A summary was presented of the Bureau's thin section petrographic work from its beginning to 1956.16/

Mild Chemical Treatment

Studies of coal structure have been hampered by lack of a method for reductive degradation of coal at low temperatures. Metals in liquid ammonia reduce many organic sutstances, including lignin; however, the insolubility of coal in ammonia renders this reagent useless. Lithium in ethylenediamine, a good coal solvent, was found to be effective in reducing phenols and polycyclic aromatic hydrocarbons.17/ Four coals of varying ranks and a pyridine-soluble extract of one of them were reduced by lithium in ethylenediamine at 90°-100° C. Comparison of the infrared and ultraviolet spectra of the reduced coals with those of the untreated coals showed direct addition of hydrogen to carbon, a decreased number of oxygen linkages, and decreased aromatic structure. The pyridine extract showed further reduction than the coals. This reagent reduced even an anthracite, its hydrogen content increasing 1.3 percent by weight.

Researchers studied another low-temperature hydrogenation reaction: Two coals were treated with an equimolar mixture of $CO+H_2$ in the presence of dicobalt octacarbonyl at 200° C. Infrared analysis of the products showed that carbonyl and hydroxyl groups had been added and hydrogenation had occurred. This is the first example of the addition of molecular hydrogen to coal at temperatures as low as 200° C. These experiments also indicated the presence of nonaromatic double bonds in coal. Optimum conditions for reducing and solubilizing coal are being investigated to provide samples for an intensive characterization study.

Previous work has shown the merits of hexamethyldisilazane, $(CH_3)_3SiNHSi(CH_3)_3$, for quantitative determination of hydroxyl groups. More than 20 coals of varying rank have been treated with this reagent and the resulting silyl ethers analyzed for silicon. From the silicon analyses the percentage of oxygen present in the coals as hydroxyl groups has been calculated. Plots of hydroxyl content as a function of rank or of carbon content indicate that for coals of carbon content up to about 80 percent the hydroxyl groups are approximately 5 percent by weight of the coal; above 80-percent carbon content, the percentage of hydroxyl groups steadily decreases to zero at about 94 percent carbon. The ratio of oxygen present in hydroxyl groups to the total oxygen content shows a maximum value of about 50 percent for a coal of about 81 percent carbon; this ratio decreases continuously to values of about 10 percent for lignite and anthracite.

Humic Acids

Humic acids, essentially a class of hydroxy carboxylic organic acids available from oxidized coal or humic soils, are readily obtained from naturally or

16/ Parks, B. C., and O'Donnell, H. J., Petrography of American Coals: Bureau of Mines Bull. 550, 1956, 193 pp.

17/ Reggel, L., Friedel, R. A., and Wender, I., Lithium in Ethylenediamine; a New Reducing System for Organic Compounds: Jour. Org. Chem., vol. 22, No. 8, August 1957, pp. 891-894.

artificially oxidized lignite, and their investigation may serve two purposes: Ultimate utilization of the acids as such or as intermediates and their use in solving problems of coal structure and coalification. Samples of oxidized lignite from large deposits in southwestern North Dakota, locally known as leonardite, were extracted with mild alkali, dissolving essentially all but the inorganic mineral content. This alkali-soluble material, recovered by acidifying the caustic solution and collecting the precipitated acids, was fractionated by extraction with various organic solvents. This work is continuing, and the object is to further simplify fractions so that basic units of the original acid complex may ultimately be identified.

Pulverized samples of a "normal" lignite were oxidized in air at 100°-150° C., and the product was extracted as in the case of leonardite. This material appears to be quite similar to the soluble portions obtained from naturally occurring leonardite. On the other hand, H:C and O:C ratios differ somewhat between leonardite and oxidized lignite, indicating the possibility of chemical structure differences between the two materials.

High moisture-holding capacity is characteristic of both humic acids and lignite, and a paper has been published on determination of moisture in lignite.[18]

Microbial Degradation

Further studies of bacteriostatic and fungistatic materials in coals have shown that extraction of the active portions of methanol-soluble material with water may increase the activity roughly three- to five-fold. A five-fold increase in activity brings the potency of the material to within 1/300 to 1/500 that of the antibiotic penicillin. A large sample of methanol-soluble material has been obtained by treatment of a 20-pound coal sample; an attempt will be made to concentrate the active principle from this material.

The best growth of organisms on coal to date has been found in two mold cultures isolated from an Illinois coal from the Eddy Mine. One of the cultures is an *Aspergillus*; the other is as yet unidentified. The cultures have been carried through a number of transfers in a medium containing 4 percent of the coal as the sole carbon source, and growth has been maintained with no nutrient additions to the medium.

Additional studies on the oxidation of polycyclic aromatic compounds[19 20] by bacteria confirm the hypothesis that different enzymes are formed in response

18/ Fowkes, W. W., Hoeppner, J. J., and McMurtrie, R., Some Notes on the Determination of Moisture in Low-Rank Fuel (Lignite): Fuel, vol. 36, No. 4, October 1957, pp. 469-474.

