete the electrical circuit for operating the locomotives.

The provisions under electric equipment implement the Federal Mine Safety Code, but because of the exemptions, it may be many years before the law will be effective in replacing nonpermissible equipment.

Electric wires are potential sources of sparks and arcs. The areas of a coal mine beyond the last open crosscuts and the pillar workings are areas in which explosive gas is most likely to accumulate. Therefore, the act prohibits trolley or feeder wires beyond the last open crosscuts or within 150 feet of an area from which pillars are being extracted.

The mine-safety provisions include miscellaneous but potentially dangerous aspects of

coal mining. Smoking and carrying smoking materials, matches, and lighters into a gassy mine are prohibited. The act requires that only permissible electric lamps be used for portable illumination. It prohibits the use of black blasting powder underground.

Provisions in the law specify how mining shall be done when abandoned workings are approached, in the same or an adjacent mine, that might contain dangerous accumulations of gas or water.

Open or unconfined (adobe) shots are prohibited in any bituminous-coal mine, but open shots may be used under certain specified conditions in anthracite mines.

CHANGES IN EXPLOSION SAFETY STANDARDS

LESSONS FROM ORIENT NO. 2 EXPLOSION

Although the Orient mine No. 2 was rock-dusted about as well as the average mine at the time of the explosion, the protection was below the recommended standard, and the explosion was not closely confined. The inadequacy of the rock dusting was recognized in the inspection reports; but the risk was not thought serious, because it was assumed that places low in rock dust would be redusted according to recommendations within a short time. The risk of methane accumulations in "old ends" was recognized, but since the continued use of open-type electric equipment in face areas was permitted by the Code, nothing was said about it. The flagrant smoking was noted and reported by the Federal inspectors.

In the new Federal Coal-Mine Safety Act the ventilation practices were rigidly prescribed, resulting in much planning and discussion to revamp ventilating methods in mines which, like the Orient, were in violation. These changes were made with some allowances permitted. Rock-dusting requirements were made stronger, and tests were conducted in the field and in the Experimental Mine of the Bureau of Mines to find more definite limits of hazards to guide the operators and the inspectors in recognizing safe and unsafe conditions. The removal of coal dust, as well as its suppression, was reemphasized, but compliance standards were left to be worked out as indicated by further tests and experience.

The intent of the law was that new electric face equipment used in gassy mines should be permissible, but the provisions permitting continued use of open-type equipment allow indefinite prolongation of this hazard. Smoking and use of open lights were prohibited in gassy mines.

LESSONS FROM JAMISON NO. 9 EXPLOSION

As was stated in the explosion report, the Jamison No. 9 mine was regarded to be above average in rock dusting. The deficiencies revealed by the explosion were the reliance on blanket rock dusting of the floor to compensate for places of substandard application on roof and ribs. Inadequately protected back entries formed avenues for spread of the explosion. Strict regard for standard uniform distribution of rock dust and precautions against accumulations of fine coal dust were shown necessary.

The extreme hazard of methane accumulations in and adjoining working places was demonstrated again. Effective and carefully controlled ventilation to remove methane and prevent any accumulations must be required throughout the mines. The source of ignition—blasting of exposed or underburdened shots in the presence of methane—was against rules but evidently was not considered dangerous by the pillar crew; nor was the use of a mine circuit for shot firing recognized as inviting an explosion, even in the absence of gas.

COAL-DUST AND ROCK-DUST STANDARDS

Reexamination of the standards needed for removing and treating coal dust found that suppressing dust at the immediate source of generation was the best factor in obtaining effective control. Application of water in many operations is the most practical means of control. Any direct control method must be supplemented by ventilation to keep dust from accumulating in a danger zone. Water sprays are being built in on most models of new heavy mining equipment and on conveyors and dumping installations (*18*, *42*).

The standards for rock-dust application and sampling were reexamined to determine the variation of incombustible content of dust on the floor and on rib-roof surfaces along main entries, secondary entries, and rooms; comparing spot or grab sampling with concurrent band sampling; determining the amount and fineness of dust in entries; examining the nature of incombustible in mine dust; and checking underground the utility of a rapid, approximate color-sorting procedure for separating dust of high and low combustible contents (*31*).

The sampling study at several bituminous-coal mines showed that:

(1) Band or perimeter sampling of dust can be substituted for the more time-consuming road and rib-roof sampling, if there is not too much variation in the application of dust to the different surfaces. Very low incombustible content of the dust on roof and rib or on the floor

cannot be compensated by higher concentrations on the other surfaces.

(2) The incombustible in the top 1-inch layer of dust on roadways normally gives a good estimate of the incombustible in the full-depth dust deposit.

(3) The quantity of dust on haulageways and other roads may be excessively high, thus requiring very large tonnages of rock dust. Every effort should be made to reduce dust formation during mining and to allay and clean up the dust that is formed.

(4) The weight of dust deposited on the floor exceeds by many times the dust on rib and roof surfaces. The incombustible content is higher in overhead dust than in road dust.

(5) The theoretical minimum number of dust samples required to give adequate information on the average incombustible content in mine workings is greater than could be collected with desired frequency by Federal inspectors using present sampling procedures. As a partial remedy of the situation, coal-mine operating personnel might collect supplementary samples. Bureau inspectors might examine more locations than hitherto by taking spot increments in some areas between band samples and by sorting out samples of high incombustible content by the visual color-sorting technique.

(6) The incombustible in many mine dusts contains large proportions of sand, shale, or other coarse material much less effective in stopping explosions than normal finely divided limestone. To ascertain the proportion of this type of inert, the calcium carbonate contents of at least 1 or 2 dust samples from each mine might be determined, and—what is equally important—a sieve analysis made of the same dusts.

Determination of explosive characteristics of several ranks of coals showed that the rock-dust standards were adequate (*30*).

To be effective, rock dust must be applied uniformly on the rib and roof, as well as on the floor of coal-mine entries. The minimum incombustible content of most mine dusts is 65 percent. Before rock dust is applied excessive coal dust and loose coal must be removed. Rock dusting in active entries must be carried as close to the face as possible to quench coal-dust explosions that originate near active coal faces. Entries must be adequately rock-dusted to prevent propagation of explosions that originate away from face areas.

An explosion may propagate several hundred feet from a non-rock-dusted area into a rock-dusted zone before the flame is extinguished. Explosions that originate in unprotected areas of 100 to 300 feet may become violent and propagate for 1,000 feet or more in well-protected zones.

Because of the difficulty in making rock dust adhere to smooth and dry surfaces of roof and ribs, tests were made to determine whether wetting these surfaces might increase adherence of the rock dust. An additional 13 percent of rock dust adhered to the wetted surfaces. Experiments and trials in applying rock dust as a slurry or by mixing dry rock dust with water at the nozzle of a rock-dusting machine were favorable, and the practice has been approved for face areas.

The advantages of wet rock dusting are that the air in working sections is relatively free from dust during its application and that more rock dust adheres to the roof and ribs. The protection afforded is considerably reduced until the coatings dry out completely unless the rock-dusted zone is kept within 50 feet of the face. Where unprotected zones are 100 feet or more in length or fine coal dust covered the wet rock dust explosions were not stopped.

VENTILATION STANDARDS

Recommendations regarding standard ventilation practices included (*2*, *pp. 2*, *3*) the following recommendations, which are considered important to minimize the possibility of methane accumulations and ignition from electrical sources. These recommendations are not intended to replace Article V, Ventilation and Mine Gases, of the Federal Mine Safety Code but to emphasize and supplement the provisions in the Code.

1. A split system of ventilation should be provided for operation of not more than 2, preferably not more than 1, mechanized unit on each split of air.

2. The air in each split should be circulated to each active working place and all dead ends on the split; after which, it may be used to ventilate abandoned, worked-out areas or the edges thereof before passing into the main return.

3. A system of bleeder openings and aircourses providing for the continuous movement of air through abandoned or caved areas should be established to prevent accumulation of standing bodies of methane in these areas and to minimize the effect of variations in atmospheric pressure.

4. Worked-out, abandoned areas should be either ventilated or sealed. If abandoned areas are sealed, the seals should not be adjacent to intake airways, but openings in which seals are placed should communicate directly with the return airway.

5. The ventilation system should be designed so that air will circulate to the working faces without interruption. Use of doors on entries should be reduced so far as possible; but, where doors are used, they should be erected in pairs to form air locks.

6. No electrical equipment other than permissible equipment should be taken into or operated in other

it is electrical only to the extent that a small dry cell and a lamp bulb are required to supply a beam of light for the optical system on which the instrument depends for its method of indication.

After passing through a condenser lens, the light from the lamp bulb is separated into two beams on striking a thick, parallel-plane glass plate. One of these beams is made to pass twice through a chamber containing fresh air. The other is made to pass twice through a chamber into which a sample containing methane can be introduced. The two light beams unite later to pass through a movable reflecting prism and thence into a small telescope focused on a reading scale.

