Toxic Mine Atmospheres

In connection with the work carried on under the provisions of the Federal Coal Mine Inspection Act, approximately 15,000 samples of mine air were analyzed to determine the adequacy of ventilation in coal mines and to aid in the control and extinguishment of mine fires. Seven hundred and fifty samples of air-borne dusts and other mineral materials were examined to determine the free-silica content and dust concentration in connection with studies relating to health hazards from dust in mining operations. These analytical operations required more than 100,000 individual determinations.

As the sampling and analysis of mine atmospheres play an important part in promoting and maintaining safe and healthful conditions in mining, information on the subject was revised and brought up to date in a publication designed as a practical working manual for the mine operator and mining engineer.27/

An investigation of the causes of explosions and formation of carbon monoxide in compressed-air systems demonstrated that a "carbon-oxygen complex" exists in the carbon deposits that are formed normally in such systems.28/ This complex may act as an initiator of the exothermic reactions that result in explosions and formation of carbon monoxide in compressed-air systems. The findings of this investigation may point the way to increased safety in the use of compressed-air in mining and other industries.

Approval testing was continued on respiratory protective devices applicable to use in the mining and mineral industries. Six new approvals and 37 extensions of approval, representing modifications and improvements in design, were granted. To aid in the selection of respiratory protective devices, and to bring up to date information on the subject, a listing of the newly approved devices was prepared.29/

Electrical Equipment for Mines

Unless electric equipment is built, maintained, and used properly in gassy coal mines, such equipment can be hazardous from the standpoint of initiating mine fires and explosions. As a means of avoiding this hazard, the Bureau of Mines has established certain standards, published as "schedules," for the guidance of manufacturers who produce mine equipment. A design of equipment that passes the tests and inspections prescribed by these standards is formally approved by the Bureau of Mines and becomes known as "permissible" equipment, that is, permissible for use in gassy coal mines. Each item of equipment of this design sold by the manufacturer as permissible is identified by an approval plate bearing the Bureau of Mines' seal. Manufacturers in increasing numbers, both in this country and abroad, are becoming more and more interested in the standards of the United States, so much so that it was necessary to reprint Schedule 2E 30/ to satisfy the large demand for this publication.

27/ Berger, L. B., and Schrenk, H. H., Sampling and Analysis of Mine Atmospheres: Bureau of Mines Miners Circ. 34, 1948 revision, 103 pp.

28/ Busch, H. W., Berger, L. B., and Schrenk, H. H., The Carbon-Oxygen Complex as a Possible Initiator of Explosions and Formation of Carbon Monoxide in Compressed-Air Systems: Bureau of Mines Rept. of Investigations 4465, 1949, 22 pp.

29/ Berger, L. B., Supplemental List of Respiratory Protective Devices Approved by the Bureau of Mines (additions to list published in Inf. Circ. 7444): Bureau of Mines Inf. Circ. 7513, 1949, 3 pp.

30/ Bureau of Mines Schedule 2E - Procedure for Testing Junction Boxes and Electric Motor-Driven Mine Equipment for Permissibility: Federal Register, vol. 10, No. 41, Feb. 27, 1945, pp. 2230-2240, incl. Amendment to Schedule 2E: Federal Register, vol. 12, No. 219, Nov. 7, 1947, pp. 7285-7287, incl.

Under the eight schedules now in effect, a manufacturer can have almost every type of equipment used at or near the face of active mine workings investigated for its liability to ignite gas or coal dust or a combination of these. During the fiscal year 1949, 53 approvals were issued. These included the designs for 21 loading machines and conveyors, 1 cutting machine, 1 continuous miner, 5 drilling machines, 1 mining-machine truck, 2 air compressors, 1 battery-operated shuttle car, 1 post puller, 1 timbering machine, 5 fan-drive units, 1 greasing truck, 2 battery-operated utility trucks, 1 ear-spotting hoist, 1 junction box, 1 distribution box, 1 cleaner, 3 rock-dust distributors, 1 ten-shot blasting unit, 1 one-shot blasting unit, 1 electric cap lamp, and 1 flame safety lamp.

Electrical Control Mechanisms in Underground Pumping Plants

The physical lay-out of two large, modern, underground, automatic pumping plants in the anthracite region are described.31/ A detailed technical explanation, accompanied by wiring diagrams, was given of the functioning of the individual electrical control mechanisms and safety features incorporated into the controls and the effect each mechanism has on the over-all automatic operation of the plant.

Roof Control

Falls of roof and coal account for about half the total fatalities in coal mines. Bureau of Mines engineers have conducted studies of roof-control measures through the years when funds for such work were available, and some practical solutions to special problems, such as "bumps," have been developed. However, no new roof-control method that could be applied generally in mines was discovered until 1948, when two Bureau of Mines engineers investigated a roof-control method used for many years in metal mines in southeast Missouri, recognized its possibilities, and applied the method in coal mines and some ore mines in the United States. Experimental work was conducted to prove its value and practicability under actual operating conditions.32/, 33/, 34/ The method is referred to as "Suspension Roof Supports."

