and blasting devices.[34] Eight brands of permissible explosives were added to the active permissible list as a result of tests, changes in brand names, or transfers from the inactive list. Twenty-two permissible explosives were transferred from the active to the inactive list. The present list contains 180 brand names. Nine models of Cardox on the list of permissible blasting devices last year remain approved. The work on permissible explosives and blasting devices has been described in connection with the discussion of the work of the Explosives Division.[35]

Burning Rate of Fuse

Many accidents are caused by not knowing the burning rate of fuse due to the erroneous impression that fuse always burns a foot a minute and the widespread use of short fuses. It is recommended[36] that all users of fuse know the burning rate of the fuse concerned. This fact can be determined by timing a length of burning fuse in the place and under the conditions to which it is subjected during blasting. Closer supervision of blasting practices is advocated. A minimum length of fuse should be designated as a safety factor. To be on the safe side, 2 feet a minute should be assumed as the burning rate, and the use of electrical detonators or a "warning fuse" should become standard practice.

Inflammability and Ignition Temperatures of Acetic Anhydride

The limits of inflammability and ignition temperatures of combustible gases, vapors, and solids are of practical importance in the promotion of safety in mining and industry. Acetic anhydride is especially important at this time because of its direct application in the manufacture of munitions.[37] The temperature limits between which air saturated with acetic anhydride vapor forms inflammable mixtures were found to be 47.3° and 74.4° C. (117° and 166° F.). These values correspond to concentrations of 2.67 and 10.13 percent by volume. All mixtures between these percentages at the temperatures stated are inflammable. The flash point by the standard closed-cup tester was found to be 124° F. (51° C.). The ignition temperatures were found to be 392° C. (738° F.) in air and 361° C. (682° F.) in oxygen.

Acetylene-Generator Explosions

The use of acetylene has expanded greatly during the past 2 years. At the request of the War Production Board, the Bureau of Mines investigated the causes of explosions that occurred in acetylene-generator plants in shipyards

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34/ Tiffany, J. E., and Gaugler, Z. C., Active List of Permissible Explosives and Blasting Devices Approved Previous to June 30, 1943: Bureau of Mines Rept. of Investigations 3736, 1943, 23 pp.

35/ Huff, W. J., Studies on Explosives and Explosions, Fiscal Year 1943: Bureau of Mines Rept. of Investigations 3745, 1944, 49 pp.

36/ Harrington, D., and Warncke, R. G., The Burning Rate of Fuse: Bureau of Mines Inf. Circ. 7281, 1944, 10 pp.

37/ Jones, G. W., Scott, F. E., and Scott, G. S., Limits of Inflammability and Ignition Temperatures of Acetic Anhydride: Bureau of Mines Rept. of Investigations 3741, 1943, 5 pp.

on the Pacific coast.[38] These shipbuilding companies erected acetylene-generator equipment, which was soon found to be inadequate to meet expanding acetylene requirements for welding, cutting, shrinking, and other purposes. In some instances the companies found it necessary to operate their equipment at rates greater than deemed consistent with safe operating practice. It was found that carbides meeting Federal Specifications O-C-101, Amendment 1, December 27, 1938, did not prove entirely safe for use under the observed conditions. Some manufacturers have been lax in permitting foreign material to get into the carbide and thereby varying its quality. A majority of the explosions occurred near the end of a run when the generators were at temperatures of 60° to 75° C. and when the liberated acetylene gas carried enough water vapor to heat fine-size carbide to critically high temperatures, thus becoming the source of ignition of the compressed acetylene in generators. It is recommended: (1) That the Federal specifications be amended, (2) that the Underwriters' Laboratories, Inc., make approval tests on the 500-pound, double-rated generators involved in the explosions so that the time for generation of the charge is not less than 2 hours and 15 minutes and the generator-water temperature should not exceed 150° F.; (3) that all pea- or quarter-size carbide be passed through a 0.75-inch screen to aid in eliminating trash and oversize carbide; (4) that the use of second-hand, 100-pound drums for shipment of carbide be discontinued; (5) that the generators be dismantled and cleaned thoroughly at least once each month; (6) that routine chemical analyses and physical tests be made of the carbide used in generators; and (7) that the acetylene generator plants be redesigned to operate at lower specified pressures, if the above recommendations do not solve the explosion problems.