The passage of the light beams through the system results in interference bands or fringes. These bands are seen as two black lines in the center, with lines of different color and width on either side. When there is fresh air in both chambers of the instrument, the interference bands can be set so that one of the black lines coincides with the zero point on the scale. However, when methane is drawn into one of the chambers by means of the aspirator bulb, the bands shift in proportion to the amount of methane present. The new position of the same black line that originally was set at zero then is read on the scale, giving the amount of methane in percent. The scale is calibrated to read from 0 to 6 percent methane in 0.25-percent divisions.

The instrument is provided with absorbents for removing water vapor and carbon dioxide, which because of their effect upon the index of light refraction would otherwise impair the accuracy.

MINE SAFETY APPLIANCES CO. ALARM-TYPE CONTINUOUS METHANE DETECTOR, APPROVAL 811

This instrument employs an electric circuit very similar to that of the type W–8 indicating detector, made by the same manufacturer, except that relays and visual signals are added to give warning when the methane in the surrounding atmosphere has reached the amount of 1 percent. This value is important in that mine operators are required by Federal mining law to change or adjust the mine ventilation so that air at working faces does not contain more than 1 percent of methane.

NATIONAL MINE SERVICE CO. TYPE 18 RIKEN METHANE DETECTOR, APPROVAL 812

The Riken 18 methane detector is similar to the Riken 17 except that a vernier scale has been added for increased accuracy. The scale is calibrated to read from 0 to 10 percent methane in 0.5-percent graduations.

1957–58

HAZARDS AND OCCURRENCE OF EXPLOSIONS

After 2 years in which no major disasters occurred, 59 lives were lost in 4 major explosions in 1957 and 36 were killed in 2 major explosions in 1958.

The Evan Jones slope-mine explosion in Alaska, January 18, 1957, killed the 5 men in the mine; the No. 34 (Bishop) mine explosion in West Virginia, February 4, 1957, caused the death of 37; the Marianna No. 58 mine explosion in Pennsylvania, September 23, 1957, killed 6; the No. 31 (Amonate) mine explosion in West Virginia, December 27, 1957, killed 11; the Bishop (No. 34) mine explosion in West Virginia, October 27, 1958, resulted in the death of 22; and the Burton mine explosion in West Virginia, October 28, 1958, killed 14.

The Evan Jones slope explosion was caused by faulty ventilation and accumulations of coal dust in a pillar section poorly rock dusted. The ignition was from permissible explosives in underburdened shots.

The explosion in No. 34 mine was caused by faulty ventilation and accumulations of coal dust in an advancing section inadequately rock dusted. The ignition was from a nipping station or from permissible equipment not kept in safe condition.

The Marianna No. 58 mine explosion occurred when underground conditions were being investigated; one of the two main fans was stopped because of broken impeller blades. A reversed air current caused an explosive atmosphere to seep onto a haulage road, where it was ignited by an electric arc from a trolley pole or cutout switch.

The No. 31 mine explosion was caused by inadequate face ventilation when check curtains were opened or destroyed while supplies were being procured from an outby location. Ac-

than pure intake air; equipment should be maintained in a good state of repair and in permissible condition.

7. Installation of trolley wire and all other power wires and cables, except trailing cables and insulated cables leading to permissible junction boxes, should be confined to pure intake air.

8. All power connections for face electrical equipment should be made in pure intake air unless such connections are made through permissible junction boxes.

9. Air entering each split should be pure intake air.

Pure intake air is defined as air that has not passed through any active working places in face regions and has not passed through any worked-out or abandoned areas or through or by the unsealed entrances to any abandoned or worked-out areas.

METHANE DETECTORS

New methane-detecting devices are now in use that have passed the tests for Bureau of Mines approval and trial in mine operation. These are described in a Bureau publication (*21*).

TABLE 14.—*List of approved methane detectors*

Name	Approval No.	Date of approval	Special features
Burrell	800	Mar. 10, 1922	Read by contraction of water column in glass tube.
Martiennsen	801	Jan. 9, 1928	Read by color and extent of heating of U-shaped filament.
U. C. C	802	Nov. 27, 1928	Direct reading by meter calibrated 0 to 7 percent.
M. S. A. (AP–6)	803	Oct. 29, 1932	Dry-cell type. Read by meter calibrated for 2 and 5 percent.
Do	804	do	Wet-cell type—otherwise same as approval 803.
M. S. A. (W–8)	805	May 5, 1936	Smaller design of M. S. A. (AP–6) wet-cell type.
M. S. A. tester	806	Aug. 26, 1938	Compact model of W–8 dry-cell type.
M. S. A. alarm	807	Sept. 13, 1940	Continuous detector, alarm type—wet cell.
M. S. A. (E–1)	808	July 23, 1941	Obsolete.
M. S. A. (E–2)	809	Aug. 9, 1941	Hand-held indicating type—wet cell.
Riken 17	810	May 11, 1953	Interferometer type.
M. S. A. alarm	811	Sept. 4, 1953	Continuous detector, alarm type—wet cell.
Riken 18	812	July 23, 1954	Similar to Riken 17 with vernier scale added.

Instruments covered by approvals 805, 809, 810, 811, and 812 are the only detectors actively marketed today. The other units listed have been replaced by later models or have been withdrawn from manufacture. Accordingly, the discussion will be confined to a description of the five current models.

MINE SAFETY APPLIANCES CO. TYPE W–8 DETECTOR, APPROVAL 805

This detector employs an electrical circuit, the basis of which is the Wheatstone bridge. The detector unit has a filament of specially activated platinum, which is heated by means of current from an Edison electric cap-lamp battery. The temperature of the filament is high enough to burn methane and particles of dust or other foreign matter that might tend to poison the filament and destroy the accuracy of the device.

MINE SAFETY APPLIANCES CO. TYPE E–2 DETECTOR, APPROVAL 809

The type E–2 detector utilizes an electrical bridge circuit and is considerably smaller and more easily carried than the type W–8 detector; however, it is not as sensitive or as accurate as the larger type. The E–2 detector depends for its operation upon the heat developed by the combustion of methane in the sampled atmosphere as it is drawn over a heated filament, which forms parts of the balanced bridge circuit. The current for this bridge circuit is provided by an Edison electric cap-lamp battery through a connection in the battery cover or in the cord between the battery and the headpiece. When methane is burned on the filament, the temperature and resistance of the filament are increased in proportion to the concentration of the gas in the sample. This results in unbalancing the electric circuit, which, in turn, causes a deflection of the meter pointer that indicates on the scale the amount of methane in the sample. The scale is calibrated to read from 0 to 5 percent, with divisions of 0.02 from 0.02 to 2 percent and with divisions of 0.5 from 2 to 5 percent.

NATIONAL MINE SERVICE CO. TYPE 17 RIKEN METHANE DETECTOR, APPROVAL 810

The Riken type 17 detector operates on an entirely different principle from that employed in the instruments previously described. Although it is of the interferometer type and might be classified as an electrical instrument,

cumulated gas was ignited by an electric arc from face equipment.

The Bishop mine explosion resulted from the ignition of a large quantity of methane that was liberated during blasting operations and which was ignited when one or more shots blasted through into an entry where the face had been blasted shortly before.

The Burton mine explosion resulted from the ignition of methane by an electric arc or spark from a power conductor. Gas accumulated when the ventilating current was short-circuited by removing stoppings from crosscuts. The foregoing circumstances are repetitions of those revealed by investigations of 44 minor explosions in several States during 1955 and 1956.

Of the 44 minor explosions, 15 were from electric arcs, 14 from open flames, such as smoking, open lights, and defective or misused flame safety lamps; 10 from frictional heating, and 5 from blasting. One of the ignitions was from gas or dust, 1 from gas and dust, 2 from dust, and 40 from gas.

Nine ignitions of methane have been attributed to frictional heating when hard rocks were struck while cutting and drilling coalbeds. Although none of those ignitions caused major explosions, they call attention to a problem that is becoming increasingly significant because of the greater use of high-speed machinery, particularly continuous mining machines.

DESCRIPTION OF MAJOR DISASTERS

January 18, 1957; Evan Jones Slope, Jonesville, Alaska; 5 Killed

(From Bureau of Mines report, by R. L. Ellis)

After the second shift left the mine at 11:00 p. m. January 17, the fan was stopped and was started about 7:20 the next morning, just before the crew of five men went in. At 10:02 a. m. two distinct reports were heard on the surface, followed by smoke and dust issuing from the slope portal and the fan shaft. The fan duct was damaged and the fan stopped.