19/ Rogoff, M. H., and Wender, I., The Microbiology of Coal. I. Bacterial Oxidation of Phenanthrene: Jour. Bacteriology, vol. 73, No. 2, February 1957, pp. 264-268.

20/ Rogoff, M. H., and Wender, I., 3-Hydroxy-2-Naphthoic Acid as an Intermediate in Bacterial Dissimilation of Anthracene: Jour. Bacteriology, vol. 74, 1957, pp. 108-109.

to linear polycyclic aromatic hydrocarbons (anthracene) as opposed to angular polycyclics (phenanthrene).

Irradiation of Coal

Five coals subjected to pile irradiation by the Federal Geological Survey have been investigated by infrared and by electron resonance. The greatest change in these irradiated coals was a pronounced increase in hardness. The infrared spectrum for each irradiated coal was more diffuse than that of the nonirradiated coal, but the characters of the spectra were identical. The results indicate that the apparent rank of the coal had not been changed, as had been postulated from changes in carbon-hydrogen ratios. Free-radical contents of these five coals were investigated before and after pile irradiation. The two highest rank coals (about 90 percent carbon) showed a five-fold increase in free-radical content, but the lower rank coals showed no increase.

A small amount of soluble material extracted from a coal subjected to gamma radiation in a carbon tetrachloride slurry was obtained from another laboratory. The infrared spectrum of this product differed considerably from the spectrum of the original coal.

A book on the chemistry and physics of coal was reviewed.[21/]

EXPLORATION AND MINING

Exploration of Alaska Coals

The Bureau of Mines is cooperating with other Federal agencies in an effort to develop a coal-mining industry in Alaska to supply the increasing solid-fuel requirements for both military and civilian installations. The work includes trenching and diamond core drilling to determine the position, size of reserves, and quality of coalbeds where these data are not known.

Both churn- and core-drilling were continued throughout the 1957 field season in the western part of the Wishbone Hill district, Matanuska coalfield (fig. 1). This coalfield has been studied for many years and contains both bituminous and subbituminous coal.[22/] The objective of the drilling was to obtain data on the location and character of the coal measured. Several beds intersected and correlation of their location with known series of the beds is in progress.

The Bureau of Mines conducted a reconnaissance examination of the less accessible parts of the Beluga coalfield in August 1957 (fig. 2). This coalfield, 50 (airline) miles west of Anchorage, is of increasing interest as a possible source of large tonnages of strip coal for on-site production of power.

21/ Howard, Henry, C., Book Review of Coal Science: Scientific Monthly, vol. 85, No. 5, November 1957, pp. 278.

22/ May, R. R., and Warfield, R. S., Investigation of Subbituminous-Coal Beds Near Houston, Westward Extremity of Matanuska Coalfield, Alaska: Bureau of Mines Rept. of Investigations 5350, 1957, 20 pp.

Technologists examined 13 separate coal outcrops from which 8 samples were taken. The coal is of subbituminous rank. Further investigation will be necessary to determine the extent of possible strippable coal.

Anthracite Mining

Longwall Mining

Since 1945 mining engineers have initiated and conducted experiments for planing coal and for a roof-support system (yielding steel props) applicable to longwall mining. The results of experiments with the Bureau-designed pneumatic coal planer have been published.23/ In the Northern anthracite field, where continuous miners, universal shearers, mobile loaders, and shuttle cars cannot be used in seams with a pitch greater than 10°, full mechanization of the longwall caving system might be applied to recover the millions of tons of coal in seams with pitches from 10° to 20°. A cooperative agreement has been made to test this method in an operating mine. The block of coal to be mined in this experiment is approximately 1,200 feet in length, providing for 200 days of operation with an average advance of 6 feet per 24-hour day.

Scraper-Shaker Loader

Several years ago the Bureau designed a scraper-shaker loader employing the relatively low-cost, low-maintenance scraper in combination with a shaker conveyor for developing gangways in thin (4 to 8 feet thick), steeply pitching (60° or more) beds. Investigations disclosed a location in the Western Middle field of the Anthracite region where a new rock slope was to be driven from the surface to develop a new section of a mine in which the machine could be tested. In this test the machine was modified by removing the shaker drive and rear suspension bridge, and the slope was driven 200 feet, the limit originally established for penetrating the bed to be mined. The scraper-shaker loader removed blasted material in one-fourth the usual time, with one-fourth the number of men - a sixteenfold improvement over conventional hand-loading methods.

