

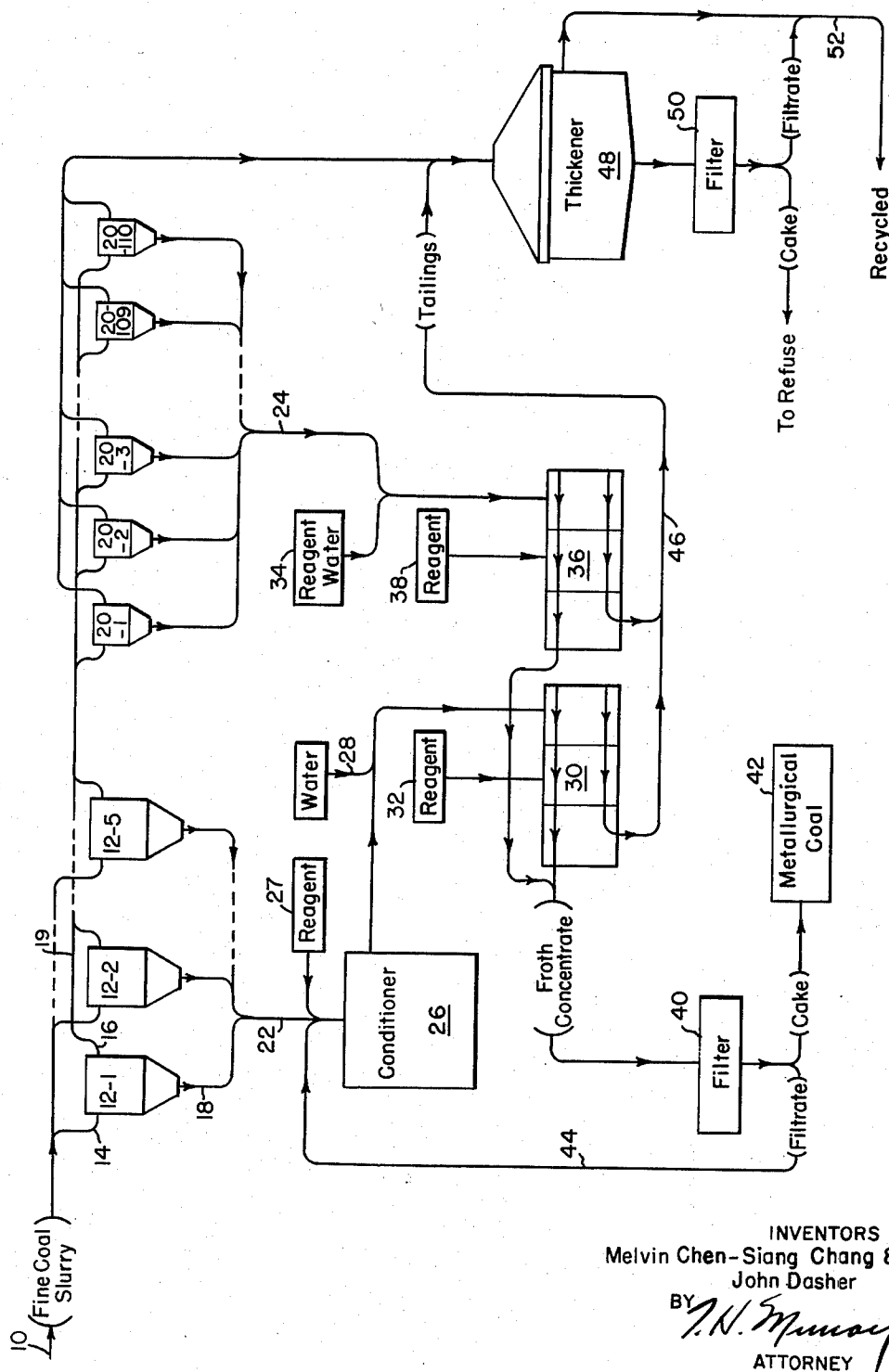
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COAL TREATING PROCESS

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COAL TREATING PROCESS

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This invention relates to a method for beneficiating metallurgical coal and, more particularly, to a process which employs froth flotation for beneficiating fine coal slurry.

In a soft coal washing process, a mineral slurry is produced which contains fine particles of coal and ash material suspended in water. It is, of course, highly desirable to separate the ash material from the coal which may then be employed for various useful purposes; and, accordingly, it is a primary object of this invention to provide a method for treating mineral slurry to separate fine coal particles from ash and slime material.

More specifically, an object of the invention is to provide a process employing froth flotation for beneficiating fine coal slurry. Generally speaking, the application of the flotation process has been rare in the soft coal industry. Soft coal slurry contains an excessive quantity of slimes which coat mineral surfaces and tend to equalize the surface properties of the different phases, a phenomenon which makes separation by flotation extremely difficult. The high specific surface of slimes also causes an excessive reagent requirement in the flotation process as well as considerable difficulty in the handling of the froth product. The present invention, therefore, provides for desliming of the slurry before the flotation step.