The superintendent sent men to examine the fan and powerlines, notified the Federal and Territorial mine inspectors, doctors, and Territorial police, and called men from the main mine. An emergency fan was taken to the fanshaft, and crews were organized to recover the mine. Attempts to enter the slope were blocked by fumes and a roof fall in the slope above the fault. After the emergency fan was placed in operation, temporary stoppings were erected in the crosscuts by crews wearing Chemox breathing apparatus and gas masks. Later the fan duct was repaired and the main fan was started.

Apparatus crews explored the pillar section and found four bodies. After the workings were better ventilated the last body was found, and all were removed by the evening of January 19. After an underground investigation on January 22 to determine the causes of the explosion, the mine was abandoned and the openings were sealed.

The mine was gassy, and ventilation was inadequate to prevent accumulations of methane along the gob area, the fault line, and the blind crosscut above the pillar being mined. A blower fan and tubing used to ventilate the top counter being advanced to the slope would circulate any gas coming to it from the pillar work. The mine was dry and dusty, no water was used to wet dust, and rock-dust applications were insufficient. Apparently the pillar stump between Nos. 4 and 5 chutes was being blasted when the explosion occurred. As the flame safety lamp was found hanging in the top crosscut off No. 2 chute, it was unlikely that any test for gas was made before blasting.

Delay-action detonators and permissible explosives were used, and coal was blasted off the solid. Probably one or more of the holes was underburdened, causing an ignition of methane and coal dust. A second ignition of methane and dust, possibly from the top counter or the gob area, probably was responsible for the second report. Evidences of conflicting forces were found in the upper crosscuts between Nos. 2 and 3 chutes.

There was no electrical power in the area, as equipment was operated by compressed air. The storage-battery locomotive on the gangway was not being operated. The flame safety lamp was tested and found in safe condition. Smoking materials or matches were not found. The explosion was propagated by gas and dust almost to the counter entry (fig. 180). The forces extended to the surface, demolishing stoppings and the door and knocking out timbers in the slope from the gangway to within 400 feet of the surface.

February 4, 1957; No. 34 Mine, McDowell County, W. Va.; 37 Killed

(From Bureau of Mines report, by W. R. Park, E. M. Lewis, and W. M. Cordray)

The mine was idle on Sunday, February 3, except that supervisors entered to check ventilation and other conditions. Working sections were firebossed before the shift entered the mine at midnight, and all conditions were recorded in the preshift records as normal. The general shift foreman was about 3,000 feet north of the manshaft just before 2:00 a. m., when he was engulfed in a strong rush of air and dust. He went to a telephone and notified the superintendent of the occurrence. All working sections were called, and the men in the unaffected sections were sent to the surface. No response came from the Day, Shaft, or Bleeder entries.

Plans were made to examine those parts of the mine, and State and Federal mine-inspection officials were notified. Mine officials led recovery crews in restoring ventilation and exploring the explosion area. As experienced recovery men arrived they joined the crews in the mine. Oxygen-breathing-apparatus teams explored the Bleeder entries ahead of brattice crews and helped to clear out accumulations of methane without forcing explosive mixtures into unexplored entry faces. Recovery of the Day, Shaft, and Little Horse Pen entries did not require apparatus crews. All bodies were removed by afternoon of February 4.

During the initial exploration of the Shaft headings and Little Horse Pen entries 4 small fires were extinguished, and 3 days later 3 small smoldering fires were found and extinguished in these areas by crews collecting dust samples.

A section foreman and 12 men were producing coal in the Day entries when the explosion occurred. The positions of the bodies of 11 of these men showed that they had moved little, if any, from their usual places of work. The body of the mechanic was at a pump near the entrance to the section, and the body of the

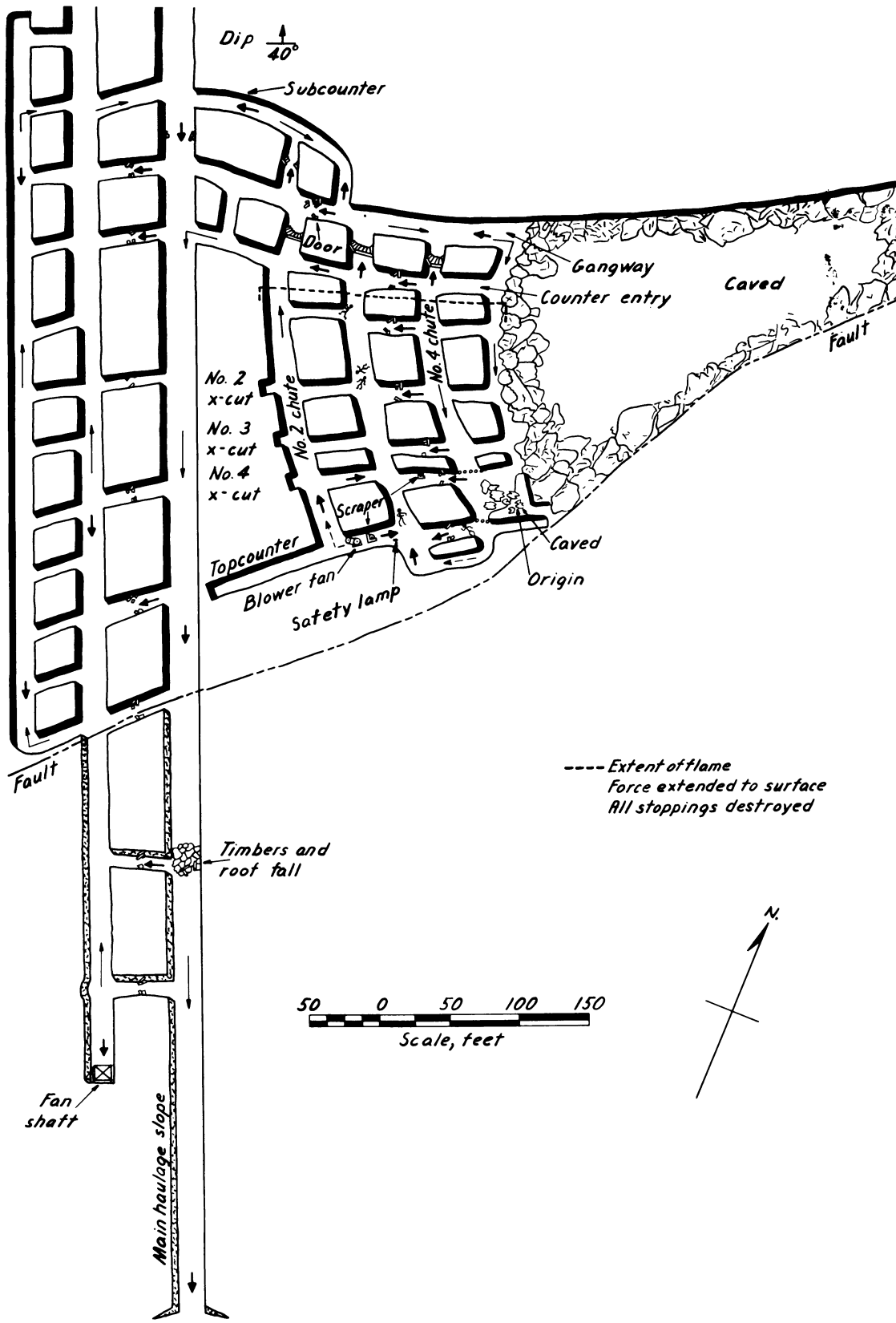

FIGURE 180.—Sketch of explosion area, Evan Jones slope mine, Jonesville, Alaska, January 18, 1957.

Joy operator's helper was in a crosscut near the air-lock doors at the entrance to the section. The indications were that these men had been sent to these locations before the explosion.

A section foreman and 10 men were moving equipment and preparing to start a new working section in the Shaft entries. The bodies of these 11 men showed that they were killed immediately by flame and forces of the explosion.

A section foreman and 12 men were producing coal in the Bleeder entries when the explosion occurred. These entry face regions were not affected by the explosion, but telephone and power lines were blown down, and stoppings were blown out, short-circuiting the intake air currents just outby the intersections of Little Horse Pen entries, 3,500 feet from the faces of the Bleeder entries. Locations of equipment, flame safety lamps, and clothing in the face regions indicated that the 13 men began walking toward the manshaft immediatedy after the power failure and concussion; they apparently walked into the fumes of the explosion and died close to the Little Horse Pen intersection, as the bodies were found there together. It is entirely possible that these men might have lived without erecting barricades if they had remained at their working-face regions. If they had erected barricades there is little doubt that they would have been saved.

About 10 days before the explosion the No. 1 entry of the Little Horse Pen entries was "holed through" to the Bleeder entries. The others were connected subsequently, No. 5 entry on February 2, and the electric equipment was being moved to the Shaft entries. The connection of these entries caused little difference in the flow of air in either set of entries. However, in moving the equipment four stoppings between intake and return were removed near the intersection of the Shaft and Little Horse Pen entries. This change also made little difference in the ventilation.