Mine-Drainage Control

A joint Federal-State program for controlling water in anthracite mines was initiated in 1955 under enabling legislation of the Congress of the United States and of the General Assembly of the Commonwealth of Pennsylvania. A total fund of $17 million was provided for the installation of surface drainage works, pumping works, and related facilities for controlling and draining water, which, if not so controlled or drained, would cause flooding of anthracite formations. Two projects were approved in 1956, and an additional 14 were approved in 1957. The first project to be completed under the program was installation of concrete flumes and pipes in the stream bed of Boston Creek in Luzerne County (fig. 3). The need for this improvement has been shown by the fact that water 6 to 9 inches deep now flows through the flume for several days

23/ Buch, J. W., Griffith, W. R., and Schimmel, J. T., Design and Testing of Bureau of Mines Pneumatic Coal Planer: Rept. of Investigations 5380, 1957, 25 pp.

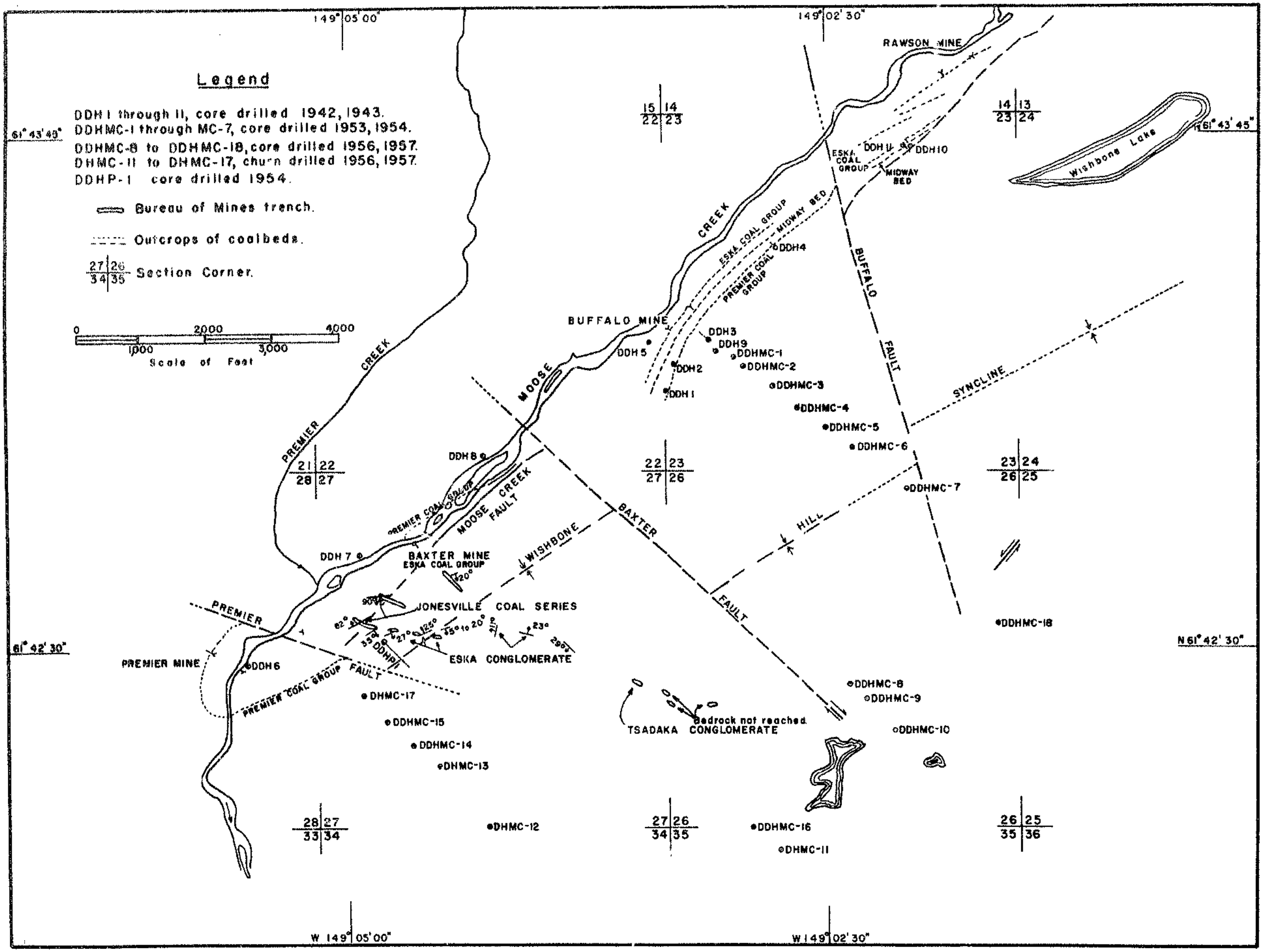

FIGURE 1. - Western Part of Wishbone Hill District, Matanuska Coalfield, Alaska.

