passed the tests was, at the request of the manufacturer, placed directly on the inactive list.

Substitutions in Permissible Explosives

A great variety of materials is used in compounding permissible explosives. Changing conditions and demands of the chemical industry have made many of these substances very difficult or virtually impossible to obtain. It has, therefore, been necessary for manufacturers to seek safe and suitable substitutes for some of the ingredients entering into the composition of these explosives. Seven permissible explosives containing proposed new ingredients have been tested for approval.

A permissible explosive approved originally in two different cartridge diameters was resubmitted in six additional diameters to establish the basic data for these sizes.

Field Samples of Permissible Explosives

A permissible explosive or blasting device, after approval for use in gassy and dusty coal mines, must be so manufactured that it will have all the chemical and physical characteristics of the basic sample. For a check on their quality, 18 samples of permissible explosives were collected from the manufacturers' magazines. All samples passed the gallery tests, although several did not meet the established tolerances of some of their physical characteristics. The items in which these explosives failed, and the number of failures respectively, were as follows: Physical examinations, 2; chemical analyses, 8; rate of detonation, 5.

Consumption of Permissible Explosives

During the fiscal year 1947, the consumption of permissible explosives in coal mines was approximately 110 million pounds. In addition to this, approximately 33 million pounds of black blasting powder and approximately 119 million pounds of high explosives other than permissibles were used, chiefly in strip-mining operations. Thus, over three and one-half times as much permissible explosives as black blasting powder was used. This ratio has been steadily increasing since 1940, the first year in which the consumption of permissible explosives exceeded that of black blasting powder.

Firedamp Safety of Powder-Powered Tools for Splicing Cables and Punching Rails

It is to be anticipated that demands for increased production of coal will result in the production of special tools for performing tasks in coal mines with greater ease and efficiency. Tools for splicing cables and punching rails have recently been placed on the market. They are powered by cartridges containing requisite amounts of propellent powder.

Tests have been made to determine the firedamp safety of such tools.[33] They have been tested under a variety of conditions in a mixture of natural gas and air. The studies suggest that employment of these tools in a normal functional manner under the conditions outlined involves very little, if any, ignition of firedamp. A total of 83 gallery tests of the cable splicer, including 33 under drastic conditions emphasizing ignition hazards, and a total of 60 gallery tests of the rail punches were made without ignition of 8 percent mixtures of natural gas and air. Some hazard was found to attend some of the ammunition supplied for the rail punch. When fired directly into natural gas and air, the ignitions were obtained with the cartridge alone. This ammunition can be modified to minimize such hazards.

Determination of the Reactivity of Calcium Carbide and Acetylene-Water Vapor Mixtures

In studies made by the Bureau of Mines to determine the causes of explosions in medium-pressure acetylene generators, it was shown[34] that, when these are operated at elevated temperatures, the acetylene generator carries enough water vapor to heat certain types of carbides to a high temperature, when the acetylene-water vapor mixtures are passed through the carbide. It was found that reproducible results on the test characteristics of carbides could not be obtained in a small laboratory-type apparatus. Accordingly, a larger testing apparatus was designed which more closely simulated conditions prevailing in a commercial generator. It consists of a 20-pound portable acetylene generator, suitably altered to allow the desired tests to be made. Details of the apparatus and procedures are described elsewhere.[35]

The acetylene-water mixture is passed through the test carbide for 4 hours, or less if the test carbide heats to a maximum and then cools down in all three thermocouple locations before the 4-hour period has expired. Experience has shown that a highly reactive carbide will develop its maximum temperature within the time limit of 1-1/2 to 2-1/2 hours under the experimental conditions described. Low reactive carbides may require 4 hours to develop a maximum temperature.

Typical heating curves of different carbides, namely, low reactive, moderately reactive, and highly reactive, were obtained. In all cases the temperature of the generator water was 65° C., and thus the saturated acetylene had a water vapor content of 24.7 percent by volume. For low-reactive carbide, the maximum temperature reached in any part of the charge during

33/ Denues, A. R. T., Powder-Powered Tools; The Firedamp-Safety of Devices for Splicing Cables and Punching Rails: Bureau of Mines Rept. of Investigations 4105, 1947, 11 pp.

34/ 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.