The principle involved in this improved method of roof control is the prevention of initial sag and subsequent failure of thin bands of roof strata by reinforcing the strata with steel rods as soon as the roof is exposed. These supports eliminate the use of timber sets and posts, and are of especial value in mechanized mines where dislodgment of the standard supports is likely to result in roof failure and possible injury to those persons in the immediate vicinity.

During the fiscal year, in answer to numerous requests by coal companies, examinations were made of the roof and mining conditions at various mines by personnel of the roof-control group to determine if suspension roof supports were applicable to the local conditions. These examinations and recommendations were made with respect to the installation of supports. During the fiscal year, 115 mine examinations for this purpose were made in 11 States.

31/ Durham, A. C., Design and Operation of Electrical Control Mechanisms in Underground Pumping Plants: Bureau of Mines Inf. Circ. 7476, 1948, 21 pp.
32/ Thomas, E., Seeling, C., Perz, F., and Hanson, M., Control of Roof and Prevention of Accidents from Falls of Rock and Coal: Bureau of Mines Inf. Circ. 7471, 1948, 9 pp.
33/ Thomas, E., Suspension Roof Supports: Coal Age, vol. 53, 1948, pp. 87-91.
34/ Thomas, E., Conventional Timbering vs. Suspension Supports: Mechanization, vol. 13, 1949, pp. 147-152.

It is known that suspension roof supports have been installed in 60 bituminous-coal mines and 8 iron-ore mines situated in 8 States, and it is estimated that 147,038 feet of mine passageways are now supported by this means.

During the fiscal year, a stratascope has been developed and is near completion at the Naval Gun Factory, Washington, D. C. This instrument will provide precision and accuracy in determining strata separation, which usually precede failure, by exploring boreholes drilled in thinly bedded mine-roof rocks.

A "torquometer" was obtained near the close of the fiscal year, and a limited number of readings of bolt tensioning was obtained at two installations where suspension roof supports were installed, but the data are insufficient to permit accurate interpretation. To supplement the readings obtained in the field, a schedule of laboratory tests has been set up to determine factors that may affect ultimate results. Indications are that the "torquometer" readings will provide significant information relating to effectiveness of suspension-rod anchorages.

Anthracite Flood Prevention

Investigations of underground water pools, the "buried valley" of the Susquehanna River, anthracite reserves, existent pumping facilities, existent drainage tunnels, and a study of deep-well pumps and deep-well-pumping installations in the anthracite region were conducted in the search for a solution to the anthracite flood-prevention problem. The investigation of underground water pools was completed.35/ The survey revealed that there are 91 billion gallons of water impounded in 159 pools in underground workings and 2.3 billion gallons impounded in abandoned stripping excavations.

One phase of the mine-water problem, as it pertains to the northern field of the anthracite region, is the presence of the buried valley (filled ancient channels) of the Susquehanna River. The present river channel is above the channels of the ancient waterways, which the north branch of the Susquehanna River has filled with clay, sand, and gravel deposits. This valley fill is water-bearing and irregular in trend and depth. The thickness of the depositional material generally is 100 to 150 feet, though in places it is more than 300 feet thick. The coal measures underlie and outcrop beneath and at the sides of these deposits. A vast tonnage of anthracite has been mined from the area beneath the buried valley, and, because a large tonnage remains unmined, it is of prime importance that present and future mine operations in this area know the configuration, extent, and nature of the water-bearing deposits, and the relative position of the underground workings to them to prevent the mine workings breaking into the valley-fill deposits unexpectedly, with resultant loss of life and property.

To date, information on 13,000 boreholes has been compiled, and from this and other information, 57 contour maps have been prepared.

A study was begun to determine possible sites for drainage tunnels in the northern and southern fields.

35/ Ash, S. H., Eaton, W. L., Hughes, Karl, Romischer, W. M., and Westfield, J., Water Pools in Pennsylvania Anthracite Mines: Bureau of Mines Tech. Paper 727, 1949, 78 pp.

PREPARATION OF COAL

Coal Washing

Cleaning and Recovery of Fine Coal

The second commercial installation of the "kerosine-flotation" process was made at a mine in the Birmingham, Ala., district, where it operates on minus 10-mesh fines screened from run-of-mine coal.

This plant is providing a solution to what has always been a difficult problem in wet-preparation plants - the recovery, cleaning, and dewatering of "fines." The first installation of the kerosine-flotation process, reported last year, is being used for treatment of the underflow sludge from dewatering screens. Both plants are operating successfully for the recovery of coking coal. They have been built as a result of Bureau experimental plant and laboratory work initiated several years ago.

Laboratory tests have been made of the application of this process to the cleaning of middling products from jig and table plants. The results show that the development of the process will make additional recovery of coking coal feasible from seams that are high in ash because of their high bone-coal content.

Coal Washery-Water Clarification

Under a cooperative agreement with the Truax-Traer Coal Co., Chicago, Ill., the Bureau of Mines installed and operated a 14-inch-diameter cyclone thickener at the preparation plant of the Shamrock Mine, Kayford, West Virginia. The unit was placed in the fine-coal washery circuit and used as a water-clarification device. Test data indicate the recovery of substantially all coal particles 100-mesh and larger in size. Less efficient recovery is experienced as the particle size decreases with but a one-third recovery of those solids finer than 325-mesh.

