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"An accident in the pit like that is a miner's affair, and if you're a real miner, you go like a man who knows what to do. That's really the first reason and the others come after. Of course, you don't know when you may have to stay down there, and who will dig you out. With us it's true for once, as the saying is, one for all, and all for one; that's just the way miners have."—Words of Grandfather Sucha-nek in The First Rescue Party, by Karel Čapek.

Käthe Kollwitz—Warning to Prevent an Accident at Work

25-

Preventing Fatal Explosions in Coal Mines

A STUDY OF RECENT MAJOR DISASTERS IN THE UNITED STATES AS ACCOMPANIMENTS OF TECHNOLOGICAL CHANGE

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Contents

These Accidents Are Preventable—

Introductory Note

THE mother's heartbreaking discovery that her son was one of those killed underground in a mine, depicted for any industry by the German artist Käthe Kollwitz in her drawing as a "warning to guard against an accident at work," is a preventable but all too frequent tragedy in American industry. Such is the conclusion of this study. Preventable are those long, anxious hours while a rescue party searches for victims and those above ground wait in agonizing suspense. The wife, the children, the young brothers, or the old father of the man who in health and in vigor went down the shaft to work that morning may have to wait hours or even days before knowing whether he will be carried out a corpse or grievously injured, or whether the rescuers may have found him in time to save him unhurt.

All miners know what it means. All respond to the call for volunteers to go below after an explosion, regardless of risking their own lives. How they feel is the theme of an artist of another coal-mining country, Czechoslovakia, whose brilliant dramatist and novelist, Karel Čapek, wrote of an accident in the pit; on the page opposite Käthe Kollwitz's drawing we have quoted the words of Grandfather Suchanek in The First Rescue Party.[1] Similar in spirit to both these portrayals is the well-known sculptured figure of a miner's mother bending over the body of her son, which is the work of a Belgian, Meunier. To artist, novelist, and sculptor from coal-producing

[1] Permission to quote has been granted for George Allen & Unwin, Ltd., London, by W. W. Norton & Co., New York. For permission to reproduce Käthe Kollwitz's drawing we are indebted to Curt Valentin, Buchholz Gallery, New York. Permission to quote has also been granted by Coal Age.

countries we turn for interpretation of the human tragedy of accidents in mines.

The deaths of 91 miners at Bartley, West Virginia, on January 10, 1940, of 73 at Neffs, Ohio, on March 16, and of the 113 others who were killed in major disasters of the extraordinarily disastrous year 1940 challenged public responsibility for greater safety in this basic industry which serves us all. At length, in the spring of 1941, Congress enacted a new law which had been pending for two years. Taking effect on October 1, 1941, it gave the federal Bureau of Mines the right of entry, though still withholding the power to require compliance with its orders. Nevertheless this right of entry for federal agents may have far-reaching effects in raising standards for state inspection. It makes timely this study, initiated before passage of the law, but designed now, as then, to encourage public support for a more vigorous program of safety, involving management, miners, and governmental agencies, both state and federal.

Safety in industry, like health in the human body, can be promoted by analysis of disaster. To find means of prevention, this study of fatal explosions in 1940 was undertaken. Material for it was found in reports of safety experts in federal and state agencies, supplemented by conclusions of committees of investigation of the United Mine Workers, comments of management, and other first-hand observations. Reports of these governmental agencies are mimeographed, and therefore not easily accessible to the public. To make their findings available in print seemed a useful undertaking. Though the analyses contained in this study are based on technical observations, the effort has been made to clarify them for the general reader, whose support is needed to enable governmental bureaus to extend and energize their work; while at the same time these facts must be made useful to the miners

and to technical men to whom the technical details are essential if future accidents are to be prevented. The author, Edward A. Wieck, is a coal miner of twenty-five years' experience in the mines. He has been able to read and reproduce technical reports with an eye to their practical significance for the lives of men working in the mines.

When the new law took effect in October, 1941, it was hoped that greater safety would result. To be sure, fatalities were fewer in 1941, but recurrence of disasters on January 22 at Kimball, West Virginia, on March 13 near Revloc, Pennsylvania, on May 22 at Bicknell, Indiana, on June 3 at Docena, Alabama, on June 30 near Indiana, Pennsylvania, on July 10 at Acmar, Alabama, on October 27 near Nortonville, Kentucky, and on December 28 at Harco, Illinois, showed that the lessons of 1940 had not been learned. As recently as January 28, 1942, after this report had gone to the printer, came news of Colorado's worst disaster in twenty-five years, when 34 miners were killed in an explosion deep within a mine of the Victor American Fuel Company, 200 miles northwest of Denver. Accounts of the disaster showed that it followed the same pattern revealed so persistently in the last two years.

As this study will show, efforts toward prevention have extended over a long period in the history of coal mining in the United States. These efforts have resulted in the establishment of state mining bureaus to enforce laws enacted in the various coal-mining states, and in the establishment and gradual extension of powers of the federal Bureau of Mines. The miners themselves have been most active in promoting these preventive measures, but they could not have done so without support of the public and of certain leaders among the operators, though lack of concern and even opposition to such legislation by management in the industry is a regrettable fact. Among the agencies representing the public should be

mentioned the American Association for Labor Legislation, which has for several years called attention to the importance of preventing accidents, especially through rock-dusting, and has supported more adequate legislation and enforcement.

The need for renewed effort is emphasized today because mechanization, which has proceeded rapidly during the past decade, has been accompanied by new hazards, while old safeguards have been sacrificed to new speed and uninterrupted operations. The details of the relation between technological change and these new hazards are amply demonstrated in the recent disasters analyzed in this study. At the same time it is shown how technology could overcome these hazards if it were applied in new methods of ventilation or air conditioning and in automatic tests which would reveal the presence of danger. The program of prevention through providing air and light is so simple and so feasible as to leave no possible excuse for recurrence of tragedies which affect not only the miner and his family, but the whole community.

"Stop the Slaughter in Coal Mines" was the title of the leading editorial in the United Mine Workers Journal of January 15, 1942. The miners have surely the right to public sympathy and support in this effort. A nation at war must conserve its resources. Safety in the mines is vital to national defense, as it is an ever-present obligation in time of peace.

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Russell Sage Foundation

New York, February, 1942

Part I

Recent Disastrous Explosions

THE six major disasters [1] which occurred in the coal mines of the United States during the year 1940 resulted in the loss of 277 lives—the highest number of fatalities in major disasters during any year since 1928, when 326 men were killed. Besides these "mass deaths," fatalities that affected fewer than five persons each brought the 1940 death toll of miners to 1,400.[2] Commenting on the "accident record of United States coal mines in 1940," the United States Bureau of Mines has said:

> . . . the situation is so grave that serious thought and relatively quick action are demanded if the coal-mining industry of this country is to avoid stigma of a national, even a world-wide, scandal because of the callousness with which the lives of its workers are being sacrificed.[3]

If, in comparison with deaths on a battlefield, or even in proportion to fatal motor accidents on highways, 277 fatalities in major disasters, or the total of 1,400 deaths from all coal-mining accidents, seem to be a small number, it should be pointed out that even one preventable death challenges an industry and a nation; and when such a death is due to conditions which accompany the technical development of a whole industry, it indicates a hazard confronting all the thousands of workers in that industry. Moreover, the death of a wage-earner

[1] A major disaster is defined by the United States Bureau of Mines as an accident causing deaths of five or more persons.

[2] Preliminary verbal report from United States Bureau of Mines; subject to revision.

[3] Kossoris, Max D., Bureau of Labor Statistics, "Coal-Mine Disasters in 1940," in Labor Information Bulletin, vol. 8, no. 3, March, 1941, p. 1; quotation from United States Bureau of Mines.

affects immediately the wife and children who depend upon him for support, and, in turn, the community is thereby impoverished. Miners and their families throughout the country may justly claim the sympathy of the whole nation and its expression in support of a program of prevention.

Nearly 82,000 coal miners died as the result of accidents in the mines of the United States during the forty-year period, 1901-1940. Over 600,000 sustained nonfatal injuries during the nine-year period, 1930-1938.[1] The annual average during the later 1930's has been about 1,200 killed and 63,000 injured, although, as already indicated, the total of deaths in 1940 was 1,400.

The disruptions and hardships suffered in readjustment of family life through loss of a bread-winner cannot be measured in statistics, and even data on the number of widows and orphans left by the casualties in coal mines are admittedly inadequate. The Bureau of Mines for a number of years past, in its annual reports on coal-mine accidents, has published such figures as were available, accompanying them with the warning that they "fall far short of the full number" because "some companies," in reporting fatalities, fail to report the number of widows and orphans. Nor are adequate and uniform data on this phase of mine accidents available in reports of state departments of mines.

However, a segment of this tragedy, both in its family and community aspects, may be portrayed by available vital

[1] Compiled from United States Bureau of Mines, Bulletin no. 430, Coal-Mine Accidents in the United States: 1937, pp. 119-121; Bulletin no. 437, Coal-Mine Accidents in the United States: 1938, pp. 7 and 105; and from unpublished figures of fatalities for 1939 and 1940, supplied through courtesy of United States Bureau of Mines. The accuracy of reports on nonfatal accidents in coal mines has been improved in recent years, but even the figures for 1930-1938 undoubtedly fail to show the total number of accidents in this group.

statistics relating to two of the mine explosions of 1940. An explosion on January 10, 1940, in the Bartley mine of the Pond Creek Pocahontas Company, at Bartley, West Virginia, killed 91 men, leaving 77 widows and 161 children under sixteen.[1] The dead ranged in age from nineteen to fifty-eight; five were under twenty-one. Expressed in percentages, 48 per cent were thirty years and under, and 78 per cent forty years and under. In an explosion on July 15, 1940, at the Sonman "E" Mine of the Koppers Coal Company at Sonman, Pennsylvania, 63 men were killed, leaving 34 widows and 107 children. The ages of the dead were between nineteen and sixty; five were not yet twenty-one. The percentage under thirty-one years of age was 52; and 73 per cent were forty years old and under. Seven families lost more than one member; two lost a father and two sons each; three lost a father and a son; and in each of two families two brothers were killed, in one instance, youths of twenty and twenty-two. Based on a life expectancy of sixty years, in the Bartley explosion a potential total of 2,468 years[2] of life useful to their families and to the community, an average of twenty-seven years for each of the dead, was wiped out. In the Sonman disaster, on the same basis, a potential total of 1,694 years was lost, again an average of twenty-seven years for each man killed.[3]

No financial compensation to the families can acquit mine-owners and the community from responsibility for such losses, or justify their continuance. Consequences so disastrous as these challenge the theory upon which workmen's compensa-

[1] Including seven posthumous children.

[2] This relates to 90 men; the age of one man was not given in the list from which these figures were compiled.

[3] Compiled from list of victims of Sonman disaster, in United Mine Workers Journal, vol. 52, no. 20, October 15, 1941, p. 14; and list of victims of Bartley explosion, furnished through courtesy of West Virginia Department of Mines.

tion laws were first enacted, that this legislation would tend to make industrial accidents too expensive to have them go on, and would compel the adoption of measures of prevention. What has resulted has been the passing of compensation costs on to the consumer, with continued neglect of safety conditions. Other measures are indicated as necessary if adequate reduction in the number and severity of mine accidents is to be achieved. Since men with long experience in mine-safety work are convinced that it is possible with an adequate program and co-operation of all agencies interested in mine safety to reduce accidents by 75 per cent, it is time that the industry faced the problem squarely, not as individuals, but as an organ-

TABLE 1.—MAJOR DISASTERS FROM EXPLOSIONS AND OTHER CAUSES; AND RESULTING FATALITIES, IN COAL MINES IN THE UNITED STATES, 1931-1940 [a]

Year	Major disasters	Total fatalities	Maximum number of fatalities in any one disaster
1931	6	56	28
1932	6	145	54
1933	1	7	7
1934	2[b]	22	17
1935	4[c]	35	13
1936	5[d]	37	10
1937	6[e]	101	34
1938	6[f]	84	45
1939	1	28	28
1940	6	277	91

[a] Includes all major disasters for the period; those due to causes other than gas and dust explosions are indicated in the following footnotes.
[b] Includes one disaster with five deaths caused by "asphyxiation."
[c] Includes one disaster with seven deaths caused by rock falling down hoisting shaft and striking ascending cage, and one disaster with six deaths caused by fire in hoisting shaft.
[d] Includes one disaster with nine deaths caused by mine fire.
[e] Includes one disaster with six deaths caused by powder explosion.
[f] Includes one disaster with six deaths from fall of rock.

ized group. In view of the mine-accident record such a program and such co-operation cannot be established too soon.

The recent record, year by year, is indicated in Table 1. It should be emphasized that this record is limited to fatalities resulting from "major disasters"; that is, as already explained, disasters, each resulting in five or more deaths.

With more than 6,000 mines, large and small, operating in the bituminous coal industry alone, the problem of achieving a greater degree of safety is not a minor one. However, a source of encouragement for a safety program is found in the fact that each year the number of bituminous coal mines having no fatal accidents is large. Any mine-safety program has this base from which to begin operations.

Although gas and dust explosions were responsible for only about 20 per cent of the total number of deaths in coal mines during 1940, recent developments with respect to this type of accident are alarming for reasons aside from the fact that this figure represents a sharp increase over recent years.[1] Gas and dust explosions are a type of accident that it is possible, not only theoretically, but actually, to eliminate entirely from mines. By use of proper precautions, accidents resulting from falls of roof and coal, and those related to haulage, electricity, and machinery, can be reduced greatly in number and severity, but can never be eliminated entirely.

Failure to take adequate precautions to prevent explosions indicates a general neglect in prevention of other types of accident. Although an explosion disaster kills tens and hundreds at one stroke, and other accidents kill men singly, it is almost a general rule that only in mines where the safety program also takes into account the possibility of a disastrous explosion,

[1] The rate of fatalities from explosions per million man-hours rose to .484 in 1940, as compared with .323 in 1932 and .068 in 1933, the highest and lowest rates, respectively, in the previous years of the decade 1931-1940.

are serious efforts made to prevent other types of accident. It is important, therefore, that any mine-safety program, regardless of the record of the particular mine with respect to gas and dust ignitions, should include adequate precautions against explosions. This need is particularly pertinent, because managers, especially higher executives, are almost invariably astounded when a major disaster from explosion strikes in their mines.

An adequate basis for preventions requires detailed analysis of the circumstances of each disaster. Those occurring in the year 1940 are shown in the following list:

Date	Location	Operating company	Fatalities	Cause
Jan. 10	Bartley, West Virginia	Pond Creek Pocahontas Company	91	Gas and dust
March 16	Neffs, Ohio [a]	Hanna Coal Company of Ohio	73	Dust
July 15	Sonman, Pennsylvania	Koppers Coal Company	63	Gas
Aug. 27	Bates, Arkansas	Bates Coal Corporation	10	Gas
Nov. 29	Nelms, Ohio	Ohio and Pennsylvania Coal Company	31	Gas and dust
Dec. 17	Raleigh, West Virginia	Raleigh Coal and Coke Company	9	Gas

[a] Willow Grove Mine, No. 10.

Bartley, West Virginia

A violent explosion of gas and coal dust occurred in Mine No. 1 of the Pond Creek Pocahontas Company at Bartley, West Virginia, about 2:30 p.m. on January 10, 1940, thirty minutes before the time for the day shift to finish work. The explosion was general throughout the sections of the mine to the north and east of the shafts, but did not affect the section to the west. Of the 138 men in the mine at the time of the explosion, all of the 91 working in the area affected by the explosion were killed. Among the victims were 15 men who had gathered together

after escaping death from the flame and violent forces of the explosion, but were asphyxiated before they were able to erect barricades for protection from the afterdamp.[1]

The men working in the vicinity of the shaft bottoms became aware of the explosion after a sudden rush of air along the entry, coming from the northeast portion of the mine with a sound "like a fire siren" and accompanied by dust. The 37 men working in the west portion of the mine, unaware of the explosion, were notified and, along with the 10 men employed near the shaft bottoms, were hoisted to safety. Columns of dust, rising to a height of 100 feet above the shaft openings, were the first indication to those on the surface of any trouble in the mine.

The company operating officials, including the vice-president, the general manager, the mine superintendent, and the safety engineer, were holding a safety meeting at the general office near the mine. When notified of the explosion, the safety engineer and the mine superintendent organized a rescue party and proceeded into the mine at about three o'clock. The district mine inspector of the state Department of Mines arrived shortly afterward and joined the rescue party. A mine-rescue car of the United States Bureau of Mines arrived that night, and during the night and the next day a total of eight Bureau of Mines engineers and safety men reached the scene, joining additional inspectors of the state Department of Mines, and mine-rescue crews from other mines trained in the use of oxygen-breathing apparatus.

The first rescue parties worked to restore ventilation as they advanced into the mine, but were driven out by a second explosion, which occurred at 9:30 p.m., about seven hours after the first. No one was injured by the second explosion. After con-

[1] Afterdamp is an irrespirable gas remaining after an explosion in a mine. It consists principally of carbon dioxide and nitrogen.

sultation on measures to cope with this hazard to rescue crews, which was more than ordinarily acute because of the presence of storage-battery tanks with attached cables in the explosion area, recovery operations were resumed the same night and continued without interruption until the last body was recovered on the night of January 14.

Damage to mine equipment had been negligible, but much labor and material were needed to remove the extensive falls of roof from the haulage ways, and to restore ventilation by reconstruction of stoppings and overcasts. Large crews of men were engaged day and night on this work, under extremely hazardous conditions of explosive gas, carbon monoxide, and bad roof; none was injured.

The Pond Creek Pocahontas Company is an affiliate of the Island Creek Coal Company of Holden, and the Mallory Coal Company of Mallory, West Virginia. Mine No. 1 is located at Bartley, McDowell County, in the southern part of the state, on the Norfolk and Western Railway. There is no record of any previous explosion in the Bartley mine during the fifteen years of its operation, but numerous explosions have occurred in other mines in the surrounding coal field in McDowell County. The mine works in Pocahontas No. 4 seam, which averages about five and one-half feet in thickness. Practically all production is from pillar work, as the mine is on retreat.[1] A total of 310 men are employed underground on two regular seven-hour shifts, producing about 3,000 tons daily.

The mine is extremely gassy,[2] ranking among the very high-

[1] The mining of pillars, which have previously been left for roof support, after the mine has been worked to the boundary, begins with the boundary and works back toward the shaft; hence the term "retreat."

[2] In this use of the term "gassy," in preference to "gaseous," the author has followed the usage recommended by the United States Bureau of Mines. In the sense in which it is used here, "gassy" is considered by the Bureau to be more accurate, and is beginning to be more widely used.

est in the United States in the amount of explosive gas [1] given off, as well as being dry and dusty. In mines of this type an explosion is an ever present hazard, and becomes imminent when precautions are relaxed or neglected. In recognition of this danger, the company collected and analyzed mine-air samples daily at the Bartley mine. Samples of air collected on the day of the explosion and analyzed by employes of the company, showed the mine to be liberating methane at the rate of 6,602,113 cubic feet in twenty-four hours, with a methane content of 1.69 per cent in the full air return of the mine. Air samples collected by representatives of the Bureau of Mines a month and four days after the explosion—a period during which the mine was not in operation—closely approximated these figures of the company (after adjustment to allow for the greater quantity of methane liberated under actual operating conditions).

The lower limit of explosibility of methane-air mixture is 5 per cent, but the Bureau of Mines recommends 0.5 per cent methane content as a safe maximum in the return air from the entire mine or from any section. The Bureau further recommends that if at any time the methane content in the return air from any group of workings exceeds 1.5 per cent, such workings be considered in a dangerous condition, and only men properly protected and officially designated to improve ventilation be allowed to enter or remain in such workings.[2]

[1] Methane (CH_4), known also as firedamp and marsh gas, is a gaseous hydrocarbon, light and inflammable, odorless and tasteless, occurring naturally as a product of decomposition of organic matter in mines and marshes. In coal mines methane may exude from the strata above or below the coal seam, or from the coal itself.

[2] Mine Safety Board Decision No. 9, approved February 13, 1928. The Mine Safety Board of the United States Bureau of Mines was established in 1924 to define officially the Bureau's "collective opinion as to safety practices, safety devices, or safety methods for underground operations or open-pit mining." Its decisions "form the basis of teaching and policy for the

Independently of the findings of Bureau of Mines representatives after the Bartley explosion, the company's records showed that this maximum had sometimes been exceeded, and company representatives stated that explosive mixtures had frequently been found in the last working place on pillar lines, next to the worked-out and caved areas. In the opinion of investigators of the Bureau of Mines, the amount of air circulated was not sufficient to dilute, render harmless, and carry away the methane generated in this mine. They were also of the opinion that adequate provisions had not been made to control the circulation of air and to prevent interruption of ventilation, as evidenced by single doors and by the lack of "bleeder" entries extending into or around the caved areas.

As a precaution against precipitation of an explosion by ignition of gas, electric trolley wires and power lines had been eliminated from the Bartley mine by the use of storage-battery locomotives for both gathering and main-line haulage; and portable storage-battery power tanks were used to operate coal-cutting machines and pit-car loader conveyors.[1] Permissible [2] electric cap lamps were used by everyone in the mine; foremen, fire bosses,[3] shot firers, and mining-machine operators

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Bureau," and are recommendatory only, as the Bureau has no power to make them mandatory. (United States Bureau of Mines Information Circular 6946, June, 1937, mimeographed.)

[1] The coal was loaded largely with pit-car loader conveyors, but there was some hand loading.

[2] The United States Bureau of Mines has devised certain tests and specifications relating to materials, devices, and equipment, and methods of using them, which, if met, entitle a manufacturer to label such material and appliances as approved by the Bureau of Mines and "permissible" for use in mines under the limitations prescribed in the approval. "Permissible" has a recommendatory meaning; the Bureau has no mandatory power. The authority, if exercised, to compel the use of "permissible" materials and appliances lies with the officials of the respective states. (United States Bureau of Mines Information Circular 6946, June, 1937, mimeographed.)

[3] Mine examiners.

were provided with permissible flame safety lamps for gas-testing purposes; smoking was prohibited, and all persons were searched for matches and smokers' articles before entering the mine. Blasting was done with permissible explosives, by shot firers using permissible blasting units, but shots were fired at any time during a shift. Most, but not all, of the electrical equipment in the mine was of the type permissible for use in gassy mines, but in the investigation following the explosion some of the permissible type was found to be in nonpermissible condition owing to lack of proper maintenance, or modification contrary to the original specifications of permissibility.

Although the mine was dry and dusty, no water was used to allay the dust at its source, in mining and loading operations and on the haulage roads. Rock dust, used to reduce the explosibility of coal dust by adding incombustible matter, had been applied on haulage roads and in working places, but generally trackless entries and return airways had not been rock-dusted. Dust samples collected and analyzed by representatives of the United States Bureau of Mines after the explosion showed that the inert content of the dust had been far below the minimum required.

The Bureau of Mines, in its report on the Bartley explosion, credits the company's management with a genuine interest in safe operation. In addition to the precautions to prevent ignition of gas, already mentioned, the Bureau's report lists the following among the "commendable safety practices" in effect at the mine: Employment of a safety director who spent all his time on safety work at the four mines of the company; monthly meetings of all employes, at which cash safety bonuses were distributed by lot to employes with no accident record; meetings of company officials to consider this subject; training of employes in first-aid work; training of company officials in accident prevention through the course prepared by the Bureau

of Mines; checking all men on entering and leaving the mine; appointing a section foreman for each 22 workers in seven working places, thus making possible frequent inspection; ventilation coursed so as to furnish air separately to each section, with a maximum of 38 men on each air split; placing haulage roads so as to receive incoming or "intake" air, even in the working sections; letting intake air sweep first over the solid workings; pre-heating incoming fresh air to prevent formation of ice in shafts; daily sampling and analysis of mine air; and the use of "hard" hats and safety-toe shoes at all times, and of goggles for certain operations.

The use of permissible equipment, the elimination of trolley wires in the mine, and the application of rock dust, are also commended, but with the reservation that maintenance of equipment and application of rock dust were not adequate. When men met underground in the Bartley mine, each repeated the slogan, "Be careful." Ironically, at the time the explosion occurred the company officials were meeting for the purpose of revising the printed safety rules distributed to all new employes when hired.

Because the second explosion, seven hours later, destroyed evidence left by the forces and flame of the original blast, and for other reasons, it was impossible to determine the point of ignition, or even the particular section in which the explosion originated. For the same reasons the exact source of ignition also is obscured, and its probability could only be inferred by a process of elimination. Of the common sources of ignition, there was no evidence to support the probability that blasting, open lights, or defective flame safety lamps had been the source; on the contrary, the available evidence tended to eliminate these as the cause.

Although two cigarettes were found in the jacket of one of the victims, no matches were found, nor any evidence that any-

one had been smoking. The search of all persons before entering the mine for matches and smokers' articles, the general knowledge that persons found in possession of such articles would be prosecuted, the strong probability that, in the interest of safety, other miners would report violators of this rule to the foreman, and the failure to learn of anyone who had ever been caught smoking in the mine, led the investigators to conclude that "while smoking could have been the cause of the ignition of this explosion," they were "exceedingly doubtful that this was the case."

The final conclusion of the Bureau of Mines as to the probable source of ignition was that

> . . . the condition of the electrical equipment and of the cables connected thereto leads the investigators to believe that the probable source was an electric spark or arc. This belief is based upon the multiplicity of substandard electrical conditions rather than upon the findings on any specific machine or cable.