35/ Jones, G. W., Scott, G. S., Kennedy, R. E., and Spolan, I., Apparatus for Determining the Reactivity of Calcium Carbide and Acetylene-Water Vapor Mixtures: Bureau of Mines Rept. of Investigations 4067, 1947, 15 pp.

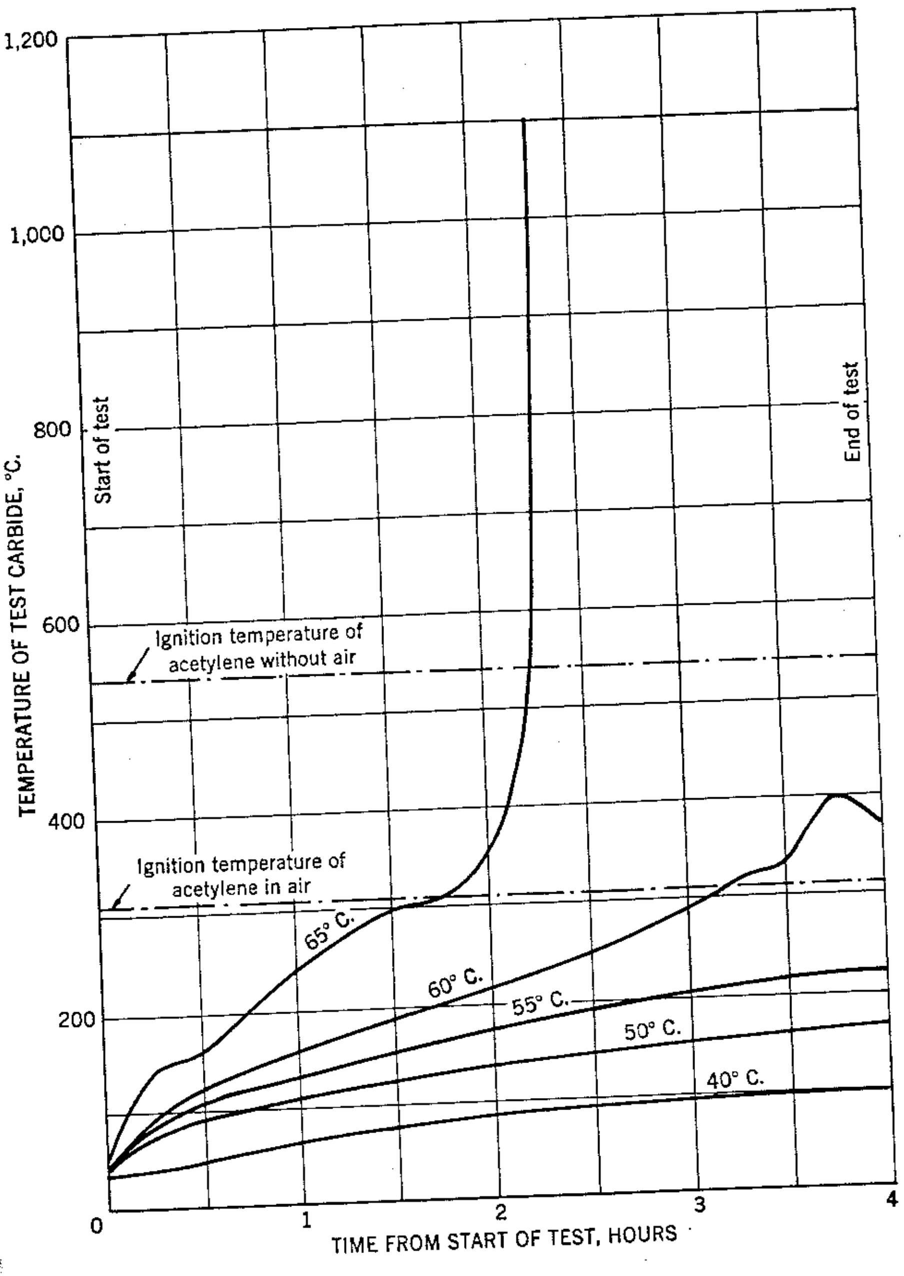

Figure 32. - Effect of temperature of water in generation on heating of carbide. Highly reactive carbide; size, 1/4 x 1/12 inch; generator pressure, 4 lb. per sq. in. gage.