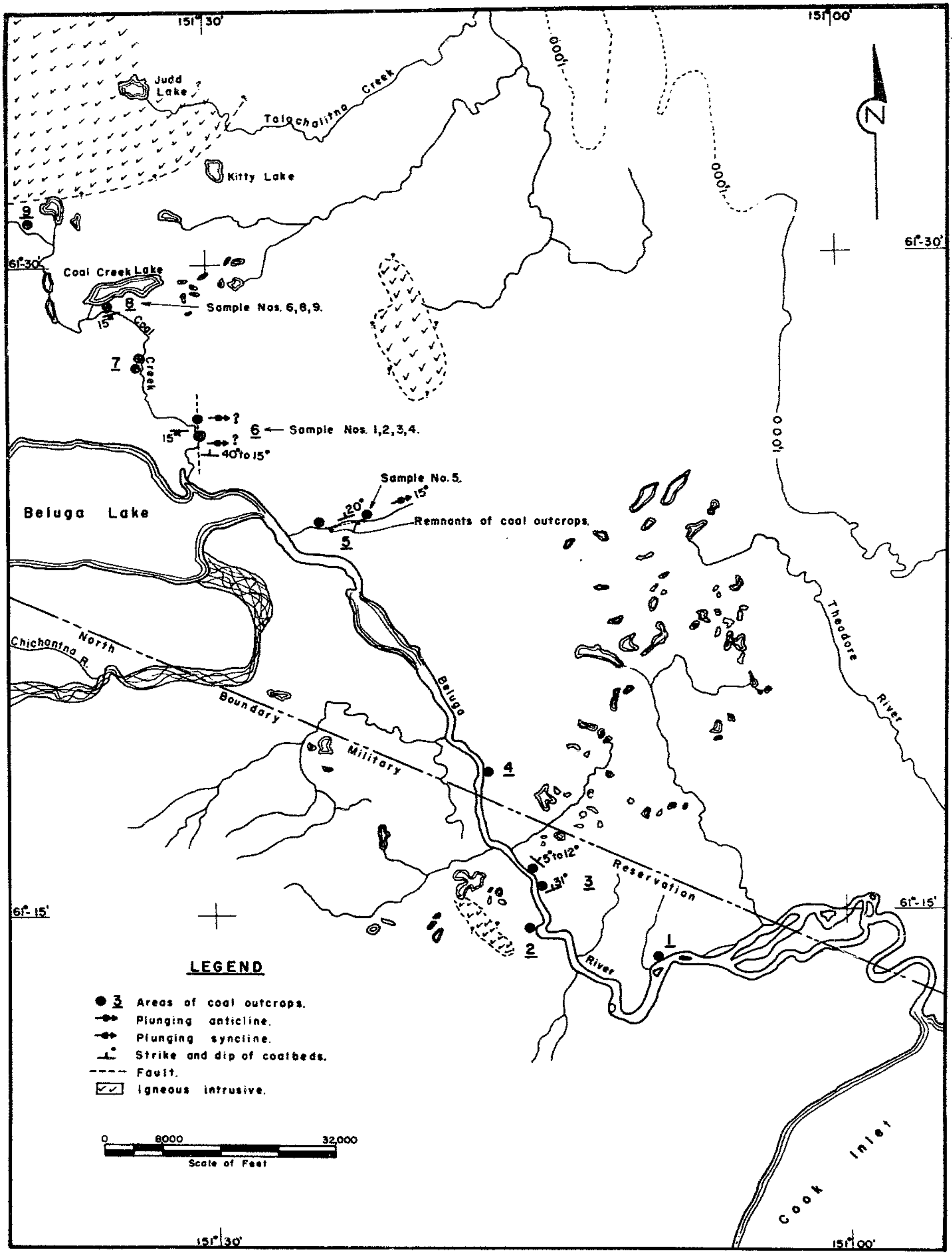

FIGURE 2. - Coal Outcrops Near Beluga Lake, Alaska.
(Modified from Map of U.S. Geological Survey.)

after a heavy rain. Before this project was constructed there was virtually no flow of water in the creek bed after heavy rains because all the surface water reaching the creek seeped through broken rock strata into the underground workings.

FIGURE 3. - Improvement of Stream Bed, Boston Creek, Larksville, Pa.

Bituminous Coal Mining

The objective of the work on bituminous coal is to develop improved methods for: (1) Increasing the rate of production to reduce the cost of coal and (2) increasing coal recovery in mining to conserve natural resources. Data on various mining methods and performance of equipment are collected, compiled, evaluated, and published so that the results for given operating conditions can be compared.

Longwall Mining

Longwall mining of thin beds of coal with a German coal planer has proved successful. A report has been published summarizing, to June 30, 1957, the planer operations at five coal mines.[24] When the publication was prepared,

24/ Haley, W. A., and Dowd, J. J., Modified Longwall Mining With German Coal Planers. Summary of Operations at Five Coal Mines: Bureau of Mines Rept. of Investigations 5355, 1957, 31 pp.

one of the planers had been taken out of service because the coal being mined was too hard. Another planer was just being placed in operation but had not produced any coal. The total production to the end of 1957 was 2,381,546 tons.