The investigators also reported that inadequate ventilation permitted accumulation of methane in dangerous amount, and that the explosion was augmented by coal dust because of failure to wet dust at its source, and because of inadequate rock-dusting.

Commenting on the report of the engineers of the Bureau of Mines who investigated the explosion, Daniel Harrington, Chief, Health and Safety Branch of the Bureau,[1] agreed that the probable ignition agency in the first explosion was an electric arc, but contended that, because of finding cigarettes in the clothing of a worker, smoking could not be ruled out as a

[1] Appendix 1 of the Bureau of Mines' final report on the Bartley explosion. This official report of the Bureau, and the reports on the explosions at Willow Grove, Sonman, Bates, Nelms, and Raleigh, issued in mimeograph form, have been the chief sources of information for the accounts in this study of the six major coal-mine disasters of 1940.

possible source. Although the report gave a clean bill of health to the blasting practices in use, Mr. Harrington contended that, despite the use of permissible explosives and permissible blasting units and the employment of shot firers (all recommended by the Bureau of Mines), "this mine is too dangerously gassy and dusty to allow of blasting during the working shift or even of allowing any explosive in the mine while the working shift is in the mine."

Mr. Harrington considered the ventilating system entirely inadequate, both as to amount of air sent into the mine, and because of failure to ventilate properly the caved areas. On the basis of the amount of air circulated as measured by employes of the company, and the amount of methane found in the return air, it was recommended that the amount of air per minute should be increased at least twice, if not three times, even though it be necessary to sink additional shafts to accomplish this end.

Mr. Harrington commended the owners of the mine for having gone farther in the taking of precautions against explosion disasters than 99 per cent of the coal operators of the United States,

> . . . yet had relaxed in connection with such details as maintenance or safe use of its permissible electrical equipment; its ventilation practices failed to take adequate care of the large amounts of explosive gas given off; and while much rock dust was used, the rock dusting was not done or kept in effect in a manner which would insure its being effective; and essentially nothing was done to try to suppress the formation and dissemination of coal dust by using watering methods at the face and elsewhere, though the coal is inherently friable and produces maximum amounts of very fine dust.

Mr. Harrington criticized the report of the Bureau's representatives for failure to recommend the holding of "an inquiry or inquest," insisting that "a properly conducted inquest

might bring out facts which would lead to the solution of the cause of the explosion and even as to the place of origin." Probably as a result of this criticism, a perfunctory inquest was held by the county coroner some weeks after the report of the Bureau of Mines was made public. A five-man coroner's jury found that methane gas had been ignited "from some source or sources unknown." [1]

In addition to the representatives of the Bureau of Mines who hastened to the scene of the explosion as soon as word of it was received, state mine inspectors and mine rescue directors of the West Virginia Department of Mines took part in the recovery work and the subsequent investigation into the cause of the explosion. The West Virginia Department of Mines made no public announcement of its findings. Thus on the basis of the available information, the cause and origin of the disaster in the Bartley mine on January 10, 1940, may be summed up as follows:

The primary reason for the occurrence of this explosion was inadequate ventilation which permitted accumulation of explosive mixtures of gas in the mine atmosphere. Explosive coal dust played its usual role by augmenting the force and extent of the explosion, and may be credited with increasing the number of fatalities. The presence of gas in explosive mixtures, and excessive amounts of explosive coal dust, were chronic conditions in the Bartley mine. The mine had been in normal operation on the preceding day, with no particular change for the worse in these conditions on the day of the explosion. The barometer for the twenty-four hours just preceding the disaster had shown no appreciable drop in atmospheric pressure that might have facilitated the liberation of more than the usual amount of methane.

[1] United Mine Workers Journal, March 15, 1940, p. 15.

Whether the source of ignition was an electric spark or arc from nonpermissible or defective permissible electrical equipment, or resulted from a violation of the rule against smoking, is distinctly secondary to the real cause. In the absence of gas in explosive mixture, no ignition could take place. In the tragic chronicle of coal-mine disasters in this and other countries, the Bartley explosion is one more demonstration to add to many others, that the only way to prevent such disasters is to provide adequate and properly circulated ventilation which dilutes explosive gas, renders it harmless, and carries it out of the mine. Permissible equipment, devices, and materials, and rules designed to prevent accidental ignition, all have a distinct place in mine safety, but merely as additional safeguards, and not as substitutes for adequate ventilation. It is unfortunate that permissible equipment and materials, by giving a false sense of security, have often led in the past, as in this instance, to neglect of ventilation, and hence to disaster.

Willow Grove Mine, Neffs, Ohio

On March 16, 1940, at about 11:05 a.m., at Neffs, Ohio, an explosion occurred in Willow Grove Mine No. 10 of the Hanna Coal Company of Ohio, killing 73 men. Sixty-nine were killed outright by the forces and flame of the explosion. Fifty of these were immediately buried under hundreds of tons of rock that fell when the timbers supporting the roof were blown out by the explosion. The mine superintendent and the outside foreman were asphyxiated by afterdamp encountered on the main haulage way only a short distance inside the mine portal, when they entered to investigate after the accident had become evident to those on the outside.

Twenty-three men working in a section of the mine not affected by the blast were overcome by afterdamp in their effort to reach the outside by way of the main haulage road.

Falling as they were overcome, they were found by rescue parties, scattered for a distance of 3,000 feet along the haulage road, with the last man to go down still 4,600 feet from the mouth of the mine. Described when reached by the rescue party as "down, but breathing," all were revived after being taken out of the mine, but one died six days later from the effects of carbon-monoxide poisoning. In addition, one man was severely burned and injured by the explosion,[1] and eleven days later two others were badly hurt by a fall of rock while engaged in recovery operations. Seventy-nine uninjured men whose escape had been blocked for five hours were directed to the air shaft by rescue parties, and two others who were unhurt made their escape unaided.

Before outside help was available, the majority of the men left alive after the explosion had either got out of the mine or had joined the rescue parties. The district mine inspector of the Ohio Division of Mines arrived in time to take part in the later stages of this preliminary exploration. Six representatives of the United States Bureau of Mines arrived from the Pittsburgh station at 5:30 p.m., and this number was increased to 11 later in the evening. The representatives of the Bureau, with a total of 19 men from the state Division of Mines, remained at the mine and took part in the recovery work until the last body was taken out on March 28, twelve days after the accident. The work of recovery was both difficult and dangerous, owing to extensive falls of roof in the area of the explosion. Had it not been for the use of loading machines to remove the falls blocking this area, a much longer time would have been required.

The explosion was not general throughout the mine, but

[1] This man died from the effects of his injuries in June, 1941, fifteen months after the explosion. He was badly burned both internally (from breathing the flame) and externally, besides having had six ribs crushed.

traversed the entire section known as 22 south and a short distance both ways on the main haulage from the mouth of 22 south.[1] Mining equipment, such as loading machines, coal-cutting machines, locomotives, and cars, was damaged by falls of roof and by the forces of the blast. Over 12,000 tons of rock were loaded out of the area of the accident by April 2, with a considerable amount yet to be removed.[2] The ventilating fan continued to operate after the explosion, although normal circulation of air was interrupted and short-circuited in and about the area by falls of roof and destruction of overcasts, doors, and stoppings. The air was also poisoned by afterdamp. It was this afterdamp, carried out through the main haulage road in the return air current, that killed the mine superintendent and the outside foreman just 100 feet inside the mine, and overcame the 23 men who attempted to escape by that route. The use of this main haulage road for an air return, instead of a fresh-air intake, as long recommended by the Bureau of Mines,[3] was, as noted above, responsible for the death of the mine superintendent, the outside foreman, and the miner who died later from the effects of carbon-monoxide poisoning after he had been overcome on the haulage road.

The Willow Grove mine is one of four operated in Ohio by the Hanna Coal Company of Ohio, and is located on the Baltimore and Ohio and the Wheeling and Lake Erie railroads, at Neffs, Belmont County, in the eastern part of the state. No previous fatal explosion at this mine is on record, but it is reported that one which resulted from a blasting shot three weeks before the accident of March 16 blew out two stoppings

[1] The forces of explosion covered an irregularly shaped area, roughly 2,000 feet at its greatest length and breadth.

[2] The mine resumed operations on April 21, a few days over a month after the accident.

[3] Mine Safety Board Decision No. 11, approved May 1, 1929. (United States Bureau of Mines Information Circular 6946, June, 1937, mimeographed.)

and a door and threw several men off their feet. In 1924 a gas-and-dust explosion had occurred at Benwood, West Virginia, across the Ohio River, 12 miles from the Willow Grove mine, resulting in the death of 119 men.

The Willow Grove mine works in a seam known as Pittsburgh No. 8, which averages about five feet in thickness and has a heavy "soapstone" roof above the draw slate. A panel, "room-and-pillar" method of mining is used, with the butt, or development entries driven to their limits before rooms are turned. Rooms are worked in blocks of 12, beginning at the face of the entry, with 8-foot pillars between rooms in the block and 50-foot pillars between the blocks.

Completely mechanized since May, 1936, the Willow Grove mine is regarded in the industry as a model because of extensive application of modern methods of mining, transportation, and treatment of coal.[1] In three seven-hour shifts a day, six days a week, a total of 711 men are employed above and below ground. This number includes a "floating" shift, made necessary by the thirty-five-hour week provided in the union agreement. Underground employes number 215 on the day shift, and 144 on each of the afternoon and night shifts. Daily production is 4,300 tons.

All underground machinery is electrically operated. The machinery at the working face includes modern arc-wall coal-cutting machines, electric power drills, and loading machines. Room crews consist of 17 men each, and entry crews of six men.[2] Each crew prepares the face, drills and blasts, cuts and shears, and delivers the coal to the side track. Blasting was done at any time during a shift, with black pellet powder and elec-

[1] See Coal Age, vol. 42, no. 10, October, 1937, pp. 47-51 and 65-71, for description of equipment, methods of mining, and coal preparation.

[2] These numbers have since been changed by reducing the number of men on the room crews and increasing the number on the entry crews.

tric squibs, fired from an attachment on the cap-lamp battery, either by a driller or by a machine man acting as shot firer. The coal is undercut and sheared to a depth of eight and one-half feet, and the blasting holes drilled to a depth of eight feet. All underground haulage is by electric locomotives, trolley locomotives for secondary and main-line haulage, and cable-reel locomotives for gathering. All this electrical equipment was of nonpermissible type, and haulage locomotives were operated on return air.

The mine was classed as nongassy by the Ohio Division of Mines. Apparently the management accepted this rating as final; and despite an excellent official record, over a period of years, of reducing accidents in this mine as well as in others of the same company, the elementary need of being constantly on the lookout for gas, even in mines where little or none had previously been detected, was neglected. This need for watchfulness applies with particular pertinence to mechanized mines because of the rapid advance of the working places, with equally rapid change in conditions; but an added urgency existed at the Willow Grove mine because of daily three-shift operation.

Permissible electric cap lamps were used by underground workers, mainly because of the superior illumination afforded, and not as a safeguard against ignition of gas. The mine foreman, the safety inspector, and all section foremen carried flame safety lamps for testing "for oxygen deficiency and possible liberation of methane." The section bosses, who, according to the report of the Bureau of Mines, were "supposed" to test all working places for gas, were revealed in hearings after the accident by the Ohio Department of Industrial Relations, to have been lax in their inspection. The apparent acceptance as unimportant, of several previous instances of gas ignition, brought out in the hearings, gave evidence of further laxness,

for which blame must be placed upon the higher officials of the company.

Responsibility for failure to recognize the hazardous conditions and to make the necessary changes lies with the higher company officials, and cannot be shifted to the shoulders of persons in minor supervisory positions in the mine. The higher officials are responsible for operating policy and methods. Changes in equipment or in operating methods in the interest of safety, or for any other reason, are not within the power of mine supervisory personnel. Higher officials of the Hanna Coal Company are responsible for use in the Willow Grove mine of nonpermissible electrical equipment, operation of trolley and cable-reel locomotives on return air, use of nonpermissible explosives, failure to employ fire bosses to make pre-shift examinations of the mine, and failure to direct the periodic collection and analysis of mine-air samples. The higher officials alone had authority to order changes in operating methods and equipment necessary if proper precautions were to be taken when the presence of gas became evident through the several instances of its ignition prior to the explosion.

That the mine liberated gas, was verified by samples of air collected and analyzed by representatives of the Bureau of Mines ten days after the explosion. The methane content in the samples collected was found to vary from 0.02 to 0.33 per cent. The high percentage was in a sample taken from the place where the explosion originated, while another sample, taken from a high place in the roof in the same area, contained 2.46 per cent. On the basis of the samples taken, it was estimated that the mine at that time was liberating at least 50,330 cubic feet of methane in twenty-four hours, but that a somewhat greater amount would be liberated during normal operations, especially in view of the rapid advancement of working places resulting from mechanical mining. As a result of these

findings, the Bureau recommended in its report that in future the Willow Grove mine be classed as a gassy mine and operated accordingly. But unless the Hanna Coal Company voluntarily accepts this recommendation, only the Ohio Division of Mines has the power to make it mandatory and to enforce its acceptance.

The Willow Grove mine is naturally dry and dusty. No provision was made to allay by wetting with water the dust made by mechanized mining operations at the working faces. The main haulage road, which is arched and gunited,[1] had been rock-dusted six months before the explosion, but no other parts of the mine were rock-dusted. The constant scaling off of the "soapstone" roof from "weathering" increased somewhat the incombustible content of the dust. Analysis of dust samples collected along the main haulage road after the explosion showed a high incombustible content, and this is considered to have been a large factor in limiting the area of the explosion. Haulage roads nearer the face regions showed a lesser incombustible content, compared with the main haulage road, but the average was well within the explosive limit. Near the working faces the incombustible content of the dust was found to average far below the 65 per cent of incombustible matter necessary to prevent the dust from entering into an explosion.

The United States Bureau of Mines, in its report on Willow Grove, calls attention to the past good accident record of the company as evidence of an active interest in safe operation. A safety director was employed, whose duties were to inspect the mine for substandard conditions and practices, to instruct employes in first-aid methods, and to develop and foster a general plan of safety organization. Three employes' safety com-

[1] Gunite is the trademark name of a mixture of cement, sand, and water applied by pneumatic pressure through a cement gun.

mittees had been organized, one on each regular shift, composed of one member from each crew, elected by the crew. A general safety committee, composed of mine officials, held regular meetings. General employes' safety meetings were held quarterly, at which cash safety prizes were awarded to employes. Cash bonuses were paid to mine supervisory officials, on the basis of their safety record, covering periods of one, six, and twelve months.[1] The Bureau's report commends the company for the use of permissible electric cap lamps, permissible flame safety lamps for gas-testing purposes, hard hats, safety shoes, and safety goggles. It is important to note, however, that only 10 per cent of the employes had received first-aid training, and there was no program for retraining. Indicative of the management's failure to anticipate the possibility of a disastrous explosion, was the maintenance of a first-aid station on the surface, with a nurse in charge, while at the same time no oxygen-breathing apparatus was kept at the mine and no rescue teams had been organized or trained.

The real measure of lack of safety precautions in effect at the time of the explosion is to be found in the changes in underground equipment and methods of operation which the Bureau of Mines found necessary to recommend in order to prevent a repetition of the disaster. To conform with the Bureau's recommendation that the mine henceforth be operated as gassy, detailed suggestions were made for a ventilating system adequate to dilute and carry out of the mine explosive or noxious gasses liberated or formed; for control of coal dust by wetting, and for use of rock dust; for installation of permissible electrical equipment; and for use of permissible ex-

[1] Employes' safety committees, general employes' safety meetings, and employes' safety bonuses were discontinued after the explosion. Because of a growing fear of discrimination, employe members of safety committees withheld complaints about unsafe conditions, regardless of actual conditions. The safety bonus for supervisory personnel has also been restricted.

plosives in full conformity with the rules of permissibility. Among the changes designed to provide a continuous and adequate supply of fresh air for all parts of the mine, the recommendations included the driving of break-throughs promptly at a distance not to exceed 60 feet;[1] substitution of line curtains for blower fans and tubing to force the air from the last open break-throughs to the faces; and construction of overcasts to replace doors wherever possible. All doors were to be installed in pairs, and so hung as to be self-closing. For the purpose of maintaining an adequate check on any accumulation of explosive gas, it was recommended that fire bosses be employed to make pre-shift examinations and record their findings; and that section bosses and crews of cutting and loading machines make frequent tests for gas during shifts.

Recommendations made for dust control include the use of water on coal-cutting and loading machines, before and after blasting, and on loaded and empty cars, as well as thoroughly to rock-dust all parts of the mine to within 40 feet of the face, and to redust when analysis of dust samples, collected periodically, shows an incombustible content below 65 per cent. All electrical equipment used at or near the face should be of permissible type, maintained and used permissibly; trolley and cable-reel locomotives should be operated only on fresh intake air, and never inside the last open break-through. In addition to specifying the use of permissible explosives, in full conformity with the rules of permissibility, the recommendations call for employment of shot firers, and for limiting to one day's supply the amount of explosives brought into the mine or stored underground.

On March 28 and 29 a joint investigation to determine the cause of the explosion was conducted by representatives of the

[1] The investigators had found some as far as 120 feet apart.

United States Bureau of Mines, the Department of Industrial Relations of Ohio, the Ohio Division of Mines, the United Mine Workers of America, and the Hanna Coal Company, which owned and operated the mine. Hearings were held and witnesses examined by the Ohio Department of Industrial Relations on March 29 to 30 at St. Clairsville, and on April 2 to 3 at Columbus. In connection with the then pending federal mine inspection bill, a congressional subcommittee of four members of the House Committee on Mines and Mining made an inspection of the mine, and held hearings on March 20. The coroner of Belmont County held no special inquiry, but he and his staff, at the time of the recovery of the bodies, examined them and took testimony from witnesses. The coroner concluded that the deaths of the 69 men in the section of the mine immediately affected were caused by burns, but that at the time of his investigation the cause of the explosion was unknown.

The agents of the United States Bureau of Mines reported that they were

> . . . of the opinion that this explosion originated in the face of 8 west entry off 22 south; that the explosion was caused by the firing of a shot of black pellet powder stemmed with "bug dust" [1] which ignited a cloud of coal dust, in which gas may or may not have been present; and that the explosion was propagated [2] throughout the affected area by coal dust which was raised in suspension by the initial explosion.

As to the initial cause of the explosion, there was a difference of opinion between investigators of the state, the company,

[1] Fine coal including much coal dust, made by a coal-cutting machine when undercutting a seam.

[2] An initial explosion raises a cloud of coal dust in the air, giving the flame of the explosion additional fuel to feed upon. This process continues as the flame rapidly advances, and subsides only when an area is encountered where there is insufficient dust, or the dust contains sufficient inert matter to make it nonexplosive.

and the Bureau of Mines. However, all agreed that after eliminating all possible electrical sources of ignition, only two points of origin were possible: the face of the 8 west entry, where a blast had been fired; and a powder-storage box at the mouth of this entry. The company's investigators were of the opinion that the explosion originated at the powder-storage box, and the state deputy mine inspectors who testified at the hearings held in Columbus by the Ohio Department of Industrial Relations were about evenly divided as to the point of origin, between the powder-storage box and the face of the 8 west entry.

The director of the Ohio Department of Industrial Relations, however, in a press release issued on April 12,[1] was of the opinion that the "probable cause of the primary explosion was the explosion of the powder magazine, the cause of which is unknown." In arriving at this conclusion the director added the opinion that the evidence did not support the "presence of gas as the probable cause of the explosion," but agreed that "there was evidence that there may have been an overcharged shot" fired at the face of 8 west entry, "which could have been capable of causing an explosion."

The investigators of the Bureau of Mines, in arriving at the conclusion that the explosion originated at the face of 8 west entry, and not at the powder-storage box, pointed out that those who held to the contrary based their conclusion on the evidence of extreme violence in the vicinity of the powder-storage box, but had "advanced no logical means for the ignition of the powder." The possibility that the powder had been ignited by a cigarette or a match carelessly dropped into the box was rejected because no bodies were found nearer than 100 feet from the box, and none was in direct line with the box. In

[1] Text of the release incorporated in the report of the disaster by investigators of the United States Bureau of Mines.

their judgment, the evidence found following the explosion "can be correlated in a more or less logical manner if it is assumed that an explosion originating in 8 west ignited the black powder, but the evidence cannot so be correlated if the source of ignition is placed at the powder box."

The cause and origin of the disaster in the Willow Grove mine on March 16, 1940, may be summed up as follows:

The primary reason for the explosion was the failure of the management to anticipate the possibility of accumulation in this mine of explosive gas and coal dust in dangerous amounts; and to take precautions to prevent such accumulations, or their ignition. Preventive measures were more urgently necessary in the Willow Grove mine because mechanized operations increased the hazard from this source.

Nothing is unique about the Willow Grove explosion; it follows the pattern of explosions in other mines which have been erroneously or carelessly classed as nongassy. According to the Bureau of Mines, this explosion was "one of four very bad disasters which have occurred in the last four years in bituminous mines in the United States in connection with blasting in mechanized mines." Whether the management of the Willow Grove mine failed to take necessary precautions through neglect, or because of a false sense of security arising from the absence of previous explosions at this mine, the pattern is similar to that experienced in many previous disasters in the industry. Although in this instance ignition seems to have resulted from black powder used in a blast, ignition could have occurred from a number of other sources—electricity, acetylene torches used for cutting and welding metal, or the match of a smoker. All these agencies of ignition were present.

The mine inspection service of Ohio cannot escape blame for not detecting and insisting on correction of dangerous conditions in this mine before the explosion occurred. Because it

alone has the power, the Ohio Department of Industrial Relations and its Division of Mines continue at fault by reason of failure, since the explosion, to adopt and enforce the recommendation of the United States Bureau of Mines that the Willow Grove mine be classed as gassy, and operated as such. Because of this refusal, the Department of Industrial Relations becomes responsible for the failure of the company, since the explosion, to put into effect many of the precautionary measures considered necessary to prevent a possible repetition of the disaster, and recommended by the Bureau of Mines. As a result, nonpermissible electrical machinery is still used, electric trolley and cable-reel locomotives are still operated on the return air, and no fire bosses have been employed to make preshift examinations of the mine.

The order of the state mine inspection service for substitution of line curtains in place of electrically operated blower fans previously used at this mine to force the air from the last open break-through to the working face, is contrary to the assumption that the mine is nongassy, since the chief danger arising from the use of blower fans for this purpose is ignition of gas. Application of water to allay the coal dust was begun in this mine in March, 1941, almost a year after the explosion, but its use is limited to coal-cutting machines. No water is used on loading machines or on empty and loaded cars, nor is the coal wet down before loading, as recommended by the Bureau of Mines. Substitution of permissible explosive for black powder in blasting, and a rule against smoking in the mine have eliminated two agencies of ignition, but the big hazard of ignition by electricity remains as potent as before, as does that of the acetylene torch.

Sonman, Pennsylvania

In the Sonman "E" Mine of the Sonman Shaft Coal Company, in Cambria County, Pennsylvania, a gas explosion, ignited by an electric arc or spark from a trolley locomotive, occurred at about 10:40 a.m., July 15, 1940, resulting in the deaths of 63 men. A total of 93 men were at work in the section of the mine where the accident took place,[1] of whom 81 were in the immediate area of the disaster. The remainder of the 350 men in the mine were not affected. Eighteen men working in the explosion area were able to escape through the afterdamp to fresh air. Twelve others working on the same air split, but not affected by the blast, also escaped uninjured.

Most of the victims died from the effects of afterdamp; a few were killed by the violence and flame of the explosion. Thirty-four bodies were found behind "an ineffectively erected and located" barricade, which these men had built in the hope that it would protect them from the poisoned air until rescue parties could restore ventilation. At some distance from this group, seven more bodies were found. A note left by one of these men indicated that some were still alive at 6 p.m., more than seven hours after the explosion.

The explosion was ignited on a face haulage entry, and the flame did not reach the face of any of the three entries affected; it reached but few working places. The forces of the explosion covered an irregular area approximately 2,000 feet wide and 3,500 feet long at the farthest points. Coal dust entered into the explosion only to a limited extent. Numerous openings from the immediate area where the explosion originated gave opportunity for immediate expansion and prevented generation of the high pressure and velocity necessary to raise a cloud

[1] This section was known as "No. 2 air split"; that is, ventilated by one continuous circuit of air.

of coal dust of sufficient density. This and the probability that the gas was near the lower explosive limit are believed to account for the lack of extreme violence.

The mine foreman, who had been in another part of the mine when the accident occurred, had charge of the preliminary work of exploration. He was assisted by men who had escaped. Two district mine inspectors of the Pennsylvania Department of Mines arrived two hours after the explosion, and were joined by two other district inspectors later in the afternoon. Five representatives of the United States Bureau of Mines from the Pittsburgh station arrived at 4 p.m., having been notified of the disaster by the first state inspectors to reach the mine. All joined in the recovery work as soon as they arrived on the scene, and continued until the last body was taken out of the mine the following morning.

Property damage was relatively slight. Twelve haulage animals, ponies and mules, were killed, and doors and stoppings destroyed in the explosion area. The speed with which the area was explored and the bodies removed made the cost of recovery relatively small. The mine, with the exception of the section affected by the explosion, resumed operations after ten days.