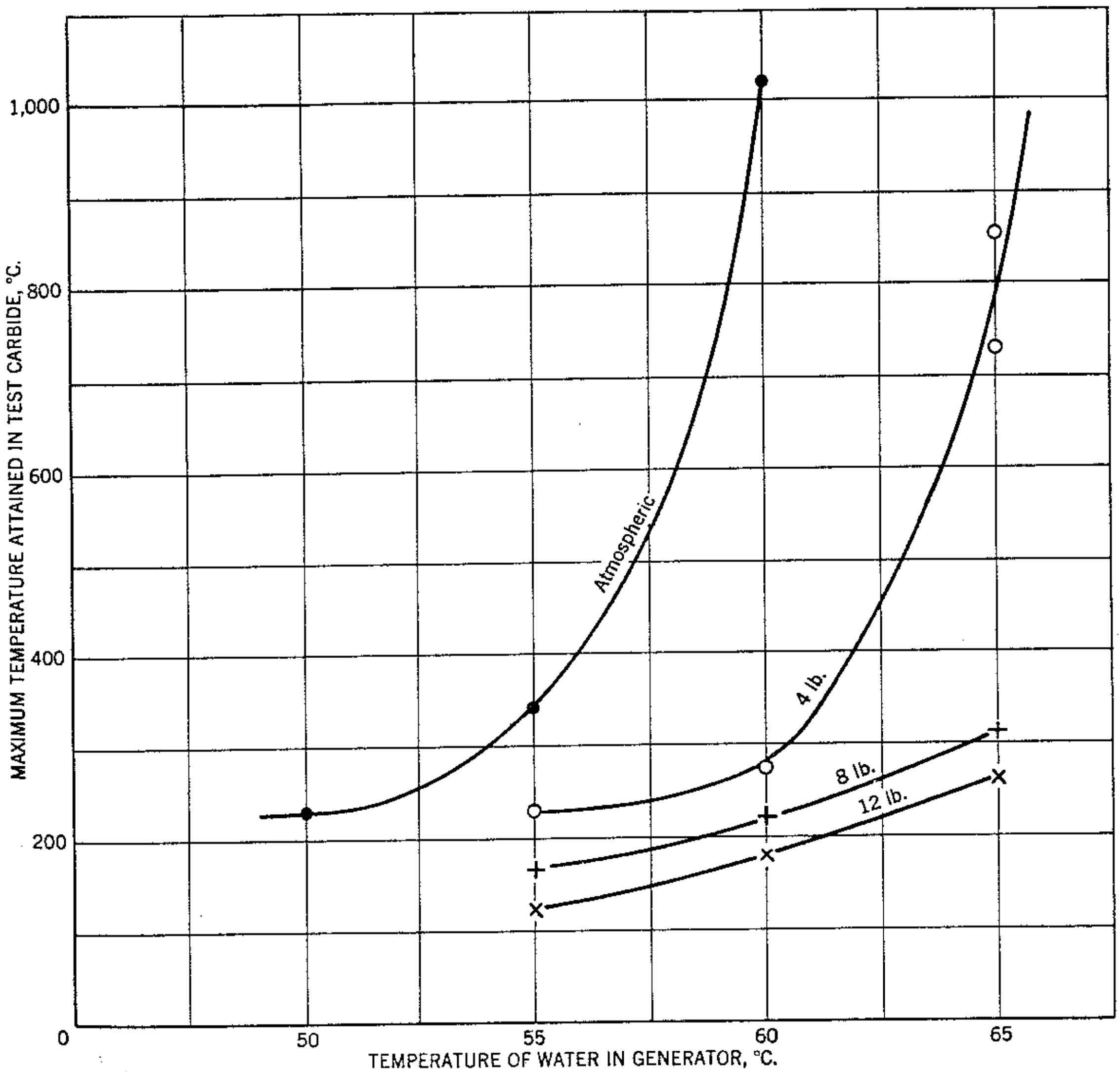

Figure 33. - Effect of generator water temperature and pressure on reactivity of carbide.

the 4-hour period never exceeded 230° C., which is well below the ignition temperature of acetylene and air (310° C.). For moderately reactive carbide, the temperatures rise somewhat above the ignition temperature of acetylene in air 2 hours after the start of the test, particularly in the middle and top part of the charge. In the top part of the charge it reaches a value of 406° C. 2-1/2 hours after the start of the test and then drops abruptly to below the ignition temperature. The bottom part of the charge remains safely below the ignition temperature of acetylene in air throughout the 4-hour test. For highly reactive carbide, very rapid rise in temperature occurs after about 1 hour; after 2 hours it rises at a rate of 100° C. per minute and attains temperatures well over 800° C. in about 2 hours. The temperature of the top part of the charge rises earlier than the rest of the charge. This rapid rise in temperature is probably due to heat liberated in the decomposition of acetylene alone (ignition temperature, 540° C.).