Recovery of coal by the longwall method can be increased by recovering some of the chain pillars now left unmined in the sets of entries driven to develop the longwall faces. Some experimental work will be needed to explore this possibility. Also, if a suitable automatic advancing prop can be developed, the manpower needed at the face could be reduced materially.

Methods and Equipment for Underground Development

A report on methods and equipment used in underground development by bituminous coal mines was published.[25] A study of 14 mine operations shows that modern development methods permit close supervision owing to close proximity of the working faces. Efficient use of machinery is possible because long moves of equipment are unnecessary. Each member of a development unit can operate each machine used, and therefore all work together as a team. The width of development openings approaches or equals that of a production place, and there is little difference in the tonnage from each class of opening. As was expected, the output per man-shift was largest with continuous-mining machines.

Roof Bolting

Studies to compare roof bolting with timbering used for mine roof support were continued at mines in Ohio, northern West Virginia, and Pennsylvania. Fieldwork is still in progress. Detailed studies have been made at two mines in Ohio, two in northern West Virginia, and one in western Pennsylvania during the year. Recent studies indicate that roof bolting is preferred over conventional timbering in some mines where the roof is considered tender. In fact, some mines use roof bolts in conjunction with timber to support tender roof.

Systems and Equipment for Face Haulage

The introduction of continuous-mining machines created a new haulage problem. The coal could not be moved away from the machines fast enough. This resulted in lost time for the mining machine until the mined coal could be moved. Systems of face haulage and equipment used in this phase of mining are being studied to determine the best systems of face haulage. Studies have been made in 12 mines in which various combinations of methods and equipment can be used. At each mine where more than one system is in use they are compared to determine the relative efficiency.

Recovery of Coal

The percentage of coal recovered in mining varies with the coal beds and methods of mining. In mines where pillars are not recovered and no complete

25/ Shields, J. J., Dowd, J. J., and Haley, W. A., Mechanical Mining in Some Bituminous-Coal Mines. Progress Report 8. Methods and Equipment Used in Underground Development: Bureau of Mines Inf. Circ. 7813, 1957, 66 pp.

record of production is available the calculated recovery must be based on the measured area of the remaining pillars, as shown on the map of a mined area. Where pillars are recovered, the percentage of recovery must be calculated from production records. These records are not always obtainable due to incomplete records or transfer of ownership. Recoveries have been calculated for five mines operated in the Upper Freeport and two in the Pittsburgh bed. Where pillars were not removed, recovery ranged from 50 to 60 percent; where pillars were removed, it ranged from 80 to 88 percent.

Augers for Surface Mining

Augers are used principally in surface mining to recover coal that cannot be mined by conventional methods. With augers, coal can be recovered near the outcrop under top that is too weak for underground mining or under too much cover to be strip mined. Auger mining requires only a few men, and the output per man-shift is larger than that from either underground or strip mining. In a recent publication the operation at eight mines revealed that, although coal can be produced cheaply by this system of mining, the recovery in mining ranges from 20 to almost 50 percent.[26]

Foreign Activities

The Bureau of Mines continues to support a program of technical assistance to friendly nations for the development of their solid fuels resources in cooperation with the International Cooperation Administration, U. S. Department of State. Inadequate health and safety measures and a shortage of trained personnel for mining operations are problems of greatest concern to Bureau engineers assigned to technical assistance posts in Afghanistan, Colombia, and Indonesia, where coal production must be increased to encourage the industrial growth of these countries.

Bureau facilities and personnel in the United States support the work of the field staff by laboratory research and by training foreign nationals in all subjects regarding exploration, mining, and utilization of coal. Eleven foreign engineers were accepted during the year for training at Bureau facilities. In addition a Bureau team of health and safety engineers conducted a 4-month training course in mine rescue and first aid for 587 employees at Mexican mines to improve standards of safety in that country.

Afghanistan

The lack of mining timber in Afghanistan has retarded development and production at the country's two producing coal mines, Karkar and Ishpushta, where bad roof conditions add hazards to generally unfavorable mining conditions. Tree gardens must be planted as part of all mining operations, and past experience shows that a 10- to 12-year growth is required to produce softwood suitable for underground roof supports. The mining companies have acknowledged the success of these experiments, and larger areas of irrigated land are being

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26/ Haley, W. A., and Dowd, J. J., The Use of Augers in Surface Mining of Bituminous Coal: Bureau of Mines Rept. of Investigations 5325, 1957, 22 pp.

acquired for cultivating approximately 100,000 trees that will be needed for future mine operations.

The Afghan Government has purchased 100 American trucks for transporting increased tonnages of coal from the Karkar and Ishpushta mines to industrial and domestic markets. A Swiss briquetting machine is now being assembled in Kabul. Degradation in handling and shipment of the friable coal has limited its use as domestic fuel; to increase domestic consumption, briquets will be made from low-grade coal mixed with ground cottonstalks as a binder.