Sonman "E" Mine is owned by the Sonman Shaft Coal Company, and at the time of the disaster was operated by the Koppers Coal Company under an operating agreement that had been in effect since 1935. The mine is located on the Sonman Branch of the Pennsylvania Railroad, at Sonman, Portage Township, Cambria County, in central Pennsylvania. No previous explosion at this mine is on record, although an ignition of gas occurred in 1920 when a slope for an air return was driven to the surface from the underground workings. Several men were burned, but there were no fatalities. In March, 1927, a coal-dust explosion, in which four men were killed, occurred

in a mine six miles from Sonman, although in a different seam of coal.

The Sonman mine operates in the Upper Freeport seam, which has an average thickness of 54 inches and an average pitch of 8 per cent. The method of mining in use is a modified room-and-pillar system. The pillars were previously extracted; this was supplanted by a system in which additional crosscuts are driven through the room pillars, leaving stumps for roof support. The same method is used in entries when they are no longer needed for haulage purposes. The new system was designed to prevent general caving of the roof in the worked-out areas, and to reduce the emission of water and gas from the upper strata. It was projected for an 80 per cent recovery of coal, of which about 72 per cent is attained. The mine employs a total of over 600 men underground on two seven-hour shifts,[1] which begin at 7 a.m. and 7 p.m., producing 2,700 tons daily.

The coal is undercut with permissible mining machines, drilled with breast augers, and blasted with permissible explosives, which are fired with a small nonpermissible dry battery. No shot firers were employed, miners charging and firing their own shots at any time during a shift. Except for two shaker conveyor units, used in a section of the mine remote from where the explosion took place, the coal is loaded by hand. Haulage from the face to the room headings is by animal power; from that point to the relay hoist—occasioned by the dip in the seam—by trolley locomotives; and from the top of the relay hoist to the main hoisting slope again by trolley locomotives. In all gathering and secondary haulage to the

[1] The United States Bureau of Mines, reporting on the Sonman explosion, gives the total number of employes as 720, of whom 680 are employed underground. The Pennsylvania Department of Mines reports 617 employed underground and 52 on the surface in two shifts.

foot of the relay hoist, the air is on return from mined-out areas, or from active workings.

Sonman "E" Mine is classed as gassy by the Pennsylvania Department of Mines. The United States Bureau of Mines, in its report on the explosion, rates it as moderately gassy. Permissible electric cap lamps are used throughout the mine, and smoking is prohibited. The mine foreman, safety inspector, assistant foremen, fire bosses, and mining-machine operators carry permissible flame safety lamps for gas testing. Fire bosses examine the mine before each shift enters, and make a second examination of each working place during the shift. Mining-machine operators are required to test for gas before taking the machine beyond the last open crosscut, and frequently while the machine is in operation. Assistant foremen were expected to examine each working place under their supervision at least once during a shift, but it was brought out in the testimony at the coroner's inquest after the explosion that, because of the large number of places assigned to each, they were often unable to visit all the places.

For the purpose of keeping a check on gas conditions in the mine, the company safety director collected and analyzed air samples from the return on each air split semi-monthly. At the time of his last official inspection of the mine, four months before the explosion, the state district mine inspector ordered these samples to be collected weekly and the analyses sent to him from locations which would more accurately reveal the amount of gas present in the mine. From the report on the explosion by the Bureau of Mines it is not apparent whether any change in frequency of collecting air samples had been made before the disaster.

Of air samples collected by the company's safety director some weeks before the explosion, analyses of six taken from company records were listed in the report of the Bureau of

Mines. One showed a methane content of 0.17 per cent; another, 0.03 per cent; while four contained no methane. A sample collected by the safety director on air split No. 2 (the section in which the disaster occurred) about ten minutes before the explosion, and later analyzed at the gas laboratory of the Bureau of Mines in Pittsburgh, showed a methane content of 0.18 per cent. Fourteen samples collected by representatives of the Bureau of Mines during the subsequent investigation showed a methane content ranging from 0.09 per cent to 1.08 per cent. One sample, not representative, however, of general conditions, taken at the edge of a roof cavity occasioned by a fall, showed a methane content of 21.9 per cent. A sample of the air from the return from the explosion area showed a 0.43 per cent methane content, indicating a liberation of 83,592 cubic feet of methane in twenty-four hours in that section.

Duplicate samples taken in the air return from the entire mine contained 0.13 and 0.14 per cent of methane, respectively, indicating that the mine was liberating from 206,538 to 222,425 cubic feet of methane in twenty-four hours. These figures also indicate that the rate of methane liberation in the area in which the explosion occurred was three times greater than in the mine as a whole. The Bureau's air samples, collected ten days after the explosion, are considered to be fairly representative of average daily conditions, except that the methane content would be somewhat higher under actual operating conditions. The Bureau's report directs attention to the higher methane content of its samples, as compared with those collected and analyzed by the company's safety director, and recommends changes in the sampling technique, as well as in the laboratory methods employed by the company, so that more accurate results may be obtained.

The main body of fresh air serving the section in which the

explosion occurred (No. 2 air split), filtered through a set of partly worked-out rooms before it found its way to the active workings. A caving of the roof in this area, and a sudden release of a considerable body of methane, which was carried along in the ventilating current and ignited by an electric arc or spark from a trolley locomotive, was the cause of the explosion. The report of the Bureau is critical of the system of coursing ventilating air through worked-out areas before it reaches the active workings; and blames the system of mining in use at this mine, which the report says "was obviously laid out with a view to obtaining a maximum recovery of coal . . . and apparently little consideration was given to proper and adequate ventilation."

The failure of coal dust to enter to any great extent into this disaster was due to fortuitous circumstances, and not to measures of dust control. No water was used to allay the dust. The mine was partly rock-dusted, including a small portion of the area in which the explosion occurred. The Bureau of Mines characterized the rock-dusting practices at the Sonman mine as falling "far short of what is necessary to prevent the ignition of coal dust and the propagation of coal-dust explosions." In only a few of the samples of coal dust collected and analyzed after the accident by the Bureau's representatives was the incombustible content found to be up to the amount required to prevent the dust from entering into an explosion.

Although severely critical of the system of ventilation and the lack of dust-control measures, the Bureau's report praised the company for progress made in safety during the four years it had operated the mine. In the Tenth Bituminous Holmes Council safety competition during the year 1939 Sonman "E" won second place, and another of the company's mines won first place, over 13 other competitors. The Bureau also commended the company for employing a safety director at the

mine, as well as a divisional safety director; and for maintenance of a safety committee composed of mine officials and employes which holds regular monthly meetings and investigates all fatal and serious accidents. The safety rules of the company carry the following penalties: For the first violation, a warning; for the second, suspension for one day; for the third, suspension for three days; and for the fourth, discharge.

No mine rescue station was maintained at the mine, no mine rescue equipment was available, and no employes were trained in its use. About 50 employes had been trained in first aid. In their failure to have this equipment at the mine and to train crews in rescue and recovery operations to begin work immediately after an accident, before the arrival of outside help, the management of the Sonman mine was little different from other operators. "Mine management," says the Bureau of Mines, reporting on the Sonman explosion, "generally fails to anticipate the possibility of a disaster."

Again in the Sonman mine, as in other fatal accidents, it is the recommendations of the Bureau of Mines to prevent recurrence which reveal the actual weaknesses in safety precautions. These recommendations include the following:

Ventilation: Drastic changes in the ventilating system designed to dilute and carry explosive gas out of the mine; the capacity and installation of the ventilating fan to be such that the entire mine will be adequately ventilated at all times; pure intake air to be conducted to active workings without first passing through or by unsealed, abandoned workings; not more than one set of rooms or developing entries to be on one split of air; return air from active or abandoned workings to be conducted directly to the main air return without passing through entries where trolley or feeder wires are installed; overcasts to replace ventilating doors wherever possible; and necessary doors to be installed in pairs to form an air lock.

Electricity: Trolley and bare feeder wires to be installed only on pure intake air, and not to pass open rooms either working or aban-

doned; electrical equipment used at or near the face to be of permissible type, used in a permissible manner and maintained in permissible condition; all permissible equipment to be inspected daily and a written report made on its condition, the inspector to be charged with the duty of seeing that the equipment is maintained in a permissible condition, and not used in a nonpermissible manner.

Dust control: Water to be used on the machine cuttings when made; all working places to be wet before and after blasting for a distance of forty feet from the face, and tops of loaded cars to be wet in working places; coal spillage to be prevented on haulage roads by not overloading cars; rock dust to be applied throughout the mine, including air courses and trackless entries; and the inert content of the dust to be maintained above 65 per cent, as checked by frequent collection and analysis of samples.

Explosives and blasting: Shot firers to be employed to do all blasting; all places to be examined for gas before and after blasting; shots not to be fired in places where gas is present in sufficient amount to be detected by a flame safety lamp; and all shots to be fired with permissible blasting units.

General: A sufficient number of section foremen to be employed so that each working place receives an official visit at least every two hours; a mine rescue station to be installed at the mine with at least 10 sets of oxygen-breathing apparatus and other necessary equipment; selected employes to be trained in mine rescue work, with retraining monthly; all employes to be trained in first-aid work; all employes, "but especially mine officials," to be given complete instructions on the subject of barricades; and a positive system of checking employes in and out of the mine to be installed.

A joint investigation to determine the cause of the explosion was conducted by representatives of the United States Bureau of Mines, the Pennsylvania Department of Mines, the Koppers Coal Company, the operators of the mine, and the United Mine Workers of America, each agency making its own report. The Pennsylvania Department of Mines found that explosive gas had been liberated suddenly in considerable quantity from a fall of roof in a partly worked-out area; that

a trolley locomotive was operating in the path of this gas as it was carried along by the ventilating current; and that the explosion

> . . . was initiated by the ignition of explosive gas in the mine atmosphere, by an arc or spark from a trolley locomotive . . . and was propagated by gas in the mine atmosphere . . . that the ignition was indirectly brought about by the failure of the system of mining, which failure might have been anticipated, yet was not expected.

The United States Bureau of Mines agrees with the Pennsylvania Department of Mines that the "explosion was caused by the ignition of gas by an arc or spark from an electric trolley locomotive; and that the gas was liberated suddenly by a fall of roof . . . and carried from there by the air current to the point of ignition."

The Bureau's report finds some violations of the Pennsylvania mining laws as they provide for ventilation of gassy mines and for precautionary measures to prevent ignition of explosive gas, as well as for dust control. But even full compliance with the law in every respect, says the report, including inspection of abandoned areas for gas, and sampling and analysis of mine air weekly, as provided by law when required by the state inspector,[1] would not have prevented the explosion. The Pennsylvania mining law permits a trolley locomotive to operate in a gassy portion of a mine, either in the intake or return air, if the air in which the locomotive operates does not contain more than 0.5 per cent of methane, and if the ventilating current is so coursed that the opening or closing of a door will not interrupt or seriously diminish the flow of air passing into and through the portion of the mine in which the locomotive operates. The Bureau's report contends, therefore,

[1] As already noted, the inspector had so recommended after his March, 1940, inspection.

that the state law was "totally inadequate to have prevented this explosion."

The Bureau's report further maintains that the Pennsylvania mining law is inadequate,

> . . . in that it does not give an inspector authority to enforce recognized safety precautions unless life is immediately in danger. In this particular case, as brought out in testimony during the coroner's inquest, it was understood by the State mine inspector and mine management that certain improvements were to be made in the ventilation in the portion of the mine affected by the explosion. However, in view of the fact that it would have been extremely difficult to prove that life was immediately in danger, the inspector did not have the required authority to remove the men or to bring about the necessary changes in a reasonable period of time.

In their report to the Pennsylvania Department of Mines, a commission of four mine inspectors who investigated the explosion recommended changes in the state mining laws to define more strictly pillared areas, and to place more drastic limitations on the use of electrical equipment in portions of mines likely to contain explosive gas.

A coroner's inquest to investigate the explosion was held on August 13, 14, and 15, 1940. Mine officials, survivors, and others testified. The jury's verdict was that the explosion was caused by gas ignited by a trolley locomotive. "The ignition was superinduced by the failure of the system of mining and negligence of officials directly in charge of mine management at the time of the explosion." The mine superintendent, mine foreman, and an assistant mine foreman were named in the jury's verdict as the officials who had been guilty of neglect. On December 3, 1940, these three mine officials were fined $100 each in court in Johnstown, Pennsylvania.[1]

The cause and origin of the disaster in Sonman "E" Mine on July 15, 1940, may be summed up as follows:

[1] Coal Age, vol. 46, no. 1, January, 1941, p. 98.

The primary reason for the occurrence was failure to adapt the system of ventilation to the system of mining in use at this mine. The method of mining, designed to obtain a high percentage of extraction of coal, caused the breaking of the roof and the sudden liberation of a considerable body of gas. The operation of a trolley locomotive in the return air from this pillar-working area was an obvious danger. The presence of gas in considerable amount in the strata above the coal in the Sonman mine was well known; and roof caving is to be expected when pillars are wholly or partly extracted. Given these conditions, the primary safeguard would have been to provide ventilation for the pillar-working area to carry any gas suddenly liberated directly into the return air by a route where there was no chance of ignition, and not through the active workings where the gas was ignited.

The trolley locomotive should not have been operating in an area where the air was likely to be contaminated with explosive gas. But the taking of the locomotive out of this run, without making the necessary changes in coursing the ventilation in this section, would not have eliminated the possibility of ignition of gas from other sources when it was carried to the active working places. The obvious way to have removed the hazard was to course the ventilation in this section of the mine so as to provide the active workings with uncontaminated air, and to conduct the return air from the pillar workings directly into the return air, where there was no chance of ignition. Such a change in the ventilation of this section of the mine would have been good practice, and would have prevented the disaster. In their reports after investigating the Sonman explosion, both the United States Bureau of Mines and the Pennsylvania Department of Mines recommended that such a change be made in the method of ventilation.

If one accepts the dictum that any effective method of pre-

venting gas explosions must include adequate and properly coursed ventilation, it is difficult to accept the conclusion of the Pennsylvania Department of Mines in its report on this disaster, that the "failure of the system of mining" by which "ignition was indirectly brought about . . . might have been anticipated, and yet was not expected." The United States Bureau of Mines investigators meet the issue without equivocation when they conclude that "the present system of mining was obviously laid out with a view to obtaining a maximum recovery of coal without making pillar falls and apparently little consideration was given to proper and adequate ventilation."

Bates, Arkansas

Sometime between 5:30 and 5:45 p.m., on August 27, 1940, a gas explosion occurred in Bates No. 2 Mine of the Bates Coal Corporation in Scott County, Arkansas, resulting in the deaths of 10 men. Seven of these men were killed in the immediate vicinity where the explosion originated, and three others, employed in another working area, some distance away, were overcome and died from afterdamp while attempting to escape to fresh air. These 10 men comprised the entire working force on the afternoon shift. The flame of the explosion traveled beyond the section in which it originated, crossing the main-slope entry and penetrating part way into the section where the three men were employed, but evidently did not reach the working face there, since these men were not burned and were able to get part way out before they were overcome. The flame died out about half way up the hoisting slope. Because the mine was damp, and because about six feet of bottom rock was blasted and loaded out in entries, coal dust entered into the explosion only to a limited extent.

A light cloud of dust, emerging from the mouth of the

slope, was the first indication of the explosion observed by the mine superintendent. The ventilating fan was not damaged, and continued to run after the blast. Recovery operations, under the direction of the superintendent, were begun at once through the main slope, which is the fresh-air intake for the mine. All bodies were recovered by 11 p.m., about five hours after the accident. No respiratory devices were used or needed in the recovery work, and only a few temporary brattices were required to restore air circulation. Property damage was negligible, limited to knocking out a few props and crossbars and some stoppings and doors along the main slope. No damage was done to equipment, and falls of roof were not extensive.

Two representatives of the United States Bureau of Mines stationed in the Southwest made the official investigation and report on the cause and origin of the explosion. Their first information of the disaster was received from the newspapers the following morning. One of them, stationed at McAlester, Oklahoma, nearest to Bates, also was notified about the same time by the Arkansas state mine inspector, who had arrived at the mine about 8 a.m. One of the Bureau's representatives reached the scene of the disaster about noon; the second arrived later in the day.

Two previous explosions had occurred in the Bates mine within four years. In May, 1940, gas exploded when no one was in the mine, and did more material damage than the explosion in August, three months later. This ignition was caused by interruption of electric current, which stopped the surface ventilating fan but did not stop a blower fan running in the mine. The blower fan somehow caught fire and ignited a body of gas. The explosion previous to May, 1940, had occurred on November 19, 1936, killing five men. On that occasion an electric arc from a nonpermissible coal-cutting machine had ignited gas from a gas feeder into which the machine had cut.

The Bureau's report on the explosion directs attention to the similarity of conditions surrounding the accidents of August, 1940, and November, 1936. Both explosions immediately followed stoppage of the machine after cutting into a gas feeder. "The explosion on August 27, 1940," says the report, "was essentially a repetition of the one on November 19, 1936; the mine, however, was under lease to and operated by different persons."

Bates No. 2 Mine is located at Bates, Scott County, Arkansas, near the Oklahoma border, on the Kansas City-Southern Railroad. Actual ownership of the property is obscure, the mine having been leased and re-leased a number of times in the recent past. At the time of the explosion in August, 1940, the mine had been operated under lease, less than a month, by two partners, one of whom acted as mine superintendent. It would probably be kind to say that the partnership had only limited resources.

The mine operates in the Hartshorne seam, taking out about three feet of clean coal from the bottom of the seam, and leaving from six to 12 feet of the upper part, which is dirty, for a roof. As already noted, six feet of bottom brushing is taken up in the entries. The mine was being worked on a modified long-wall system of mining, with faces up to over three hundred feet in length, and development entries driven ahead of the long-wall face. It was in one of these development entries that the gas feeder which caused the explosion was encountered.

A total of 57 men were employed, 47 underground and 10 on the surface. Coal was loaded and hoisted only on the day shift, the 10 men on the afternoon shift cutting the coal with mining machines, as well as blasting and loading out the rock from the bottom brushing in the entries. Production was about 225 tons daily.

Chain conveyors were used to carry the coal from the long-wall faces to cars on the entry. Blasting of the bottom rock on entries was done during a shift; coal was reported to be blasted when the men were out of the mine, but exceptions were made for misfired shots and shots to break pieces too large for the conveyors. Permissible explosives were used, set off with fuse and detonators, lighted with matches or a carbide lamp. All electrical equipment, including mining machines, conveyors, underground hoists, and drills, was of nonpermissible type. Permissible electric cap lamps were used, and smoking was apparently done in the mine; matches and smokers' articles were found in the clothes of some of the victims. A fire boss inspected the mine before each shift entered. In the inspection immediately before the afternoon shift entered the mine at three o'clock on the day of the explosion, the fire boss reported the mine clear of gas except for a small amount in a large roof cavity at the foot of the main slope.

This mine has always been known to produce gas; gas feeders are encountered and opened up by mining machines in development entries. Blower fans and tubing are used to force air to the face of the development entries, ahead of the long-wall face. It was in one of these entries that the gas feeder was cut into that caused the explosion of August, 1940. Air samples collected by investigators of the Bureau of Mines in this entry the second day after the disaster showed a methane content of 6.6 per cent, but the blower fan was still out of commission at the time this sample was collected. The feeder could still be heard giving off gas. A sample of the return air from the entire mine, collected at the air shaft the same day, showed a methane content of 0.68 per cent, indicating a liberation by the mine of 238,000 cubic feet in twenty-four hours.

As has already been noted, the mine was not dusty, and coal dust did not enter into the explosion to any great extent. A

natural stream of water flowing along the long-wall face wet the machine cuttings as they were made. Only a small quantity of coal dust was found on the timbers and ribs after the explosion. Rock dust raised along the roadways from the brushing operations reduced the explosibility of whatever coal dust there was in the mine.

No first-aid or mine-rescue training had been conducted at this mine for a number of years. According to the report of the investigators, no safety organizations are maintained at any of the mines in this coal field, which includes mines in both Arkansas and Oklahoma. The only regular inspection at the Bates mine was by the one state mine inspector of Arkansas.

The Bureau of Mines, in its report, made the following recommendations for future operation at the Bates mine:

Installation of permissible coal-cutting machines; change to electrical permissible blasting methods; prohibition of smoking, enforced by search for matches and smokers' articles before men enter; blower fans to be placed so that air is not recirculated; increase in amount of ventilation sent into the mine; air courses to be made suitable for travel; installation of means of escape through air shaft in emergency; and immediate training of employes in first-aid and mine-rescue work.

The immediate cause of the explosion, in the opinion of agents of the Bureau of Mines, was "the forming of an inflammable mixture at the face of 2nd east entry caused by the exposing of a gas feeder by a cutting machine, which was ignited by an electric arc caused by shutting off the electric current from the machine or by the flame of a match."

Despite the finding of matches and smokers' articles in the clothes of some of the dead men, and the presence of burned matches and cigarettes in the place where the gas ignited, the Bureau's investigators refused to accept this as conclusive evi-

dence that the gas had been ignited from this source. It was pointed out that other crews also carried smoking materials, and that shots were lighted with matches.

Other evidence indicates a strong probability that the gas was ignited by an arc from the machine controller when the current was shut off. The gas feeder was encountered when the cut was about completed, and the controller of the machine was found by the investigators to be in an "off" position. To quote further from the report:

> It is possible that the noise of the cutting machine prevented the men from knowing that they had opened up a rather heavy gas feeder and when they came to the end of their cut they shut off the power preparatory to pulling the machine out and the electric arc formed by moving the handle of the nonpermissible controller may have ignited the gas . . . or it is possible that the seventh man, being above the machine [1] and not knowing there was a dangerous atmosphere, decided to smoke and struck a match.

The investigators were probably impressed, also, with the similarity of the circumstances surrounding this explosion and that of November, 1936, which, as noted, had been attributed also to an electric arc from a cutting-machine controller.

The state mine inspector, in his report on the explosion, came to the same conclusion as the Bureau's investigators, as indicated below:

> The explosion was caused by igniting of a gas pocket which was cut into by an electric coal cutting machine. From all indications, the gas was ignited in the roadhead in the first east entry. It seemed there was some dust mixed with the gas, but there was no excess amount of dust.
>
> It is hard to determine just how the gas could have been set off. It might have been set off by an open switch on a coal cutting machine, or it could have been ignited by the striking of a match. The switch on the

[1] That is, on the high side of the entry, which was 24 feet wide and driven across the pitch of the seam. This man was found to have had smoking articles in his possession.

coal cutting machine was cut off, but matches were found in the pockets of some of the victims.[1]

In summary, the cause and origin of this disaster may be described as follows:

The primary reason for the explosion was the failure of the management of the mine to guard against ignition of gas suddenly released when fissures in the coal seam were encountered by cutting machines. It is apparent that these gas feeders were opened not infrequently in this mine. As already noted, the explosion of November, 1936, in which five men were killed, is attributed to this source. During the present investigation agents of the Bureau of Mines found a gas feeder bubbling in water collected at the face of the main-slope entry.

The recommendations made by the Bureau of Mines for future operation, if applied by the management, would tend to eliminate much of the hazard from gas. But the history of unprofitable operation, indicated by the leasing and re-leasing of the property to the point of obscuring actual ownership, the apparently modest resources of the current lessees and operators, the economic difficulties against which the coal industry of the Southwest has been struggling for more than two decades, and the dire need of the miners for work, forcing them to forego insistence on safety measures, plus the nonmandatory character of recommendations by the Bureau of Mines, all make highly speculative the question of whether any great improvement in safety conditions at this mine will follow as a result of the Bureau's investigations.

Nelms, Ohio

While 135 men were underground, a gas-and-dust explosion occurred in the Nelms mine of the Ohio and Pennsylvania Coal

[1] Quoted in report of the United States Bureau of Mines on the Bates explosion.

Company,[1] at Nelms, Harrison County, Ohio, at about 1:20 p.m. on November 29, 1940. Thirty-one men employed in the explosion area were killed from afterdamp and burns; and 104 men working in two other sections escaped uninjured. The gas was ignited during cutting and drilling operations at the working face by an electric arc or spark from a permissible coal-cutting machine or an electric drill. Both the machine and the drill were found by investigators after the explosion to have been "definitely in a nonpermissible condition," but the drill is believed to have been the more likely cause of the ignition. The forces of the blast extended over an irregular area approximately 2,000 by 2,300 feet at its maximum dimensions.

A main-line haulage motorman, who had felt the rush of air, was the first to report to the mine superintendent at the shaft bottom that "something was wrong." The mine safety director, who was nearer to the area and was knocked off his feet by a "sudden rush of air," reached the inside dispatcher's office and found that two sections of the mine were working normally; since the third section did not answer the telephone, he concluded that the explosion had occurred in that section and so notified the mine superintendent at the shaft bottom by telephone. He, in turn, notified the general superintendent on the surface. The men in the unaffected sections were at once ordered out of the mine and made their escape without difficulty.

The Ohio Department of Industrial Relations and the Ohio Division of Mines at Columbus were notified about an hour after the explosion occurred; the United States Bureau of Mines station at Pittsburgh was informed by a news association about an hour later. The Bureau immediately called the mine and offered its services. A representative of the Bureau

[1] According to Tom O'Connor, of PM, February 25, 1941, the company is a family corporation of moderate holdings and resources.

who was already in that part of Ohio, within 25 miles of Nelms, arrived at the mine at about 4 p.m. Three other representatives of the Bureau arrived from Pittsburgh at 7 p.m., two more at 10 p.m., and five others during the following morning. These men entered the mine at once upon their arrival and, with the state mine inspectors who had reached the scene during the afternoon of the day of the disaster, assisted in the work of restoring ventilation and recovering the bodies of the victims.

