Drying Lignite

During the year, the Grand Forks, N. Dak., Pilot Plant continued its investigation of drying of lignite. Some 200,000 pounds of lignite was dried by the modified Fleissner method, using steam at 400 p.s.i. Although this operation reduced the moisture content from approximately 37 percent to approximately 12 percent, the removal of this moisture increased the tendency to spontaneous ignition. To this end, a cooling tower was constructed, over which the freshly dried coal was passed at a temperature of approximately 150° F. After passage over the tower, the temperature was approximately 80° F. or less. This drop in temperature reduced the tendency of the dried lignite to ignite during storage.

During November-January drying runs, 20 tons of dried lignite was placed in outside storage. Over a period of 7 months, no spontaneous ignition occurred. In May an additional 20 tons was placed in inside storage; to the end of June there had been no indication of spontaneous ignition.

As dried lignite slowly absorbs moisture from the air, the outside storage pile has been frequently sampled. During the winter, it was exposed to snow and the water resulting from melting snow. Preliminary experiments indicate that dried lignite will reach moisture equilibrium with the atmosphere when the lignite contains approximately 15 percent moisture, the exact figure depending upon the temperature and humidity of the surroundings. When extreme conditions, such as snow or rain, prevail the moisture content may temporarily exceed this value. From January through April the average moisture regained was one percent per month.

STORAGE OF COAL

Field investigations on storage of coal in cooperation with industrial concerns and Government agencies were continued during the year. Several years of practice in the storage of subbituminous coal in open pits has proved that this method is satisfactory. However, storage in concrete pits is expensive, and the method might not be justified if such pits are not available. Many concerns desire to store coal on level ground, but heretofore this method has not been feasible when subbituminous coal is handled because of spontaneous combustion.

A sugar-manufacturing company placed 25,000 tons of subbituminous A coal in storage in 5,000-ton piles at five factories. The general method employed was to unload a coal car with a clamshell crane and build up a pile by distributing the coal in small increments. The average size of the completed piles was 40 to 60 feet wide, 275 to 480 feet long, and 14 to 24 feet high. The piles were leveled, compacting the top surface quite well. The side walls, however, were not compacted and the coal was allowed to assume the angle of repose, which ranged from 35° to 40°. The completed piles were then sprayed with petroleum asphalt to form a surface veneer, amounting to about 3 gallons per square yard of surface.

Soon after these piles were placed, spontaneous combustion set in. Surveys of temperature and gas composition were made, and the physical condition of the several piles was determined. It was found that the sides were loosely packed and the asphalt veneer did not seal the sides. All of the piles were undergoing spontaneous combustion along the sides, and it appeared to be only a matter of time before the coal would have to be removed. Hot spots were corrected as far as possible, and attempts were made to allay combustion by covering the sides with 1 to 2 feet of cinders. None of these attempts were successful, and within 90 days all of the piles had to be moved to prevent further loss. This rather costly experiment by the company proved conclusively that ordinary storage of subbituminous coal on level ground is not feasible and that the asphalt capping was not beneficial.

The need for storing subbituminous coal increased during the fall of 1947 and the spring of 1948, and plans were formulated to build a model pile of 5,000 tons under the most favorable conditions. Figure 27 shows the placing of the model pile at the Brighton sugar plant. The pile was carefully designed to restrict air circulation, and the coal was placed in the following manner: (1) Coal was unloaded from cars with a clamshell crane and spotted over the storage area in small piles; (2) the small piles were then leveled and compacted with an Athey loader (as shown in figure 27), which made the benches about 6 inches thick; (3) the unloading crane then placed new coal on top of the first bench, and the pile was again leveled; and (4) precautions were taken to maintain the slope of all sides of the pile at about 17° and to compact all surfaces as the pile built up. The center height of the final pile was approximately 10 feet, and the base was approximately 118 by 290 feet. Measurements of the pile indicated that bulk densities of 65 to 70 pounds per cubic foot were attained by this method.

The model pile was placed during February-April 1948, and during 103 days of summer storage there was no evidence of spontaneous combustion. This proved method of safe storage for all low-rank coals requires careful supervision during placement of the coal and somewhat more area than is required for ordinary storage. A similar pile was completed at the Windsor sugar plant during June 1948, and the Bureau will continue the study of this pile.