Hazards from Common Gases and Vapors

In the interest of safety and health in mining and other industries, the Bureau has investigated the hazards that confront workers from the presence of common gases and vapors that may accumulate in dangerous concentrations under some conditions. Information has been presented[39] to provide data on the inflammability of certain of these gases and vapors so that workers may be informed how to take the necessary precautions to protect themselves and to save the injured victims of demolished operations. Leakages, insufficient ventilation, open lights, smoking, and nonpermissible electrical equipment are among the more common hazards.

Coal-Mine Explosions and Fires During the Fiscal Year 1943

While an encouraging reduction was noted in the frequency and severity of mine explosions up to 1940,[40] 152 fatalities resulted from explosions

38/ Jones, G. W., Scott, G. S., Kennedy, R. E., and Huff, W. J., Explosions in Medium-Pressure Acetylene Generators: Bureau of Mines Rept. of Investigations 3755, 1944, 20 pp.

39/ Jones, G. W., Hazards from Common Gases and Vapors Encountered at Surface Disasters: Bureau of Mines Inf. Circ. 7287, 1944, 15 pp.

40/ Harrington, D., and Fene, W. J., Coal-Mine Explosions and Coal- and Metal-Mine Fires in the United States during the Fiscal Year Ended June 30, 1943: Bureau of Mines Inf. Circ. 7274, 1944, 27 pp.

during each of the fiscal years 1942 and 1943, 163 in 1941, and 206 in 1940. Lack of proper precautions by members of the coal-mining industry seems to be indicated by the data on the causes of the disasters.

Use and Misuse of Flame Safety Lamps

No excuse can be accepted for an explosion caused by a flame safety lamp.[41] Of all the preventive measures necessary to eliminate coal-mine explosions, the problem of correct use of safety lamps should be the easiest to control, yet the records show that many operators and workers are still unaware of the dangers involved in using such equipment. Suggestions are given for the care and use of flame safety lamps.

Accidents Due to Misuse of Explosives

Examples of the misuse of explosives and faulty blasting practice were compiled[42] and recommendations were made on procedures that should be avoided when explosives are handled or used. Blasting accidents are nearly always serious, and many may be eliminated by a determined educational campaign. A rigid law should be enacted to require that all persons who engage in blasting should be prohibited from doing so until they pass an examination indicating their competency for handling explosives.

Elimination of the hazards associated with explosives begins on the surface.[43] It has also been proved that, in spite of the dangers involved, explosives can be transported safely. More coal-mining companies are using only permissible explosives and blasting devices. Efficient mining companies operate by a code of rules and standards to guide both officials and employees in the use of these explosives and blasting devices. Correct and proper supervision is essential to complete safety. Competent shot firers must be employed to minimize hazards.

There has been too much carelessness in handling blasting caps.[44] Children must be taught in the schools and by parents of the hazards of explosives to themselves and to others. Too many children come into possession of blasting caps through the negligence of older persons. The mining industry can greatly help in reducing accidents due to such negligence.

Exploration for New Coals

Coking Coals

To find new coals that can be used in coke making and to reduce transportation costs to coke plants in the Western and Southern States, explorations of coal deposits were made in areas at or near Madrid, N. Mex.;

41/ Tomlinsen, Walter H., Use and Misuse of Flame Safety Lamps: Bureau of Mines Inf. Circ. 7271, 1944, 14 pp.
42/ Harrington, D., and East, J. H., Jr., Accidents Due to Misuse of Explosives: Bureau of Mines Inf. Circ. 7259, 1943, 14 pp.
43/ Fitzgerald, L. G., Some Suggestions on Care in the Use and Handling of Explosives in Coal Mines: Bureau of Mines Inf. Circ. 7278, 1944, 7 pp.
44/ Harrington, D., and Warncke, R. G., Accidents to Children from Blasting Caps: Bureau of Mines Inf. Circ. 7275, 1944, 13 pp.