Completion of a powerline between the mine and the hydroelectric plant at Pul-i-Khumri improved ventilation at the Karkar mines by permitting electrification of mine fans. Modest improvements have been made in living accommodations for the workers at the mine, and health and safety centers at each mine have been provided with medical equipment and medicines. Mine-accident and minor surgery cases can now be handled promptly, and the patients are given post-surgery care for a few days at the health centers.

Development of the Darra-Suf coalfield is still in the planning stage and will not be started until a decision is reached regarding the location of a road needed for transporting coal.

Colombia

A reported reserve of over 200 million tons of coal in the El Valle and Cauca areas of Colombia can be the basis of a substantial and profitable coal industry if the many small and poorly equipped mines in the area are organized under some plan whereby a dependable source of export-quality coal can be established and an anticipated export trade can be realized.

A new coal washing and preparation plant was erected near Cali, in the Cauca Valley, by the Instituto de Fomento Industrial, a Colombian Government corporation responsible for industrial development. The plant operated throughout the year; although its mechanical performance has met all expectations in respect to the quality of coal produced, its potential benefits to the coal industry are not yet fully realized. The plant was built primarily to prepare coal of controlled quality for export markets. Plant operators purchase mine-run coal, and payments depend upon the percentage of mineral matter in the coal. On an average, the price paid at the washing plant is approximately $0.50 per ton less than the local market price, hence the tonnage delivered is far below the rated capacity of the plant.

One shipment of approximately 10,000 tons of washed coal was sent to France late in the year, but export shipments probably could be increased to more than 100,000 tons a year. Coal reserves, coal-preparation facilities at Cali, and transportation facilities for delivering coal to the docks at Buenaventura are all adequate for this tonnage. The principal need is financial and technical assistance for the small mine operators. Preliminary steps have been taken to provide financial assistance through loans to independent operators for purchasing equipment, and the technical assistance project has been extended to continue the advisory service, particularly in mine safety and mechanization, now being given by a Bureau of Mines engineer.

Indonesia

The Bureau assigned a coal-mining engineer early this year to Indonesia to assist the Indonesian Government in a development and expansion program for the coal industry, which, in recent years, has experienced a serious deterioration in efficiency.

Major coal production in the past has been from the Ombilin mine in central Sumatra and from the Bukit Asam coal mine in southern Sumatra. Present endeavors are aimed at reestablishing the Ombilin mine in its former position as a leading coal producer. Total reserves in range of present mine openings exceed 40 million tons of coal occurring in two main seams. Present production from underground mining operations is about 225 tons daily or approximately 75,000 tons a year. A newly established production schedule calls for an annual output of 300,000 tons, which should be attainable without an appreciable increase in the labor force.

The introduction of strip mining at the Ombilin mine has been proposed for one area and should yield approximately 500 tons of coal per day. Rehabilitation of underground workings and improvements in mining operations are expected to increase mine production to approximately 1,000 tons a day.

Seventy percent of the current coal production in Indonesia is from the Bukit Asam coal mine. The present production at this mine, amounting to approximately 20,000 tons a month, is by strip mining. A study is being made to assess possibilities of increasing production to supply part of the 18,000 tons of coal a month that will be required for a proposed powerplant at Surabaja.

The Bureau's engineer has prepared and submitted reports outlining procedures whereby production can be increased and improvements made in health and safety practices at the mines.

India

A Denver engineering firm, under the direction of Bureau engineers, has completed the design and fabrication of all major units for a complete pilot plant to crush, dry, briquet, and carbonize lignite. This pilot plant has been shipped to the Neyveli Lignite Corporation and will be erected at Neyveli, Madras State. The plant should be operating in May or June 1958; two Bureau engineers will then go to India to supervise initial operation and to work with Indian technologists in interpreting operating data and to assist in working out a program of further research directed toward utilization of lignite. Further details will be found under Utilization of Lignite From India, page 59.

Health and Safety

Roof Control

The expense of roof support ranks as one of the major items in the production cost of bituminous coal. To a considerable extent, roof bolting has offset this increase in cost by providing more unobstructed operating space than is provided with conventional timbering. Long haulways, airways, and unattended belt haulage systems have focused attention on the necessity of providing a stable roof to give greater security, continuity of operation, and a lower mine maintenance cost.

Roof bonding, or solidification of ground has been studied during the past year. Initially, experiments were conducted with oils to determine the extent of penetration at various pressures in different types of roof rock. Epoxy resins of various viscosities were used in later experiments as bonding agents to determine penetration, bonding qualities, and setting. Indications are that resins can be injected into strata and that such resins will effectively bond pieces of rock. Important goals in future experimental work are to design mining and pumping equipment, to discover a low cost bonding agent, and to develop a systematic, economic procedure.