Flotation of soft coal is also impeded by the fact that fine coal particles are middling. That is, each contains some coal and some ash, a factor which tends to equalize the flotability of particles in the slurry. In order to efficiently separate different minerals by flotation, however, they should have wide differences in flotability. Variation in flotability of middling coal particles can be achieved efficiently only when the particles are approximately the same size; and, accordingly, the present invention provides for classification of the feed before flotation.

In accordance with one embodiment of the invention, hereinafter described in detail, fine coal slurry is passed through two sets of parallel-connected cyclone separators, with the respective sets of separators being connected in series. The diameters of the first set are larger than those of the second set whereby the bulk of the underflows from the respective sets are in different size ranges. These underflows are floated separately and their froth concentrates are combined and filtered to produce a cake of metallurgical coal, the filtrate from the filtering process preferably being recycled through the flotation apparatus. The tailings from the flotation process and the overflows from the cyclones in the second set of cyclones are combined and passed to a thickener. The sludge underflow from the thickener is discarded with or without filtering, and the filtrate, if filtration is employed and the overflow are combined and recycled through the coal washing process which produces the original slurry.

The above and other objects and features of the invention will become apparent from the following detailed

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description taken in connection with the accompanying single figure drawing which schematically illustrates the process of the invention.

Referring to the drawing, fine coal slurry at 10 is fed to five fourteen-inch diameter cyclone separators, 12-1, 12-2, etc. As is well known, cyclone separators are constructed whereby the fine coal slurry entering at 14 in cyclone 12-1, for example, is rotated whereby centrifugal force directs fine particles through outlet 16 10 while the heavier or coarser particles gravitate to the bottom of the cyclone and into outlet 18. The fine particles passing through outlet 16 are called the "overflow" while those which drop into outlet 18 are called the "underflow." As shown, the five fourteen-inch cyclones are connected in parallel whereby the incoming slurry is divided between the inlets, and the slurry from the outlets is combined in one conduit 19. The overflows from the respective cyclones in conduit 19 are fed to 110 parallel-connected 3 inch diameter cyclones 20-1, 20-2, etc. It is apparent that the individual cyclones in each set of cyclones are connected together in parallel; whereas, the respective sets of cyclones are connected in series, meaning that the combined overflows of the first cyclone group are passed to the inlets of the second cyclone group. Since the diameters of the first set of cyclones are larger than those of the second set, the particles in the underflow appearing in line 22 are larger than those in the underflow from the second set appearing in line 24. The underflow from the first set of cyclones is fed to a conditioner 26 where a reagent from source 27, such as Aerofroth #73 (trademark), is added. The underflow from the conditioner 26 has water added thereto at 28 and is passed to three No. 30 Denver Sub A flotation cells 30 where additional reagent from source 32 is added.

The underflow from the second set of three inch cyclones has a reagent and water added from source 34, the reagent in this case preferably being methyl isobutyl carbinol. The underflow with reagent added thereto is fed to three No. 30 Denver Sub A flotation cells 36 as was the case with the underflow from the first set of cyclones. A reagent from source 38 is also added to the flotation cells to assist in the flotation process. The froth concentrates from the respective sets of flotation cells 30 and 36 are combined and passed to a 4-disk Oliver filter 40 to produce a cake of metallurgical coal at 42. The filtrate from the filtration process contains some of the reagent and is, therefore, preferably recycled through line 44 to the conditioner 26 where it is again used in the flotation process.

The tailings from the respective sets of flotation cells 30 and 36 are combined in line 46 with the combined overflows from the parallel-connected 3 inch cyclones. After passing through both sets of cyclones, this final overflow will consist almost entirely of slime material. The combined tailings and slime material are thereafter passed through a Dorr thickener 48 where a flocculant such as causticized potato starch is added. The sludge underflow from the thickener is then passed to a 12-disk Eimco filter to produce a sludge cake which is discarded. The filtrate from the filtering process and the overflow from the thickener 48 consist essentially of clear water and are, therefore, combined in conduit 52 and recycled to the coal washing process which produces the fine coal slurry at 10.

The following is an example of actual test data taken on the process of the invention, showing the size and weight distribution of ash and coal at various points in the process:

Slurry at about 9% solids with the size and weight distribution shown in Table I was fed at approximately

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1400 gallons per minute to the five 14 inch parallel-connected cyclones as shown in the drawing.

Table I

Size, mesh:	Percent, weight
+16-----	2.53
16/32-----	4.11
32/60-----	11.74
60/100-----	12.64
100/140-----	6.19
140/200-----	7.68
200/325-----	7.11
-325-----	48.00

It can be seen that the bulk of the feed is either in the 32 to 100 mesh size or smaller than 325 mesh, this latter segment being high ash and slime material.