Kemmerer, Wyo.; Paonia, Colo.; and Fort Payne, Ala. The investigation in these areas included exploration to determine the thickness, extent, physical characteristics in and surrounding the beds, and the minable reserves. The chemical and coking properties of the coals were determined from the coal cores. Some of these areas can profitably serve as additional sources of coals needed by western and southern coke plants.

Coal Reserves in Areas of Critical Fuel Supplies

The critical coal shortage in the Northwest and the demand for fuel for war plants and Army camps justified explorations to determine minable reserves of coal in California, Nevada, Oregon, and Washington.

Reconnaissance of a lignite area in Amador County, Calif., indicated a favorable topography for stripping, but the available information suggests that the areas are not continuous and that the thickness of the bed is variable. Diamond drilling at closely spaced locations to determine the extent of beds and their character is recommended. Briquetting tests of this lignite by the Bureau of Mines show that it briquets easily without use of binder. Valuable refractory clays lie above and below the lignite in some places. The topography of an area 5 miles east of Dos Rios in Mendocino County is mountainous, and at present the region is not accessible by railroad. Samples of coal from outcrops and abandoned mines indicate areas of subbituminous coal of fair quality in this vicinity.

Except for intermittent, small-scale mining of poor-quality coal little coal has been produced in Nevada. Construction of Army air fields and magnesium plants made the development of local sources of fuel desirable. Exploration by diamond drilling of a coal area in Esmeralda County was not completed. Coal from one slope mine shows possibilities of improvement by washing.

A reconniassance of the Coos Bay field in Oregon showed probable reserves of subbituminous coal suitable for war industries and domestic use in the Northwest. Exploration of the area by means of core drilling showed considerable variation in the thickness and extent of the minable areas, as represented by cores from the nine diamond-drill holes completed. Well-planned drilling locations will therefore be necessary to determine the best minable reserves.

Reconnaisance of an area near Toledo in Lewis County, Wash., indicated a large reserve of lignite, which could be recovered by strip mining. However, because this type of mining requires a large investment in equipment, exploration by diamond drilling to determine minable reserves is recommended. Three areas of subbituminous coal in the Hanaford Valley near Centralia, Wash., appear favorable for strip mining, but exploration is recommended to determine the depth of overburden and the thickness and extent of these coal beds.

Examinations and Reports for the Smaller War Plants Corporation

At the request of the Smaller War Plants Corporation, examinations and reports were made of one coal property in Mercer County, Pa., and of a second in Tuscarawas County, Ohio. This work was done in connection with granting Government aid for expanding operations.

PREPARATION OF COAL

Improvement of Coals for Special Purposes

Preparation of Coal for Production of Synthetic Liquid Fuels

Investigations of the development of processes for synthesizing liquid fuels from American coals have emphasized the need of examining (1) suitable coal reserves and (2) methods of preparing coals for such use. The Bureau of Mines is conducting an intensive program of float-and-sink tests and general preparation studies on large samples of reserves of middle- and low-grade coal and lignite deposits of the Midwestern and Western States. These studies will facilitate the use of these reserves of fuel for future production of liquid fuels, as well as in the general utilization of these coals for other purposes. This investigation may eventually be of even greater value in the development of local industries in areas where these vast fuel reserves are available. The preparation of these coals to make them suitable for the manufacture of synthetic liquid fuels will require extraction of more of the ash than is at present required for other special purpose fuels. Improvement of existing processes or the development of new processes to produce low-ash coal will benefit all industries using coal for special purposes.