The rate of flow through the unit and the inlet nozzle pressures were controlled by adjusting the speed of a 6- by 4-inch centrifugal pump driven by a 25-hp. motor. The underflow spigot had a fixed diameter of 1-3/8 inches, and the inlet-feed nozzle was fixed at 2 inches inside diameter. The overflow nozzle was removable and interchangeable. Tests with 2-5/8-inch and 2-3/8-inch overflow orifices gave results that might be considered practical for thickener performance, with a thickener underflow product of 50 percent or less water and a recovery of about one-half the solids from the washery circuit.

This one cyclone recovered 5 to 6 tons per hour of marketable coal, which was previously lost. The demonstration of the usefulness of this device in the preparation plant influenced the cooperating company to install three additional cyclones to handle the entire water volume of the fine-coal washery circuit.

Washing Characteristics of Chilean Coals

At the request of the Chilean Government, the washing characteristics of Chilean coals were studied. Coal samples were collected from 7 mines operating in 11 beds, and the test data were reported.[36] Many of the beds may be washed at high-gravity with the simplest of modern coal-washing equipment and yield a high-grade, low-ash, low-sulfur product. The sulfur content of all samples was either very low (1 percent or less) or exceeded 3 percent. Where the sulfur content was high, little reduction in sulfur content could be expected by mechanical cleaning.

36/ See footnote 17.

Coal samples from the Province of Concepcion responded well to mechanical cleaning for ash reduction, producing a float-coal ranging from 2.2 to 6.7 percent in ash content. The Province of Voldivia coals, containing less than 10 percent ash in the raw state, did not respond to further ash reduction. The coals from the Province of Magallanes, although very low in sulfur, contained about 17 percent ash. The samples showed very little free rock, and examination of the washability charts indicated that the coals are not adapted to substantial improvement by washing, except by an uneconomic sacrifice in yield.

Coal Washing in Washington, Oregon, and Alaska

A general summary of the status of coal-washing practices in Washington, Oregon, and Alaska - an area in which some of the coals mined are more difficult to wash than those mined elsewhere in the country - has been published.37/ Many of the coal beds mined in Washington and Alaska contain more impurities than those mined elsewhere, and this circumstance contributed to the early interest in mechanical cleaning. A much more important factor, however, was the inclination of the coal beds. With steeply pitching beds, hand sorting by the miner at the face is impossible; consequently, all material must be loaded and dealt with on the surface, just as is now proving the case with mechanical mining of flat beds. Thus, "full-seam" mining afforded the same stimulus to the early development of coal washing in the Pacific Northwest that it is providing under mechanization in the rest of the country today.

Washington leads all other States in the percentage of its total production that is cleaned mechanically - 82.1 percent, in comparison with the national average of 25.6 percent in 1945. The washing problems in this State are highly variable, because the mountain-building forces that created the Cascade Range caused such intense folding and faulting of the beds in some fields that the rank of the coal was increased to anthracite, whereas in other fields, more distant from the mountains, the beds were relatively undisturbed, and the rank of the coal ranges down through subbituminous to lignite. The washability of several Washington coals is illustrated by figures 14 and 15.

Coal occurs at a number of locations in western Oregon, but mining has been limited principally to the Coos Bay field on the southwestern coast of Oregon. The Southport mine of the Coast Fuel Corp. requires a washing plant to remove the interbedded clay of the Beaver Hill bed. This plant incorporates provision for screening the run-of-mine product at about 4-inch size, hand-picking the lump, and optionally crushing the clean lump to join the screenings as feed for a Forrester-type jig. A specific-gravity analysis of the raw coal from this mine is given in table 4.

Coal production in Alaska during recent years has been divided about equally between the subbituminous coals of the Nenana field and the bituminous coals of the Matanuska Valley. The subbituminous coals, mined at Suntrana, are clean enough to be prepared by screening and some handpicking. In contrast, the coals of the Matanuska Valley contain more impurity than most so-called "dirty" coals mined in the United States and consequently must be washed to render them suitable for even the Alaska market. The proportion of washery feed rejected as refuse in Alaska averaged 33 percent in 1945, a far higher figure than was recorded for any State in the country.

37/ Geer, M. R., and Yancey, H. F., Coal Washing in Washington, Oregon, and Alaska: Am. Inst. Min. and Met. Eng. Tech. Pub. 2566F, Mining Trans., vol. 108, 1949, pp. 200-204; Mining Eng., vol. 1, No. 6, 1949, pp. 200-214.