The work of restoring ventilation in the explosion area was slow, requiring the rebuilding of stoppings blown out by the forces of the blast, the removal of falls, and retimbering of the roof. The restricted amount of air available, and the presence of a high concentration of carbon monoxide which hung persistently in roof cavities and among the debris of falls even after ventilation had been advanced, made it necessary to exercise considerable care, and hampered progress. An official from a neighboring mine who took part in this work, disregarding instructions, went beyond the fresh air and was affected by carbon monoxide.

One body was recovered on the following day. By the end of the next day, December 1, ventilation in the explosion area had been restored and a total of 27 bodies had been recovered. Two more bodies were found on December 2, one on December 3, and the last of the dead was taken out of the mine on December 4. The location of the last four bodies under falls of roof accounts for the delay in finding them. The report of the Bureau of Mines emphasizes the extremely hazardous conditions under which recovery work was carried on; badly broken roof, and the presence of methane in such quantity, even after restoration of ventilation, that in some instances it became necessary to eliminate the use of flame safety lamps because of the danger of igniting the gas.

Property damage from the explosion consisted of blown-out stoppings, and extensive falls of roof which caused considerable damage to mine cars and locomotives in the explosion area. Other equipment was but slightly damaged. The section of the mine in which the explosion occurred was abandoned except for recovery of equipment. The rest of the mine was ready to resume operations several days after the explosion, but did not start to work until December 16.

The Nelms mine is owned and operated by the Ohio and Pennsylvania Coal Company, and is located at Nelms, Harrison County, in eastern Ohio, about four miles east of Cadiz. The mine is served by the Wheeling and Lake Erie Railway. No previous explosion is recorded, but it is within 25 miles of Neffs, in the same state, where the explosion at the Willow Grove mine killed 73 men nine months earlier.

The Nelms mine works in the Middle Kittanning seam, which averages six feet in thickness. Because of roof conditions, entries are driven 16 to 18 feet wide, rooms 24 feet wide, and few pillars are extracted. The mine is completely mechanized and operates three seven-hour shifts a day.

The coal is undercut with electric coal-cutting machines, drilled with electric drills, and loaded with mobile loading machines. Blasting is done at any time during a shift, with permissible explosive fired with a permissible battery. A crew of 11 or 12 men is assigned to four or five working places, and work is generally carried on in two places at the same time, one place being loaded out while the cutters and drillers are in another. Each crew is under the supervision of a unit foreman, who acts also as shot firer. This restriction of each crew to four or five working places results in the cutting, drilling, blasting, and loading out of a given working place two or three times a shift, or an advancement of the place more than 50 feet in a twenty-four-hour period, with a consequent heavy increase in

the quantity of methane liberated. Cable-reel locomotives were used for inside haulage, and trolley locomotives on main-line haulage. Main-line haulage was on intake air, but much of the secondary haulage, and in the sections, was on return air.

All underground machinery was electrically operated. With the exception of locomotives and pumps, this equipment was said to be of permissible type when installed. The coal-cutting machines and loading machines were of permissible type; but some of these, after the explosion, were found by investigators to lack the permissible approval plate, and both cutters and loaders were found generally to be used in a nonpermissible manner. The electric drills in use varied in design from the permissible type that they were represented to be. The coal-cutting machine and the drill in operation in the room in which the explosion was ignited were in nonpermissible condition. Two other drills and a loading machine, used in the explosion area, were also in nonpermissible condition.

Nelms is classed as a gassy mine by the Ohio Division of Mines, and was operated as such. The development of the mine so as to segregate the three producing sections may have reduced the number of fatalities in this disaster. Worked-out areas were sealed and "bleeder" pipes carried gas generated in those areas directly into the return air; in one such area the gas was carried directly to the surface through a pipe in a bore hole. The duties of the company safety director included special attention to ventilation and periodical collection and analysis of air samples from the air returns near the shaft bottom. Fire bosses made pre-shift examinations of the mine only before the second morning shift. Line brattice was used extensively to course the air to the face of the working places.

According to the company's figures, air samples collected on November 19, ten days before the explosion, showed a methane content in the return air from the main sections of the mine,

ranging from 1.15 to 1.7 per cent. The full air return contained 1.32 per cent of methane, indicating a liberation from the entire mine at that time of more than 2,500,000 cubic feet of methane in twenty-four hours. Samples of air collected by the Bureau of Mines on December 6, a week after the explosion and twenty-four hours after ventilation had been restored, showed the air returns to be carrying from 0.96 to 1.92 per cent of methane, with 1.46 per cent in the full air return, indicating a liberation from the entire mine of over two million cubic feet of methane in twenty-four hours. Some of this methane came from the sealed areas, but at the same time the methane content in the air returns from the active working areas ranged from 0.7 to 1 per cent. Samples collected in the explosion area on December 6, at the face of room 13, where the explosion was ignited, showed a methane content of 2.26 per cent, with line brattice within eight feet of the face. In the report of the Bureau of Mines the investigators expressed their opinion that to obtain a safe limit of methane the volume of air sent into the Nelms mine would need to be doubled over what was sent in previous to the explosion.

The Bureau's report stresses the danger from the increased amount of gas liberated in mechanized mining operations because of the rapid advancement of working places, and especially when working crews are restricted to four or five working places. The report also warned against the danger of further accelerating the liberation of methane by simultaneous undercutting and drilling operations.

The Nelms mine is dry in places, although the roadways are damp. Water was used on the cutter bars of mining machines to allay the dust, and tops of loaded cars were sprinkled with water at a point on the main haulage road. Haulage roads were rock-dusted, and rock-dust barriers had been erected at several points. In the explosion area, according to company

records, rock dust had been applied twelve days prior to the explosion, but owing to rapid advancement of working places in the interim there was no rock dust for a considerable distance from the face at the time of the explosion. Multiple-shift operation not only advances working places at a more rapid pace; but with three-shift operation, as in this mine, there was no time for rock-dusting except on idle days or Sunday, and for that reason it was often delayed. Samples of dust from the explosion area contained far below the amount of incombustible matter necessary to prevent the dust from entering into an explosion. Other active areas in the mine were rock-dusted on December 5, after the explosion and before samples were collected by the Bureau's investigators.

No first-aid or mine-rescue training had been given to the men at the Nelms mine, but some had received first-aid training while previously employed at other mines. No safety organization was maintained, although the management is credited by the Bureau of Mines as being "sincerely interested in safety and has adopted many safety practices not legally required." The report also commends the management for the use of permissible electric cap lamps, flame safety lamps, and explosives; use of protective caps by employes; sealing of abandoned areas with bleeder pipes to drain off gas; development of the mine so as to segregate the three producing sections; rock-dusting "which has been done"; periodic analysis of air samples from the main air returns; employment of a safety director; an efficient system of checking men in and out of the mine; and application of water on the cutter bars of mining machines to allay dust.

But in this mine, as in the others examined, the extent to which safety precautions against explosion disasters were applied may be measured by the recommendations made by the

United States Bureau of Mines for future operation. The following are indicative of lacks in safety measures:

Ventilation: Provide sufficient air to prevent the methane content in the return from any air split from exceeding 0.5 per cent; keep air courses free of obstructions; deliver a minimum of 20,000 cubic feet of air per minute at the farthest point in each split; provide sufficient air splits so that not more than "one section or working unit" will be on one air split; course the air so that a minimum velocity of 100 feet per minute will sweep the face of each working place; regulate cutting, drilling, and blasting operations so as to decrease "greatly" the "liability of liberation of exceptionally large quantities of methane and the possibility of dangerous mixtures of methane and air being carried over electrical equipment"; construct tightly of incombustible material all stoppings on face and butt entries.

Electricity: Trolley and bare feeder wires to be installed only on pure intake air; all electrical equipment used at or near the face to be of permissible type and maintained in permissible condition; gathering and haulage locomotives operated on other than pure intake air to be of permissible type; all permissible equipment to be inspected daily by a competent person, who shall make a written report on its condition and see that it is maintained at a permissible standard and not used in a nonpermissible manner; a unit foreman, or a machine operator, or driller, holding a fire boss' certificate of competency, to test for gas at least every fifteen minutes during cutting and drilling operations, and at the time of "sumping" the machine into the coal, while cutting across, and pulling out of the cut, as well as before and after drilling each hole.

Dust control: Water to be used on the cutter bars of all mining machines in such quantity that the machine cuttings will be thoroughly wet; coal to be wet as it is loaded by loading machines, and tops of loaded cars to be wet in the working places. Working places to be thoroughly wet before and after blasting; spillage of coal on haulage roads to be prevented by avoiding the overloading of cars; the entire mine to be kept thoroughly rock-dusted to within forty feet of the working faces; and redusting to be determined by frequent sampling and analysis of dust.

Blasting: Use of permissible explosives to be continued; examination to be made for gas before and after blasting; and holes to be drilled after undercutting, and no deeper than the undercut.

General: Establishment and equipment of a mine-rescue station at the mine, and training of selected employes in mine-rescue work and use of mine-rescue equipment, with retraining monthly; all employes to be trained in first-aid work; and frequent search for matches and smokers' articles to be made before a shift enters the mine.

Investigation of the explosion was made by representatives of the United States Bureau of Mines, the Division of Mines of the Ohio Department of Industrial Relations, the United Mine Workers of America, company officials, and the coroner's office. Public hearings were held at Cadiz, Ohio, December 9 to 12, 1940, under the supervision of the director of the Ohio Department of Industrial Relations.

It was the opinion of the investigators of the United States Bureau of Mines that the explosion

> . . . occurred at or near the face of room 13 off 8 east air course by the ignition of explosive gas; that the accumulation of gas occurred as a result of gas given off during drilling and cutting operations and insufficient ventilation to dilute and carry away the explosive gas, which may have been caused by a derangement in ventilation; and that the source of ignition was an electric arc or spark from a nonpermissible drill or mining machine, both of which apparently were in operation at the time of the explosion; of these two the drill appears to be the more likely cause of the ignition. It is further believed that coal dust aided in the propagation of the explosion.

The mention of derangement in ventilation refers to the possibility that the ventilation in the explosion area had been short-circuited for a brief time when a motorman left a door open on the haulage way. However this may be, and some evidence supports the possibility, two days before the explosion the state mine inspector found methane in room 13, where the gas was ignited, ranging from 1 per cent to an explosive mixture. The mine was not in operation that day. On the morning of the day of the disaster the fire boss reported about 2 per cent

of methane in room 13, but this gas was removed before the explosion. Afterward, during the investigation, an explosive mixture of gas was found at the face of room 13 and strong gas feeders were discovered issuing from the drill holes and the undercut. On the basis of these facts the Bureau's investigators were of the opinion that ventilation at times was not sufficient to keep the face of room 13 clear of gas.

The chief inspector and other agents of the Ohio Division of Mines who expressed an opinion agreed with investigators of the Bureau of Mines that the explosion was ignited at or near the face of room 13, and that the cause of the explosion was ignition of gas due to inadequate ventilation at the face, but they did not name the source of ignition.

To summarize: The disaster in the Nelms mine on November 29, 1940, must be attributed primarily to new and increased hazards incidental to mechanized mining, and the failure of the management to take necessary precautions to meet this change as it affected safety. In the effort to get maximum return on investment in machinery by three-shift operation, and by concentration of mechanical units in a smaller number of working places, the consequent need for more and better ventilation, due to the increased amount of explosive gas liberated by the more rapid advancement of working places, was neglected. This attitude of management is further emphasized by the nonpermissible condition of the equipment which caused the ignition. Although safety was a primary obligation of the operator, the Ohio Department of Industrial Relations and its Division of Mines cannot escape blame for failure to rectify conditions at this mine.

Raleigh, West Virginia

A gas-and-dust explosion occurred in Mine No. 4 of the Raleigh Coal and Coke Company, Raleigh, West Virginia,

about 10:30 a.m., December 17, 1940. Of the 15 men in the explosion area, seven were killed outright, two died of injuries several days later, four others were injured, and two escaped unhurt. Fifty-seven men employed in other sections of the mine became aware of the explosion from the concussion and from the smoke and afterdamp carried into these sections in the return air from the area of the blast. After first giving consideration to the advisability of barricading themselves and awaiting rescue, these men escaped from the mine by traveling two miles on a trolley-locomotive trip through the smoke and afterdamp in the return air on the main haulage road. None was overcome, but two were sent to the hospital for treatment. As the mine had no telephones, the arrival of men on the outside was the first information to those on the surface that an accident had occurred.

The explosion was local in extent, and was confined to one pair of development entries. Its forces traveled outward on both entries for a distance of about 1,600 feet from the face near which ignition occurred. The flame covered about 1,000 feet of that distance. Because the ignited gas mixture was near the lowest explosive point, sufficient initial heat and pressure were not developed for coal dust to enter to any great extent into the explosion. This accounts for the absence of extreme violence.

For about four preceding weeks, this section of the mine had not been in operation. Ventilation near the face of the development entries was poor; the last two crosscuts nearest the face were open, and the next three were closed only with temporary canvas curtains. On the day of the disaster mining operations in this area were confined to the face of a room entry driven in for a distance of about 150 feet off the development entry near the second open crosscut. A crew of men and the mine electrician were engaged in resetting chain-conveyor sections,

and an engineer and his helper were doing surveying work near the face of the development entry. The explosion was ignited at a point between the two open crosscuts by the engineer when he lighted a match to smoke. The mine was not considered gassy; smoking was not prohibited, and was a general practice.

The mine foreman and an assistant foreman caught just within the outer limit of the explosion area were blown through a ventilating door but not seriously injured. After some delay these men, with men from other sections who had re-entered the mine, proceeded to explore the area of the accident, and brought out three injured men before rescue teams arrived. All the dead and injured were taken out by 3 p.m., four and one-half hours after the explosion had occurred. All the bodies except one at the face of the room entry were recovered without the use of oxygen-breathing apparatus. Representatives of the United States Bureau of Mines did not reach the mine in time to participate in recovery operations, but, together with representatives of the West Virginia Department of Mines and the coal company, they took part in the subsequent investigation to determine the cause of the accident. Property damage was small, confined to electrical equipment in the area of the explosion, and the blowing out of a few stoppings.

Mine No. 4 is located on the Chesapeake and Ohio Railroad at Raleigh, near Beckley, Raleigh County, in southern West Virginia, and is one of four mines operated in that vicinity by the Raleigh Coal and Coke Company. No previous explosion is on record at this mine, which was opened in 1905, nor has any been recorded at any other mine of the company. Mine No. 4 works in the Beckley seam, which averages about 45 inches in thickness. The mine employs 105 men on two regular seven-hour shifts, producing 800 tons of coal daily.

The mine is worked on a room-and-pillar system, and in some sections pillars are extracted. Coal is undercut with elec-

tric mining machines and drilled by hand. In the section where the explosion occurred, chain conveyors were used for loading, although a loading machine was used in another section, and some loading was done by hand. Underground haulage was by trolley locomotives, and all main-line and cross-entry haulage was on return air. All electrical equipment used underground, including locomotives, coal-cutting machines, conveyor power units, pumps, and a loading machine, were of nonpermissible type. Permissible electric cap lamps were used by all underground workers.

In mechanized mining operations four men comprised a conveyor crew, and the loading machine had a crew of 12 men. Each crew prepared the face, undercut, drilled, blasted, and loaded the coal. Blasting of coal was done with permissible explosive, detonated electrically, at any time during a shift. Some black pellet powder was used in blasting rock. In the mechanical loading sections one member of the crew was designated as shot firer; hand-loading miners charged and fired their own shots.

The mine was classed as nongassy by the West Virginia Department of Mines. No fire bosses were employed to make pre-shift examinations of the mine, but it was "understood" that section bosses made infrequent inspections for gas. The distance between crosscuts was not uniform, the maximum being 200 feet, with the majority 80 feet or less apart. Blower fans and tubing were used to force the air to the working faces from the last open crosscut. During the investigation following the explosion, investigators of the Bureau of Mines found gas mixtures in several places in the area affected. Three samples of air from that area showed a methane content of 0.22, 0.30, and 1.22 per cent. In a test, in which the face of one of the development entries was blocked off for a period of sixty-seven hours, a methane content of 4.2 per cent was found to

have accumulated. On the basis of these findings the Bureau of Mines recommended that the mine be classed as gassy and henceforth operated as such with proper safeguards.

Although coal dust entered into the explosion only to a limited extent, this was not due to precautionary measures. No water was used to allay dust during mining operations at the face. After the explosion a "great amount" of coal dust along the conveyor lines was observed by the investigators. The mine had been partly rock-dusted several months prior to the explosion, but analysis of samples by the Bureau of Mines showed the incombustible content of the dust to be far below the amount necessary to prevent its entering into an explosion. To propagate an explosion through coal dust from a low volatile coal such as the Beckley seam, a high initial temperature and pressure are necessary. As already noted, sufficient heat and pressure for dust to enter more fully into the explosion were not developed in this instance because the gas, when ignited, was at or near the lowest explosive point.

The chief engineer of the company acted also in the capacity of safety director and made inspections of the company's mines for substandard conditions and practices. A few of the employes at Mine No. 4 had been trained in first-aid work. No self-contained oxygen-breathing apparatus was kept at the mine, and no mine-rescue teams had been organized or trained. Such apparatus, however, was available some 12 miles away, at Mt. Hope, West Virginia, where the West Virginia Department of Mines maintains a mine-rescue truck, and mine-rescue teams were available at several mines in the vicinity.

The report of investigators of the Bureau of Mines commends the management for a good accident record in the past at Mine No. 4; for the use of permissible electric cap lamps, safety hats, and safety shoes; for their effort to use rock dust,

though this was inadequately done, and for planning a more thorough application of rock dust in the future. However, the inadequacy of safety precautions at this mine is reflected in the following recommendations made by the Bureau for future operation.

Ventilation: That the mine be operated as gassy, with air provided for the face regions in sufficient amount to dilute and render harmless any explosive or noxious gas liberated or formed; all haulage to be on pure intake air; blower fans to be replaced with line curtains to force fresh air to the working faces; crosscuts to be made promptly at a distance not to exceed 80 feet, and all but the last crosscut to be closed with stoppings of incombustible material; obstructions in airways to be removed or leveled; overcasts to be substituted for doors as far as possible; all doors to be installed in pairs, and to be self-closing; not more than one set of cross entries to be on one air split; abandoned and worked-out areas that cannot be ventilated and inspected to be sealed; fire bosses to be employed to make pre-shift examinations of the mine and to record their findings; section bosses to carry flame safety lamps at all times, and to make frequent examinations for gas during the working shift; mining-machine and loading-machine crews to make frequent tests for gas; and consideration to be given to the feasibility of sinking an air shaft near the advanced workings to increase the efficiency of ventilation and to provide an additional emergency escapeway.

Dust control: Water to be used to allay coal dust on mining machines and loading machines, before and after blasting, and on loaded and empty cars; all working places to be kept thoroughly wet for a distance of 40 feet from the face; all mine surfaces to be thoroughly rock-dusted and redusted when dust samples collected periodically show an incombustible content of less than 65 per cent.

Explosives: Only permissible explosives to be used; no more than one day's supply of explosives to be taken into the mine or stored underground; shot firers to be employed to do all shooting of coal and rock; no more than one shot to be fired at a time; tests to be made for gas before and after each shot; and no shots to be fired in the presence of a dangerous percentage of gas.

Electricity: All electrical equipment used at or near the face to be of permissible type and maintained in a permissible manner; trolley and

cable-reel locomotives to be operated only on pure intake air; and electric cables not to be repaired underground.

General: Smoking in the mine to be prohibited, and frequent search made for smokers' articles and matches before shifts enter; selected employes to be trained in the use of oxygen-breathing apparatus and in rescue and recovery work, with periodical retraining; and installation of a mine telephone system for communication between all inside-haulage partings and the surface.

Investigators of the Bureau of Mines reported that in their opinion the explosion had been "initiated by gas and further propagated by the presence of coal dust." Gas found during the investigation in both the 3 right and 9 left entries, in which the ignition originated, the two open crosscuts in 9 left entry, and a dip in the coal seam, are mentioned as conditions favorable to accumulation of a body of gas in the 9 left. The report continues:

> The 3 right entry is going to the dip at the rate of about 10 per cent from the mouth to the face and any gas being liberated in the face region would naturally rise to the 9 left entry. The 9 left entry is rising toward the face from a point outby the 3 right and any gas liberated in 3 right would travel toward the face of 9 left. At the time of the explosion the engineer had his transit set up on 9 left inby 3 right and any gas liberated in 3 right and the face of 9 left would back up to the point where the engineer was located. Burned matches were found near the transit and it is probable that the engineer attempted to smoke and ignited the gas. . . . The position of the engineer was most favorable, due to elevations of 9 left and 3 right entry, for him to have ignited any gas which was present.

Explosives as a possible source of ignition were eliminated because no shots were being charged or fired at the time. Electricity as a source of ignition was considered somewhat remote; the only electrical equipment in operation in the section at the time was a pump, and possibly a blower fan. The location of the pump eliminated it as a possible source of ignition, but the

investigators conceded that "there is some possibility that gas could have been ignited by the blower fan."

According to the Bureau's report, inspectors of the West Virginia Department of Mines who investigated the explosion were in agreement with the Bureau's investigators that the "most likely cause of the explosion was ignition of gas by smoking and that the most likely point of ignition was at the point where the engineer had his transit set up." However, the chief of the West Virginia Department of Mines in a later statement, which was termed "preliminary," said that "the point of ignition and means of ignition are not yet known." In this same statement the chief said that "ventilation and rock dust did not comply with the standards" set by his department, and that "the mining law does not specifically cover these items." For that reason, he continued, "recommendations for advanced safety measures to guard against explosions of this type will be presented to the legislature." [1]

In the coroner's investigation of the explosion the jury came to the conclusion that the cause of the explosion could not be determined, but they found evidence of an accumulation of gas in 9 left entry. The state mine inspector of the district, in testifying at the coroner's hearing, said that "if the regulations and recommendations of the mines department had been complied with, this explosion would not have occurred," and in his opinion if the mine had been properly rock-dusted not more than two fatalities would have resulted from the explosion.[2]

To summarize: The primary reason for the disaster was the apparent assumption by the management that since no gas "had ever been reported" in this mine, the possibility of its presence could be ignored. Clearly demonstrated by the explosion to have been a false and dangerous assumption in the operation of

[1] United Mine Workers Journal, January 15, 1941, p. 9.
[2] *Ibid.*, March 1, 1941, p. 4.

this mine, it is also contrary to all experience and practice in the industry, and long recognized as totally unwarranted in any coal mine. Because gas is unpredictable, the mining code of practically every mining state in the country requires pre-shift examination by mine examiners, who must be licensed by the state after examinations for competency. The employment of mine examiners has been a legal requirement in many states since the first mine-safety laws were enacted more than sixty years ago. Besides inspection of ventilation and conditions relating to gas, the mine examiner's duties include inspection of roof conditions both in working places and on haulage roads. However, in this instance the company was within the law because of a serious omission in the West Virginia mining code, which exempts from this requirement mines not classed as gassy by the state Department of Mines.

There is no reason to believe that the gas that caused this explosion was the first to appear in this mine. No change in barometric pressure had occurred just prior to the explosion to account for increased liberation of gas, nor is there any evidence that an unusual amount of gas was suddenly released by cutting into a gas feeder. On the contrary, conditions near the face of the development entries, where the explosion was ignited, were favorable for the accumulation of explosive gas resulting from a slow seepage. In the light of what happened, it is safe to assume that had the mine been examined thoroughly by fire bosses before each shift, and had the foremen made a practice of carrying safety lamps at all times and using them to test for gas, they would have found gas in greater or less amount on numerous occasions prior to the explosion.

Given the relatively small quantity of gas liberated in this mine, and the policy of the management in ignoring the possibility of the presence of gas, the men in the mine would have been far safer working with open lights than with closed elec-

tric lamps. Open lamps, by the harmless ignition of small amounts of gas, would have served long before the explosion occurred to call attention to the presence of gas, so that proper precautions could have been taken. From all indications, at least some of the gas that caused the explosion had already accumulated before the shift began, and would have been found in a pre-shift examination, thus averting the disaster. In view of the favorable conditions for accumulation of gas near the face of the development entries at the time of the disaster, it is hard to account for the failure of the section boss to make a test for gas before the men were permitted to enter that area. But, it seems, such precautions were seldom taken at this mine. Had the section boss made the test, the explosion would have been avoided.[1]

The official position of the United States Bureau of Mines that "all coal mines are potentially gassy" and that constant watchfulness is necessary in all of them if explosions are to be avoided, is expressed in two formal decisions of the Mine Safety Board.[2] The Bureau reiterated this warning to the industry in reports on several explosions that occurred during the year 1940. Concerning the Willow Grove explosion, already described, the Bureau's investigators took occasion to say: "Most of the very destructive coal-mine explosions in the United States have occurred in the so-called nongassy mines which give off a little gas or possibly in mines which are termed slightly gassy." The report on the Sonman explosion says: "Sudden and unusual liberations of gas in large quantities can

[1] According to the official report of the state Department of Mines an assistant foreman made an examination for gas in the 9 left entry two weeks prior to the explosion.