Low-Ash Coke for Carbon Electrodes

The possibility of using coke from low-ash Appalachian coals for carbon electrodes in the aluminum industry was investigated.[45] Float-and-sink studies were made on one Alabama and six eastern Kentucky low-ash coals to determine how pure a float coal could be obtained. Although the float portions first crushed to pass a No. 20 sieve showed considerable reduction in mineral matter, none of them met all the rigid specifications with respect to maximum allowable contents of total ash, iron, silicon, calcium and sodium, and sulfur, as specified for carbon electrode manufacture by the aluminum industry. Tests of float portions of the seven coals, obtained on 1.30 specific-gravity solutions, showed that the ash content could be reduced further by acid treatment. These float coals, crushed to pass a No. 60 sieve, were digested at room temperature for 24 hours with an equal weight of solution containing 5 percent HCl and 5 percent HF, with 1 part per million of tannic acid as wetting agent. Analyses of the ashes of these acid-treated float coals showed that the calculated amounts of iron, silicon, and calcium present in the cokes prepared from three of the Kentucky coals were within the requirements for carbon-electrode manufacture. Ash removal by the Trent process on the seven coals was not nearly as complete as by float-and-sink methods.

[45] Selvig, W. A., Ode, W. H., and Gibson, F. H., Coke from Low-Ash Appalachian Coals for Carbon Electrodes in Aluminum Industry with a chapter on Comparison of Results Obtained by Trent Process for Cleaning Coal with those by Float-and-Sink Methods by Joseph D. Davis: Bureau of Mines Rept. of Investigations 3731, 1943, 22 pp.

Marginal Special-Purpose Coals

Rapid expansion of the steel and other premium-coal-consuming industries has built up an urgent need for the development of new reserves of special-purpose coals. The possibilities of broadening the reserves of suitable coals lie very largely in improving the preparation of the remaining known reserves of "next-best" coals. Such coals are available in enormous volume and present an intricate variety of preparation problems. For example, in the industrial area of western Pennsylvania, an intensive study is being made of Pittsburgh-bed coal in marginal areas where its sulfur content is too high for production of metallurgical coke that will meet present standards. Depletion of low-sulfur coal in the western Pennsylvania industrial area has advanced to the point where either higher-sulfur coals must be used or coal of a satisfactory sulfur content must be properly prepared or blended with low-sulfur coals. Continuous sampling and classification of high-sulfur coals as mined indicate that they may be separated into a high-sulfur grade and a low-sulfur grade with more than half available as metallurgical coal conforming to current specifications. The remaining minable areas of low-volatile coal in the Georges Creek Basin of Maryland are being investigated to determine whether special purpose coals can be prepared by coal-washing methods. The washing characteristics of low- and high-volatile coals of southern West Virginia are being studied to determine their suitability for special purposes.

Miscellaneous Preparation Studies

Development of Improved Methods of Coal Preparation

As a supplement to studies of the washing characteristics of marginal coals, it was necessary to develop more precise methods for separating high- and low-grade fuel and the associated refuse. This work consists essentially in devising means for separating coal into two grades as compared with the older and simpler problem of separating coal from rock materials and involves the more difficult tasks of separating low-ash, low-sulfur components of the matrix, both from associated refuse and from inferior coal with higher ash and sulfur contents. The project demands more precisely controlled operations and separations at lower specific gravities than can be made by conventional coal-cleaning processes, as usually operated.

Many waste and semiwaste products that contain substantial proportions of good bituminous coal have been rejected because no use could be made readily of the raw material. This coal can be salvaged economically by suitable preparatory treatment. Substantial tonnages of clean bituminous coal can be recovered from dirty coal left after stripping operations in Illinois, Indiana, and western Kentucky, and large amounts of fine coal can be salvaged from these same areas through improved cleaning and dewatering methods. Present mining practices discard as waste, not only much of the bony coal of the Thick Freeport bed in western Pennsylvania but also a substantial amount of good coal which is mixed with mine rock in eastern Ohio, southern Pennsylvania, and northern West Virginia. It is estimated that more than a million tons of good coal, comparable in quality to that currently marketed in the Pittsburgh industrial area, could be salvaged each year at the larger mines of western Pennsylvania by treatment of waste material.[46] Field surveys are being made of the losses of coal in mining and preparation operations to appraise the tonnage and economic value of usable fuels now lost by wasteful practices. From these surveys practical methods of recovery can be devised and recommended.