Using 1/4- by 1/12-inch carbide, tests were made of the effect of generator-water temperature, generator pressure, and rate at which acetylene gas is passed through the carbide on the heating effects.

The generator-water temperature was varied from 40° to 65° C., the pressure being maintained at 4 pounds above atmospheric and acetylene rate at 32 cubic feet per hour. The carbide used was known to heat excessively in contact with water vapor. The maximum temperature attained in the carbide increased with generator water temperature in a manner shown in figure 32. It is clear from these results that a dangerous condition is approached at generator-water temperatures above 55° C. for this type of carbide.

Typical results showing the effect of pressure on the reactivity of a highly reactive carbide are given in figure 33. It is seen that, the lower the pressure in the generator, the higher the temperature attained, other conditions of the test being the same. For highly reactive carbides change of generator pressure had a very marked effect upon the temperature attained in the test carbide; for low-reactive carbides it had only a moderate effect. The fact that increasing the generator pressure reduces the maximum temperature attained by the carbide indicates that possibly the heating is governed by the water-vapor content because at a given temperature of the generator water, the percentage of water in the mixtures falls off with increasing acetylene pressure.

The results obtained with different flow rates of acetylene show that the temperature of the carbide increases with increasing flow rate, reaching a maximum at about 32 cubic feet per hour. Above this rate, the temperature falls again, except for the highest-reactivity carbides; and here the additional rise in temperature is small - up to 39 cubic feet per hour.

On comparing the results for various brands of carbide obtained to date, it becomes evident that particle size is not the only factor contributing to heating. It is probable that surface reactivity plays an important role.

PREPARATION OF COAL

Recovery of Fine Coal from Slurry Water

An economical method for recovering fine-size coal, on a limited scale, from slurry water that was previously wasted has been developed and installed at one of the mines in the Warrior field of Alabama.[36] The method consists principally of recovering the fine coal by pneumatic froth flotation and using the washed-coal bin as a drainage and filtering medium for recovering the fine coal out of the froth. Under normal operations, the system will recover almost 2 tons per hour of coking coal out of slurry that was previously wasted.

Progress is being made in the development of a kerosine flotation process for cleaning and dewatering fine sizes of coal from about 10-mesh to 0. A four-cell semicommercial machine has been obtained for the laboratory and for experimental work in commercial plants. Results with this machine and a larger four-cell machine installed by one of the cooperating companies have established quite definitely the feasibility and practicability of the process for treating underflow sludges from dewatering screens. Efforts are now being directed toward making the process applicable to the treatment of raw-coal fines.

Preparation Characteristics of Illinois Coals

An intensive study of the preparation characteristics of the four principal beds in Illinois - namely, the No. 2, No. 5, No. 6, and No. 7 - was undertaken. Face and tipple samples from mines in each of the several producing districts were float-and-sink tested, and sieve analyses of the slack coals were prepared. Although all the field work has been completed during the fiscal year, the final analysis and interpretation of test data have not been accomplished.

New Heavy-Medium Process for Cleaning Fine Coal

The various heavy-medium processes in use for separating the impurities from raw coal as mined are not suitable for cleaning fine sizes of coal. The particular advantage of processes that employ a suspension of solid material in water or a heavy liquid to effect a separation between coal and impurity, based alone on differences in specific gravity, is that they are able to make a more complete and efficient separation than processes that depend also on other physical properties. Unfortunately, however, heavy-medium processes cannot ordinarily be used to clean the fine sizes of coal below 1/4 inch.

As a result of observations made by members of the wartime Solid Fuels Mission at the Netherlands State Mines in Europe this situation has changed.