[2] United States Bureau of Mines, Mine Safety Board Decision No. 3, approved May 8, 1926, and Decision No. 13, approved February 8, 1930. (United States Bureau of Mines Information Circular 6946, June, 1937, mimeographed.)

occur in nongassy and moderately gassy mines; therefore, all coal mines should be so developed and operated that if and when such liberations of gas do occur, no ignition source will be present."

The report on the Raleigh explosion reiterates: "Every coal mine is potentially a gassy mine." Notwithstanding the record in this mine, that no gas had been "reported" for many years, the Bureau says: "The occurrence of this explosion and the fact that gas was found following the explosion indicates that any so-called nongassy mine can liberate gas." The Raleigh Coal and Coke Company, however, operated its Mine No. 4 without fire bosses to make pre-shift examinations, and foremen apparently seldom carried safety lamps for testing gas, since they are reported to have made only "infrequent" tests for gas. Yet a safety director was employed to check on substandard conditions and practices.

Part II

Lessons from Disasters of 1940

NONE of the mines in which major explosions occurred in 1940 was found to be adequately ventilated. In fact, ventilating practices in some were little short of reprehensible. Shortcomings were found in the way the air was coursed and split, as well as in volume and velocity. In some the ventilation was found to be entirely inadequate, and in none was it sufficient. Crosscuts were driven too far apart, left open after the next crosscut nearest the face was broken through, or closed with temporary curtains or other flimsy or inflammable material. Doors were improperly constructed and hung, and the much more efficient overcast was only infrequently substituted for them. Air courses were obstructed, and a dangerous burden was placed on many air splits. In one mine (Nelms) six mobile loading-machine units with 80 men were found on one air split. In this instance the Bureau of Mines recommended that the air be so coursed that not more than one unit (mining machine, drill, loading machine, and locomotive) be operated on one split of air.

Three of these six mines used blower fans instead of line brattice to conduct the air to the working faces. The Bureau of Mines opposes the use of blower fans for this purpose in coal mines because of the danger of accumulation of explosive and poisonous gasses by recirculation, and the complete lack of ventilation at the working faces during off-shift periods, when the blower fans are shut down and when dangerous quantities of gas may accumulate. The blower fan has no attendant, and in practice supervision is limited to starting and stopping the

motor. It also provides another source of electrical ignition of gas.

Although with the exception of Bates, all these mines maintained full-time safety inspectors, Willow Grove and Raleigh neglected entirely the elementary precaution of pre-shift examination of the mine by fire bosses, and Nelms provided such inspection previous to one only of the three daily shifts. Bartley, Sonman, and Nelms collected and analyzed air samples. In Bartley only was this done in a manner adequately to reveal the true condition of the mine, but even there the remedy was not applied.

Leaving out of account Bates, where the blasting of bottom rock on the haulageways and a natural stream of water along the long-wall face nullified to a considerable extent the danger of coal dust entering into an explosion, in the other five mines rock-dusting was done inadequately and in a hit-or-miss fashion. In none were the trackless parts of the mine rock-dusted, and in some rock-dusting was confined to the main haulageway. Only in Bartley was any attempt made to scatter rock dust in the working places. Three-shift operation in the Willow Grove and Nelms mines complicated any effort to keep rock dust scattered up to a point near the working faces; but it could have been done, had the management been willing to sacrifice some minutes of production at the end of each shift for this necessary safety precaution. Only at the Nelms mine, where water generally was used on the cutter bars of the mining machines, and on the tops of loaded trips on the way out, was any effort made to allay dust by wetting. At none of these six mines was the precaution taken to ascertain by systematic analysis the degree of explosibility of the mine dust.

In four of these explosions, Bartley, Sonman, Bates, and Nelms, the source of ignition has been attributed officially to an electric arc or spark from electrical equipment. In two of

the four, Bartley and Bates, some evidence was noted that a smoker's match could have been the cause of ignition. But granting the plausibility of the match theory, in Bartley a "multiplicity of substandard electrical conditions" and in Bates an open switchbox of a nonpermissible mining machine were present and sufficient to set off the explosion. In Raleigh, where the gas was probably ignited by a smoker's match, any piece of nonpermissible electrical machinery with which the mine was equipped could have ignited the explosion, had it been moved into the area where the explosive mixture had been permitted to accumulate. Of the four explosions ignited by electricity, two resulted from neglected permissible equipment, one from nonpermissible equipment, and another from the use of a trolley locomotive in return air near the working face, although permissible equipment was used at the face.

Three of the six mines, Willow Grove, Bates, and Raleigh, were equipped entirely with nonpermissible electrical machinery. In Willow Grove and Raleigh this was probably considered by the management to be safe, since these mines were not classed as gassy. The Bates mine, however, was known to be gassy. By the use of permissible equipment and elimination of power lines through the use of storage batteries, Bartley went farther, from an engineering standpoint, than any of the others in the effort to eliminate this hazard, but failed to maintain the equipment in permissible condition, or to use it in a permissible manner. Sonman used permissible mining machines, but the method used to connect them with the power lines was substandard. In Nelms the permissible machinery used at the face was in bad condition, in terms of permissibility; the mining machine and the drill in use in the place where the explosion was ignited divided responsibility for the explosion. Either one or the other ignited the gas; which of them touched it off, it is impossible to determine.

With the exception of Bates, where the coal was pulled to the main slope by stationary underground hoists, and Bartley, where battery locomotives were used, the other four mines used trolley and cable-reel locomotives for haulage. Because of the danger of ignition by arcs or sparks from a trolley, and the cable "nips" of the cable-reel types of locomotives, safe procedure is to avoid operating these locomotives on return air likely to contain explosive mixtures. Although using the much safer battery locomotives, Bartley came nearest to fulfilling this condition. In Willow Grove and Raleigh both main and secondary haulage was on return air, and in Sonman and Nelms the secondary haulage was on return air. This practice was responsible for the ignition of the Sonman explosion by an arc from a trolley locomotive.

With the exception of Willow Grove, where the explosion was attributed to a "gripping" shot charged with black pellet powder stemmed with "bug dust" (machine cuttings), all these mines used permissible explosives for blasting coal, although some of them used a limited amount of nonpermissible explosives for blasting rock. In the five mechanized mines, in particular, careless disregard for safe blasting practices was displayed. Management cannot escape responsibility for this condition, because in mechanized mines management plans every detail of the work and provides close supervision to see that the procedure is followed. In only one of these mines (Bartley) were regular shot firers employed, and in all of them shots were fired at any time during a shift.

Each of the five mechanized mines was guilty of one or more of the following unsafe blasting practices: Placing too heavy a burden on individual shots; drilling holes deeper than the undercut, or on the solid; using excessive amounts of explosives in one shot; stemming shots with "bug dust"; firing shots with unsafe batteries; firing more than one shot at a time;

and storing excessive amounts of explosives in the mine. The reports of the Bureau of Mines are silent as to whether any of them made a practice of testing for gas before and after blasting, but they recommend this practice in future.

It should be noted as a good feature that in all six of these mines one common source of ignition of mine explosions had been eliminated—the miner's open lamp. Miners' permissible electric cap lamps were used in all of them, including Willow Grove and Raleigh, which before the explosions were considered to be nongassy, and in which the use of permissible machinery and equipment was deemed to be unnecessary. The miner's electric cap lamp, however, is a safety device that costs the company nothing; on the contrary, the management checks off the miners' pay a stipulated sum each day for its use, which in most instances yields the company a handsome profit. If management were as eager to put in other safety devices and to maintain them in effective condition, fewer explosions would occur in our mines.

The six mines in which major explosions occurred in 1940 are shown by the evidence to have been poor insurance risks for a long time before the explosions occurred. In none did the occurrence of an explosion depend upon the particular set of circumstances surrounding the actual disaster. In each of them a variety of substandard conditions could have formed an entirely different set of contributing causes to result in such a disaster. It will be remembered that at least two small explosions took place in Willow Grove some time before the big disaster, and in Bates one occurred when no one was in the mine, three months before the disaster of August, 1940.

Explosion Hazards and Principles of Safety in Coal Mines

To say that a majority of the bituminous coal mines in the United States are in no better condition to avoid disastrous explosions than were the six in which major accidents occurred in 1940, is probably an understatement. In the Pennsylvania anthracite mines the explosion hazard is limited to gas. Because of its high carbon content, anthracite dust does not enter into explosions, but severe explosions resulting from gas accumulations have occurred in anthracite mines. Effective precautions against explosions and other accidents in mining have aptly been called good housekeeping, a virtue which the average mine management, unfortunately, is notorious for not practicing. This indictment against the majority of coal-mine operators is on the score of poor management, and has no moral implication. At the same time, the honorable exceptions should be noted in mines where good safety records have been achieved, in many instances under difficulties, by application of known safety principles.

VENTILATION AND GAS

About 35 per cent of the total production of bituminous coal from underground mines comes from mines rated as gassy by state mining departments. Mechanization, by concentrating operations, with the consequent rapid advancement of working places, is turning many so-called nongassy mines into gassy mines and increasing the percentage of those rated as gassy in the industry. Errors for various reasons in classification by state mining departments, in favor of the nongassy group, and the oft-repeated judgment of the United States Bureau of Mines that all coal mines are potentially gassy, must be taken into account in any attempt to measure the extent of the gas hazard.

Adequate ventilation, a primary requisite if explosions are to be avoided, is generally poor in the coal mines of the United States. Rarely at any mine is more air provided than is necessary. The maximum is usually the resultant of the relative force of the recommendations of the state mine inspector, countered by the passive resistance of the operator. Only the best mines deliver to the working sections as much as 85 per cent of the air sent into the mine. To achieve 70 per cent is considered good, and many mines drop to 40 per cent and even much lower.

As a rule, although not always, sufficient air passes through the ventilating fan on the surface, but much is lost through leaky stoppings, or crosscuts left open to save labor or through carelessness, and doors left open to facilitate haulage. Reluctance to incur the expense of substituting overcasts for doors near working sections, and resort to short cuts of temporary and inadequate air-coursing facilities in mechanized mines, prompted by the rapidity with which sections are worked out in such mines, have much to do with the fact that sufficient air so generally fails to reach the working faces. The blower fan and tubing, rarely seen in coal mines before the advent of mechanization, and now confined mainly to mechanized mines, is one of these short cuts. Such haphazard ventilating practices not only are dangerous to the health and lives of the miners, but are the height of inefficiency because of the waste of power in putting into the mine so much air that never reaches the places where it is needed.

To deliver to the working faces a sufficient volume of air at the necessary velocity to dilute and carry away explosive gas, crosscuts are required at right locations, wide enough, and free from refuse and other material. Airways must be unobstructed, and overcasts, regulators, stoppings, and doors must be properly installed and maintained. Adequate and preferably excess

air should be delivered to the working faces. Often, however, a ventilating fan installed when the mine was first opened is kept in service long after the advancement of the work requires its replacement by a larger one, capable of ventilating the larger area and of forcing air through miles of old air courses long since obstructed by falls of roof. All too frequently the surface fan picks up foul air from a badly located nearby return-air outlet, filled with methane, carbon monoxide, and dust from the tipple, and sends it back into the mine for another round trip.

In addition to delivering sufficient air to the working faces, a given split of air must not be overburdened to the point where it contains a dangerous volume of methane, and all return air should be led directly into the main return and not through other active workings. Too often air splits thus overburdened carry methane-laden air into other working sections where danger of ignition exists. Few mines in the United States would be able to meet the requirements of British mining regulations that an airway, to be considered free of gas, must contain not more than one-fourth of one per cent of methane, as determined by analysis of air samples collected at different times and in different locations.

Obviously, greater vigilance is needed in mechanized mines to keep working places free from explosive gas, and a more exact technique is required to detect promptly any unusual accumulation. An occasional, or even more frequent, test in working places by a member of the supervisory force will no longer suffice, and must be supplemented by more systematic attention if ignitions are to be avoided. A fixed minimum routine of making tests must be worked out, based on experience at each mine and adaptable to the work of the moment, such as operations before and after blasting and during undercutting and drilling. In the absence of a member of the supervisory

force, where conditions warrant it, workers familiar with the use of safety lamps should be authorized to make tests for gas. Actually in many mechanized mines a hurried and harassed section boss, responsible for production and often including in his many duties the work of firing shots, is solely responsible for watching for gas in his section.

If higher management officials are to have exact knowledge of air conditions, the watchfulness of those in charge in each area must be supplemented by the work of a competent and trustworthy person, who should collect and analyze at frequent and regular intervals mine-air samples from each air-split return, and from the full mine return, and make a permanent record of his findings. No mine should be without methane and carbon-monoxide detectors. Yet despite the vital need for such precautions, periodical analyses and the employment of more exact gas-detecting devices are a rarity. Irregularity, infrequency, and faulty methods of collecting air samples, and defective equipment for analysis in two of the mines having major disasters in 1940, Sonman and Nelms, gave evidence that even in the few places where the procedure is practiced, the importance of exactitude is not sufficiently appreciated.

A methane detector which automatically sounds an alarm in the presence of a given quantity, has been installed in some British mines on the initiative and insistence of the British Miners' Federation. Although the latest reports on its efficacy are not altogether favorable, automatic alarms to warn miners of the presence of methane, and other alarms to warn against weakening of the mine roof, have been mentioned as possible future safety devices for mechanized mines in this country if multiple-shift mechanical operation is to be made safe.

Coal Age, prominent organ and spokesman of the industry in the United States, in a supplement to its issue of April, 1940, under the title, "130 Cues to Coal-Mining Profits," listed sug-

gestions for more efficient and hence more profitable operation. The following queries appeared under the heading of ventilation:

Have ventilating practices been surveyed from the viewpoints of:
Increasing airway area to cut velocity and resistance and raise flow?
Sealing off old sections, driving new airways to cut travel, etc.?
Sinking shafts or making new openings at the back end of the property to establish one-way air travel?
Using more overcasts to eliminate doors?
Employing air locks, automatic doors, etc., for greater efficiency?
Better timbering of airways and regular cleaning to eliminate restrictions, reduce turbulence, etc.?
Use of vanes, curves, etc., to prevent turbulence and loss of power where direction changes?
Installation or increased use of brattice lines, auxiliary tubing blowers,[1] etc., in carrying away gas, smoke and dust?
Will a new fan supply as much or more air with less power?
Are standby fan drives provided?
Is the proper equipment for gas detection and air sampling available?

It is not to be expected that Coal Age would have compiled this list, had the suggested improvements already been in general use in the industry. In offering them as a means of paving the road to profits Coal Age, by implication, makes the important point that safety is consistent with profitable operation.

COAL-DUST CONTROL

As a method of coal-dust control to localize and prevent the spread of explosions, rock-dusting to dilute and reduce the explosibility of coal dust has been advocated in the United States for more than a quarter of a century, following many years of study of causes of mine explosions both in this country

[1] In suggesting the use of blower fans and tubing, Coal Age sides with minority opinion. A large supplier of tubing for blower fans is a regular advertiser in Coal Age.

and abroad. At the same time, to lessen its amount, recommendations have been made to decrease spillage by using tight mine cars, to avoid excessive amounts of explosives in blasting, to load out machine cuttings before blasting, to use water on cutter bars of mining machines, to wet down coal with a hose before loading, and to sprinkle the tops of loaded cars on the way out.

In 1940 only 481 out of some 6,000 bituminous coal mines in the United States claimed to use rock dust, and of these only 10 per cent were rock-dusted adequately. Exact figures are not available, but according to the best information obtainable very few mines use water to allay dust during operations at the face, or on loaded cars. This is true despite general knowledge that mechanized mining operations have increased the amount of dust many fold.

Mechanized mining is inherently more dusty than hand loading. Moreover, the practice in many mechanized mines of speeding operations by neglecting to load first the cuttings made by the machine before blasting, and instead blasting coal down on top of machine cuttings, not only raises dust immediately at hand for possible ignition by the flame of the blast, but, by making the entire loading operation extremely dusty, creates a health hazard. In hand-loading the miner, when opportunity is afforded, usually loads out machine cuttings before blasting, if for no other reason than to escape the discomfort of working in dust the entire day. In mechanized mines another bad practice occasioned by the speed of operations is to put into the "gob" [1] any machine cuttings of high sulphur and high ash content, adding further to the dust hazard, as well as to the danger of fire from spontaneous combustion. Thus, in handling machine cuttings the methods

[1] Refuse left in the mine.

employed in most mechanized mines are a distinctly backward step in efforts for safety.

Increase in the quantity of coal dust and its spread throughout the mine is, however, only part of the greater dust hazard resulting from mechanization. With hand-loading methods the dust had time to settle and to absorb considerable moisture before other dust was added to it, which, together with rock-dusting, reduced the hazard to a minimum. In a mechanized mine, frequent blasting and heat from machinery raise the temperature and the air absorbs much of the natural moisture and carries it away. The difficulty of spreading rock dust in mechanized mines with multiple-shift operations has already been mentioned. With three-shift operations rock-dusting can be done only on idle days or Sundays. In consequence, even though the management is desirous of keeping the mine adequately rock-dusted, at times no rock dust will be within four or five hundred feet of a working face. This distance comprises a vital area for damping and localizing ignitions of gas that may occur at the face.

Since only 50 mines at most are adequately rock-dusted, it is extremely unlikely that in any great number trouble is taken to check on the extent of dust hazard by collecting and analyzing samples of dust. It is interesting to note that although three of the six mines with major explosions in 1940 tested mine air through analysis, none analyzed dust samples. Coal Age's previously mentioned "130 Cues to Coal-Mining Profits," under the heading of safety, asks if the safety program contemplates such steps as "regular checking for hazards," and if surveys have been made of the possibilities of protective measures such as "sprinkling to allay dust" and "rock-dusting, including improved barriers and new-type (conveyor, etc.) dusting machines."

MACHINERY AND ELECTRICITY

Electrical ignitions have been the greatest single cause of explosions in mines and are responsible for more than half of the fatalities from that cause during the twelve-year period 1929-1940.[1] Therefore the need for a wider use of safer types of electrical equipment and machines, and safer installations of power-transmission facilities in mines, as well as exercise of greater care in use and maintenance of electrically operated apparatus, is clearly evident. To say this, however, is to repeat what has been said many times by experts both within and without the coal industry. In addition to disasters resulting from explosions, moreover, electricity is responsible annually for about 100 mine deaths resulting from contacts and other causes. Out of a total of 308 explosions during the twelve-year period, 125 were electrical in origin, of which about half were caused by trolley or cable-reel locomotives, and nonpermissible mining machines.

Although the use of permissible machinery in coal mines is on the increase, this type of equipment is still lacking in too many mines where it is badly needed. In most mines where the machinery at the working face is permissible, trolley and cable-reel locomotives are still used for haulage. These types of locomotives were responsible for the ignition of 36 explosions in the twelve-year period, an average of three a year, while in four of the twelve years the number ran as high as five.

In most mines, whether the machinery in use is permissible or nonpermissible, transmission facilities for distribution of

[1] Fiscal, not calendar years, with the twelve-year period ending June 30, 1940. The figures given are from United States Bureau of Mines Information Circular 7136, November, 1940, mimeographed. It will be noted that the last half of 1940 is not included. The total number of fatalities from explosions for the calendar year 1940 was 296, of which 277 are accounted for by six major explosions, and 19 by local explosions.

electricity and its application to machines in various parts of the mine are definitely substandard. Few mines in the United States could meet the specifications of the most liberal code of standards for electrical installation and maintenance. In some of the better managed mines, surveys have been made in an effort to devise improvements to reduce power costs, though many continue with wasteful installations and but few concern themselves with attaining the standard in electrical installations which is favorable to the maximum in safety.

An important and disturbing element in the problem of safety in mines is the widespread failure to maintain permissible machinery in permissible condition, thus destroying its efficacy in preventing explosions. Failure to do so was amply demonstrated by the state of the machinery in the Bartley and Nelms mines, where gassy conditions are such that extreme care must be taken if ignitions are to be avoided. Neglect by management to maintain permissible equipment in permissible condition is risky in any mine because of the inclination of too many operators, once devices to prevent ignition have been introduced, to place too much dependence upon them, to the neglect of the primary preventive of explosions, which is adequate ventilation. Such shortsightedness is not of recent date, but can be illustrated by many instances in the history of the industry both in the United States and abroad. More than one generation of operators has been guilty of this fault, and miners have had to pay for it with their lives.

Introduction of the first safety lamp into the coal mines of Great Britain in 1816 was followed by general neglect of ventilation and an increase in explosions to the extent that during the 1830's many competent observers began to doubt the efficacy of Sir Humphry Davy's invention to prevent ignitions of gas. An impartial committee investigating an explosion that occurred in a British coal mine in 1839 reported (1) that reli-

ance on lamps alone in a gassy mine was a fatal mistake; (2) that since the introduction of the safety lamp the ventilation of mines had fallen into a secondary position instead of continuing as the primary means of avoiding explosions.[1]

Miners in this country during the last quarter of a century have had justification for their charge that many operators took advantage of the introduction of the electric cap lamp to neglect ventilation. Since with the open-flame lamp miners can readily detect oxygen deficiency in the air, they were reluctant to accept the new lamp, despite its safety under gassy conditions, because it took away their only independent check on air conditions. When an operator introduces electric cap lamps and permissible machinery into his mine, he acknowledges danger of gas ignition; and in so doing he is under the obligation of keeping these devices in condition to be effective preventives of explosions, not to mention his continuing primary responsibility for providing adequate ventilation to prevent dangerous accumulations of gas. Unhappily, as recent disasters demonstrate, these obligations are not sufficiently recognized.

The false sense of security derived from the use of permissible machinery and equipment, and the resultant neglect of ventilation can be understood, but this can neither be condoned nor accepted as anything other than bad management. The new speed of operations in mechanized mines, which will be discussed later in more detail, also affects the men who maintain and repair the machines. Although the work of these men requires some of the skill both of the machinist and of the electrician, they are usually designated on the payroll as electricians. An electrician in a mine is not required to be certified

[1] Report of South Shields Committee on explosion at St. Hilda Pit, South Shields, June, 1839, in which 52 lives were lost. (Historical Review of Coal Mining, printed and published for Mining Association of Great Britain by Fleetway Press, Ltd., London, n.d., p. 119.)

as competent. His knowledge of the work has usually been picked up around the mine. Aptness with tools, and quickness in improvisation to put a broken-down machine back into production with the minimum of delay, are about all that are asked of him. His wages are usually set on that basis, and are not those of an "all-around expert" electrician.

Because of dependence of each machine on every other machine in a working unit in a mechanized mine, time lost from production in making repairs is a matter of keen interest to mine officials. In an increasing number of mines, time standards for completion of a given repair job, based on experience, are being applied to reduce losses due to breakdowns. Repair men are under constant pressure, and the kind of man described above fits into this pressure system. The repairs are sufficient to get the desired result in production, but the condition of the machine in terms of safety is another matter.

In a paper read before a session of the 1941 meeting of the American Mining Congress the maintenance superintendent of a large coal company called attention to the special problem presented in maintenance of permissible equipment, warning that without skilled labor and close supervision the flameproof qualities may be destroyed by the first repair job on a new machine. A pertinent example of the result of slipshod methods is the condition of the electric drills found in the explosion area in the Nelms mine, with eight out of 10 bolts missing from each switchbox. In a hearing on this explosion held by the Ohio Department of Industrial Relations a repairman testified that this was the usual practice at the mine; that it was easier to get to the inside of the switchbox to make repairs if only two instead of 10 bolts had to be loosened.

Impairment of the permissibility of machines is not confined to hurried repair jobs done at the working face, but may and does happen when machines are taken to the shop for gen-

eral overhauling and major repairs. Coal Age, in a recent editorial, states the problem succinctly, but expresses little optimism that it will soon be overcome.

> Rigid specifications for the construction of permissible equipment may be laid down by the Bureau of Mines. Manufacturers may follow these specifications to the last bolt and thread to win the coveted [approval] plate. And the first time that piece of equipment goes into the mine shop for inspection, overhauling or repair its permissibility may be destroyed through carelessness or ignorance. A little too much speed in reassembling and some of the vital protective parts may be left out or improperly replaced. Where such conditions exist, the remedy is plain: thorough and continuous education of the maintenance men on what permissibility means. There is no other way—and that way is closed if top management is indifferent.[1]

Coal Age might have added, if top management insists on production regardless of safety.

EXPLOSIVES AND BLASTING

During the twelve-year period 1929-1940 explosives used in blasting caused 47 explosions and 23.3 per cent of explosion fatalities. About 52 per cent of the production of bituminous coal from underground mines comes from mines using nonpermissible explosives exclusively, or in association with permissibles. But a high degree of hazard from blasting still exists in many mines using permissible explosives only, because of the use of nonpermissible devices for igniting shots, and other unsafe blasting practices. Although five of the six mines that experienced major explosions during 1940 used permissible explosives, none was free from unsafe blasting practices.

With but few exceptions, on-shift blasting is the general practice in mechanized mines, thus exposing all men in the

[1] Coal Age, vol. 46, no. 1, January, 1941, p. 38.

mine to the danger of any disaster that may result from blasting. Unless steps are taken to stop it, this dangerous practice will increase as more mines are mechanized. Had all blasting in Willow Grove been done at the end of each shift by certified shot firers, with all other men out of the mine, the fatalities from that disaster would have been confined, at the most, to the shot firers. The use of shot firers, with no one else in the mine when blasts are set off, will limit the number of men exposed to explosions resulting from blasting, but will not eliminate the danger from this source.