Similar experiments were made on the storage of natural lignite at the Garrison Dam site in North Dakota in cooperation with Army Engineers, and a model pile of 9,000 tons was placed late in 1947 (see fig. 28). There has been no evidence of heating at this pile, and it is planned to extend the method to build up piles 40 feet high to take care of 1 million tons. Several such piles will be needed to accommodate the 5,000,000 tons of lignite to be removed from the dam site.

UTILIZATION OF COAL FOR COMBUSTION

Fuel-Engineering Service

Fuel-engineering service to Government establishments in the selection and use of fuel and fuel-burning equipment and in the economical use of steam was continued. Such services were utilized, particularly by installations in the Washington area as listed below:

(1) At Fort Leslie J. McNair, Washington, D. C., changes in stoker-control adjustments reduced the fuel bill $3,000 a year;

(2) Analyses of combustion products from oil-fired boilers at the Howard University power plant, Washington, D. C., during low-load periods resulted in adjustments saving $1,000 of fuel oil a year;

(3) As a result of tests at Gallinger Municipal Hospital boiler plant, Washington, D. C., recommendations for better oil-burner operation were made which will reduce operating costs $4,000 a year; a survey of steam-utilization practices at this hospital indicated that $13,000 could be saved yearly by closer control of steam for heating buildings;