The explosion destroyed 70 concrete-block stoppings, 1 overcast, and many wooden and canvas stoppings. Trolley wire and telephone lines were blown down at several places, and some roof falls occurred. Damage to equipment was negligible. The elevator in the manshaft was slightly damaged, but it was placed in operation about 8:00 a. m. on February 4. Several windows were broken in buildings at the top of the manshaft.

The mine is gassy, and line curtains were kept up to about 10 feet of the faces when loading and closer during blasting. From the evidence it appears that the air current was short-circuited from the Shaft entries, particularly Nos. 5 and 6 returns, and from the working places in and off the Day entries by leaving open the air-lock doors at the entrance to the section. Gas had accumulated in these places and was ignited by an electric arc or spark from face electric equipment or trailing cables. Coal dust aided propagation of the explosion, which extended more than 4,000 feet through the Shaft and Little Horse Pen entries. The force of the explosion also was felt for 4,000 feet to the northeast (fig. 181), but the explosion did not propagate in this direction, because the rock dust was not as contaminated with coal dust as in the Day and Little Horse Pen entries, where coal had been produced and loaded, and gas was not present in the air as it was where ventilation had been short circuited. A large quantity of gas had burned in the face regions of the Day entries. Coking and soot streamers were found here. Figure 182 shows the conditions found in this section. All electric equipment in the section was found in nonpermissible condition, and the nipping stations could have been in explosive mixtures of air and methane if a check curtain was raised or ventilation was cut off in some other way.

September 23, 1957; Marianna No. 58 Mine, Marianna, Pa.; 6 Killed

(From Bureau of Mines report, by F. E. Griffith, G. W. Chastain, and R. J. Kirk)

An explosion followed by about 25 fires occurred about 7:15 a. m., Monday, September 23, 1957. Eleven men were underground; 5 were killed, and 6 were rescued and hospitalized; 1 of them died 5 days later.

The man-hoisting elevator was destroyed by the explosion forces. The injured men and dead bodies were hoisted and rescue and fire-fighting personnel were lowered in the 580-foot-deep Moore shaft by the improvised hoisting facilities shown in figures 183 and 184. This equipment was subsequently replaced by a conventional shaft-sinking hoist and bucket.

The explosion originated on 30 mains haulage road between the angle chutes connecting C face west with 30 mains when an explosive mixture of methane and air was ignited by an arc from the trolley pole of an electric-powered utility truck, known as a "jeep," or when a trolleywire cutout switch was opened. Forces of the explosion extended in all of the 30 mains entries, from the entry faces for 4,400 feet outby, and into C face west for 900 feet.

On Saturday morning, September 21, with all men out of the mine, the Piper fan, 1 of 2 main fans ventilating the mine, was disabled when the impeller blades sheared off at the hub. On Sunday morning, September 22, four assistant foremen made a ventilation survey with battery locomotives to determine the behavior of the ventilation currents with only the Hoover fan in operation. They found some air currents reversed and noticed a musty odor, like that of return air, along 30 mains haulage road between the angle chutes connecting with C face west. They made no gas tests at this location and did not record their findings when they returned to the surface about noon.

About midnight Sunday, 10 foremen, a fireboss, and a pumper entered the mine at the Moore shaft. The foremen were assigned to examine designated sections and make air measurements, the fireboss was assigned to examine all places where pumps were to be operated, and the pumper was to operate the pumps. Eight of the foremen, in pairs, used trolley locomotives for transportation, two foremen and the fireboss used battery locomotives, and the pumper traveled by trolley "jeep."

After completing their assigned duties, the foremen returned to the Moore-shaft bottom. The general assistant went to the surface via the Moore shaft, the other foremen were near the shaft bottom, in man-trip cars or in the new shop, awaiting quitting time, and the fireboss and pumper were in 30 mains haulageway near C face west, about 2,500 feet from Moore shaft, when the explosion occurred at 7:15 a. m. Undoubtedly, the man-trip cars saved some of the men from death from the explosion forces that engulfed them.

In about 10 minutes communication was established with some of the survivors by shouting up and down the Moore shaft. Later a telephone line and first-aid materials and fire-fighting equipment were lowered.

Attempts to enter the mine from the Marianna No. 2 shaft failed. A company-owned truck with an A-frame and pole-hoisting winch was equipped with 600 feet of ⅝-inch wire rope and a 55-gallon steel oil drum to provide emergency facilities for hoisting the injured and the dead and lowering rescuers and fire-fighting equipment.

The body of the pumper was found lying on 30 mains a short distance outby the junction with C face west. He had apparently been operating the "jeep," which was about 112 feet outby his body, toward Moore shaft. The body of the fireboss was in the cab of the battery locomotive a short distance outby the jeep. A trolley-

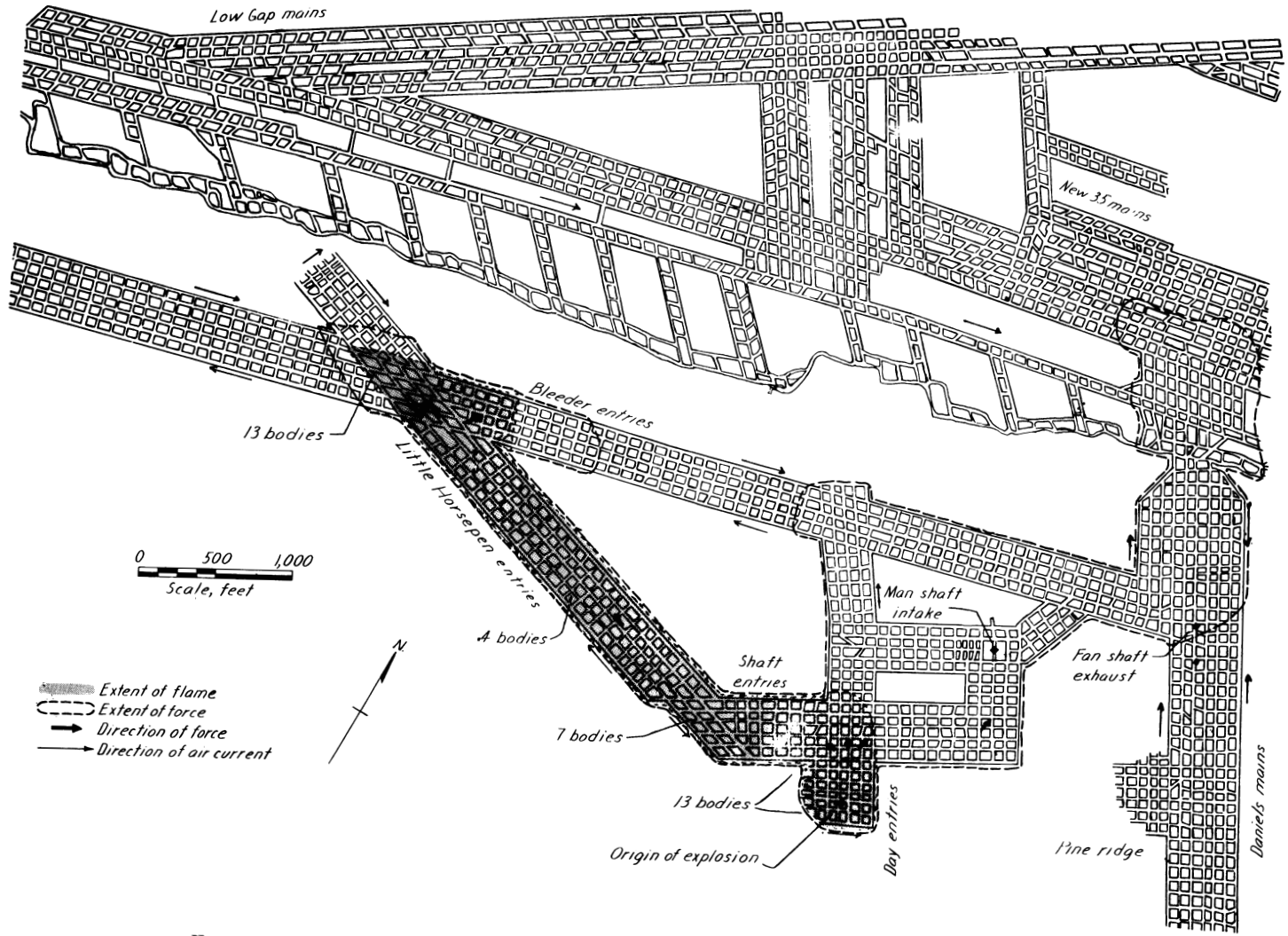

FIGURE 181.—Map of explosion area, No. 34 mine, McDowell County, W. Va., February 4, 1957.