Unless and until some safer means than explosives is devised to break down the coal, the only safe way is to fire shots from a central switchboard on the outside, with all men out of the mine. The use of either shot firers or a central switchboard would limit working time to not more than two shifts a day, with not more than one cut taken from each working place per shift. A larger number of working places would be necessary, and production costs would to some extent be increased. But there are those prominent in promotion of mine safety who insist that savings in production costs at the expense of safety are not real savings and should be relinquished in the interest of safety. The rapid increase in tonnage of bituminous coal blasted during a shift in multiple-shift mechanized mines is clearly a growing hazard which can be controlled only by abolition of on-shift blasting.

Mechanical Mining

Any ignition of explosive gas in a coal mine is potentially a major disaster, because the extent to which the explosion, once ignited, will spread depends on a combination of contributing factors. Even ignition of a relatively small accumulation of gas, which of itself would be capable of only a small amount of damage in the immediate vicinity of the place of ignition,

given favorable conditions for its spread, may easily result in a major disaster with a large death toll. Because conditions favorable for the spread of an explosion are not always present, an extensive major disaster, although responsible for the major number of deaths from explosions, is only a small part of the total number of explosions that occur in coal mines. But the total number of all explosions, major and local, is the most dependable signal of danger confronting the whole industry. Failure of management to recognize small accumulations of gas as a danger signal calling for additional safety precautions too often results in disaster. Such an attitude is poor management; it leaves the possibility of disaster to chance.

Explosions in coal mines can be foreseen and prevented, and cannot be classed in the legal category of "an act of God." All groups in the industry, mine-owners, management, technical men, and miners, as well as state mining departments and the United States Bureau of Mines, are generally agreed that practical, effective, and well-known methods of prevention are available. Aside from humanitarian considerations, the cost in dollars and cents of applying these preventives is less in the long run than payment of workmen's compensation claims, and damage to mine property in the event of an explosion; but explosions continue to occur.

Thus the record of disasters for 1940 is a challenge to action, not only because of the alarming increase in fatalities resulting from explosions, but because it reveals that the relatively good record of recent years prior to 1940 may have been the result of luck rather than of a planned and comprehensive application of known preventive measures. The need for a program of prevention becomes the more urgent because, as the analyses of recent disasters have shown, these explosions have been associated with present practices in mechanized mines. The rapid increase in mechanization is spreading also

the hazards accompanying the new techniques of operation. Accidents in mines today call for awareness of the nature and tempo of mechanization, and the new problems of safety resulting from change in operations.

Although only about one-third of the bituminous coal from underground mines [1] in the United States is now produced by mechanized operations, these mechanized mines have been responsible in recent years for much more than their share of fatalities from major explosions. The increasing frequency and added severity of the major explosions which have occurred in mechanized mines have been called to the attention of the industry more than once by officials of the Bureau of Mines. The year 1940 and the first half of 1941 continued this black record of disastrous explosions in mechanized mines. Five of the six major explosions of 1940, with their 214 fatalities, occurred under conditions of mechanization. The one exception, Sonman, operated some mechanical units, but the explosion in that mine, with 63 fatalities, occurred in a hand-loading section. Although resulting in a smaller number of fatalities, the first half of 1941 saw three major explosions as compared with two in the first half of 1940. Two of the three major explosions of the first half of 1941 occurred in highly mechanized, multiple-shift mines, one operating two and the other three shifts daily.[2]

Mechanical mining in coal mines on a profitable basis dates from 1922, although experiments began earlier. In 1923, the

[1] This study is limited to underground mining and its special hazards from explosions, omitting reference to that part of the industry known as strip mining, in which all operations are on the surface.

[2] January 22, Carswell Mine, Koppers Coal Company, Kimball, West Virginia, five fatalities and 13 injured; May 22, Panhandle Mine, Bicknell Coal Company, Bicknell, Indiana, 14 fatalities; June 30, Kent No. 2 Mine, Rochester and Pittsburgh Coal Company, Indiana, Pennsylvania, seven fatalities and 20 injured. For reference to the record of the whole year see Introductory Note, p. 7.

year the United States Geological Survey began gathering data on mechanical loading, 1,900,000 tons, or 0.3 per cent of the total underground production of bituminous coal, were loaded by the new method.[1] Experimentation continues both in machine type and in design to fit loading equipment better to requirements of particular seams, but the mobile loader has emerged as the dominant type and is now producing considerably more tonnage than all other types of mechanical loading equipment combined.

In some of the earlier installations the coal was shoveled onto portable conveyors which elevated it into the mine cars. The use of the pit-car loader, with division of labor, speeding up of the tempo of work, as a result of closer supervision, and change from the traditional piecework to hourly rates of pay, was successful in increasing the average output per man. Where the earlier type of equipment remains in use it represents a survival of early experiments and is fast giving way to more efficient machines which eliminate shoveling entirely. Pit-car conveyor loaders[2] were used in loading 41 per cent of all mechanically loaded bituminous coal in 1930, but had dropped to 10 per cent by 1937. At the same time, mobile loading machines increased their proportion of mechanically loaded coal from 43 per cent in 1930 to 67 per cent in 1937.[3]

From the available record of production it is clearly evident

[1] Work Projects Administration, National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques, in cooperation with United States Department of the Interior, Bureau of Mines, Mechanization, Employment and Output per Man in Bituminous-Coal Mining. Government Printing Office, Washington, 1939, vol. 1, p. 114.

[2] The pit-car conveyor loader is not to be confused with the face conveyor used in mines which must meet peculiar seam conditions, and onto which coal is shoveled. Face conveyors handled 9.6 per cent of all mechanically loaded bituminous coal in 1930, and 17.2 per cent in 1937, the latest figures available. (*Ibid.*, vol. 2, p. 330.)

[3] *Ibid.*, vol. 2, p. 330.

that machine loading in coal mines is here to stay, and that succeeding years will see increasing tonnage handled by machines. Such a major technological change in an industry producing a basic raw material, employing hundreds of thousands of men scattered through many states, was bound to be accompanied by many collateral social and economic problems, of which unemployment and accidents are not least. But unhappily, although in keeping with the history of similar developments in other industries, little of the engineering skill that has made the machine a successful instrument of efficient production has been brought to bear on the social and economic ills that have come in its train.

The loading machine has brought with it drastic changes in the miners' work. Division of labor is complete. Coal-mining traditions and customs that have endured for centuries have been upset. Old skills have become obsolescent, and new skills are required. Investment in machinery [1] provides the incentive, the hourly rate of pay the opportunity, and close supervision the instrument for increasing the tempo of work to the utmost.

In a modern mechanized mine equipped with mobile loaders, a machine unit consists of a loading machine, a mining machine, power drills, and a locomotive, all operated by electricity; and the men needed to operate them. In addition, timbermen, trackmen, and others needed to meet conditions in the particular mine are part of the unit.[2] Each unit, as a rule, has a foreman and is self-sufficient in production, depending only on a continuous supply of empty cars on the nearby sidetrack from which the haulage system takes the loaded car to the shaft, where it is hoisted to the surface.

[1] In most mechanized mines this investment includes a mechanical cleaning plant on the surface to remove impurities from coal, as well as the underground machinery to mine and load it.

[2] A mobile loading-machine unit ranges from six to 20 men, but usually includes more than 10.

Each unit has its own territory, which may consist of as few as four or five working places. Machines are moved from one working place to another, as the work demands. The heavy loading machine and the mining machine run on the mine track, although some are tractor-mounted, under their own power. The cycle of operations of a unit begins with undercutting by the mining machine, followed by drilling and blasting and then the loading by machine on cars which the locomotive takes to the sidetrack. The trackmen lay the track in the working places, extending it as the work advances. Timbermen place bars and props to support the roof, usually in accordance with a planned system of timbering.

The whole unit is auxiliary to the loading machine, upon which production depends. Time lost by the loading machine because of failure of the mining machine to cut the coal, or of the drillers and blasters to make it ready for loading, is an irretrievable loss, which is certain to draw frowns and demands for explanations from the unit foreman. He, in turn, will be asked to explain the delay when his daily report is reviewed by his superiors. Time studies of mechanized operations center on the process of loading, and on the time taken to move a machine from one working place to another.[1]

So rapid has been the rate of introduction of loading machines in some districts, particularly in the Appalachian field in recent years, that experienced personnel necessary to get capacity production from the new equipment has been lacking. Trained technicians and supervisors have been unavailable, as well as competent machine operators, and electricians capable of properly maintaining the machines and installing and main-

[1] In certain mines the machine gears were set for a speed of somewhat over five miles an hour. This resulted in the machine operator's not being able to keep up with his machine, and a standard speed of three and a half miles an hour was recommended as likely to produce the best results.

taining the power line and other auxiliary facilities required to carry the heavier, concentrated power load of mechanized mines. Several large companies have initiated programs for training their own men for technical and supervisory positions, in some instances in co-operation with state mining schools and universities, and have financed scholarships. Reports from some of the state schools indicate that although engineering students are numerous, few elect to go into the coal mines, because of better opportunities in other industries.

The failure of coal operators to grasp the full implications of the revolutionary change that is taking place, and to face new personnel problems, has been discussed on a number of occasions in meetings of groups in the coal industry. Coal Age has published articles on the subject, and on one occasion, in discussing it editorially, declared that too many mines were "operating on the principle that technical men are a nuisance, figuratively purchasable at a dime a dozen," and that the management of such mines was offering beginners $100 to $125 a month, with "the promise of $175 to $200 per month in five or six years." [1]

A later issue of Coal Age, again discussing the question of personnel, pointed out that mechanization was rapidly turning the mine into a factory, and said that the situation demanded emulation of the conveyor-line methods of manufacturing-plant management. These methods require a higher degree of worker skill, as well as better technically trained management personnel, if the ultimate in efficiency by the new methods is to be realized. Besides the need to bid higher for the necessary technicians, the industry was warned of threatened inroads on the pick of its skilled man-power, as a result of higher wages offered by other industries because of the defense emergency,

[1] Coal Age, vol. 45, no. 3, March, 1940, p. 31.

in addition to the man-power lost through service in the armed forces. These threats, said Coal Age, are far from imaginary, and will reach into every category of workers in the mines.

Coupling safety with efficient management, Coal Age continued:

> Whether considered as a humanitarian or a coal operating-cost problem, accident prevention ranks high in managerial responsibility. The closer coordination and supervision demanded by mechanical mining opens the door to greater improvement in safety records. This is not theory but demonstrated fact. But the improvement does not come by chance. Where effected, it is the result of intelligent planning, continuous attention and wise discipline—the successful coordination of men, management and machines.[1]

An additional disturbing element in this pressing need for better trained technical and supervisory personnel in the mines is the belief on the part both of progressive educators and of progressive mine officials that many of the schools have not kept pace with developments in the industry. Coal Age quotes one educator as saying: "There is such a thing as obsolescence in education as in machinery." [1] If this condition is widespread in our technical schools, it would indicate that our advance in technology is running not only away from management, but ahead of our schools as well. The consequences of such a condition, unless promptly corrected, are not pleasant to contemplate.

The influence of mechanization on safety in mines is a managerial rather than a mechanical problem. Because of the greater speed of cutting and loading coal by machine, the area of working face in operation at any one time in a mechanized mine is much smaller, as compared with a hand-loading mine producing the same amount of coal. Similarly, the rate of advancement of working places in a mechanized mine where

[1] Coal Age, vol. 46, no. 4, April, 1941, p. 54.

three-shift operation is carried on may be ten or twelve times as rapid as with hand-loading.[1]

Under average conditions this more rapid process would increase the normal emission of methane in the same ratio. To remove this increased volume of explosive gas, and to avoid dangerous accumulations, ventilation in mechanized mines must be correspondingly increased in volume and velocity, and so directed as to sweep the working faces. Moreover, because of greater frequency of blasting, increased ventilation is necessary also to remove promptly smoke and noxious gases, following a blast. Any interruption of ventilation, even for a short time, is likely to result in accumulation of explosive or poisonous mixtures.

All mechanized operations increase the amount of coal dust. Some types of equipment make ten times as much dust as hand-loading. This dust is picked up in the air and deposited throughout the mine, particularly in the returns where rock-dusting is often neglected, especially in entries where the track has been removed. Without adequate ventilation and dust control, mechanization sets the stage for disaster.

The augmented use of electricity in mechanized mines increases not only the danger of explosion, but the risk of fire and contact as well.

Multiple shifts, which mechanization encourages, are also increasing the dangers confronting the miner. Although in

[1] A mechanized mine in Ohio on three-shift operation is reported to have produced a daily average of 5,680 tons of coal during January, 1941, from 37 working places. In this mine rooms are said to be driven 300 feet in five or six days. (Proceedings of American Mining Congress, Cincinnati, April 28-May 2, 1941, in Coal Age, vol. 46, no. 6, June, 1941, p. 40.) To produce this tonnage in an average hand-loading mine working one shift per day would probably require 500 or more loaders and as many working places, with six months to a year to drive a room 300 feet, depending on the height of the coal seam and the width to which the room was driven.

hand-loading mines a limited number of men are employed on a night shift, with few exceptions mines of this type produce coal only on a day shift. In multiple-shift mechanized mines productive operations are duplicated on each shift. With three shifts of seven hours each, and a half-hour lunch period, the half-hour intervening between each shift is used to change shifts, with no time left to apply needed safety measures.

If the welfare of the industry as a whole is considered, multiple-shift operation is inexcusable, since it increases the rate of output in an industry long suffering from excess capacity. The purpose of multiple-shift operation is to get a greater return on investment in machinery. As one prominent operator publicly stated, the third shift "is where we'll get the last squeal out of our investment in equipment." [1] In view of the general absence of full three-shift operation in manufacturing, it may be questioned whether the coal operators now working their mines "around the clock" have sufficiently investigated and taken into account the offsetting disadvantages of the third, or "graveyard," shift.

The hazards of machine mining have been intensified by multiple-shift operation, which has also increased the difficulties of applying necessary safeguards. The higher supervisory officials and technicians are at the mine only during a day shift. Afternoon and night shifts are in charge of minor officials with limited authority and disinclined to make important decisions, particularly when such a decision involves loss of production for their shift. Since their services are measured mainly by the amount of coal their shift produces, they are likely to take a chance rather than interrupt production. The natural desire to work by day results in promotion of the best

[1] R. L. Ireland, Jr., president of the Hanna Coal Company, speaking before Illinois Mining Institute, Springfield, Illinois, October 25, 1940. (Coal Age, vol. 45, no. 12, December, 1940, p. 108.)

men on the supervisory force to the day shift, leaving men of less capacity and experience to work at night.

Lack of co-operation between shifts is a common complaint in mechanized mines, and "passing the buck" is a common practice. As a result, electric cables and other electrical connections are neglected or temporarily repaired, to the detriment of safety. Under such conditions it is not surprising that so much permissible electrical machinery and equipment in mines is in nonpermissible condition, or used contrary to conditions of permissibility.

Three-shift operation cannot be carried on without the dangerous practice of on-shift blasting. Rock-dusting must wait to be done on Sunday or on an idle day. Installation of facilities for ventilation in regions of the rapidly advancing working face is neglected. Little time is left for inspection of equipment, and less time to make it safe to operate. Because of additional investment, the number of standby machines to permit a faulty piece of equipment to be taken to the shop for repairs is kept at a minimum.

That in recent years mechanized mines have been responsible for a much greater number of fatalities from explosions, in proportion to their total production, than have hand-loading mines, is known. No figures have been compiled, however, to show the relative numbers of fatalities and lost-time accidents from other causes as between mechanized and hand-loading mines. Such information is badly needed. Mechanization, plus multiple-shift operation, has made such drastic changes in safety conditions that a separate analysis of the causes and frequency of the various types of accidents in mechanized mines is essential before a program of prevention can be worked out with any measurable degree of assurance of success. Such an analysis should include a comparative study of accidents, separately, in one-, two-, and three-shift mechanized mines, as

well as the relative frequency of accidents on each shift. Through such a study information would be gained on the hazards inherent in mechanization itself, as well as on accidents attributable to complications arising from multiple shifts.

The United States Bureau of Mines has in view a separate compilation of accidents in mechanized mines, and it is to be hoped that Congress will provide the necessary funds. But this will be only the spadework. Because of rapid increase in mechanization, there should be no delay in studying the whole problem of mine safety from the standpoint of new hazards created by the machine, and formulating measures of prevention to fit changed conditions. In recommending safeguards, insistence should be unequivocal that technological change, to be progressive, must reduce rather than increase accidents, and, above all, be chargeable with the cost of adequate provision for safety.

That mechanization has introduced new hazards into coal mines, and increased certain old hazards, is generally admitted. Involved in the problem is the inadequacy of many techniques and practices useful in guarding against certain hazards in hand-loading mines, when applied in the mechanized mine. The worker in a mechanized mine has much less opportunity to guard himself against injury; for that reason, responsibility lies more heavily on management to provide safe working conditions.

Although some machine enthusiasts insist that many of the new hazards are merely accompaniments of the transition from hand-loading to machine-loading and will disappear when the change is complete, they all agree that safety in mechanized mining depends entirely on management. As an engineering problem, it can be solved only by application of sound engineering principles, with the same zeal, determination, and

thoroughness that have made machine-loading profitable. To these must be added willingness on the part of management to apply some of the savings resulting from the use of machines to provide safer working conditions. To all of this, most operators agree in principle, but many ignore it in practice.

Part III

Agencies for Safety

THE preceding analyses of accidents have already demonstrated that several agencies are involved in the promotion of safety. Primarily, prevention of accidents is a responsibility of management. The community has recognized the necessity for prescribing minimum conditions through legislation to be enforced by qualified inspectors. Both federal and state governments have enacted laws and provided for agencies to administer them. Finally, because the workers have most at stake, though they have the least authority, the union has been responsible for securing enactment of these laws and more or less vigorously watching over compliance with them by local mine officials. The severity of recent fatalities, however, clearly indicates that conditions now demand careful consideration of the responsibility and power of these various agencies, and the proper policy to be followed in co-ordinating their activities.

Responsibility of Managers

The industry is not entirely complacent about its accident record. Safe operating practices, and failure to apply them, are frequently the subject of papers read by mine officials and technicians in their meetings. Coal Age reports such proceedings in summarized form, publishes articles on better managerial practices and accident prevention, and often discusses the matter editorially.

Among officials of mining companies, Eugene McAuliffe, who is a pioneer in mechanization and president of the Union Pacific Coal Company, operating mines with an excellent safety

record in Wyoming, is recognized as one of the foremost advocates of safety and always has a respectful hearing, even though his criticism is usually severe. A vigorous champion of the rights and prerogatives of management, Mr. McAuliffe sees the inevitability of encroachments on those rights if management fails or refuses to solve the problems of the industry. In a recent issue of Coal Age, Mr. McAuliffe sharply warned operators to expect further restrictions on their prerogatives if they did not assume responsibility for correction of conditions. The Guffey Act,[1] prescribing the selling price of coal, said he, came "only after rugged salesmanship confessed failure," and a federal mine safety law [2] was imminent because of the failure of management to reduce accident rates in the mines. Mr. McAuliffe said:

> Coal, more than any other industry, is still following the trail blazed by the pioneers of northern England 250 years ago. Woeful waste of a rapidly exhausting invaluable natural resource, archaic hand-mining methods, poor ventilation responsible for frequent mine explosions and a too general acceptance of the theory that accidents must happen constitute the sins of omission and of commission that, to a large extent, yet attach to the industry. . . .
>
> Time after time the industry gets a fresh black eye out of a mine explosion, with all the gruesome details played up in the newspapers. Do these tragedies bring about better ventilation, rock-dusting, water on cutter bars, sprinkling dust at the source and on roadways, and the other proved preventives we all know about? Such, unfortunately, is not the case; we clean up the mine, pay the workmen's compensation, and get back on production.

[1] Public Law 48, 75th Congress, 1st Session, H.R. 4985, approved April 26, 1937. An Act to regulate interstate commerce in bituminous coal, and for other purposes.

[2] Public Law 49, 77th Congress, 1st Session, H.R. 2082, approved May 7, 1941. An Act relating to certain inspections and investigations in coal mines for the purpose of obtaining information relating to health and safety conditions, accidents, and occupational diseases therein, and for other purposes. The act had not yet been passed when Mr. McAuliffe's article appeared.

Why should our accident rate be quite four times that of the British mines? Will it take the British theory of more rigid laws and law enforcement to lift us out of the condition we are in?

Why, as an industry, have we not made the same ratio of accident reduction achieved by the railroads, the steel industry and manufacturing in general? Again, are the United Mine Workers, through legislation, to further become our pace makers? It is important that owners and management make a more serious effort toward accident prevention. Our failure in this direction is doing more to hasten new regulatory laws than our failure to sell coal at a profit. . . .

We should, and without further delay, make up our minds to take the full responsibility of leadership in the conduct of the industry. City resident administrators who never go into their mines—many are too old and too stout—have failed to absorb the implications of the new dispensation. They fail to vision the manufacturing viewpoint, look upon their labor as a necessary liability to be repurchased in March on odd years, and depend on Goodman, Jeffrey, Sullivan, Joy, and a host of other manufacturers to mechanize their mines on a "make-good" basis.[1]

Further evidence of absence of consistent effort in application of safety measures may be deduced from a report by the United States Bureau of Mines. In an effort to account for the curious zigzag pattern of rise and fall in fatalities from explosions during the period from 1924 to 1935, despite a "definite, fairly steady" decline in deaths from this cause, the report adds this note:

It is significant that every alternate year from 1924 to 1936 the number of deaths has increased over the preceding year, although the general trend has been downward. A plausible explanation is that a year with a relatively low explosion-fatality record results in relaxation of accident-prevention (or at least explosion-prevention) efforts during the following year and, conversely, a year with high explosion-fatality record results in additional precautionary measures being taken.[2]

[1] McAuliffe, Eugene, "Bituminous Management Must Take Leadership to Protect Future," in Coal Age, vol. 46, no. 4, April, 1941, pp. 88-89.

[2] United States Bureau of Mines Information Circular 7136, November, 1940, p. 14, mimeographed.

Joint Action by Management and Union

Only recently has provision been made for representation of the mine workers through the union in an effort to prevent accidents. In the current Appalachian Agreement, signed in the spring of 1941, which serves as a pattern for the bituminous district wage agreements, provision for miners' safety committees is an opening wedge for participation in safety questions by miners' union representatives. The inadequate employe safety committees organized by individual operators at some mines during recent years had their origin in non-union fields, and where they have existed in union mines employe members were recognized as individuals and not as members of the union speaking for the organization.

For more than forty years wage agreements in the industry have expressly limited the duties of pit committees to the adjustment of grievances arising out of the agreement. Since the agreement did not include safety provisions, such questions could not be handled by the pit committee. Even the new Appalachian Agreement contains the stipulation carried in district wage agreements for four decades, that management of the mine and direction of the working force are vested exclusively in the operator, and that the miners will not abridge that right. This clause has in the past prevented the miners' representatives from taking up hazardous conditions as grievances for discussion through the machinery of the union.

In thus limiting at its source the possibility of collective action on safety, the Illinois district wage agreement goes much farther. In it the miners agree not to "initiate or encourage the passage" of mining legislation. The pertinent section, which has been a part of the Illinois agreement since 1910, reads as follows:

This contract is based upon existing mining laws and neither party to the same shall initiate or encourage the passage of laws pertaining solely to the mining industry that would in any manner affect the obligation of this contract or abrogate any of the provisions unless such proposed laws be mutually agreed to by the parties hereto, or be recommended by the Mining Investigation Commission appointed under the laws of the State of Illinois, the parties hereto agreeing to unite in securing the continuance of such commission during the life of this agreement. The foregoing does not apply to proposed legislation relating to the industries of the state in general.[1]

Behind the agreement is the general principle that collective bargaining in the district shall not disturb the competitive balance between competing districts by any action which would increase the cost of producing coal. The basis of all district agreements has been the assumption that their terms would maintain a competitive balance. Even before 1910 such a basis had been accepted in the following section of the district agreement:

No changes or conditions shall be imposed in the Illinois scale for the period of this agreement that increase the cost of production of coal in any district in the state, except as may be provided.[2]

Mining Investigation Commission of Illinois

The Mining Investigation Commission mentioned in the contract previously quoted embodies, theoretically at least, the concept of joint action by operators and miners in establishing conditions of safety through state legislation. Beginning with 1909, each General Assembly of the Illinois legislature has

[1] This section is a part of the wage agreements between the United Mine Workers of America and the Illinois Coal Operators' Association, and the Progressive Mine Workers of America and the Coal Producers' Association of Illinois. When the section was first inserted in the Illinois agreement in 1910 it was not limited to mining legislation. This clarification was made in 1914.

[2] Agreement between Illinois Coal Operators' Association and United Mine Workers of America, District No. 12 (Illinois), April 1, 1908-March 31, 1910, p. 6.

enacted a short-term law providing for a Mining Investigation Commission; each law has carried provision for its expiration with the adjournment of the following legislature. The Commission is composed of three representatives of the operators; three representatives of the miners; and three additional members, not dependent upon nor affiliated in any way with either miners or operators, nor active in political life. In appointing the operators' and miners' representatives, who receive no compensation from the state beyond actual expenses, the Governor follows the wishes of their respective organizations. The remaining members receive a per diem remuneration from the state, in addition to actual expenses.