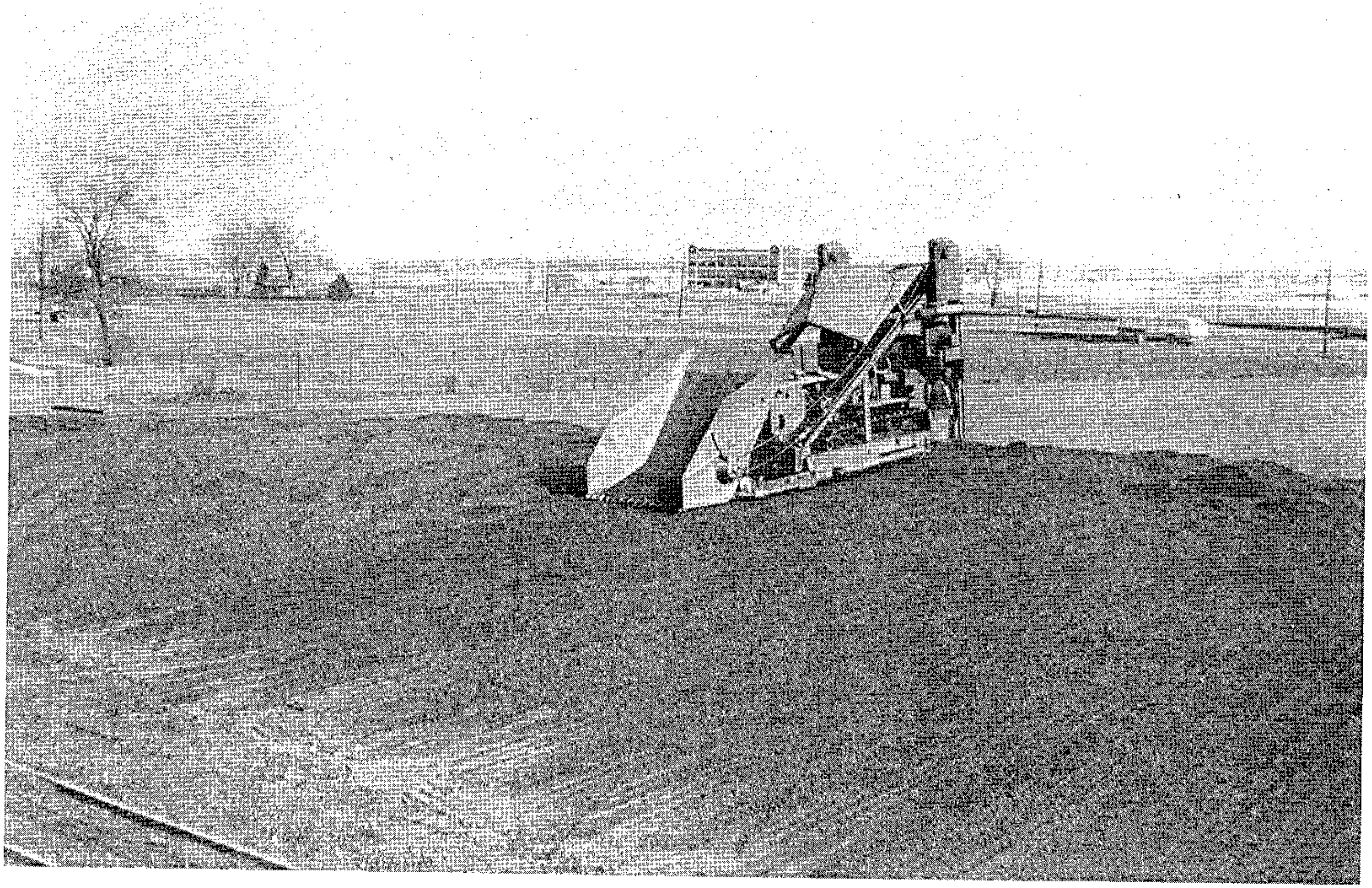

Figure 27. - Model subbituminous-coal storage pile. The pile is built in thin layers, and the sides are compacted at an angle of 17°.