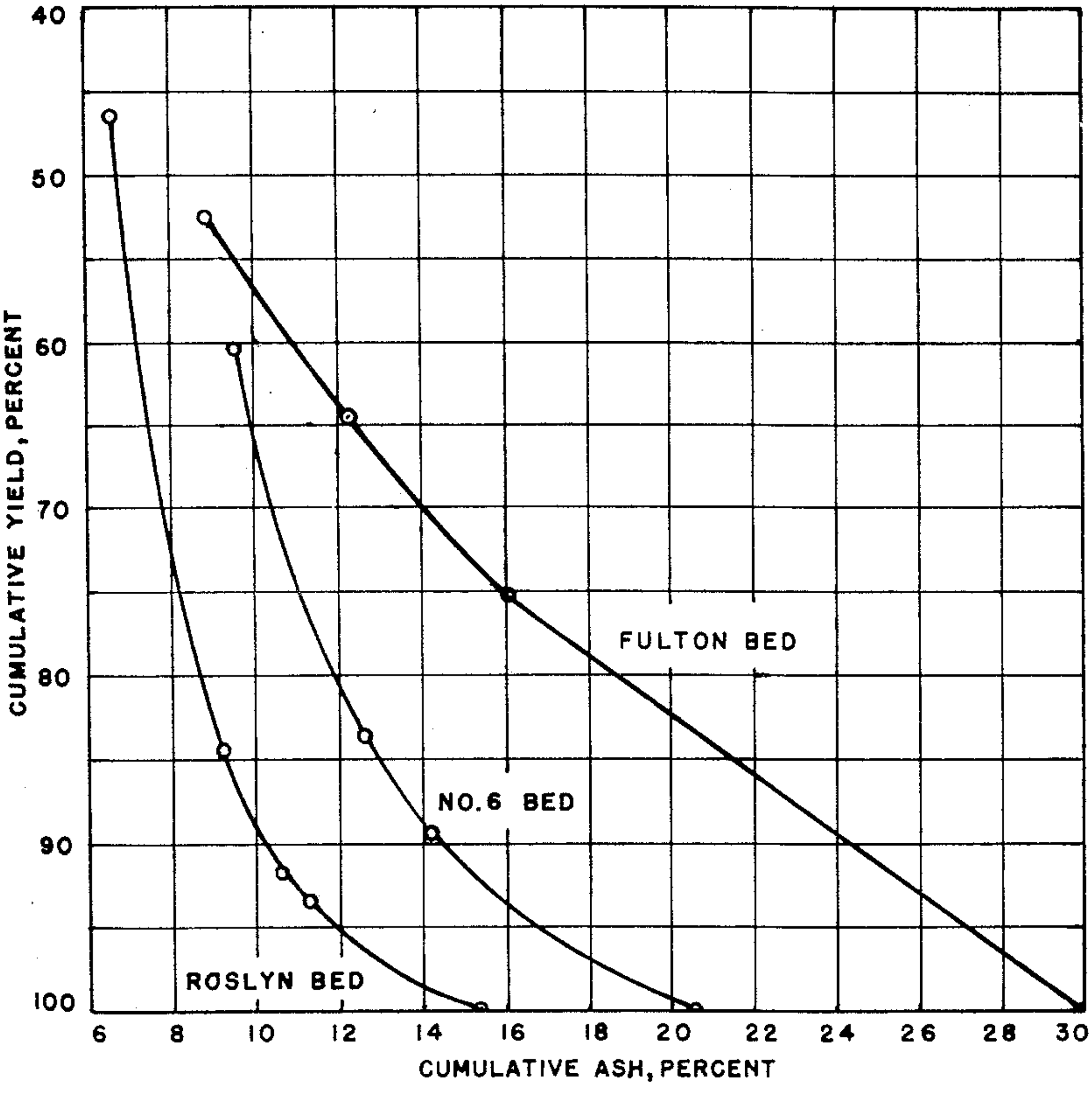

Figure 14. - Float-and-sink yield-ash curves for Roslyn, No. 6, and Fulton beds.