Characteristics of Coal and Its Associated Impurities

The physical, chemical, and petrographic characteristics of coal and the composition of associated impurities were evaluated in connection with an investigation of mechanical cleaning of coal.[47] Coal preparation was shown actually to begin at the face of the coal bed in the mine. The most important single characteristic of both coal and its impurities, from the standpoint of cleaning, is specific gravity. Among other characteristics related in one way or another to coal preparation are rank, petrographic composition, structure and breakage, size composition, hardness, strength, friability, grindability, slacking or weathering properties, and the amount and composition of ash-forming impurities and of sulfur. These characteristics, as they affect the selection of coking coals, were considered.

Washability Studies

Washability studies were made of run-of-mine coal from the Brockwood bed, Alabama, in connection with tests of coking coals at a byproduct plant at Holt, Ala. Washability data of run-of-mine coal from the American coal bed, Virginia mine, were obtained for use in planning a new washer required because of proposed changes in mining methods. Contracts, based on the data obtained, have been let by the mining company for the new preparation plant. Coke breeze from a dump pile was subjected to washability studies to determine its suitability for replacing old mine refuse being used for producing steam coal. Plans, based on this study, are well-advanced for the installation of treating equipment at the coke-breeze dump. At the request of the Deputy Solid Fuels Administrator for War, an investigation was made of the practical recovery of semianthracite from culm piles at Merrimac and Shelby Junction, Va. It has been estimated that these piles contain about 340,000 tons of 9/16- to 0-inch culm. The study showed that about 72 percent can be recovered by table washing. The ash content of the culm was 21 percent. A suitable treating plant was recommended and its costs were estimated for the Deputy Solid Fuels Administrator for War.

46/ Fraser, T., Kelley, J. A., and Graham, H. G., Salvage of Coal from Mine Refuse in the Pittsburgh District: Bureau of Mines Rept. of Investigations 3768, 1944, 23 pp.

47/ Yancey, H. F., Geer, M. R., and Davis, J. D., Characteristics of Coal and Its Associated Impurities. Chap. 2 in Coal Preparation (D. R. Mitchell, ed.): Am. Inst. Min. and Met. Eng., 1943, pp. 31-79.

One of the Bureau engineers collaborated with the Brazilian National Department of Mineral Production in a study of washing characteristics of Braziliazan coals.[48]

Mechanical Cleaning

Recent introduction of small coal jigs in Alabama, Pennsylvania, and Tennessee to meet the needs of hundreds of truck-mine and other low-tonnage operators has increased the demand for information on cheap and economical coal-cleaning equipment.[49] The publication describes two small jigs of the Montgomery type and one of the Elmore type and includes performance data obtained recently in cooperation with the University of Alabama on one of the Montgomery-type jigs. This jig has a capacity of 5 to 10 tons per hour and was studied at the installation operated by the Pen Coal Co. at the Pen Wadsworth mine near Birmingham, Ala. Samples of the jig products (feed, washed coal, and refuse) were screened into the following sizes: 1 1/4- to 3/4-inch, 3/4- to 3/16-inch, 3/16-inch to 14-mesh, and minus 14-mesh. Each size was subjected to float-and-sink fractionations, and the resulting products were analyzed for ash. The jig treatment of the four sizes named reduced the ash contents from 6.5 to 4.1 percent, from 11.8 to 5.3 percent, from 18.1 to 9.5 percent, and from 28.0 to 23.3 percent, respectively. Corresponding percentages of the total available coal recovered as washed coal were 98.5, 98.0, 98.3, and 96.8. For the composite minus-1 1/4-inch jig feed, 97.3 percent of the total available coal was recovered as washed coal, and the ash content was reduced from 16.2 to 8.7 percent. Both the recoveries and ash reductions on the two coarsest sizes about equaled those obtained from single-compartment jigs, regardless of size or type. Recoveries on the two finest sizes were quite satisfactory, but the ash reductions were slightly substandard. An additional 1 or 2 percent reduction in ash can be expected with improved operation of the jig.