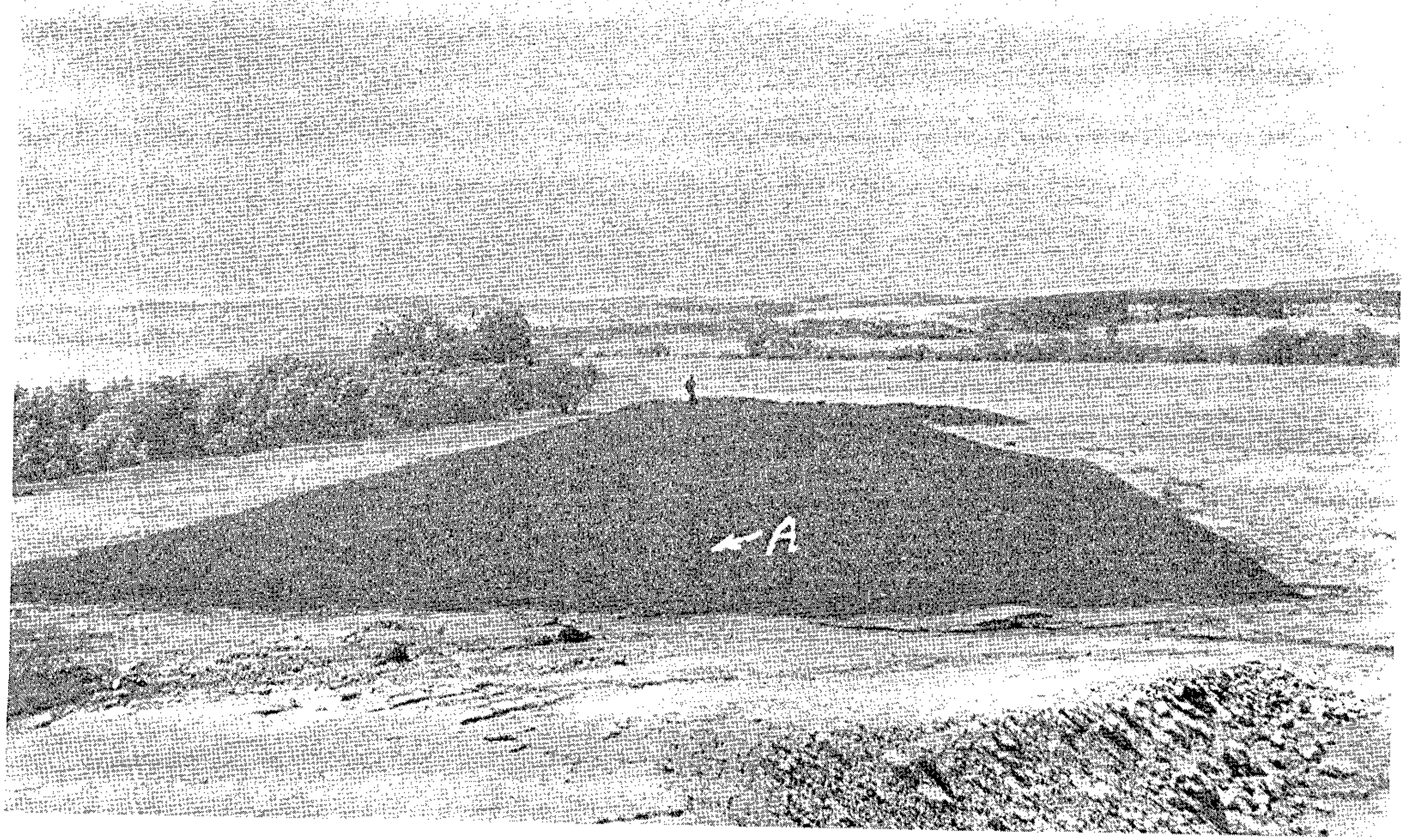

Figure 28. - Experimental storage of lignite, Garrison, N. Dak.

(4) At the request of the Columbia Institution for the Deaf, Washington, D. C., recommendations were made for instruments and operating methods to reduce smoke emission from the stack of the central boiler plant;

(5) Recommendations were made pertaining to firing procedures and type and size of coal to be fired at six housing projects, comprising 1,469 dwelling units individually heated, supervised by the National Capital Housing Authority of Washington, D. C. It is estimated that the recommendations made will result in yearly savings of $11,500;

(6) A survey was made of boiler-plant operation and steam-utilization practices at Lincoln Heights Dwellings of the National Capital Housing Authority, Washington, D. C., which resulted in annual savings of $2,600.

Upon request, service was rendered to Government fuel-burning plants elsewhere in the United States and Alaska as follows:

(1) Studies of boiler-plant equipment and operation made at Fort Richardson and Ladd Field, Alaska, resulted in saving a proposed expenditure of $196,000 for new equipment;

(2) For the Veterans Administration, total operating-cost comparisons were made when using oil, gas, and coal, and the type of fuel-burning equipment recommended for 29 projects;

(3) Acceptance tests were made of a new boiler-and stoker-installation at the Fort Howard, Md., Veterans' Hospital, resulting in improved stoker equipment, saving $1,400 in fuel a year;

(4) Extensive testing was done in the boiler plant of the Veterans Administration Hospital at Lyons, N. J., to obtain needed data on the performance of chain-grate stokers burning anthracite Rice and Barley coal.

Coal-analysis limitations and purchasing procedures for all coal purchases of the Veterans Administration, the Office of Indian Affairs, and the Bureau of Reclamation were reviewed and changes recommended. Additional services on some 95 special problems were given 23 different Government agencies. A standard Federal specification for coke was promulgated. Experiences in the operation of Government plants were reported.[74] A handbook-type guide for reducing fuel consumption in commercial plants assembled in one volume educational "quiz sheets" and reference material used in the National Fuel Efficiency Program carried on during the war years.[75] Material was chosen that would have permanent value in detecting waste and in lowering fuel consumption. Each quiz sheet was prepared and checked by many engineers expert in the particular subject matter of the sheet. Committees of men with much experience in the manufacture and operation of equipment and in the training of operators helped in the work of preparation.

74/ Barkley, J. F., Experiences with Government-Operated Plants: Solid Fuel Eng., vol. 7, No. 2, November 1947, p. 8.
Barkley, J. F., Experiences with Government-Operated Plants: Coal-Heat, vol. 53, No. 2, February 1948, p. 29.

75/ Barkley, J. F., Cheasley, C. T., and Waddell, K. M., A Guide for Reducing Fuel Consumption in Commercial Plants: Bureau of Mines Bulletin 466, 1947, 168 pp.

The Presidential edict of January 17, 1948, "Order for Conservation of Fuel Oil, Gasoline, and Gas," which carried a clause "No Federal equipment shall be installed for burning fuel oil or gas, or liquefied petroleum gas, and no permanent building or establishment shall be converted to these fuels, without the prior approval of the Bureau of Mines ----," required that over 300 projects be studied and approvals or disapprovals made.