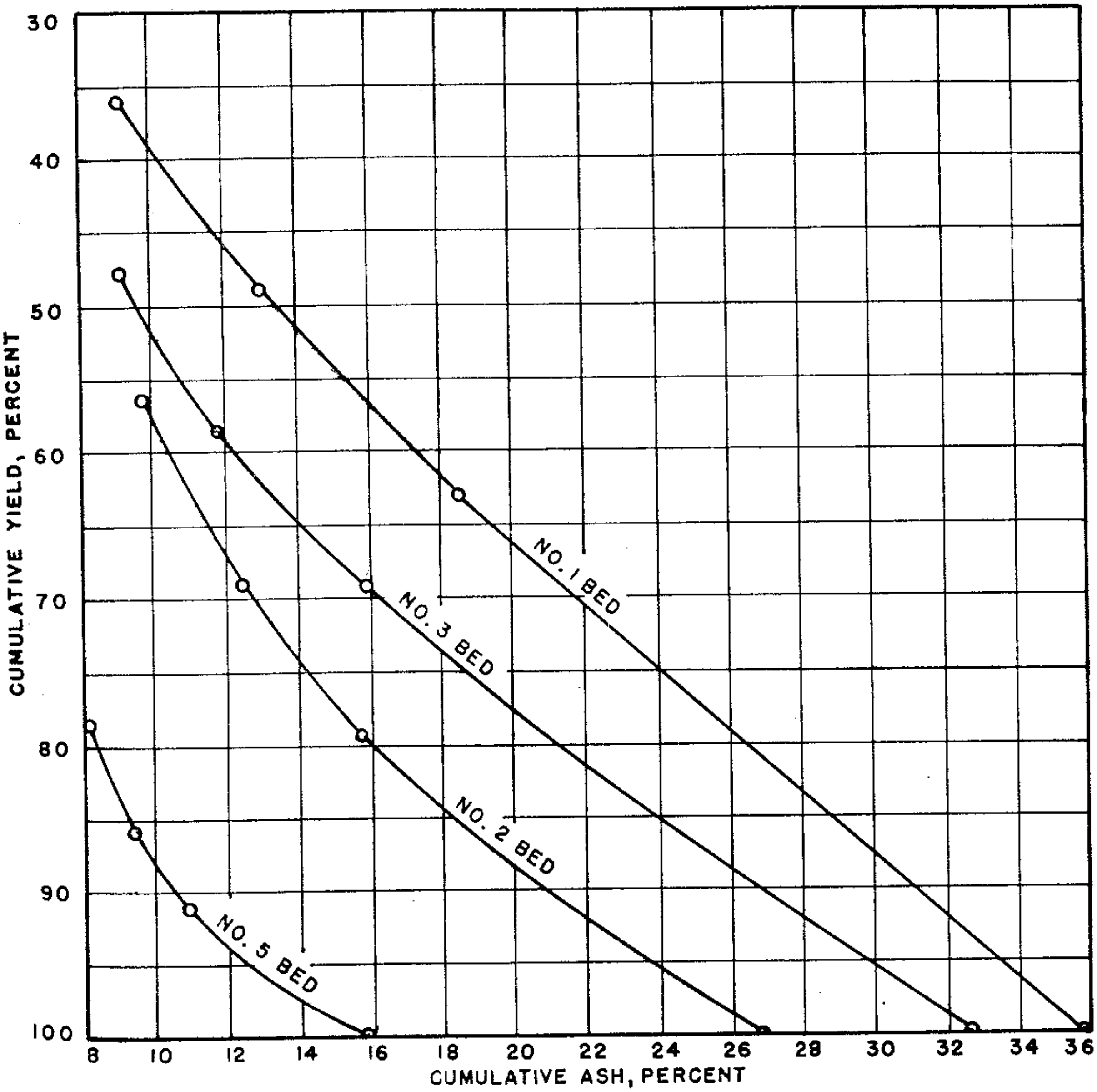

Figure 15. - Float-and-sink yield-ash curves for Wilkeson coal beds.