[36] Gandrud, B. W., and Riley, H. L., Flotation Treatment of Washery Water at the Empire, Alabama, Mine of the DeBardeleben Coal Corporation: Am. Inst. Min. and Met. Eng., Tech. Pub. 2205, 1947, 8 pp.

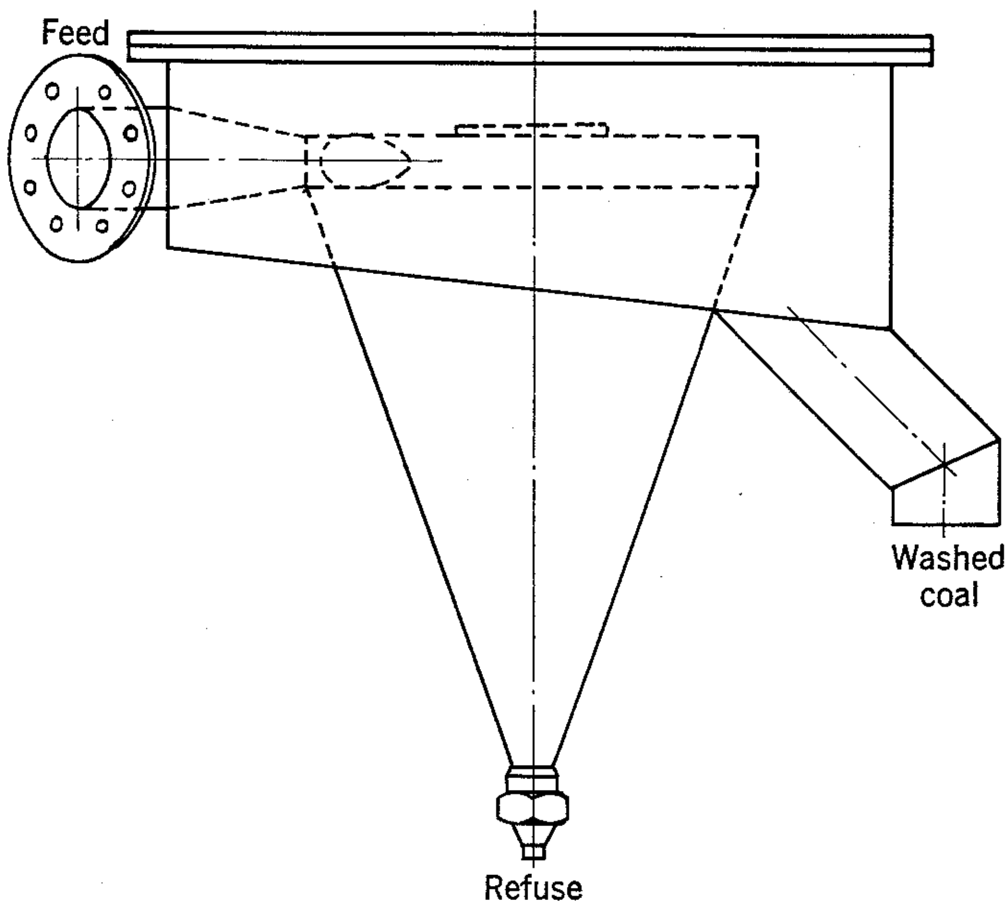

Figure 34. - Netherlands State Mines cyclone washer for fine coal.

A cyclone-type coal washer for fine coal was developed at the State Mines, Heerlen, The Netherlands, during the German occupation, and the information concerning it has been brought back to the United States. Since then the Northwest Experiment Station of the Bureau at Seattle, Wash., has built one of these Netherlands cyclones of laboratory size and studied its performance as a cleaner of fine coal. The results of this preliminary investigation were presented at the joint fuel conference of the American Institute of Mining and Metallurgical Engineers and American Society of Mechanical Engineers held in Philadelphia, Pa., in October 1946, and have since been published.[37]

Figure 34 shows a sketch of the cyclone washer. The 14-inch diameter size has a capacity of about 16 tons of feed coal an hour.

In appearance and operation the cyclone device looks much like the ordinary cyclone dust collector, except that it is operated wet. In shape it is an inverted cone, with an open, spigot-type discharge at the bottom and an overflow through an orifice at the center of the cone at the top. The coal feed, in a suspension of barite, loess, flotation refuse, or other high-gravity liquid, is introduced tangentially at the top of the cone along the side. The pulp density is about 6 of suspension to 1 of coal. In effect, this cyclone cleaner acts as a device for separating continuously the float-and-sink particles present in a bath having a density intermediate between coal and impurity. The coal feed must be suspended in a heavy medium.