The results of research at the Washington Naval Gun Factory on unusual corrosive deposits that accumulated on boiler tubes were published.76/ These deposits were very difficult to remove and caused much draft loss. Test data were obtained on two boilers, one equipped with an underfeed stoker with a long rear arch and water-cooled furnace, and the other equipped with an underfeed stoker without arch and a refractory furnace. Both used the same coal. Many factors were involved, such as the temperature of the collecting surface, the temperature of the gases, the quantity, size and chemical analysis of the fly ash, the relative amount of burning of SO_2 and SO_3, and the relative saturation of the moisture and of the sulfurous gases which depend upon the CO_2 carried and the amount of sulfur coming from the coal. Any one of these factors might be the governing one under a particular set of conditions. The deposit on specially devised ferrous test tubes characteristically had an inner layer of white deposit of ferrous sulfate, formed largely from the iron of the tube and sulfuric acid; the remainder of the deposit consisted chiefly of sulfates and silica, such as would be formed from entrained fly ash acted upon by sulfuric acid. The deposit can form on nonferrous equipment, showing that the initial action of sulfurous gases on iron is not necessary. The fact that the deposit can form at temperatures so much higher than are ordinarily anticipated from dew-point considerations calls for more study. It was found that larger quantities of fly ash physically sweep the tubes, apparently taking out a greater amount of sulfurous gases from the products of combustion. It appears reasonable to assume that the fly ash takes out SO_3 in preference to SO_2, probably resulting in an appreciably lower dew point of the gases. As an operating matter, it was found that, by dropping the CO_2 at the economizer inlet from above 14 percent for one boiler to about 12 percent CO_2, a year's operation could be had without draft loss and with only a small accumulation of deposit, which was effectively removed by an off-the-line water-washing procedure devised by the plant personnel. To obtain all of the test data needed it was necessary to analyze products of combustion for SO_2 and SO_3 content. It was found that the standard test method of the American Society of Mechanical Engineers, the only standard published, was unsatisfactory, since certain minerals from the coal destroyed the accuracy of the analytical test methods used. Changes and modifications of the standard were developed that resulted in a satisfactory method of analysis.

Cooperative research with the Air Preheater Corp. of New York on the prevention of deposits and corrosion of boiler-air preheaters was continued. Laboratory tests were run and field studies made of many installations throughout the United States. A great number of different metallic and nonmetallic elements are now under test.

76/ Barkley, J. F., Burdick, L. R., and Berk, A. A., Test Data on Gas-Side Sulfate-Type Deposits on Tubes Beyond the Boiler Furnace: Trans. Am. Soc. Mech. Eng., vol. 70, No. 2, 1948, pp. 81-89.
Barkley, J. F., Burdick, L. R., and Berk, A. A., Sulfate-Type Deposits on Boiler Tubes: Combustion, vol. 19, No. 1, July 1947, pp. 26-27.
Barkley, J. F., Burdick, L. R., and Berk, A. A., Gas-Side Sulfate-Type Deposits: Modern Power and Eng., vol. 41, No. 9, September 1947, pp. 68, 70, 72.

Boiler Feed-Water Conditioning

Analyses and resulting recommendations were made on 8,180 samples of boiler water during the fiscal year as follows: 5,388 from the Army and Air Forces, 1,432 from the Veterans Administration, 393 from the Housing Authority, 292 from the District of Columbia, 218 from the Office of Indian Affairs, 154 from the Justice Department, 131 from the Post Office Department, 60 from the Navy Department, 54 from the Public Health Service, 13 from the Commerce Department, 13 from the Agriculture Department, 11 from the Atomic Energy Commission, 9 from the Federal Security Agency, 7 from the War Assets Administration, 2 from the Public Buildings Administration, 2 from the Smithsonian Institution, and 1 from the Fish and Wildlife Service, Interior Department. Reports and recommendations covering 19 analyses of various scales, sludges, and deposits and 9 covering analyses of boiler compounds were made. An average annual saving of about $300.00 was effected by using standard chemicals instead of proprietary compounds at several Public Housing Administration projects. Two hundred and thirty-two special Bureau of Mines field water-test kits, 8,829 bottles of chemical reagents, and 10,677 test-kit replacement items were distributed to various Government activities.