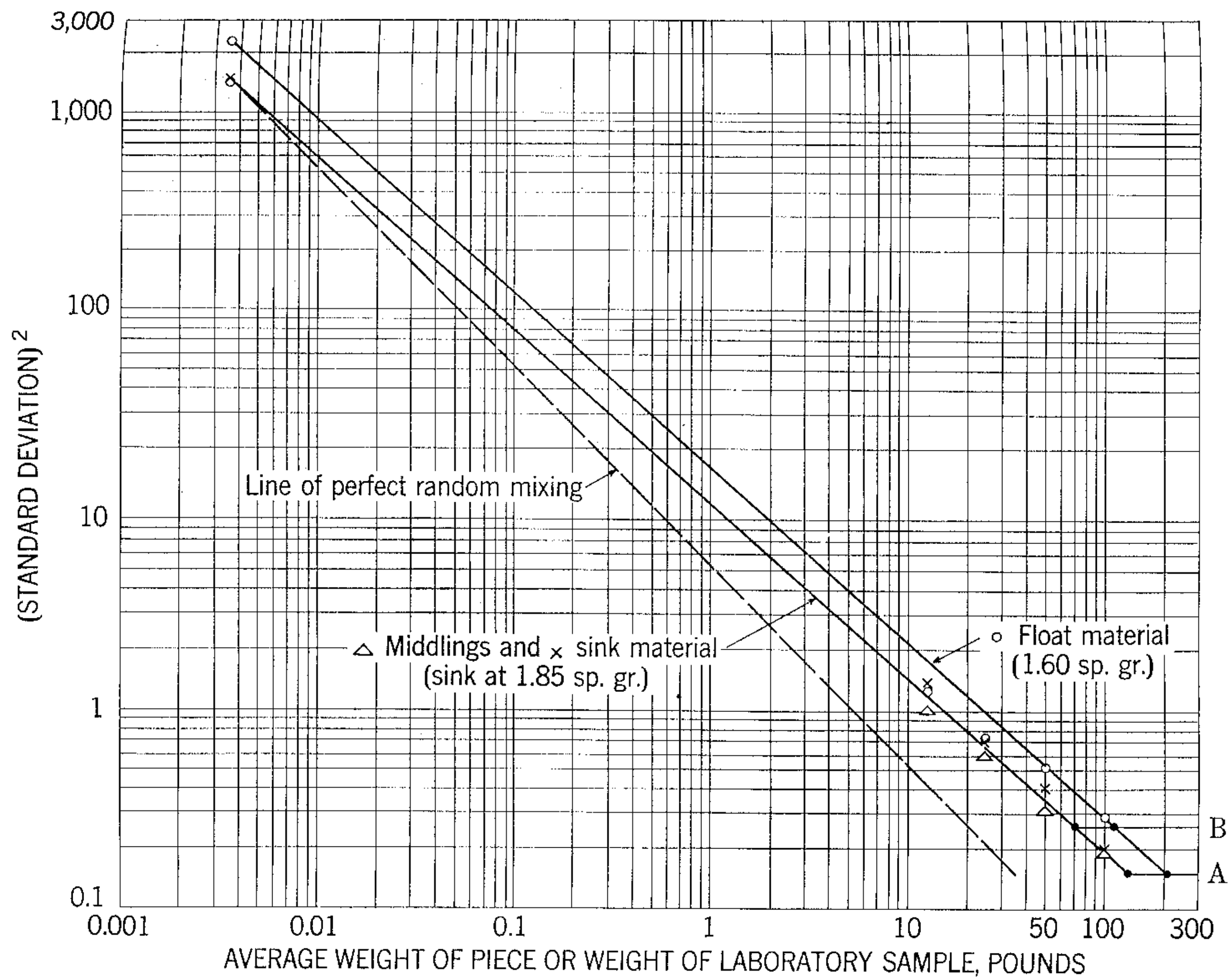

Figure 16. - Sampling characteristics of a Pennsylvania anthracite. Line A refers to an accuracy of ± 1%, 99 times in 100. Line B refers to an accuracy of ± 1%, 95 times in 100.

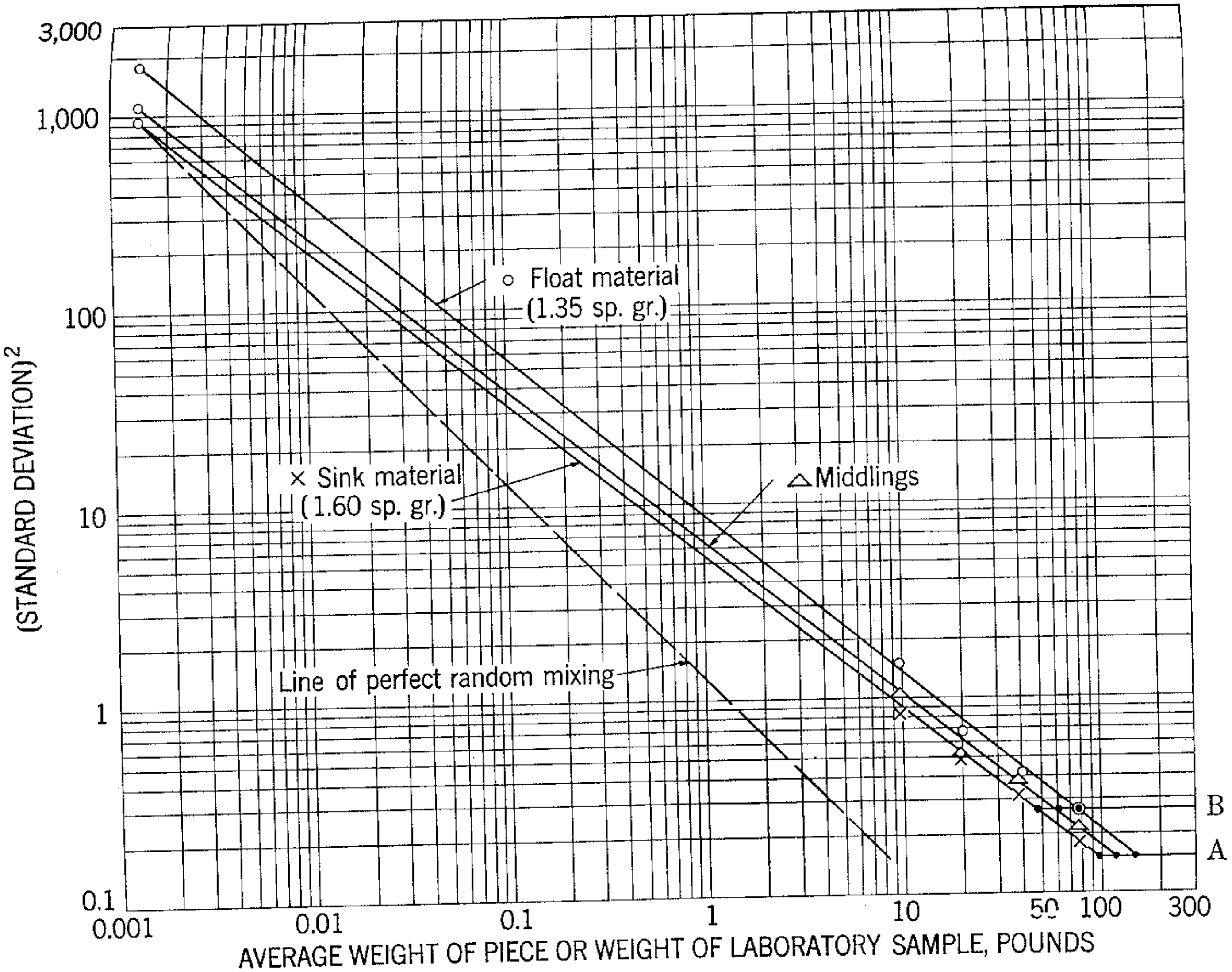

Figure 17. - Sampling characteristics of a western Pennsylvania bituminous coal. Line A refers to an accuracy of ± 1%, 99 times in 100. Line B refers to an accuracy of ± 1%, 95 times in 100.