Although the Commission is authorized to investigate mine accidents, its work has been confined chiefly to consideration of proposals for mining legislation, and to reporting

> . . . to the Governor and to the General Assembly at its next regular session . . . so far as they have unanimously agreed, a proposed revision of mining laws of the State, together with such other recommendations as to the Commission shall seem fit and proper relating to mining in the State of Illinois.[1]

While the law permits the submission of reports by a minority, in practice the legislature has never made any change in the mining laws that did not have the Commission's unanimous endorsement. Whatever virtues or faults the plan may have, there can be little doubt that it has been a great boon to Illinois lawmakers, since it relieves them of responsibility for mining legislation.

Few changes of major importance have been made in the Illinois mining code in the past thirty years, although during the past ten years the rapid advancement of mechanization in the Illinois mines should have compelled revision by the Com-

[1] Laws of Illinois, 54th General Assembly, 1925, p. 112.

mission. Competent observers are apprehensive of dangers, particularly in gassy and highly mechanized mines in the southern part of the state, even though Illinois mines have not shared in the recent increase in major disasters.[1]

The Illinois method of handling legislation for safety in mines has been optimistically characterized as an extension of collective bargaining to labor laws. To be sure, the opposing interests meet at the council table, as in collective bargaining; and as usual, the demands, in the form of proposals for change or addition to the mining code, come from the miners. But possession by the operators of an absolute veto, which may be exercised with or without good reason and from which there is no appeal, nullifies any resemblance to genuine collective bargaining. It is true that all members of the Commission have the same veto power; but since the potency of the veto resides in the power to maintain the status quo, it is of little use to the miners, whose interests lie in the promotion of new legislation to meet new hazards as they arise. The provision that the Commission must be unanimous in its recommendations, combined with undue weight given to cost as the chief consideration in proposals for safety, virtually nullifies the Commission as an instrument for promotion of adequate mine-safety laws. That high standards of safety can be made the basis for more economical operation, appears to have been overlooked entirely.[2]

[1] Events since the above was written reveal this apprehension to have been well founded. On December 28, 1941, an explosion causing eight deaths occurred in Mine No. 47 of the Peabody Coal Company at Harco, Saline County, in southern Illinois.

[2] See Accident-Cost Data on Most of the Bituminous Coal Mined East of the Mississippi River from April 1, 1934 to January 31, 1935. United States Bureau of Mines, Information Circular 6896, July, 1936, mimeographed. For more complete discussion of the Illinois Mining Investigation Commission, see Bloch, Louis, Labor Agreements in Coal Mines, Chapter VIII, Collective Bargaining in Labor Legislation, Russell Sage Foundation, New York, 1931.

Joint Safety Committee in Mines in State of Washington

In the state of Washington since 1914 provision for local joint safety committees has been part of the wage agreement between District No. 10 of the United Mine Workers of America and the operators of Washington. The only precedent in the coal industry of the United States for the safety committee provided in the Appalachian Agreement between miners and operators in the spring of 1941, is this section of the Washington district agreement which reads:

> A committee composed of the President of the Local Union, the Mine Superintendent, Safety Inspector or the Manager of the Mines and a third member selected by these two, who shall be paid not less than the miners' basic rate and who shall not be a member of the Pit Committee, shall constitute a committee whose duty it shall be to investigate all serious and fatal accidents, their findings and recommendations to be presented in writing to the Manager or General Superintendent of the Company, a duplicate of this report to be filed with the District Office [of the union], also to make a bi-monthly examination of the mine, and make recommendations in writing as to dangerous conditions and safety methods.[1]

Inspections authorized under this agreement furnish the superintendent with a complete check on the work of his subordinates in the maintenance of safety. The general manager, in turn, through the written report of the committee, has a check on the work of the safety director, and also on the efficiency of the superintendent, who is ultimately responsible for

[1] Agreement Between United Mine Workers of America, District No. 10, and Coal Producers of Washington, April 1, 1941, to March 31, 1943, p. 21. This provision is identical with clause in agreements in the late 1930's. The original clause in the 1914 agreement made no mention of safety inspector, nor did it provide payment for the third member, or prohibit service by a member of the Pit Committee.

any failure of mine supervisory officials to maintain safe conditions. The district officials of the union, through their copies of reports kept on file in the union office, have access to exact knowledge of conditions in any mine in the district if it becomes necessary for them to intervene for their correction.

The effect on management of being thus reminded of safety conditions at regular intervals is obvious. Payment by the company for time lost from work by the miner members of the safety committee while making inspections emphasizes the point that the cost of safety should be charged to production, and not to the workers through payment of this expense by the union.[1]

The right of the union to participate in safety matters in Washington mines has recently been strengthened by an amendment to the mining laws of that state, which provides that

> . . . in case of any major or fatal accident, the resident district officers of the miners' organization shall be notified by telephone or telegraph at the same time the mine inspector is notified, and shall have the privilege of appearing at all investigations held to determine the cause of such accident, and to recommend safety measures for the prevention of accidents.[2]

Appalachian Agreement of 1941

The safety clause of the current Appalachian Agreement is not so strong as that originally proposed by the miners, but is an excellent beginning upon which to build as experience accumulates. This clause is one of several sections of the agreement upon which miners and operators were unable to agree. The disagreement resulted in calling the National Defense Me-

[1] Textual comment on the Washington mine safety committee is based on the author's experience in Washington mines, and as a member of a local safety committee.

[2] Approved March 10, 1939.

diation Board into the dispute. Indicative of the backward attitude of coal operators on this question is the amazement reported to have been expressed by a representative of management from another industry on the Board's panel handling the case, when the operators objected to a safety clause. Evidently to overcome some of the fears of operators, the Board rewrote the clause in the form in which, with minor changes, it appears in the agreement. The final text, which follows, plainly reveals the reluctance with which the operators agreed to it, and the safeguards they insisted upon:

> Reasonable rules and regulations of the Operator for the protection of the persons of the Mine Workers and the preservation of property shall be complied with.
>
> At each mine there shall be a Safety Committee. This committee shall be designated by the district president of the United Mine Workers of America, who shall also have authority to change its personnel. Its membership shall consist of a maximum of six Mine Workers, not less than 40 years of age and not less than 15 years' experience. No member of the Mine Committee shall be a member of the Safety Committee. The Safety Committee shall serve without compensation.
>
> This committee shall have the right to inspect any mine development or equipment used in producing coal, for the purpose of observing its safe or unsafe condition when such questions are brought to its attention. If the committee believes conditions found are dangerous to life, it shall report its findings to management.
>
> The international union, United Mine Workers of America, may designate memorial periods provided it shall give proper notice to each district.[1]

Much of the effectiveness of this provision depends upon its interpretation, and the extent to which the operators are willing to co-operate with the miners. But the important fact to be emphasized is that for the first time the industry as a

[1] "Safety Practices," Appalachian Agreement, signed June 19, 1941, in United Mine Workers Journal, July 1, 1941, p. 7.

whole has conceded that safety is a joint concern of miners and operators, and that miners' participation shall be exercised through their union. The beginning of collective bargaining on matters affecting safety is here. What is made of the opportunity depends on how both parties approach it.

The desirability of extending collective bargaining to include safety would seem to be self-evident. Once the principle of collective bargaining is conceded as applying to wages, hours, and conditions of employment, no good reason remains for excluding its application to conditions affecting the safety and health of the workers. State mining codes and law enforcement agencies would not be displaced, but supplemented. The insertion of a clause in the union agreement, requiring complete compliance by operators with state mining laws, with violators subject to discipline through the machinery of the joint agreement, or the operators' associations concerned, would, if properly enforced, not only increase safety, but help to preserve the competitive balance for operators who of their own volition obey the law.

Safety could be advanced through this method, even beyond the standard set by law. The number of shifts worked per day, on-shift blasting, rock-dusting, allaying of dust at its source with water, pre-shift examination of mines (where such is not required by law), regular inspection of equipment, periodic collection and analysis of samples of air and dust, are among many questions vital to safety that would lend themselves to joint determination between union and management, with final determination after local disagreement to be made through the machinery of the joint agreement exactly as in any other dispute. Few if any coal-mining states have achieved a standard so satisfactory that application of such a program would not make for greater safety.

The feasibility of settling matters of this kind jointly is

recognized in a clause of the new agreement between the Progressive Mine Workers of America and the Coal Producers' Association of Illinois, that blasting of coal with "powder or any other explosive that may prove injurious to the health and well being of the employes, during the regular working shift, is prohibited, and shall cease at once."[1]

Coal producers' associations act collectively on a variety of matters affecting the common interests of their members. One good reason why matters pertaining to safety should receive their collective attention is that individually they have given it so little notice. Indications are many that they will not be able much longer to continue in this passive role. Repeated explosions resulting in major disasters call for more stringent governmental regulations. Safety requires strengthening of laws and their administration along lines which will constitute a new chapter in the fairly long history of action by the community to protect the lives of men who dig coal.

State Mining Laws and State Mining Departments

The first legislation for mine safety in the United States was enacted in a number of coal-mining states during the 1870's, a culmination of unsuccessful attempts by the miners during the previous decade. Even this legislation would probably have been further delayed, had it not been for a sympathetic public opinion created by several major disasters, in one of which 179 miners were killed. In the subsequent history of mining laws it has become clear that they are strengthened only when public opinion has been aroused over particularly shocking disasters. Tragic examples are the flooding of the Diamond Mine at Braidwood, Illinois, in 1883, with the drowning of 69 miners, and the large death toll taken during the period of

[1] Progressive Miner, vol. 63, no. 6, December 1, 1941.

1900-1909, in which 600 men were killed in two explosions in December, 1907, and 259 died in the Cherry, Illinois, Mine fire in November, 1909. Only at the end of one of the most ghastly decades in the history of coal mining in the United States,[1] was a bill for establishment of a federal Bureau of Mines, backed by the United Mine Workers of America, which had been pending in Congress for five years, finally enacted in 1910.

It took the major explosions that occurred with appalling repetition during 1940 to blast away opposition to the federal mine inspection bill[2] in the House of Representatives, where it was held up for more than a year after it had been approved by the Senate in January, 1940. The establishment of the federal Bureau of Mines in 1910 was paid for by the miners who lost their lives in Monongah, Jacobs Creek, Cherry, and the other major disasters during the preceding decade. Again, for the federal mine inspection law of 1941, designed to make the Bureau's work more effective, the price was paid by the men who died in Bartley, Willow Grove, and the other mines which were the scenes of the major disasters of 1940.

State mining legislation has always lagged behind the need for it. New hazards introduced by the opening up of larger mines, and by the use of machinery and electricity, took their greater toll of lives before state legislatures could be convinced that new legislation was needed to meet the new dangers. An almost continuous battle has been waged through the years in the legislatures of the coal-mining states, with the

[1] Ten coal-mine disasters in which 100 or more men were killed, with a total of 1,965 fatalities, occurred during the period 1900-1909. These disasters took place in seven states, including Pennsylvania in the East, Utah in the West, and Alabama in the South. Included in the 10 is Monongah, West Virginia, with 361 fatalities, the largest mine disaster the United States has ever experienced.

[2] This bill will be more fully described later. See pp. 129-137.

miners and their union officials asking for legislation while the operators opposed it. Except at times when public opinion has been aroused by news of spectacular mine disasters, the operators have usually had the greater influence with the legislatures.

The result has been that state mining codes, instead of being scientifically drawn to fit the needs of the industry, are a mixture of good and bad. Often the best represent compromises of politically minded legislators striving to please both sides, as well as to placate public opinion. The time lag that has occurred in the past between the introduction of new hazards, and legislative measures to counter them, is now being repeated in the introduction of mechanical mining. No state has as yet taken up seriously the question of rewriting its mining code to take care of the many new problems of safety that have arisen as the result of the introduction of the loading machine.

Some of the larger coal-producing states have set up mining departments [1] of equal rank with other major divisions of their state governments, charged with the duty of inspecting mines, enforcing state mining laws, and compiling and publishing statistics of coal production and mine accidents. In some states this agency is a bureau or division of the state labor department. In states having a smaller number of mines the one or two mine inspectors necessary may be attached directly to the labor department, or in some instances to the state geological survey.

A total of about 175 coal-mine inspectors are employed by the coal-producing states. In practically all states inspectors are appointed on a political basis and are changed when the political complexion of the administration changes, although

[1] State agencies responsible for inspection of coal mines and enforcement of state mining laws are referred to in this report as state mining departments, though their names vary in different states.

the requirement is now practically universal in the principal coal-producing states that an applicant for the position must have passed an examination and hold a state certificate of competency as a mine inspector before appointment. This examination includes a knowledge of mine gases, ventilation, and other technical mining subjects. In addition, in most states an inspector is required to be trained in first aid, in use of oxygen-breathing apparatus, and in mine-rescue and recovery work. State laws almost invariably require inspectors to have had a certain number of years of experience as practical miners. To pass a state mine inspector's examination requires a more advanced knowledge of technical mining subjects than the examination for a mine manager's certificate. For that reason state inspectors may be holders of certificates as first-class mine managers, even though they may never have held such positions nor even intended to be so employed.

Most state mining laws divide the state coal fields into inspection districts, and an inspector is assigned to a particular district, which in practice is usually his home. Some of the larger coal-producing states have additional inspectors, either for emergencies or to help in districts where the industry has expanded. State laws specify how often a mine must be inspected, varying from three to six months or more in different states, but additional inspections are often made when a mine is known to be dangerous, or complaints of unsafe conditions are made. Although the laws of many states specify that a petition signed by a nominal number of men employed at a mine is necessary to call for a special inspection, in practice a letter or telephone call to the inspector from a responsible official of the miners' local union is usually accepted as meeting the requirements of the law. Reports of inspections, setting forth the conditions found, and recommendations of the inspector, are posted at the mine, usually protected by glass, and a copy

filed with the state mining department. The inspector also makes an immediate investigation of all fatal accidents.

State inspectors are usually good mining men, honest as a rule, who would much rather enforce the law than wink at violations, but they have difficulty in following that inclination. Too often they are forced to compromise. The difficulty arises from the political nature of their appointment, as well as from ambiguities and omissions in the laws, and the resistance of operators who wish to shirk the legal provisions. Nor are heads of state mining departments immune to political influences.

At a recent meeting of the Mine Inspectors' Institute of America, Thomas Moses, for many years a state mine inspector in Illinois, and more recently president of the mining properties of the United States Steel Corporation, deplored the fact that in

> . . . many cases the mine inspector must be acceptable politically to the home representatives of the political organization in power in his State, often to his great embarrassment. Inspectors have had to take sides in industrial relations because of the political power of either party. Yet, mine inspectors desire to apply themselves solely to improving the safety and health of the men in the mines.
>
> Salaries have been too low. State legislators have always felt that the position of the state mine inspector was more or less political, and, as a surplus of men sought the position, the salary was adequate. Owners regarded the inspectorate as a place from which they could draw supervisors or in which they could place a man grown old in their service. Mine inspectors, when they reach a retiring age, should get a suitable pension, and changes in political control should not be occasion for dismissal.[1]

[1] Proceedings of 32nd Annual Convention of Mine Inspectors' Institute of America, June 2-4, 1941, Bluefield, West Virginia, as summarized in Coal Age, vol. 46, no. 7, July, 1941, p. 82. Thomas Moses is a charter member of the Institute, and was elected first vice-president at the organization meeting held in 1908.

The Bureau of Mines, in its report on the Sonman explosion of July, 1940, mentions two instances of difficulties encountered at that mine during a routine visit by the state inspector some months prior to the explosion. In his report the inspector had noted that "these two recommendations seem to be perpetual." That such notations are probably frequent, is significant. More significant is the compromise which the inspector had been obliged to make with the management of the Sonman mine regarding ventilation in the very section of the mine where the explosion later took place, because the law left him powerless to order the change to be made in a reasonable period of time unless he could show that life was immediately in danger. Too many states hamper their inspectors by carrying similar provisions in their mining codes.

Delay by the management in accepting recommendations is a common difficulty. It may be illustrated in a casual reference appearing in an article on dust control, written by a general mine foreman in a southern Appalachian district and published in a recent issue of Coal Age.[1] "The State mine inspectors were continually harrying us about the dust," he remarks, in describing his experience in trying to control this situation. Too many mine managers need to be harried by the inspector before they take his recommendations seriously.

Sometimes management goes farther than merely ignoring the inspector, and resists an order in the courts. For example, early in 1941 an order of the West Virginia Department of Mines to compel use of rock dust and employment of fire bosses to make pre-shift examinations in the operations of the Page Coal and Coke Company in McDowell County had to be

[1] Hornsby, Walter, "Timely Warning That Will Pay Big Dividends, Sprinkle Air and Mine Near Face," in Coal Age, vol. 46, no. 1, January, 1941, p. 64. The writer was general foreman of the Glogora Coal Company, Glo, Kentucky, and more recently district mine inspector of the Kentucky Department of Mines and Minerals.

tried in the circuit court. The company contended that its mines were not gassy, and that the precautions ordered by the Department were therefore unnecessary. The decision took official notice of the fact that explosions had occurred in three West Virginia mines during the preceding twelve months, and upheld the order of the Department of Mines. At the time, it was indicated that the company intended to appeal the case to the state supreme court.[1] The fact that a new state administration, pledged to promoting greater safety in the mines, had recently assumed office, doubtless had its effect in this instance.

In enforcement of state mining laws and regulations much depends on the state administration. Complaints by miners of official laxness in inspection, and inadequate enforcement of law, are not uncommon. For several years past the Illinois miners' union has been making attempts to have rescinded an order by the state Department of Mines and Minerals, permitting blasting during the working shift in certain mechanized mines. The miners contend that this practice is not only unsafe but contrary to the state mining laws. At the same time, delay in the appointment by the Governor of the Mining Investigation Commission, authorized biennially by the legislature, is another illustration of the dependence of mining legislation upon the attitude of the party in power. With an unfavorable state administration in office, the miners had little success. The fact that, fortunately, no major disasters have occurred recently in Illinois mines, does not invalidate the miners' efforts to obtain better enforcement of the existing law, and to hasten its revision to cover new hazards due to mechanical mining.

The recent record in Ohio in this respect, however, is a tragic one. Despite the introduction of mechanical mining in

[1] United Mine Workers Journal, March 1, 1941, p. 14.

the interim, until recently the mining laws had not been revised since before the miners' union collapsed in that state in the late twenties.[1] Months before the disaster at the Willow Grove mine in March, 1940, and during the interval before the Nelms explosion more than eight months later, the miners of Ohio, uneasy about conditions in their mines, made numerous unsuccessful efforts to secure more adequate inspection and better enforcement of the mining laws. Early in November, 1939, the Ohio miners protested to the Governor against evasion of the state mining laws by the appointment of men as mine inspectors who were "physically unfit and without experience." A later appeal by the miners to the courts to remove one such inspector was resisted by the state administration, and after numerous delays the case was finally dismissed by the state supreme court on a technical motion by the state attorney general, without consideration of the merits of the case.[2]

Immediately following the Willow Grove mine disaster because of the miners' increasing apprehension, Local Union No. 283, United Mine Workers of America, at the Nelms mine, made a formal request of the Ohio Department of Industrial Relations and the United States Bureau of Mines for a joint investigation of conditions in that mine. They asserted: "The workers feel that dangerous conditions exist, and also that the preventive measures are far from adequate." [3] The Bureau of Mines expressed willingness to co-operate in an investigation, if satisfactory to the Ohio Division of Mines, but

[1] The union was re-established in 1933.

[2] United Mine Workers Journal, January 15, 1941, p. 6, article by John P. Jones and Howard R. Hill, of New Philadelphia, Ohio. Both Jones and Hill are miners, and members of the United Mine Workers of America. Both took part in conferences with the Governor and in other actions in the effort to remedy conditions complained of.

[3] PM, February 24, 1941, series of articles on Ohio mine disasters, by Tom O'Connor. Copyright 1941, by The Newspaper PM, Inc. Reprinted by permission of The Newspaper PM.

was prevented from doing so because no such assurance was given.

However, as a result of this request by the miners the Ohio Division of Mines sent three inspectors to make a special inspection of the Nelms mine. According to a letter to the local union secretary from the acting chief of the Division, these inspectors found the mine "in a fair condition. Water spray being used, also rock-dusting; ventilation good." The Division of Mines was willing to co-operate with the United States Bureau of Mines in any disaster in the state, "but the inspection of mines in the state of Ohio is done by state mine inspectors. The federal Bureau of Mines has no jurisdiction in issuing any orders to coal operators by law in this state." The acting chief added: "I have ordered all machine-loading mines to be inspected every six weeks instead of every three months, or sooner if necessary." [1]

This promise of the Division of Mines to make more frequent inspections of mechanized mines was carried out at the Nelms mine. Testimony in hearings after the Nelms explosion, held at Cadiz, Ohio, under the direction of the state Department of Industrial Relations, revealed that six inspections of the Nelms mine had been made between January 22 and November 27, 1940, with the last inspection two days prior to the explosion. Reports of these inspections, according to the report of the Bureau of Mines on the explosion, were not posted at the mine, as is the custom, and only part of the contents of the reports was revealed at the hearing held by the Department of Industrial Relations. The inspector whom the miners had previously sought to have removed for incompetency was one of the four who made the last inspection before the disaster. At the time of this inspection, gas from an esti-

[1] *Ibid.*

mated one per cent to an explosive mixture was found in room 13 off 8 east air course, where the blast occurred two days later, and gas was found generally in the area affected.

The inadequacy of these inspections of ventilation and gas conditions in the Nelms mine, and the tragic failure to take effective measures to prevent disaster, were made clear by the present chief of the Ohio Division of Mines in a report on this explosion in a symposium on recent mine disasters at the 1941 meeting of the Mine Inspectors' Institute of America.

> A bank of rooms had cut into a clay vein which liberated large quantities of methane. A move necessitated the splitting of an air current which was probably already none too adequate to clear methane from the coal face, and the revision of the ventilation made necessary the use of large quantities of line brattice and many doors, which probably contributed to the disaster.[1]

Another of the Ohio inspectors who took part in the inspection of the Nelms mine just prior to the explosion, testifying during the subsequent investigation, in reply to a question as to whether he had examined the mine equipment, said that he had ceased such inspection several months previously, after he had been told by the company's safety director that he had no business to inspect equipment because "the law did not provide for it." In reply to a question as to whether he had at any time made recommendations on this subject at the Nelms mine, he replied: "I issued no recommendations, but as I remember about in January or February [1940] I made a statement in the report that there was no piece of equipment in the mine that could possibly be called permissible." He replied in the negative when asked if he had done anything since that time

[1] Proceedings of 32nd Annual Convention of Mine Inspectors' Institute of America, June 2-4, 1941, Bluefield, West Virginia, as summarized in Coal Age, vol. 46, no. 7, July, 1941, p. 76.

with reference to this condition.[1] This testimony not only indicates inadequate inspection and lack of law enforcement; but its importance is emphasized by the fact that the explosion at the Nelms mine was found to have been ignited by an electric arc or spark from defective equipment.

Following the Nelms explosion, the Governor of Ohio appointed a commission to study conditions in the mines. The Ohio miners had petitioned him to do so more than eight months earlier, immediately following the Willow Grove disaster in March, 1940. This commission was composed of four members of the state legislature (two Senators and two members of the House of Representatives), the Director of Industrial Relations, the Chief of the Division of Mines, two representatives of the Ohio coal operators, and two representatives of District No. 6, United Mine Workers of America. Because of differences of opinion among members of the commission, the recommendations submitted to the legislature were signed only by the miners' representatives and the four members of the legislature. The resultant revision of the mining law by the legislature increases the number of state mine inspectors, including provision for an electrical inspector; gives the inspectors power to close mines or parts of mines when necessary for the safety of the men; establishes a special board of examiners to examine applicants for certificates as mine foremen or state mine inspectors, and to hear appeals from decisions of the Chief of the Division of Mines; prescribes rock-dusting methods where it is determined that rock-dusting is necessary; establishes a laboratory for analysis of mine-air and dust samples; and provides for mine-rescue stations in charge of crews trained in mine-rescue and recovery work.

[1] PM, February 24, 1941, verbatim testimony at the hearings, quoted by Tom O'Connor. Copyright 1941, by The Newspaper PM, Inc. Reprinted by permission of The Newspaper PM.

A unique and significant feature of the new Ohio law is the section providing for miners' safety committees, which reads as follows:

> The miners in a mine may appoint two of their number to act as a committee to inspect, not oftener than once in every month, the mine and the machinery connected therewith, and to measure the ventilating current. If the owner, lessee or agent so desires, he may accompany such committee, or appoint two or more persons for that purpose. The owner, lessee or agent shall afford every necessary facility for making such inspection and measurement, but the committee shall not in any way interrupt or impede the work in the mine, at the time of such inspection and measurement. After such inspection and measurement, such committee shall forthwith make a report thereof to the chief, division of mines, on a blank furnished by him.

To make such a plan general, as is indeed contemplated by the United Mine Workers of America in the recent Appalachian Agreement, is probably the most important step which could be taken today for protection of miners' lives.

The miners attempted unsuccessfully to have the law amended in a number of particulars to curtail the discretionary power of the Division of Mines, maintaining that safety would be enhanced if the law were made more mandatory, instead of permitting certain practices in the mines at the discretion of the Chief of the Division of Mines. The Director of Industrial Relations and the Chief of the Division of Mines stood out against any curtailment of their powers, and the operators on the commission stood with them. Whether the amendments made to the law will result in greater safety in the mines of Ohio, remains to be seen. The unwillingness of the operators' representatives on the commission to sign the report, especially after the two recent disasters in the state, with their toll of 104 lives, is discouraging, in view of the great necessity for acceptance of responsibility by management for conditions of safety in the mines.