Visits were made to 28 heating plants operated by a number of Federal agencies in the local area of the District of Columbia to determine difficulties, advise on boiler-water treatment, give instructions in boiler-water testing, and inspect boilers for scale and sludge. Upon request, service visits were made to installations outside this area as follows:

(1) A survey was made of the six-boiler plant of the Veterans Administration Hospital, Perry Point, Md., to determine the cause of repeated tube failures. Boilers were being retubed at a cost of $10,000 each. It was found that plugs of sludge forming in the tubes were stopping circulation, causing them to burn out. Recommendations for control were made to prevent this condition.

(2) A study of boiler-water treatment practices was made at the Veterans Administration Hospital, Aspinwall, Pa. The principal difficulty reported was return-line corrosion. This was caused by sluggish circulation, as water filled the lines and essentially stood for long periods; the oxygen concentration in the return water decreased as it moved along in the line. It was recommended that changes in the system be made to increase the rate of flow of the condensate. At this plant, it had been found necessary to replace a set of five 150-hp. horizontal-return tubular boilers about every 10 years at a cost of $50,000. The present set of boilers is being treated chemically in accordance with Bureau of Mines procedure, and the condition of the boilers is being kept satisfactory.

At the Jefferson Junior High School, Washington, D. C., the boiler water of a three-boiler plant was treated under supervision of the Bureau of Mines, and no tube failures occurred. Without this treatment, such boilers had been costing $1,400 each for tube replacement every few years. A detailed analysis of savings resulting from Bureau of Mines procedures of boiler-water treatment made at the Atomic Energy Commission, Los Alamos, N. Mex., showed that $139,000 were saved annually in operating 40 boilers.

At the request of the Post Office Department, a special questionnaire on boiler-water treatment was prepared for its use in making surveys of the Post Office low-pressure boiler plants. A Navy Department manual on boiler-water treatment was reviewed, and suggestions were made for revision, and a questionnaire on boiler-water treatment for use in making a survey of Navy plants was prepared in collaboration with Navy Department chemical engineers. Consulting service was given the Public Buildings Administration on corrosion control in low-pressure boilers; the District Government, on the use of sodium sulfite to protect idle boilers; the Veterans Administration, on the protection of idle boilers from corrosion, the use of external phosphate softening, the preparation of log sheets for recording boiler water treatment data at all plants, external water treatment for a proposed hospital at Marlin, Tex., and a special water-treating device at Boise, Idaho; the Post Office Department, on tube cleaners for water-tube boilers, on threshold treatment, the preparation of instructions for the feeding of boiler-water chemicals, and boiler-tube difficulties at Boston, Mass.; the Bureau of Yards and Docks, on a special water-treatment condition at Tacoma, Wash.; the Fish and Wildlife Service, Interior Department, on the use of boiler compounds; and the Army on new schemes of water analysis.

Boiler-Water Research

Research was continued during the fiscal year on the use of volatile alkaline amines in boiler water. These chemicals volatilize and condense with the steam, neutralizing any carbonic acid content of the steam and also removing accumulations of solid corrosion products in the piping. Studies are being made to reduce treatment cost for greater savings and therefore possible extension to plants in which the corrosion problem is not of major importance. The degree of volatility and alkalinity most desirable varied with operating conditions of the plant. Volatility was especially important at low pressures. A highly volatile compound, such as cyclohexylamine, was more suitable for systems operated at 5 to 15 pounds pressure, while at higher pressures, and especially for systems operated at about 100 pounds per square inch, a less-volatile amine can be used, such as morpholine. Morpholine, with its relatively low alkalinity, permits a greater elimination of carbon dioxide at the vents in the heating system.77/ Corrosion tests in the field and in the laboratory verified the general operating experience that chemical treatment of steam systems with amines effectively reduces the corrosiveness of the condensate when it is maintained slightly on the alkaline side. At one Federal Public Housing project where experimental work was being done, it was found that about $500.00 per year could be saved by substituting a more-appropriate amine than was formerly being used. Laboratory testing data were obtained on the effects of rate of flow, carbon dioxide concentration, dissolved oxygen concentration, and temperature on the rate of corrosion of pipe sections. A study of the effect of ammonia in condensate on the deterioration of brass and other copper alloys was begun.