TABLE 4. - Specific-gravity analyses of raw coal from Southport mine, Oregon

Size, inches and mesh	Specific gravity	Weight, percent	Ash,1/ percent	Cumulative Weight, percent	Cumulative Ash,1/ percent
2 to 1-1/2 inches	Under 1.40	73.2	9.8	73.2	9.8
Weight, 10.9 percent ..	1.40 to 1.50	10.6	22.9	83.8	11.5
Ash, 22.4 percent1/ ...	1.50 to 1.70	2.8	39.3	86.6	12.4
	Over 1.70	13.4	87.8	100.0	22.4
1-1/2 to 3/4 inch	Under 1.40	72.4	9.8	72.4	9.8
Weight, 21.3 percent ..	1.40 to 1.50	11.2	22.1	83.7	11.4
Ash, 22.1 percent1/ ...	1.50 to 1.70	3.4	40.3	87.1	12.6
	Over 1.70	13.0	85.9	100.0	22.1
3/4 to 3/8 inches	Under 1.40	72.4	9.4	72.4	9.4
Weight, 23.7 percent ..	1.40 to 1.50	9.9	21.2	85.3	10.8
Ash, 20.1 percent1/ ...	1.50 to 1.70	3.7	39.0	89.0	11.9
	Over 1.70	11.0	86.3	100.0	20.1
3/8 inch to 20 mesh ...	Under 1.40	72.4	8.2	72.4	8.2
Weight, 36.2 percent ..	1.40 to 1.50	10.1	18.4	82.6	9.4
Ash, 19.3 percent1/ ...	1.50 to 1.70	3.6	33.6	86.2	10.5
	Over 1.70	13.9	74.0	100.0	19.3
Under 20 mesh	Under 1.40	49.0	8.0	49.0	8.0
Weight, 7.9 percent ...	1.40 to 1.50	11.0	18.4	60.0	9.9
Ash, 34.7 percent1/ ...	1.50 to 1.70	7.1	32.9	67.1	12.3
	Over 1.70	32.9	80.3	100.0	34.7
Composite, 2 inches to 0	Under 1.40	71.3	9.0	71.3	9.0
Weight, 100.0 percent .	1.40 to 1.50	10.4	20.4	81.7	10.5
Ash, 21.6 percent1/ ...	1.50 to 1.70	3.8	36.5	85.5	11.6
	Over 1.70	14.5	81.0	100.0	21.7

1/ Moisture-free basis.

Sampling of Coal for Float-and-Sink Tests

Three typical coal samples, one anthracite and two bituminous, representing nationally important deposits, were examined in an intensive experimental study of the variability of several items of analytical data, and the relation of variability to particle size and sample bulk.38/

The data presented covered two of the samples and set up a relationship between particle size and sample size referred to a range of variability tolerance to suit the many situations in which float-and-sink data are used.

The findings are summarized in figures 16 and 17, showing standard deviation from the mean in relation to sample weight for each of the two coals. On these charts, the requirement for a variability tolerance of ± 1 percent of the sample in

38/ Bailey, A. L., and Landry, B. A., Sampling of Coal for Float-and-Sink Tests: Mining Eng., vol. 1, No. 3, 1949; A.I.M.E. Mining Transactions, pp. 79-84; A.I.M.E. T.P. 2539F.

99 samples out of 100 is shown where the cross line A intersects the curves. Line B similarly indicates the conditions for a precision of ± 1 percent 95 times out of 100.

For the two coals covered by this investigation, the sample weights of sink material indicated for these two precision standards are (1) for the Pittsburgh coal of 1-1/2-inch top size, 96 lb. for 99 out of 100 samples to fall within the tolerance of ± 1 percent sink, and 46 pounds to yield an accuracy of 95 out of 100, and (2) for the anthracite pea size, 130 lb. and 70 lb., respectively, for the above tolerances.

Upgrading Marginal Coking Coals by Coal-Preparation Methods

As part of the study to determine the amount of available coking-coal reserves suitable for the production of metallurgical coke, preparation characteristics of high-sulfur coking coals in southwestern Pennsylvania and northern West Virginia were investigated. It was desired to determine whether the sulfur and ash in these coals can be reduced to meet present metallurgical coking-coal standards by conventional coal-preparation methods and to develop methods that can be used to upgrade high-sulfur and high-ash coals with strong coking properties to make them suitable for metallurgical use.

Production of Electrode Carbon in Germany

Several processes for the production of ultra-clean coal for electrode carbon were developed in Germany prior to and during World War II. These processes have been investigated by British and U. S. Government missions since the end of the war.39/

Almost all the ultra-clean coal was used in the manufacture of electrodes for the production of aluminum and magnesium. Standard raw materials for making these electrodes are pitch coke and petroleum coke, which are nearly ashless. The inclusion of ash in the electrode carbon results in lowered efficiency and impure metal for the reduction process. Petroleum coke and pitch coke were in very short supply in Germany during the war, so that it was necessary to augment the supply with carbon produced from coal. In the emergency, methods were developed to clean coal, which never before had been economically feasible. Other uses of ultra-clean coal are in direct hydrogenation of coal, in production of activated carbon, and for special fuels. Specifications for electrode carbon are rather severe owing to the necessity for producing pure metal.