Table 7 shows the results of a trial run made of coal from a mine in the Pittsburgh bed at Bruceton, Pa., crushed to pass 14-mesh. The results are summarized according to the individual size fractions present.

TABLE 7. - Summary of results obtained in cyclone test on 14- to 100-mesh Bruceton coal[1]

Data	Screen size, mesh					
	14-35	35-48	48-65	65-100	-100	14-100
Screen analysis of feed .... percent	66.3	10.2	7.5	4.9	11.1	88.9
Sink 1.60 sp. gr. in feed .... do.	4.6	4.6	4.6	5.5		4.7
Yield of refuse .... do.	4.9	5.0	6.5	9.0		5.3
Specific gravity of separation	1.60	1.67	1.68	1.88		
Sink 1.60 sp. gr. in washed coal ... .percent	.2	.9	1.2	2.4		.5
Float 1.60 sp. gr. in refuse . do.	9.6	25.7	47.2	62.1		20.8
Ash in feed .... do.	7.4	6.8	6.8	7.4	6.5	7.3
Ash in washed coal .... do.	4.8	4.6	4.8	5.6		4.9
Ash in refuse .... do.	57.8	48.0	35.0	26.2		51.0
Efficiency .... do.	99.7	98.8	96.8	93.6		99.0

1/ Barite suspension, 1.40 sp. gr.; feed-tube opening, 7/16 in.; washed-coal orifice, 7/16 in.; refuse opening, 1-3/32 in.; operating pressure, 20 psi.

37/ Geer, M. R., and Yancey, H. F., Preliminary American Tests of a Cyclone Coal Washer Developed in The Netherlands (with discussion): Am. Inst. Min. and Met. Eng., Tech. Pub. 2136, February 1947, 20 pp.

In general, these results show a very efficient separation. The efficiency on all sizes combined, from 14- to 100-mesh, was 99.0 percent. The finer sizes of coal were separated at higher specific gravities than the coarser ones. The quantity of heavy impurity remaining in the washed coal increased with decreasing particle size. Similarly, the quantity of coal lost in the refuse product increased with decreasing particle size. Thus the efficiency of the separation between coal and impurity decreased with decrease particle size. Only the material coarser than about 48-mesh was handled with satisfactory efficiency. Below that size, the sharpness of the separation dropped rapidly.

The work showed that the cyclone has a high capacity and is able to make a sharp, efficient separation between coal and impurity at a particle size down to about 48-mesh. Thus the cyclone offers promise of extending substantially the size range that may be effectively treated by heavy-medium processes.

European Practice

Coal Preparation in The Netherlands

Current developments in the field of separation by heavy suspensions constitute the most interesting European development, because of present activity in this direction in America. It will be recalled that the practical application of this principle to the separation of minerals started with the introduction of the Chance sand-flotation process and large-scale experiments with the Conklin process in the Pennsylvania anthracite region during and immediately after the First World War.

In The Netherlands, three heavy-medium processes have been perfected and reduced to practice. Like our American processes, these differ primarily in the method of maintaining a controlled dispersion of the suspended solids.

The Barvoys process is the most widely used at present in Europe. The preferred medium for this process is a mixture of barite and clay of a size consist that will settle very slowly in water at operating gravities. It may be considered a semistable suspension. In this process, Conklin's problem of recovering the dispersed medium of the rinse water has been solved by exploiting the phenomenon that, with properly controlled size consist, a very fine medium will settle very slowly at the high concentrations used for separations and yet will settle rapidly in very dispersed suspensions, such as rinse water.

In contradistinction to this, the principle of the Tromp process uses a finely ground but yet definitely settlable magnetite suspension, which is just allowed to settle naturally in traversing the separating bath. Control involves only preknowledge of the rate of settling, so that the effective separation gravity may be predetermined. To avoid blocking the machine by accumulation of middlings in the bath, which naturally comes about with a difference in specific gravity between the top and the bottom areas of the medium, the material in the middle-depth portion of the bath is continually removed and reprocessed elsewhere in the plant.