Concentrating Tables

A discussion of developments in the wet-process coal-washing systems from the early bumping tables to present-day, differential-motion, concentrating tables was contributed to a recent volume on coal preparation.[50] Principles of the tabling process, the importance of correct operating conditions, the efficiency of the concentrating table as a coal-cleaning device, the evaluation of table performance from washability data, and the comparison with other cleaning devices were concisely discussed.

Screening of Coals

In coal preparation, sizing is generally accomplished by passing the coal over screens. Different types of screening machinery, screening practices for anthracite and bituminous coal, and performance ratings of screening

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48/ Fraser, T., and Paiva Abreu, Alvaro de, Lavabilidade de Carvões do Brasil (Washing of Brazilian Coals): Brazil. Dept. nacional da produção mineral, Laboratório da produção mineral Boletim, No. 13, 1943, 185 pp.

49/ Gandrud, B. W., and Bator, G. T., Some Small Coal Jigs for Mechanical Cleaning of Coal at Truck Mines and Other Low-Tonnage Operations: Bureau of Mines Rept. of Investigations 3718, 1943, 17 pp.

50/ Gandrud, B. W., Concentrating Tables. Chap. 13 in Coal Preparation (D. R. Mitchell, ed.): Am. Inst. Min. and Met. Eng., 1943, pp. 425-456.

equipment were discussed in a recent publication.[51] This chapter presents numerous data showing results obtained with various types of screening equipment and for coals under different physical conditions.

Methods for Loading Coals

The operations of commercial loading plants in transferring coal from preparation machines to railroad car, truck, or barge, in which it is to move to market, have been described with reference to minimum breakage and segregation of coal and to maintenance of uniformity in the different shipments.[52] The extent of expected degradation of coal during typical conditions of storage, loading, and shipment is discussed. Methods of loading and loading devices for handling anthracite and bituminous coal are described.

STORAGE OF COAL

Action of Coal in Storage

Valuable new information on the action of coal in storage was gained through field surveys, laboratory investigations, questionnaires, and mutual exchange of ideas between representatives of the coal industry and Bureau engineers. The storing characteristics of a series of coals were investigated, among them coals mined in the Midwestern States, the New Mexico-Arizona area, the Oklahoma-Arkansas area, and Washington. Additional studies were made of materials used for capping coal piles, particularly of the effect of weathering and length of life of sisal kraft paper. The effect on the durability of capping materials of the increased vapor pressure of high-moisture coals resulting from increased temperature was determined. Consulting service on various problems of coal storage was given to the Solid Fuels Administration for War, the Federal Public Housing Authority, the Department of Justice, the Navy Department, the War Department, and other Federal institutions, as well as many industrial plants.

Pointers on the Storage of Coal

Frequent questions arising in the minds of coal users concerning the effect of storage on the physical and chemical properties of coal are answered in a recent article.[53] A concise review is given of early and more recent work on storage of coal and related problems conducted by the Bureau of Mines. The effect of rank of coal on slacking, important factors affecting spontaneous combustion, and methods of its prevention are discussed.

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[51] Fraser, T., and Johnson, J. S., Screening. Chap. 5 in Coal Preparation (D. R. Mitchell, ed.): Am. Inst. Min. and Met. Eng., 1943, pp. 127-183.

[52] Fraser, T., Loading. Chap. 23 in Coal Preparation (D. R. Mitchell, ed.): Am. Inst. Min. and Met. Eng., 1943, pp. 699-720.

[53] Barkley, J. F., Pointers on the Storage of Coal: The Black Diamond, vol. 111, Sept. 18, 1943, pp. 18-19.