The most important process for ultra cleaning of coal in Germany was froth flotation. In two plants the coal cleaned by froth flotation was treated with acid or caustic to lower the ash content further. Another process used on an industrial scale was dissolving the coal substance in the middle oil from direct hydrogenation of coal under controlled pressure and temperature. The resulting paste was heated, filtered, and the oil distilled off. The residue was a low-ash organic material that could be carbonized for electrode carbon or could be hydrogenated directly. Several other processes had been developed to the laboratory or pilot-plant stage but had never been used on a commercial scale. These processes included cleaning by centrifugal action, cleaning by electrostatic action, and cleaning by forming a paste with oil in water.

39/ Graham, H. G., and Schmidt, L. D., Methods of Producing Ultra-Clean Coal for Electrode Carbon in Germany: Bureau of Mines Inf. Circ. 7481, 1948, 13 pp.

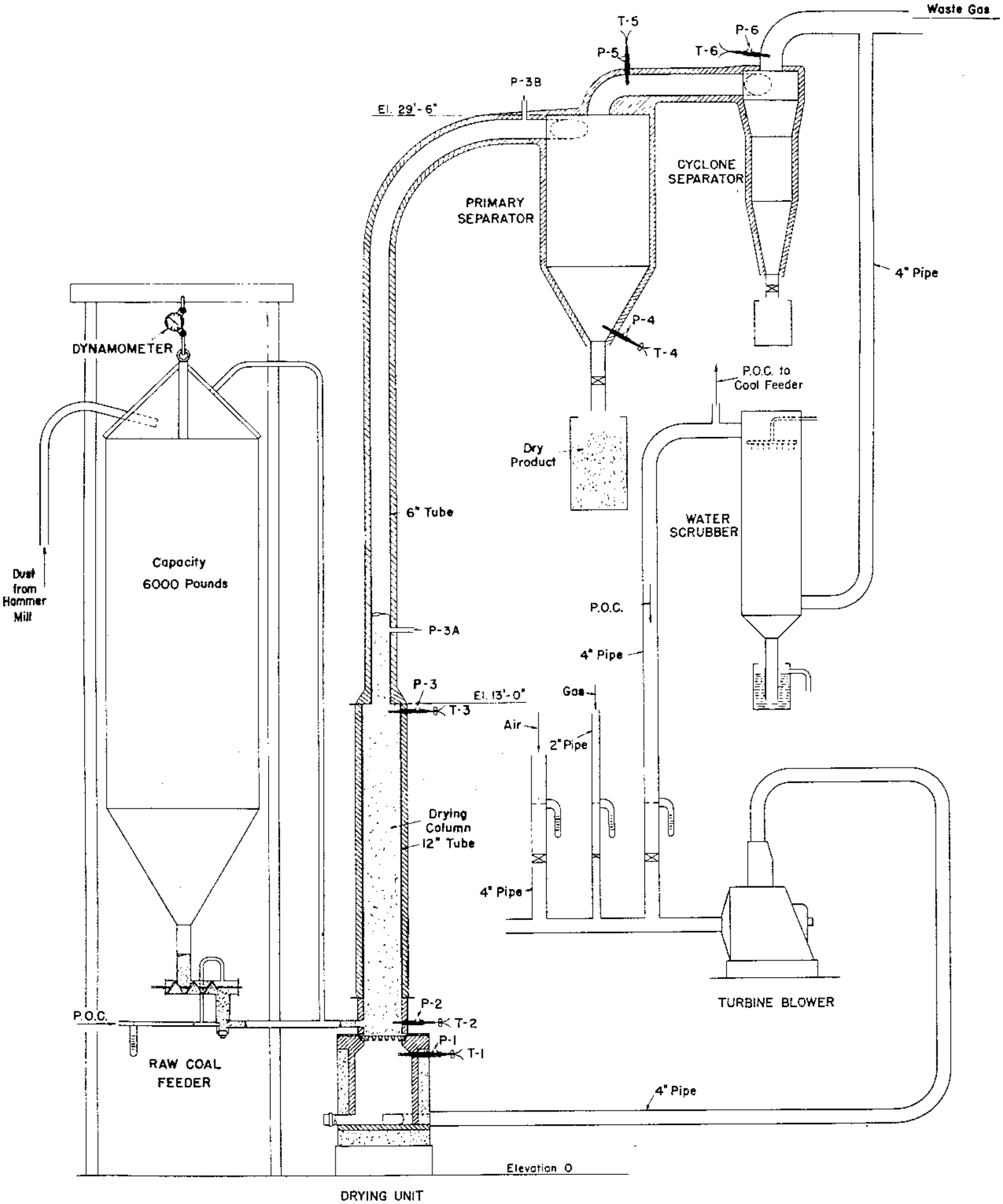

Figure 18. - No. 4 Pilot plant for drying fine coal. Capacity, 2,400 pounds per hour.