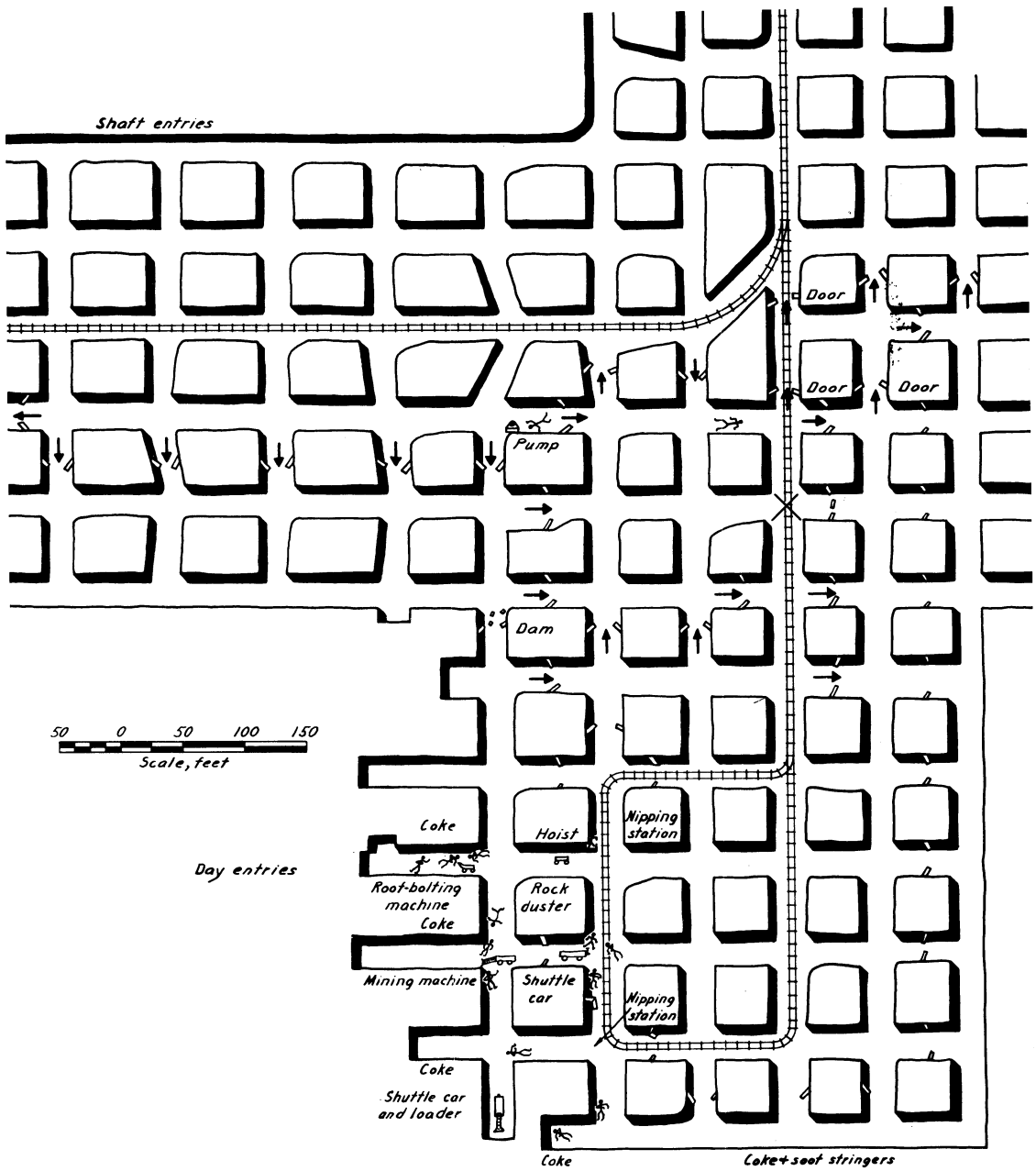

FIGURE 182.—Sketch of Day entries, origin of explosion, No. 34 mine, McDowell County, W. Va., February 4, 1957.

FIGURE 183.—View of damage to Moore-shaft headframe and truck with winch and A-frame after explosion, Marianna No. 58 mine, Marianna, Pa., September 23, 1957.

wire cutoff switch about 20 feet outby the locomotive had been opened, and the trolley wire was kinked near the location of the pumper's body.

Owing to the disrupted ventilation, gas liberated in the 30 mains face area moved slowly out No. 7 and 8 entries, passed through an opening in a stopping at the abandoned compressor station, or through a trap door in a stopping that was blocked partly open by a roof fall, and thence onto 30 mains haulageway, where it was ignited by an arc from the "jeep" trolley or the opening of the trolley-wire cutout switch at the junction with C face west (see fig. 185 for roof fall at trap door). The flame traveled to the parallel intake entry and then to the back-entry returns on the north side to the parallel intake entry and then to the back-entry returns on the north side of 30 mains haulageway, where it was propagated by gas and some mine dust (mixed coal and rock dust that was rendered explosive by the presence of methane) to the faces of these adjoining entries.

December 27, 1957; No. 31 Mine, McDowell County, W. Va.; 11 Killed

(From Bureau of Mines report, by W. R. Park, E. M. Lewis, and J. Zeleskey)

An explosion occurred about 6:35 p. m., Friday, December 27. 1957. Eleven men were killed by the explosion; all died from burns and/or forces. None of the other 147 men in the mine at the time of the explosion was injured; however, 14 men, including a foreman, were entrapped when forces of the explosion destroyed the section ventilation facilities (stoppings and an overcast). The 14 men erected a barricade in 2 right off Q left headings and remained behind the barricade until they were rescued about 5 hours later (12:00 midnight, December 27) by a recovery crew; these men were in good physical condition when rescued.

The explosion originated in No. 4 entry of Q left airways when an explosive mixture of methane-air was ignited by an electric arc or spark from the face electric equipment or a power conductor. Forces of the explosion extended throughout the Q left airways to the junction of Q left airways and Q left headings and then spread right at the Q junction and were dissipated as they traveled right toward the manshaft and left toward the faces of Q left headings.

A section foreman and 9 men were producing coal in the Q left airways section when the explosion occurred; a fireboss was also in the section. The bodies of the 11 men were found within 35 to 300 feet of the face of No. 4 entry. It is extremely doubtful that any of these men moved more than a few feet after the explosion, and all were apparently performing normal duties in connection with production of coal. The bodies of the

FIGURE 184.—Rescue officials preparing to enter Moore shaft in oil drum rigged for emergency hoisting following explosion, Marianna No. 58 mine, Marianna, Pa., September 23, 1957.

11 men showed that they had been killed immediately by flame and forces of the explosion.

A section foreman and 13 men were performing normal coal-producing duties in the Q left headings section when the explosion occurred. These entry face regions were affected only slightly by the explosion, but telephone lines were blown down and stoppings were blown out, short-circuiting the intake air currents at the intersection of Q left airways and Q left headings, a distance of 2,500 feet outby the working faces of Q left headings.

A map of the explosion area in Q left airways and Q left headings is given in figure 186 (p. 273).

Realizing that an explosion had occurred and assuring themselves that it was not in their section, the men in Q left headings removed the cable nips from the power source and attempted to reach cutout switches to deenergize the power circuits but were driven back by smoke and fumes. They then decided to barricade themselves in 2 right off Q left headings, using 4- and 5-ply brattice cloth, and await rescue.

When rescue workers reached the junction of Q left airways and Q left headings and determined that the explosion had occurred in Q left airways, demolished stoppings were replaced with canvas, ventilation was restored in Q left headings, and the 14 men behind the barricade were released uninjured. Ventilation was then restored in Q left airways, and the bodies of the 11 victims were recovered at various times during the morning of December 28; the first 2 bodies were found near the trolley locomotive in a crosscut between Nos. 3 and 4 entries of Q left airways. These bodies were removed from the area about 3:00 a. m.; the other 9 bodies were located inby and nearer the faces, and all bodies were removed to the surface by 8:00 a. m.

Following the explosion in the company's No. 34 mine, February 1957, when 13 men were killed trying to escape through irrespirable air, the value of barricading following an explosion was discussed in detail at safety meetings and conferences. This lesson paid off handsomely and undoubtedly saved 14 lives.

Only the No. 4 entry of the 7 Q left airways was being advanced at the time of the explosion. Face ventilation was controlled by line brattices and canvas check curtains. It was not necessary to disturb these brattices and curtains during the normal production of coal, except when supplies were needed. Shortly before the explosion the boom man told the dispatcher that production in Q left airways would be slower during the next hour, because the crew had to haul supplies. These supplies had been left in cars on the haulage loop outby the line of canvas curtains.

The investigation revealed that the needed supplies had been procured, as this material was in the shuttle car in the last crosscut and adjacent to the 4 entry.