Roof bolting continued its growth during the year. More than 50 percent of the underground bituminous coal is mined under bolted roof. Roof-bolt failures caused less than 2 percent of the roof-fall fatalities. Bureau records show that approximately 80 percent of all roof-fall fatalities in bolted areas occurred beyond the point where the bolts were installed.

Determination of roof stability, under bolted conditions, is one of the remaining complex problems, due to the variations of rocks that make up mine roof and the diversity of mining systems. This problem is associated, to some degree, with the extent and time of roof sag and with the change in bolt load. Significant data have been collected in mines operating in the Pittsburgh coal bed where test zones of varied bolting patterns have been established. In other zones slotted-type and expansion-type shells are used under similar conditions to determine their comparative effectiveness in stabilizing roofs.

New developments being studied include: (1) An expanding rubber sleeve to provide more anchorage in softer shales; (2) a self-indicating tension device, which is a headed bolt with a crimped flash that flattens at a predetermined pressure; (3) a penetrometer to measure the hardness of rock in drilled holes; and (4) a mining shield to protect miners and other underground workers from the hazards of falling rock and other materials.

Roof-Fall Fatalities

During 1956, 214 fatalities from falls of roof, face, or rib were investigated, and the circumstances and causes of the accidents were reported.[27] About 63 percent of all underground fatalities in bituminous coal and lignite mines resulted from such falling material, compared with 65 percent for 1955; however, the fatality rate of deaths per million man-hours from this cause was 0.58 in 1956, as compared with 0.54 in 1955 and 0.52 in 1954. Human failure was considered responsible for 96 percent of these fatalities, and only 4 percent were charged to circumstances or risks that apparently could not be

27/ Joseph, R. O., and Thomas, E. M., Falls of Roof. The No. 1 Killer at Bituminous-Coal Mines, 1956: Bureau of Mines HSS 454, Mineral Industry Surveys, 1957, 13 pp.

foreseen. Seventy-five percent of the fatalities resulted from accidents within 25 feet of the working face, and 52 percent of the fatalities in this area occurred between the last permanent roof support and the working face. The average length of the comparatively small area from the face to the last permanent support - the most dangerous part of a mine - was 9 feet.

The average dimensions of the pieces of roof rock that fell and resulted in fatalities were: Length, 13 feet; width, 12 feet; and maximum thickness, 2 feet. The relatively large area of these falls shows that adequate minimum standards for roof control should be adopted and followed in all mines. Coal was loaded mechanically in places where 69 percent of the face fatalities occurred; the remaining 31 percent of the fatalities occurred in places where the coal was hand-loaded.

Twenty-four fatalities occurred in places where roof bolts were used, which represent 11 percent of the total roof-fall fatalities. In only four of the falls did roof-bolt failure cause the accident. In most of these accidents the fall occurred inby the bolted area; and temporary roof supports, such as safety posts, had not been installed. Roof bolts generally offer an improved method of roof control but do not obviate the necessity of providing temporary support inby the bolted area. Indications are that the fatality rate, based on tonnage, from falls of roof in bolted areas is less than that in areas where conventional timbers are used.

Reports on 48 underground fatalities in the Pennsylvania anthracite mines in 1956 revealed that roof falls were responsible for about two-thirds of the underground deaths.[28/] Haulage accidents caused one-eighth of the fatalities. The remainder were due to strip-mine accidents, electricity, and other causes. The responsibilities of management and employees in preventing fatalities from roof falls were discussed, and suggestions to assist in accomplishing this goal were presented.

Haulage Fatalities

During 1956, 82 haulage fatalities occurred at underground bituminous coal mines.[29/] Of these, 71 occurred underground and 11 on the surface. Haulage accidents at strip mines caused nine fatalities but are not included in the report. Exactly one-half of the reported haulage fatalities were in West Virginia. Alaska and 17 coal-producing States were free of such fatalities. Of the 82 fatalities, 36 occurred in violation of some section of article VII of the Federal Mine Safety Code.

Some form of physical or operating hazard was considered to be the primary cause of 54 percent of the fatalities. Unsafe practices, either involuntary acts or deliberate chance taking, were considered to be the primary cause of 40 percent of the fatalities. The Bureau analyzed the responsibilities of

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28/ Mather, J. V., Fatalities at Pennsylvania Anthracite Mines, 1956: Bureau of Mines HSS 452, Mineral Industry Surveys, 1957, 24 pp.

29/ Smith, G. M., Haulage Fatalities in Bituminous-Coal Mines, 1956: Bureau of Mines HSS 453, Mineral Industry Surveys, 1957, 13 pp.

management and employees with relation to safe haulage operations and presented recommendations to reduce the frequency of haulage accidents.