Research work on caustic embrittlement or intercrystalline cracking in locomotive boilers - a very serious problem of the railroads - is being rounded out through field test work. Sodium nitrate treatment has proved to be the most satisfactory method for controlling cracking, protecting the metal by forming and keeping in repair a continuous film on the steel of the boiler seams. Embrittlement detectors were maintained on 16 locomotive boilers to determine whether the treatment was satisfactory. The evidence of the detectors, plus a very large decrease in the number and severity of the cracks found, showed the treatment to be effective.

77/ Berk, A. A., Treating Steam Chemically to Reduce Return-Line Corrosion: Ind. and Power, vol. 53, No. 5, November 1947, pp. 79-81, 110, 112.

Smoke Abatement

Civic interest in smoke abatement continued high through the year, with many requests coming to the Bureau of Mines from various cities for publications and consulting service, including Los Angeles, Calif.; Denver, Colo.; Coffeeville, Kans.; Mount Sterling, Ky.; Portland, Maine; Muskegon, Mich.; Kansas City and St. Louis, Mo.; Albany, Elmira, Kenmore, and New York, N. Y.; Portsmouth, Ohio; Erie and Philadelphia, Pa.; Memphis, Tenn.; Houston, Tex.; Provo, Utah; Richmond, Va.; Parkersburg, W. Va.; Manitowoc, Milwaukee, and Reedsburg, Wis.; and Kingston, Ontario, Canada. Information and consulting service were also given Allegheny County, Pa. Smoke abatement as related to anthracite was discussed in a published report.78/

Coal and Energy in the Western States

A study of the western fuel situation showed that, with the increasing demand for energy coincident with increase in population, the production of coal in the Western States probably will increase threefold in 25 years if there is no substantial increase in oil production.79, 80/

A résumé of Bureau of Mines research and development work on western coals during 1942-4781/ discussed drilling projects to locate and evaluate new sources of coking coal, carbonizing properties of coal, storage of coal, drying of low-rank fuels, combustion of low-rank coals, gasification of subbituminous coal and lignite, and investigations in progress at Golden, Colo., and at Grand Forks, N. Dak., in 1947.

Removal of Ash as Molten Slag from Pulverized-Coal-Fired Furnaces

In 1947 there was burned in the boilers in the electric power stations of the United States a record quantity of 86,000,000 tons of coal, most of it in pulverized form. Probably the most important single variable affecting the efficient and continuous operation of these utility boilers is the nature and behavior in the furnace of the ash in the coal. Because the quality of coal economically suitable for utility consumption has steadily declined, many units now on order are designed for coals containing 12 to 15 percent ash, making it increasingly difficult to meet the continued upward trend in final steam temperatures, reaching 1,000° F. in units recently installed.

To provide the basic information required for an understanding of the behavior of ash, the Bureau of Mines has for many years conducted a systematic study of the properties of ash and slag and the behavior of ash in furnaces. To clarify the current status of the knowledge of coal ash, as it is related to behavior in pulverized-coal furnaces, a publication82/ summarized what is known of (a) the fundamental flow

78/ Barkley, J. F., Anthracite's Part in Smoke Abatement: Trans. 6th Ann. Anthracite Conf. of Lehigh University, May 1948, pp. 35-42.
79/ Parry, V. F., Trends in the Production of Coal and Energy in the Western States as a Result of the War: Proc. Rocky Mt. Coal Min. Inst., 1947, pp. 10-18.
80/ Parry, V. F., Future Prospects for Western Fuel Supply: Western Industry, 1948, Rocky Mt. Petrol. Year Book, 1947-48: spec. issue, Oil Reporter, spring 1948, pp. 33-36.
81/ Parry, V. F., Résumé of Bureau of Mines Research and Development Work on Western Coals, 1942-47: Bureau of Mines Rept. of Investigations 4171, 1948, 9 pp.; Proc. Rocky Mt. Coal Min. Inst., 1947, pp. 18-26.
82/ Cohen, P., and Corey, R. C., Behavior of Ash in Pulverized-Coal-Fired Furnaces: Combustion, vol. 19, No. 1, January 1948, pp. 33-40.