The disaster was caused by the ignition of a large quantity of methane that had accumulated in the Nos. 3, 4, 5, 6, and 7 entries of Q left airways during normal mining operations. Gas had accumulated in these working places as a result of short-circuiting of the ventilating current, which occurred when check curtains in No. 3 entry were opened or raised and fastened or destroyed while supplies were being procured from an outby location. The gas was ignited by an electric arc or spark from a piece of face electric equipment in No. 4 entry or from a trailing cable to this equipment. Coal dust in the immediate face areas entered into the explosion and aided in its propagation. All electric face equipment in the area was in nonpermissible condition.

The value of roof bolting following mine explosions has been inestimable. Where this means of roof support was used, recovery work, removal of injured and other survivors, and extinguishment of residual fires have been expedited immeasurably.

FIGURE 185.—Roof fall near trap door in vicinity of explosion source, Marianna No. 58 mine, Marianna, Pa., September 23, 1957.

October 27, 1958; Bishop (No. 34) Mine, McDowell County, W. Va.; 22 killed

(From Bureau of Mines report, by W. R. Park, E. M. Lewis, G. Noe, and E. Menta)

Shots fired at the face of No. 6 place, 2 left off Pine Ridge left section, blasted through to No. 5 place (No. 3 Drainway entry) and ignited an explosive mixture of methane and air about 8:28 a.m., resulting in the death of 22 men. None of the other 185 men in the mine at the time of the explosion was injured. However, 37 men in the inby Pine Ridge left and Pine Ridge main sections observed forces, dust, and fumes from the explosion enter their working areas. These men erected barricades and remained behind the barricades until rescued. The men in the Pine Ridge main section were removed from behind the barricade about 9:35 a.m. and the men in the Pine Ridge left section were removed from behind the barricade at 10:15 a.m. on the day of the explosion.

The disaster resulted from the ignition of a large quantity of methane that was liberated during blasting operations in No. 5 working place (No. 3 Drainway entry). The ignition occurred when one or more shots from the face of No. 6 entry of 2 left entries blasted through into No. 3 Drainway entry, where the face had been blasted shortly before. The victims of the explosion, all found within 875 feet of the faces of 2 left section, were burned severely.

Coal dust in the areas inby the mine-car loading point entered into the explosion and aided in its propagation.

The 2 left off Pine Ridge left section (explosion area) consisted of a set of 6 entries turned off Pine Ridge left entries and driven a distance of about 2,900 feet. Until shortly before the disaster, the 6 entries were ventilated with intake air coursed through the Nos. 3, 4, and 5 (center) entries, split right and left near the faces, and returned through Nos. 1, 2, and 6 entries. During a Federal ventilation survey of the mine in September 1958, 49,000 c.f.m. of intake air was coursed through the 3 center entries; 28,000 and 21,000 c.f.m. of air was measured in the immediate returns, Nos. 1 and 6 entries, respectively. However, after the ventilation survey was completed, a new set of entries (Drainway entries) was turned right off 2 left entries, and the 2 left entries and the Drainway entries were developed simultaneously with one set of face equipment and one loading ramp. The turning and driving of the Drainway entries with the 2 left entries required ventilation changes in the immediate face regions. Previous to turning the Drainway entries, 3 entries left and 3 entries right of 2 left were ventilated with

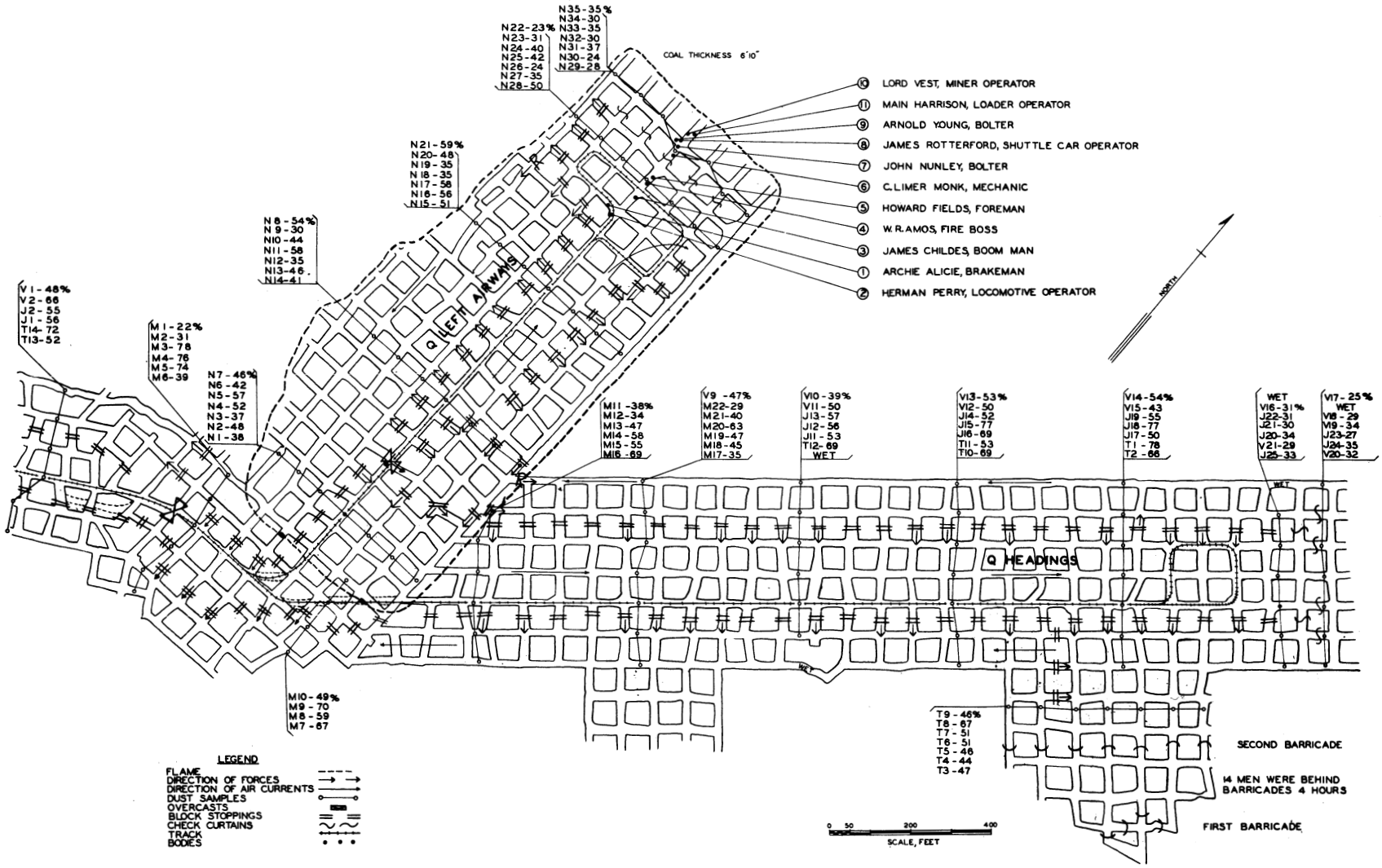

FIGURE 186.—Sketch of explosion area, No. 31 mine, McDowell County, W. Va., December 27, 1957.