Coal-Mine Injury Data

A summary and analysis of reports from coal-producing companies and State mine officials on injuries and related employment data in the coal-mining industry for 1952 through 1955 showed a progressive and gradual improvement over the preceding years. Incomplete reports (those received in the Washington office by June 15, 1957) for the year 1956 showed a slight upward trend in frequency of injuries as compared with 1953, 1954, and 1955, although slightly lower than in 1952. The lowest number of deaths to occur in coal mines in the United States was in 1954 when, for the first time since statistics have been collected by the Bureau of Mines, the death toll dropped below 400 in a year. In 1952 there were 2 major disasters (single accidents in which 5 or more men are killed) which claimed the lives of 11 men; in 1953 there was 1 in which 5 men were killed; and in 1954, 1 in which 16 were killed. From November 13, 1954, no major disaster occurred in the industry through 1956 - a period of more than 2 years.

In 1956, 444 men were killed in accidents at bituminous coal, lignite, and anthracite mines at frequency rates of 0.84 per million tons of coal produced and 1.08 per million man-hours of time worked.[30/] Although 27 more men were killed at coal mines in 1956 than in 1955, the rate of 0.84 per million tons remained the same as in 1955. The rate per million man-hours worked increased from 1.04 to 1.08. The increase in the number of fatalities in 1956 occurred in underground mines. Sixteen more men were killed by falls of roof, face, or rib in 1956, and underground haulage accidents claimed the lives of 11 more men than in the preceding year. Surface operations at deep mines showed a decrease of 14 fatalities and strip operations had 1 more fatality. The coal mines in the United States were free of a major disaster (one in which 5 or more men are killed) during 1956. The last major disaster occurred in a West Virginia mine on November 13, 1954, when a gas explosion resulted in the death of 16 men.

Safety in Shaft Sinking

Unfortunate occurrences resulting in injuries, loss of life, and destruction of property by explosion, fire, and other mishaps during shaft sinking in the past few years have focused the attention of the Bureau of Mines on the need for safety standards for such operations.[31/] One hundred and eighty safety standards have been assembled under the following main categories: Fire prevention, fire protection; housekeeping and sanitation; electricity; explosives storage and transportation; timbering - safeguarding personnel and equipment; hoisting, hauling, and handling excavated material; ventilation; drilling; blasting, welding and burning; and lighting. Bureau personnel has compiled the

30/ Reid, Elizabeth J., and Wrenn, Virginia E., Coal-Mine Fatalities in 1956: Mineral Industry Surveys CMF 306, 1957, 9 pp.

31/ Recommended Safety Standards for Shaft Sinking: Bureau of Mines Inf. Circ. 7810, 1957, 21 pp.

recommended standards included in this publication in all areas where shaft sinking is practiced. Existing applicable State rules were considered and included. Representatives of the mineral industries, coal and noncoal, were given an opportunity to participate in preparing these suggested standards.

Mine Rescue Equipment

In recent years the Bureau of Mines has tested and approved four new types of self-contained breathing apparatus and a facepiece designed for use with the McCaa 2-hour self-contained oxygen breathing apparatus.32/ The breathing apparati are 1/2- and 3/4-hour self-contained types of much simpler design than the conventional 2-hour unit ordinarily used by mine rescue crews. The new equipment is approved only as auxiliary equipment; the 2-hour, conventional-type apparatus should be used for training.

Communication

Recent developments in portable communication equipment for use in emergency recovery work following mine fires and explosions have made possible a convenient and dependable means of directing rescue teams working under hazardous conditions.33/ Mine rescue and recovery operations following fires and explosions are frequently conducted under adverse conditions that require the use of oxygen breathing apparatus by members of a five- or six-man team. The use of conventional apparatus presented difficulties in developing telephone communication because of the wearer's inability to speak while wearing the mouthpiece. The report cited discusses development of communication equipment and devices, from the sash-cord lifeline to the recent transistor-operated telephone.

Trailing Cables

As a result of research suggested by the Bureau of Mines, a cable manufacturer has developed an incombustible, thermoplastic trailing cable that has satisfactorily passed the flame and damage tests for fire-resistant cables under Schedule 2F, Regulations Governing Permissibility Tests for Electric Face Equipment. Favorable reports from field tests of these cables indicate that the durability of these cables in actual service exceeds that of some fire-resistant cables previously available to the industry. Acceptance of these cables by the mining industry should greatly reduce the frequency of cable failures - the most serious mine-fire hazard confronting it.

The reduction of effective insulation and the increased rigidity of trailing cables necessitated by incorporating an additional conductor for frame grounding have caused many trailing-cable failures, some with disastrous results. Through research by the Bureau of Mines and the cooperation of

32/ Walker, W. Dan Jr., Chastain, G. W., and Dornenburg, D. D., Auxiliary and Supplemental Mine Rescue Equipment: Bureau of Mines Inf. Circ. 7808, 1957, 50 pp.

33/ Brown, C. L., Development of a Transistor-Type Telephone System for Mine Rescue Operations: Bureau of Mines Rept. of Investigations 5318, 1957, 11 pp.