This recent experience in Ohio, involved as it is with two of the major disasters of 1940, is a clear illustration of the many obstacles in the way of effective action through state legislation. These discouragements in the past, together with the realization that the mining industry is national and calls for federal action, have led to the development of the United States Bureau of Mines.

United States Bureau of Mines

The United States Bureau of Mines was established in 1910 in the Department of the Interior. Transferred to the Department of Commerce in 1925, it was returned to the Department of the Interior in 1934. The organic act establishing the Bureau set forth its scope and duties as follows:

> . . . 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 treatment of ores and other mineral substances, the use of explosives and electricity, the prevention of accidents, and other inquiries and technologic investigations pertinent to said industries, and from time to time make such public reports of the work, investigations, and information obtained as the Secretary of said department may direct.

The act specifically denied to officers and employes of the Bureau "any right or authority in connection with the inspection or supervision of mines or metallurgical plants in any state." The act was amended in 1913 to make it more specific in relation to "inquiries and scientific and technologic investigations" covering economic aspects of mining and metallurgy, and added occupational diseases as another subject to be studied. In 1915 the first mining experiment and mine-safety stations were provided. The Bureau, as already noted, has no mandatory power to enforce its recommendations, and prior

to the enactment of the federal Mine Inspection Act [1] in the spring of 1941 officials and employes of the Bureau had no authority to enter any mine without the consent of the owner or operator.

In its work for safety the Bureau makes studies and carries on experiments to discover causes of accidents and occupational diseases, maintains stations in and near mine fields for instruction in safety, first aid, and mine-rescue work, and offers the services of its engineers and technicians in rescue and recovery work in the event of mine disasters. Through its investigations of mine explosions, made incident to engaging in rescue and recovery work, as well as through experiments carried on in its experimental mine at Bruceton, Pennsylvania, the Bureau has been able to add much to knowledge of the nature and causes of mine explosions, and to formulate effective means of prevention. Its technical personnel is of higher caliber than the men employed by state mining departments, due in large part to civil service status and higher salaries in the federal service.[2] The Bureau also has laboratory equipment for making tests and analyses. Such aids to safety are almost wholly lacking in state mining departments.

Past policy of the Bureau has been not to make public reports of its investigations of mine disasters, although the findings have been used in formulation of measures of prevention which have been passed on to the industry through the Bureau's publications. Early in 1940 the Secretary of the Interior, Harold L. Ickes, giving heed to protests by the United Mine Workers of America, ordered the Bureau's report on the ex-

[1] Public Law 49, 77th Congress, 1st Session, H. R. 2082. An Act relating to certain inspections and investigations in coal mines for the purpose of obtaining information relating to health and safety conditions, accidents, and occupational diseases therein, and for other purposes.

[2] Many of the technicians in the Bureau of Mines could no doubt command higher salaries in private employment.

plosion of January 10, 1940, at Bartley, West Virginia, and all future reports on mine disasters to be made available to the public. The coal industry has always been extremely sensitive to the wide newspaper publicity given to disastrous mine explosions. Publication of detailed reports by the Bureau will increase this aversion, but the educational effect of these reports on state mining departments and inspectors should result in improvement in those services.

The Bureau's reports on explosions are made by engineers of the Bureau who take part in the rescue and recovery work following an explosion. In most instances they reach the scene of the disaster from the Bureau's regional stations within a few hours after the occurrence. The reports of the disasters of 1940, from which the foregoing summaries were written, are detailed and objective, and show the results of a thorough and impartial search for the facts by competent men. Recommendations for safeguards against future disasters, based on conditions found in the mine, and incorporated in each report, if adopted and maintained, would make a repetition of the disaster highly improbable. Therefore it has been the more unfortunate that this federal agency has lacked and still lacks power to enforce such competent recommendations.

New Federal Legislation

The federal Mine Inspection Act of 1941 and the safety clause in the Appalachian Agreement, previously described,[1] sprang from a common source. Both grew out of increasing activity with relation to mine accidents by the United Mine Workers of America, following adoption of a resolution on that subject at the international convention of the union in January, 1938. Reciting the gains made by the organization in

[1] See pp. 112-115.

higher wages and shorter hours, this resolution called attention to the "outstanding evil remaining," namely, the "failure of the industry to provide safe and healthful conditions of employment." The international officers were instructed to

> . . . request the President of the United States to arrange for a national conference in which all national or state organizations and associations of mine owners, mine workers, Federal and State Mining Bureaus and Departments will be invited to participate, for the purpose of deciding upon a definite plan for the promotion of greater safety in the coal mining industry, and to reorganize the United States Bureau of Mines.[1]

Although President Roosevelt expressed sympathetic approval of the proposal for a conference, a preliminary meeting held in December, 1938, called at his suggestion by the Secretary of the Interior, Harold L. Ickes, did not result in a general conference such as the miners' convention had requested. Instead, the following May, the Neely-Keller Bill (S. 2420), sponsored by the United Mine Workers of America, providing for federal inspection of mines, was introduced simultaneously in the Senate and the House. The bill passed the Senate in January, 1940. Extensive hearings were held by a subcommittee of the House Committee on Mines and Mining at intervals during the spring and summer of 1940, including the taking of testimony in Ohio on the occasion of the Willow Grove mine disaster; but despite strenuous efforts on the part of its supporters, the bill did not reach the floor of the House before the end of the session. Apparently it was blocked by powerful influences exerted through the House Rules Committee.

International and district officers of the United Mine Work-

[1] United Mine Workers of America, Proceedings, Thirty-fifth Constitutional Convention, Washington, D. C., January 25 to February 3, 1938, vol. 1, pp. 297-298.

ers of America and rank-and-file miners appeared before the committee in favor of the bill. Representatives of coal operators' associations and the National Coal Association, individual operators, heads of state mining departments, and governors of several mining states were among those who opposed it before the committee. Reasons advanced by opponents of the bill covered a wide range, and included the broad question of states' rights, and waste of public money by duplication of the services of state mining departments, which were represented as doing excellent work. Many opponents sent their statements to the committee.

With the opening of the 77th Congress in January, 1941, two bills for federal inspection of mines were introduced in the House. The original bill was offered by a representative from West Virginia who had opposed it in the previous session. In the interim an explosion had occurred in a mine in his home district. Another bill (H. R. 2082), with minor differences, was passed by the House in March without a record vote, and with none speaking in opposition. The bill was concurred in by the Senate in April. The greater part of the short time the bill was on the floor of the House for passage was taken up by members who had previously opposed it, but who now took the opportunity to explain for the record why they were no longer against it. Undoubtedly the record of explosions in 1940 was influential, if not the determining factor in bringing about this change of opinion in the House. In fact, news of an explosion, with four fatalities, in a Pennsylvania mine [1] was announced from the floor of the House while the bill was under discussion there. In this there was no departure from the usual pattern; dead miners have always been the most powerful influence in securing passage of mining legislation.

[1] Revloc, Cambria County.

From the first introduction of the bill in 1939, Coal Age opposed it, using such terms as "vicious" and "monstrosity" in describing it, but at the same time warning the industry that opposition alone would not obtain its defeat. In succeeding editorials Coal Age advised counter activities by working for improvement of state mining departments and their services through more adequate appropriations, removing them from political influences, more inspectors, and giving inspectors civil service protection. But it conceded the enactment of the bill some time before its passage by the House. "The series of major coal-mine disasters of 1940," said Coal Age, "set the stage for such action. When the public oratory is unleashed, the bitter fact that the measure will not live up to the specious promises of its proponents will carry little weight." But Coal Age continued to insist that it was "the job of every forward-looking coal-mine executive and operators' association" to seek improvements in state mining departments.[1]

Giving full credit to the editor of Coal Age for sincerity in this advice, the spectacle of representatives of the coal industry hurrying to their respective state capitals to demand improvement in mine inspection standards and law enforcement is so unrealistic and unprecedented as to be almost a grim joke. But the fact that Coal Age suggested it shows how complicated and many-faceted is the task of achieving safe operation of coal mines.

The new federal mine inspection act gives the Bureau authority to make annual "or necessary" inspections and investigations in coal mines for the purpose of obtaining information "relating to health and safety conditions." When such arrangements are agreeable, the Bureau is to co-operate with state mining departments in making inspections. All reports of in-

[1] Coal Age, vol. 46, no. 2, February, 1941, p. 42. See also vol. 45, no. 3, March, 1940, p. 31, and vol. 44, no. 7, July, 1939, p. 32.

spections are to be made available to the public. The act includes a section requiring mine owners and operators to report to the Bureau, on request, details of all fatal and nonfatal accidents. This section of the act should have the effect of improving the accuracy of mine accident statistics, which have never been completely satisfactory, particularly with regard to lost-time accidents. Inspectors will be appointed, subject to civil service laws, and are required to have

> . . . the basic qualification of at least five years' practical experience in the mining of coal, and . . . recognized by the United States Bureau of Mines as having the training or experience of a practical mining engineer in those essentials necessary for competent coal-mine inspection.

Although an important step in the long fight for mine safety, no immediate improvement in safety conditions in the mines can be expected as a result of the passage of this act alone. Considerable time will be needed to recruit and train a force of inspectors, and the number eventually needed to meet the requirements of the law will depend upon experience. The act authorizes appropriations to carry out its provisions, but the number of inspectors that can be put to work depends on the amount of money Congress appropriates for that purpose. While estimating that 250 inspectors would be an adequate force, the Bureau of Mines asked for and obtained an initial force of 107, because of objections by the Bureau of the Budget.[1] From information available, the salaries proposed for inspectors, while not high, appear to be sufficient to attract competent men.

Adequate salaries are necessary not only to attract men to the service, but to avoid losing them once they are trained in

[1] See Coal Age, vol. 46, no. 8, August, 1941, p. 92, news item on number of federal mine inspectors for the initial staff, and salaries in various categories.

the inspection methods of the Bureau. If the present pressure for safer conditions in the mines continues, mine operators may be expected to look in the direction of the Bureau's inspection force when engaging safety directors for their mines. While the Bureau doubtless would favor the choice of men trained under its auspices to have responsibility for safety, any further drain on the federal inspection force resulting from inadequate salaries would have a tendency to endanger the effectiveness of the service. Adequate salaries for federal inspectors will also serve as an example to mining companies, many of which expect to get results from a safety department manned by a mediocre staff at low salaries.

The proposal of the Bureau of Mines to include a number of electrical inspectors, and eventually to train all its inspectors in this branch of its service, cannot be commended too highly. Although electricity has been used in the mines for more than forty years, and few present-day mines are without it, most state mining departments and state mining laws pay too little attention to electrical hazards. Most state mine inspectors are good mining men, but few among them know enough about electricity and electrical machinery to make adequate recommendations on electrical hazards. Those who have some knowledge of electricity may be hampered by the inadequacy of their state mining laws. If this action of the Bureau of Mines results in greater emphasis in state mining laws and mine inspection services on electrical hazards, and more general employment of electrical inspectors by state mining departments, a long step toward safer mining will have been achieved.

The new federal inspection act does not give the Bureau of Mines power to enforce its recommendations. This authority remains with the officials of the several state mining departments, who may order application of all or none of the federal inspectors' recommendations, as they see fit, or as they may be

restricted by inadequacy of state laws. The act depends upon moral pressure through giving publicity to the facts, although the beneficial results on state mining inspection services from frequent contacts of state mining department officials and inspectors with the federal inspectors should not be minimized.

The following paragraphs of section 6 of the federal inspection act authorize the Secretary of the Interior, through the Bureau of Mines:

(b) To compile, analyze, and publish, either in summary or detailed form, the information obtained by him under this Act, together with such findings concerning the causes of unhealthy or unsafe conditions, accidents, or occupational diseases in coal mines, and such recommendations for the prevention or amelioration of unhealthy or unsafe conditions, accidents, or occupational diseases in coal mines as he may deem proper;

(c) To prepare and disseminate reports, studies, statistics, and other educational materials pertaining to the protection or advancement of health or safety in coal mines and to the prevention or relief of accidents or occupational diseases in coal mines;

(f) To make available for public inspection, either in summary or detailed form, the information obtained under this Act, as soon as practicable after the acquisition of such information.

Section 7 provides that

. . . copies of all findings, recommendations, reports, studies, statistics and information made public under the authority of clauses (b), (c), and (f) of section 6 of this Act shall, whenever practicable, be furnished any cooperating State or Territorial agency which may request the same.

Apparently the foregoing sections of the law give authority for the two immediate parties concerned—the management of the mine inspected, and the mine workers through their local union—to be furnished with a copy of the inspector's report containing his findings and recommendations, or that a copy be

posted at the mine, where all interested persons may read it. Posting of state inspectors' reports is a custom of long standing and has been provided for in the laws of practically all coal-mining states. One or the other of these means appears to be the most effective method immediately to acquaint mine workers with the contents of inspectors' reports, although at the time of writing these details have not yet been worked out by the Bureau of Mines.[1]

Besides bringing pressure through publicity on operators who persist in neglecting safety conditions in their mines, federal inspection will act as a check on adequacy of state mining laws and enforcement standards. Findings and recommendations of inspectors of the Bureau of Mines will be based on the Bureau's standards of safety, and will not be limited to those set by the mining law of any particular state. Employes of the Bureau enjoy an excellent reputation as experts in safety, and are so regarded by all groups connected with the industry. Some criticism has been made of administrative policies of the Bureau, but the honesty and capability of its engineers and technicians are generally recognized. Despite possible mental reservations on the part of higher officials of a few state mining departments in the beginning, cordial co-operation with the federal inspection service may be expected from most of them, even though federal inspectors' reports may at times reveal serious inadequacies in standards of inspection and law enforcement in the state departments.

Most state inspectors may be expected to welcome the opportunity to accompany federal inspectors making inspections in their districts, for the sake of the knowledge and experience

[1] Recent amendments to the Ohio mining laws provide that in mines where the "miners have a mine safety committee" a copy of the state inspector's report be furnished to the committee, in addition to the copy posted at the mine. This is excellent procedure, and there is no good reason why it should not be adopted by the federal inspection service.

they will gain through such association. Discrepancies in state inspection reports, due to lax inspection and low standards of enforcement, revealed by federal inspectors' reports, will eventually, if not at once, lead to adoption of higher standards by state departments, with demands on state legislatures for more adequate laws where such steps are necessary. Improved and more uniform state mining laws, higher standards of inspection and law enforcement, more adequately financed state mining departments, adequate staffs of fully qualified state inspectors, and establishment of adequately equipped and staffed state mining department laboratories, are not too much to expect eventually to result from federal inspection of mines. And there are few coal-mining states in which all or most of these suggested improvements are not badly needed.

Section 8 of the act, which has received little publicity, but which may prove of considerable influence in determining the benefits to be derived from the new law, provides that the Secretary of the Interior "may, in his discretion, create and establish an advisory committee composed of not more than six members to exercise consultative functions, when required by the Secretary, in connection with the administration of this Act." Operators and mine workers are accorded equal representation on this committee. Although there is nothing to indicate that the role of such a committee will be so limited, even a mere frank exchange of views exploring the whole subject of accident prevention, long ignored in official meetings between representatives of miners and of operators, would be an encouraging beginning. The larger possibilities of this committee will depend on the manner in which the subject is approached, and the willingness of leaders in the industry to make a serious and sustained effort to reduce accidents.[1]

[1] The advisory committee was appointed on August 23, 1941, by the Secretary of the Interior and held its first meeting with officials of the Bureau of Mines

Suggested Program for Miners' Safety

Coal mining is inherently a dangerous occupation; and as long as it remains necessary for men to go into mines to get out coal, it may be expected that some will be killed and maimed in the process. But the technical knowledge available leaves no excuse for continuance of the present high accident rate. The question is not whether the number of mine accidents can be reduced, but how much they can be reduced, and how soon this can be accomplished. Officials of the Health and Safety Branch of the United States Bureau of Mines estimate that it is possible to lessen the present figure by 75 per cent, that is, to decrease the present annual average of 1,200 deaths to 250 or 300, with a commensurate reduction in nonfatal accidents. That such an improvement is feasible may be startling to many, but its reiteration in a recently published article by the Secretary of the Interior, of whose department the Bureau of Mines is a part, gives the estimate official status.[1]

Such a reduction can be achieved only with proper organization and co-operation of all mine-safety agencies. Although the authority of the United States Bureau of Mines remains limited, federal inspection of mines will put the Bureau more closely in touch with the industry and bring about a wider ac-

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on September 3. Details of the organization of the inspection staff, and methods of giving publicity to inspectors' reports were discussed. Members of the committee were: Thomas Kennedy, secretary-treasurer, United Mine Workers of America; John T. Jones, president, District no. 16 (Maryland), United Mine Workers of America; Percy Tetlow, industrial representative, United Mine Workers of America; Cadwallader Evans, Jr., vice-president and general manager, Hudson Coal Company, Scranton, Pa.; L. C. Campbell, general manager, Koppers Coal Company, Pittsburgh, Pa.; and T. J. Thomas, president, Valier Coal Company, Chicago, Ill. (United Mine Workers Journal, September 15, 1941, and Coal Age, vol. 46, no. 10, October, 1941, p. 150.)

[1] Ickes, Harold L., "Federal Mine Inspection," in American Labor Legislation Review, vol. 31, no. 2, June, 1941, pp. 53-56.

ceptance of its safety standards and procedures, particularly by state mining departments, and probably, in the beginning, to a lesser extent by management. To the degree that state mining departments are influenced, improvement in state mining laws may be expected to follow. But the attitude of operators toward safety, and the extent to which managers are willing to co-operate with mine workers as a group through their union, will be the chief factors in determining whether the saving of miners' lives considered possible by the Bureau is eventually realized. All mine-safety agencies must work together.

MANAGEMENT

The primary obligation of management to provide and maintain safeguards against accidents can be effectively fulfilled only by a carefully planned and executed safety program. Management should not only take advantage of all available technical knowledge, but should work in close co-operation with the other agencies interested in safe operation—mine workers, state mining departments, and the United States Bureau of Mines. Such a plan should include:

(1) A voluntary code of safety standards based upon complete compliance with all applicable sections of state mining laws and with safety standards and procedures of the United States Bureau of Mines, including the Bureau's Mine Safety Board Decisions, and provision for conditions and hazards peculiar to the mine or mines for which the code is made.

(2) A safety department, organized as an autonomous part of the management organization, with clearly defined powers and duties, and held strictly to account on the basis of results, to enforce the code; and to check for new hazards, before their introduction, plans for any proposed changes in systems or methods of operation, installation of new types of machinery

and equipment, changes in blasting methods or materials, opening of new developments, and any new construction.

(3) Establishment, under supervision of the safety department, of a mine-rescue station containing an adequate number of sets of oxygen-breathing apparatus, gas masks, and gas-detecting devices, available for use in emergencies, and a course of instruction to train employes in their use.

(4) Recognition of the mutual interest of management and mine workers in safe operation, and that co-operation between them in safety planning can best be expressed through the process of collective bargaining.

MINE WORKERS

(5) The mine workers can improve safety conditions by demanding, through their local safety committees, complete compliance with state mining laws and United States Bureau of Mines safety standards, as this lack may be revealed in the mines by reports of state and federal inspectors; by raising the question of increased hazards involved in multiple-shift operation and on-shift blasting; the need for use of water to allay coal dust at the face, for rock-dusting or redusting, and for periodic analyses of air and dust samples; to increase their opportunity to share in safety planning by insisting that the collective bargaining process be applied to all matters affecting safety; and to demand that state mining laws be brought up to date, particularly with relation to new hazards created by mechanical mining.

THE STATES

(6) State mining laws should be revised to cover more fully the hazards of present-day mining methods; to empower state mining boards, after public hearings, to promulgate and enforce safety regulations to cover new hazards as they appear,

or old hazards not specifically covered by law; to provide for adequately financed state mining departments, free from political influence, with adequate staffs of fully qualified inspectors, including electrical and other necessary specially qualified inspectors; and to provide, in the larger mining states, for establishment of adequately staffed and fully equipped research laboratories.

THE FEDERAL GOVERNMENT

(7) The staff of the mine inspection service of the United States Bureau of Mines should be enlarged beyond the initial number provided for; more funds should be made available for dissemination of information on safety conditions in mines as revealed by the federal inspection service, as well as for other investigations and experiments of the Bureau; sufficient funds should be made available for a thorough study of new hazards created by mechanical mining, particularly in relation to multiple-shift operation, increased and concentrated electric-power load, blasting practices, increased methane liberation, and ventilation. Funds should also be provided for a statistical study of the relative frequency of accidents in mechanized mines as compared with hand-loading mines, and separately, in one-, two-, and three-shift mechanized mines. Most important in effecting the purposes of the federal Mine Inspection Act would be an amendment to give power to the United States Bureau of Mines to enforce compliance with recommendations of its inspection service.

(8) The advisory committee composed of equal representation of operators and miners, provided for by section 8 of the federal mine inspection law, affords an excellent opportunity for discussion by leaders of these groups of some of the broader aspects of safety planning. An urgent problem is the formulation of a standard code of electrical installation in coal mines.

This matter, as well as the broader aspects of multiple-shift operation, should receive the immediate attention of the advisory committee. In general, this committee can be made the means for the much needed co-ordination in the efforts for safety by management, mine workers, and governmental experts.

The Need for Workers' Participation

It is abundantly clear that coal-mine management has failed in its responsibility to prevent needless accidents. Long experience has amply demonstrated that state laws alone cannot be relied upon to secure safe conditions. Basically, the problems involved in reduction of mine accidents do not differ from those encountered in other industries. The remedy lies primarily in providing safer physical surroundings in which to work. That the coal industry is strongly influenced by tradition and is hostile to change may be given as a reason, but cannot be accepted as a valid excuse for failure to provide these essentials to safe operation.

Adequate lighting and ventilation are important elements in safe and efficient operation in any industry. The coal industry has neglected to take advantage of the progress made in either of these essentials, while manufacturing industries have largely abandoned natural light for more efficient artificial lighting, and air conditioning in manufacturing plants has gone far beyond the experimental stage. The incentive for this improvement in manufacturing industries has been greater efficiency, and its corollary, greater safety. But, paradoxically, in mines, where light and ventilation must of necessity be supplied by artificial means, little improvement has been made over methods used in the early years of the industry.

A recent notable example of air conditioning in manufacturing industries is a new airplane-engine plant recently built

in the Middle West. A ventilating system puts 2,000,000 cubic feet of air per minute into this $23,000,000 building, changing the air completely every ten minutes. The building has no windows for natural ventilation; air conditioning supplies this need, as well as providing controls for temperature, humidity, and dust. The 2,000,000 cubic feet of air per minute put into this plant may be compared with the 271,000 cubic feet per minute sent into the mine at Bartley, West Virginia, which, as already shown, is one of the most gassy mines in the United States; or the 100,000 cubic feet per minute put into the Sonman "E" Mine, which is also rated as gassy.

The primitive state of lighting in coal mines may be inferred from the number of state laws to force placing of stationary lights at key points along main haulageways, and headlights on haulage locomotives. The miner's cap lamp, although now of somewhat higher candlepower than the lamp of two hundred years ago, still remains the source of light by which work is carried on in coal mines. Moreover, the miner pays for it. To ask a worker in a manufacturing plant to supply and pay for light by which to work would seem to approach the ridiculous. Nevertheless this is a prevailing practice in coal mines. Inadequate ventilation and poor lighting are contributing factors in many accidents commonly attributed to other causes. The maximum in safety cannot be attained until these conditions have been remedied.

The causes of industrial accidents are to be found in the day-to-day operations. Continuously changing conditions in workplaces in coal mines present unique safety problems not present under the more static conditions found in manufacturing plants. But these impediments to safety in coal mines can be overcome by an adequate safety program. Constant watchfulness is required to meet these changing conditions, not only by providing defenses against new hazards as they

appear, but by maintaining the efficacy of defenses already set up. It is in this field that workers' participation in accident prevention will bear fruit, by their demands for a high standard of safety, and insistence that it be maintained.

Nor is this demand for workers' participation in matters of safety confined to coal mines. Already in certain mass-production plants, union shop stewards, as a part of their regular duties, report to the plant safety inspector, for immediate attention, unsafe conditions observed by them; and in emergency the workers' representative even has the power to order work to cease at once on any job that appears sufficiently unsafe to expose a worker to immediate danger of injury. The effect on industrial safety of widespread acceptance of such participation by workers' representatives is obvious; but prejudices, based on antiquated conceptions of the rights of management, will need to be broken down before the full benefits of workers' participation can be realized. Similar prejudices with regard to collective bargaining on wages and hours have gradually been overcome. Acceptance of unionism in the coal industry gives ground for hope that collective action will become the practice also in matters relating to safe operation.

In our industrial society, when any group fails to live up to its obligations to the community, other groups must eventually assume that responsibility. The community has already intervened in the coal industry through enactment of mine-safety legislation, but has been only partly successful. The mine-workers, through their union safety committees, are now demanding the right to share in the work of making the mines safe. This demand has behind it the social force generated by the failure of operators to provide safe conditions, just as in the history of unions the demand of the workers for a voice in determining wages, hours, and other working conditions has

been motivated and re-enforced by the failure of employers to make possible adequate living standards.

The community, which is ultimately responsible for safety, must now give support to state and federal agencies for enforcement of mining laws and require high standards of administration. This in itself will promote the equally urgent joint planning by management and mine-workers, which alone can insure greater safety as a permanent feature of new mechanized mining, instead of its new hazards.

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Index