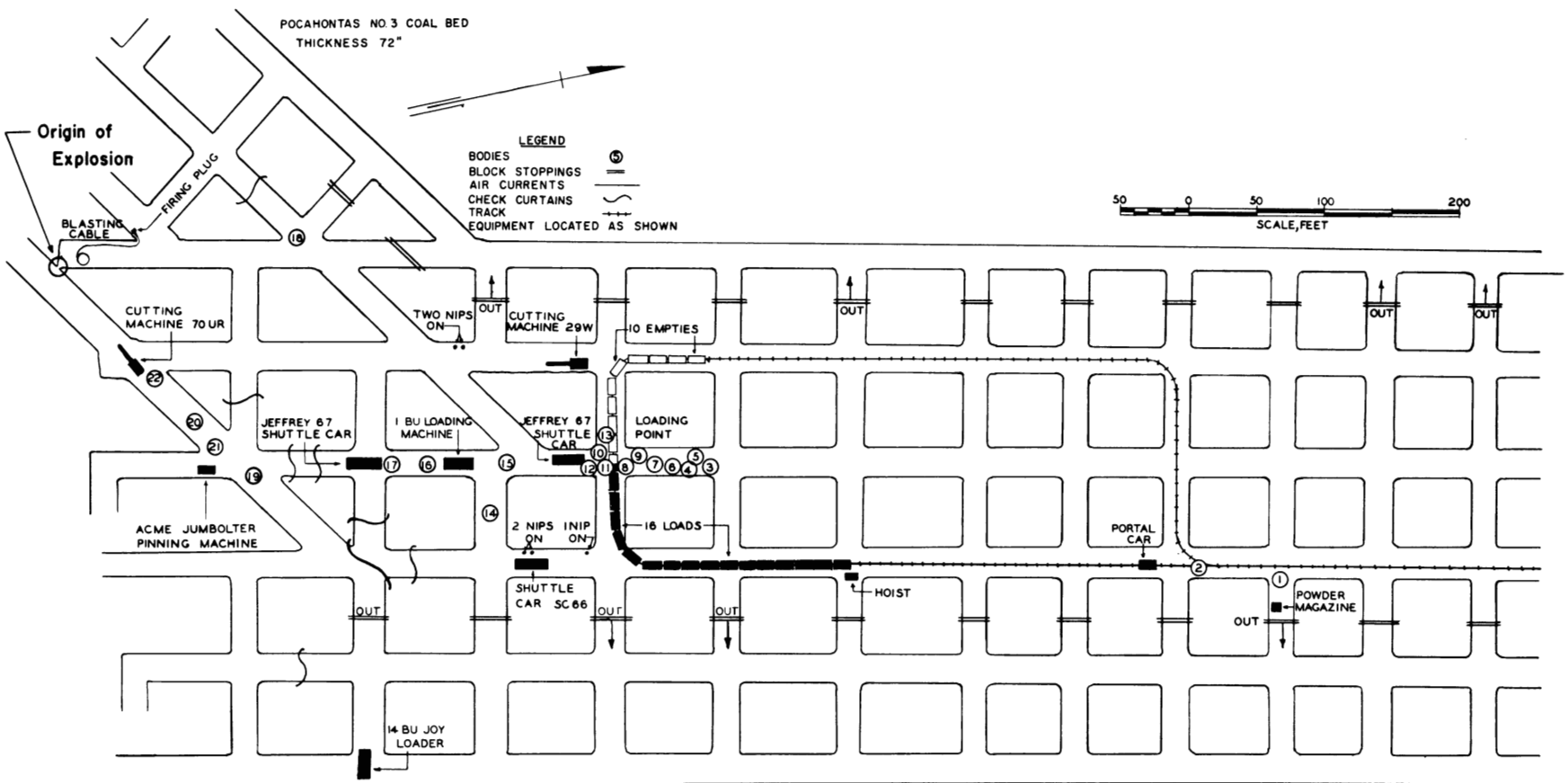

FIGURE 187.—Map of 2d left off Pine Ridge entries, No. 34 mine, McDowell County, W. Va., October 27, 1958.

separate splits of air; whereas, on the day of the explosion, the left split of air ventilated 5 entry faces, and the right split of air was coursed past 4 additional entry faces. Providing adequate face ventilation for the additional entries necessitated the use of additional check curtains and line brattice, which in turn increased the hazards of air leakage and ventilation interruptions.

The diluting and quenching effect of the rock dust applied was the principal factor in preventing further spread of this explosion. Other factors that helped limit the explosion were the cooling effect of the extensive rib, roof, and floor surfaces of the numerous entries in the path of the explosion and ample open areas for expansion of forces.

October 28, 1958; Burton Mine, Near Craigsville, W. Va.; 14 killed

(From Bureau of Mines report, by W. R. Park, F. H. Henderson, and A. Charlesworth)

Tuesday morning about 10:25 a gas explosion killed 13 men instantly and injured 4 others. One of the injured men died about 5:15 p.m., October 30. None of the remaining 37 men in the mine at the time of the explosion was injured, and they returned to the surface unassisted.

The disaster was caused when a large quantity of methane, released from formations in the roof by large falls or emitted from heaving bottom in the active workings or in the worked-out and abandoned areas adjacent to active workings in the 15 left section, accumulated in the active working areas and was ignited. Gas accumulated in these working areas when the ventilating current was short-circuited outby the active workings by the removal of stoppings from crosscuts between the 15 left entries.

The explosion originated in the No. 2 (belt) entry of 15 left entries when an explosive mixture of methane and air was ignited by an electric arc or spark from a power conductor.

Statements by survivors of the explosion indicated that there was a second explosion immediately after the initial blast occurred. A short circuit in the electrical system was found in No. 2 entry near No. 17 crosscut, where the feeder wires were down and the positive and return wires were in contact. It is believed that this short circuit occurred after the initial explosion, because the forces of the explosion dislodged the power wires from the J hooks and insulators at this location. It is possible that an arc or spark from this short circuit could have ignited methane and caused a second explosion. Coal or wood fires were not found in the explosion area.

Coal dust in the face regions entered into the explosion slightly and aided in its propagation.

On the morning of the explosion, the only permissible flame safety lamp taken into the 15 left section was carried by the section foreman. During the recovery operations, parts of this lamp were found scattered about the floor near a roof fall about 280 feet inby the mouth of No. 17 room right, a considerable distance from where the body of the section foreman was recovered in No. 2 belt entry. It was definitely established during the official hearing that continuous-miner operators did not carry flame safety lamps underground, except when inspectors were examining the mine.

The explosion resulted in the loss of production from the entire mine from October 28 until November 10, when 3 working sections resumed operation. Permanent ventilation was restored in the affected 15 left section November 13, 1958, and this section was rock-dusted, the permissible-type electric face equipment was restored to permissible condition, and the section resumed coal-producing operations November 17, 1958.

INDICATIONS FOR FURTHER CONTROL OF EXPLOSIONS

With the approved methane detectors and handier models that may be perfected, methane can be found and diluted before a danger point is reached. The problem is to set up and keep up a customary close watch and ventilating systems that will remove the gas. If the system normally moves plenty of air to all open workings, only low percentages of methane may be found in a large majority of the mines.

The conception of explosion prevention in coal mines has changed from the older view that explosive quantities of gas and dust might be present at any time, so that chief reliance must be put on excluding sparks or flames. At this time it appears that the best insurance is to control and prevent the build-up of gas and dust, rock dust effectively, and keep ignition sources away from producing sections. All these things depend on regular checking of performance to make sure that one or another of these precautions is not neglected.

To make the program work, there must be inspection by State or Federal mine inspectors and day-to-day inspections by company officials. Men and officials must know what is required and how to do it. Education and training in standards and safe practices have to be brought to these men and repeated every 2 or 3 years. Accident-prevention instruction by classes, meetings, or other means is conducted by all groups interested in reducing coal-mine accidents and injuries. These groups include *(63, p. 1)*:

1. Federal Bureau of Mines.
2. State mining departments (in individual States where coal is produced).
3. Individual mine operators.
4. Mine workers' organizations (unions)
5. Institutes, societies, and other educational organizations.
6. Coal operators' associations (regional and national).
7. Universities, colleges, and high schools.

There are other agencies, but these are the principal ones now active. The training covers all kinds of hazards; and explosion prevention becomes a routine subject, except at mines where minor explosions emphasize the reality of the danger. When a major disaster occurs, officials look sharply into conditions in their own mines, if they are seriously concerned with keeping their mines safe. If not, the inspectors do it for them. The trouble is that such activity usually requires an unfortunate lesson

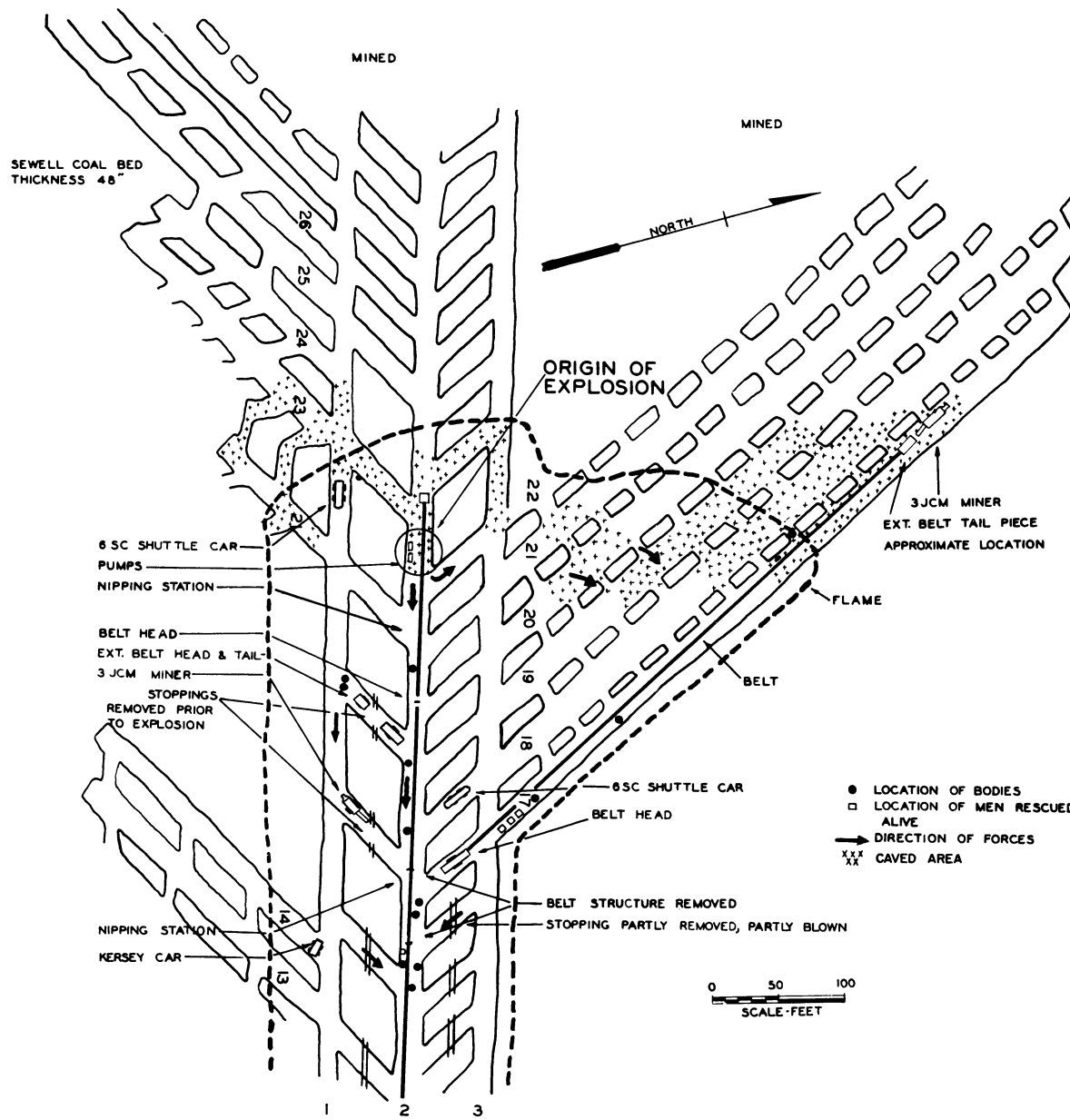

FIGURE 188.—Map of 15 left near working faces, Barton mine, near Craigsville, W. Va., October 28, 1958.

TABLE 15.—*Minor explosions in United States coal mines, 1957–58*

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1957: January 3	Loveridge	Fairview, W. Va	Gas; arc from contact of bare spots on power wires.	K–0; I–0.
January 11	No. 2	Morganfield, Ky	Gas; probably smoking	K–0; I–1.
January 17	North Point	Dora, Pa	Gas; open flame cap lamps	K–0; I–0.
January 18	Blackwood Drift	Blackwood, Pa	Gas; lit match	K–0; I–1.
January 23	South Dip Slope	Trevorton, Pa	Gas; arc from nonpermissible hand-held drill.	K–0; I–2.
February 5	North Point	Dora, Pa	Gas; open flame cap lamp	K–0; I–0.
February 19	Bird No. 3	Johnstown, Pa	Gas; arc from shuttle car contacting continuous mining machine.	K–0; I–4.
February 26	No. 4 C main opening.	Alva, Ky	Gas; lit match	K–0; I–0.
March 10	No. 93	Jordon, W. Va	Gas; arc from removing trolley pole from trolley wire.	K–0; I–2.
May 1	Phillips No. 4 Slope.	Trevorton, Pa	Gas; open flame cap lamp	K–0; I–2.
May 1	Clyde	Fredericktown, Pa	Gas; underburdened shot blew out.	K–0; I–0.
May 10	Vesta No. 5	Vestaburg, Pa	Gas; check door left open; blown-out trailing cable of loading machine.	K–0; I–0.
May 27	Dekoven	Dekoven, Ky	Gas or dust; sparks from machine bits cutting into boulders.	K–0; I–0.
June 6	Jensie	East Springfield, Ohio.	Gas; sparks from machine bits striking pyrite band or boulder.	K–0; I–0.
June 14	Loomis Colliery	Nanticoke, Pa	Gas; cleaned safety lamp with compressed air in gas filled place.	K–3; I–2.
July 29	Dutch Creek	Redstone, Colo	Dust; arc from defective wiring in shuttle car touching loading machine.	K–0; I–2.
August 2	Jensie	East Springfield, Ohio.	Gas; sparks from machine bits striking pyrite boulder.	K–0; I–0.
August 7	No. 93	Jordon, W. Va	Gas; sparks from machine bits striking sandstone.	K–0; I–0.
September 27	No. 7	Harrisburg, Ill	Gas; sparks from machine bits striking roof rock.	K–0; I–3.
October 9	Germantown Colliery.	Centralia, Pa	Gas; pole of trolley locomotive bounced from wire.	K–0; I–2.
November 16	Mayton Slope	Coal Run, Pa	Gas; short circuit in ventilation system; spark from open-type blower fan or a match.	K–0; I–3.
November 20	Wyoming No. 8 Slope, Henry Colliery.	Plains, Pa	Gas; miner struck roof with blunt end of bar.	K–0; I–1.
December 11	Peerless No. 3	Excelsior, Ark	Gas; short circuit in ventilation system; a match or mechanical lighter.	K–4; I–0.
1958: January 10	No. 5	Tookland, Va	Gas; open flame cap lamp	K–0; I–0.
January 17	Powhatan No. 3	Dilles Bottom, Ohio	Gas; arc or spark from trolley of jeep; examining abandoned area.	K–0; I–1.
January 31	No. 2	Robbins, Tenn	Gas; carbide lamp	K–0; I–0.
February 6	O'Donnell	Four States, W. Va	Gas and dust; gas ignited by continuous miner cutting bits.	K–0; I–2.
April 8	Moss No. 2	Clinchfield, Va	Gas; ignition was thought to be from some frictional source.	K–2; I–4.
May 1	No. 9 Coaldale Colliery.	Coaldale, Pa	Gas; unconfined charge of explosives in gas emitted from inaccessible area.	K–0; I–3.
June 11	Wildwood	Wildwood, Pa	Gas; ventilation disruption; spark from trolley tap of mining machine.	K–0; I–4.

TABLE 15.—*Minor explosions in United States coal mines, 1957–58*—Continued

Date	Name of mine	Location of mine	Nature of ignition	Killed and injured
1958: June 19	Maysville No. 1 Slope, Glen Burn Colliery.	Kulpmont	Gas; unconfined charge of permissible explosives.	K–1; I–4.
June 27	Osage No. 3	Osage, W. Va	Gas; in roof cavity ignited by spark from trolley locomotive.	K–0; I–1.
July 9	Slab Fork No. 0	Slab Fork, W. Va	Gas; ventilation disrupted by rising water; open-type pump motor.	K–3; I–0.
August 22	No. 6	Bradshaw, W. Va	Gas; poor face ventilation; defective flame safety lamp.	K–0; I–2.
September 6	Ernest No. 3	Ernest, Pa	Gas in roof cavity ignited by trolley locomotive.	K–0; I–1.
September 18	Conemaugh	Smokeless, Pa	Gas; continuous miner cutting bits (2 ignitions).	K–0; I–3.
September 19				
September 26	No. 34	McDowell Co., W. Va., near Bishop, Va.	Gas; bits of cutting machine striking sandstone roof.	K–0; I–0.
September 29	No. 11	Capels, W. Va	Gas in roof cavity ignited by underburdened shot of permissible explosives.	K–0; I–0.
October 2	No. 3	DeRossett, Tenn	Dust blown from borehole by jackhammer ignited by carbide lamp.	K–0; I–1.
October 17	No. 2	Robbins, Tenn	Gas; intentionally ignited by miner using carbide lamp.	K–0; I–0.
October 27	Potts Colliery	Locustdale, Pa	Gas; safety lamp put into stream of compressed air in presence of gas.	K–0; I–1.
December 5	Avondale Colliery	Plymouth, Pa	Gas; unconfined charge of permissible explosives.	K–0; I–1.
December 11	No. 1 Slope	Branch Dale, Pa	Gas; ignited when connection was made for electric drill.	K–0; I–3.
December 19	Landsburg	Landsburg, Wash	Gas; arc from nonpermissible drill; ventilation disrupted.	K–0; I–2.

after long periods without explosion disasters. This is not entirely due to complacency; the changes in methods, equipment, and working forces may create new conditions, whose effect is not foreseen.

Some of the problems being studied or due for study by the Bureau of Mines are (*13, pp. 21–31*) improved methods for stemming shot holes, the mechanism of the ignition of flammable dust particles, means of dust control with continuous mining machines, new methods of mine ventilation, degasification of coal beds, and additional control of electric circuits and equipment in face areas.

The assumption (under the Federal Coal Mine Safety Act) of new responsibility by the Bureau of Mines for preventing coal-mine disasters is in addition to the responsibilities that have been laid heretofore on all the agencies concerned. The burden on the Bureau is not to be taken lightly or evaded. The problem will remain and change its form, even if the industry enjoys a long period free from explosion disasters. Those charged with making mines safe places of work must give vigorous attention to accurate appraisals of conditions; inspection and protective measures taken against hazards must be adequate for the conditions.

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