The size and weight distribution of the underflows and overflows in the 14 inch and 3 inch cyclones, respectively, are shown in Table II. It will, of course, be understood that the overflow from the 14 inch cyclone constitutes the feed for the 3 inch cyclones.

Table II

Size, Mesh	14" Cyclone—Percent Weight		3" Cyclone—Percent Weight	
	Underflow	Overflow	Underflow	Overflow
+16-----	7.07			
16/32-----	13.50	0.70	0.83	0.08
32/60-----	34.80	0.96	2.16	0.25
60/100-----	22.12	3.41	6.83	0.93
100/140-----	5.91	3.64	6.47	1.03
140/200-----	6.24	6.55	12.80	2.01
200/325-----	3.02	9.26	16.60	2.54
-325-----	7.34	75.68	54.31	93.16
Composite-----	100.00	100.00	100.00	100.00

It will be noted that very large percentages of the overflows from the respective sets of cyclones are below the 325 mesh size, indicating that this material is primarily ash or slime. Most of the underflow from the 14 inch cyclones which is fed to flotation cells 30 is in the plus 100 mesh range, while the underflow from the 3 inch cyclones which is fed to flotation cells 36 is -140 mesh. About 77% of the -325 mesh material in the 3 inch cyclone underflow is +600 mesh while 92% of the solids in the overflow is -600 mesh. Thus, the arrangement of the cyclones of the present invention gives exceptionally good desliming and classification of the feed into two size ranges before flotation.

Table III gives the size and weight distribution of the underflow from the 14 inch cyclones together with the size and weight distribution of the froth concentrate and tailings produced in flotation cells 30. In addition, the ash percentage of the 14 inch cyclone underflow, the froth concentrate, and the tailings in cells 30 are given.

Table III

Size, Mesh	Percent Weight			Percent Ash		
	Feed	Froth Concentrate	Tail	Feed	Froth Concentrate	Tail
+16-----	7.07	3.13	11.40	6.72	6.08	6.96
16/32-----	13.50	10.20	10.70	7.48	4.92	10.20
32/60-----	34.80	33.16	15.73	9.60	4.88	15.40
60/100-----	22.12	29.30	12.23	10.56	5.24	27.60
100/140-----	5.91	9.00	5.94	17.16	5.80	40.70
140/200-----	6.24	8.35	7.25	23.84	8.12	56.80
200/325-----	3.02	2.90	7.55	42.68	17.16	72.00
-325-----	7.34	3.96	29.20	60.96	33.68	79.64
Composite-----		100.00	100.00	15.1	7.4	43.8

It will be noted that the "feed" corresponds to the 14 inch underflow given in Table II. Since most of the feed is in the plus 100 mesh size range, the bulk of the concentrate and tailings are also in this range. Furthermore, the ash percentage of the froth concentrate in the plus

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200 mesh size is the smallest. The ash percentage jumps above 10% only for sizes smaller than 200 mesh, and it will be observed that these sizes constitute only a very small percentage (6.86%) of the total weight of the concentrate.

Table IV is similar to Table III except that it shows the size and weight distribution and ash percentage of the feed, concentrate and tailings from the 3 inch cyclone underflow flotation in cells 36.

Table IV

Size, Mesh	Percent Weight			Percent Ash		
	Feed	Froth Concentrate	Tail	Feed	Froth Concentrate	Tail
+32-----	0.83	0.27	0.85	6.36		
32/60-----	2.16	1.28	2.23	5.72	2.90	6.25
60/100-----	6.83	6.40	6.85	4.20	2.34	5.30
100/140-----	6.47	6.90	6.29	4.28	2.70	6.00
140/200-----	12.80	14.05	9.53	4.56	7.48	6.90
200/325-----	16.60	19.40	12.00	5.00	3.44	7.80
-325-----	54.31	51.70	62.25	31.72	10.88	62.08
Composite-----		100.00	100.00	19.3	9.0	40.9

In general, it is undesirable to have particles larger than 32 mesh since, as was explained above, the feed to the flotation cells should be as uniform as possible.

The ash percentage of the slurry at 10 was originally 23% while it is 7.4% and 9%, respectively, in the froth concentrates from the flotation cells 30 and 36. The present invention thus provides an efficient and relatively simple means for beneficiating the slurry.

Although the invention has been shown in connection with a certain specific embodiment, it will be readily apparent that various changes in form and arrangement of steps may be made to suit requirements without departing from the spirit and scope of the invention. In this respect, it is apparent that many sets of parallel-connected cyclones could be used to separate the slurry into a number of size ranges which is greater than the two shown in the embodiment of the invention illustrated herein.

We claim as our invention:

1. A method for beneficiating coal slurry which comprises dividing said slurry between a first plurality of parallel-connected cyclones, combining the respective overflows from said first plurality of cyclones and dividing the combined overflows between a second plurality of parallel-connected cyclones having smaller diameters than the cyclones in said first plurality, separately subjecting the underflows from the respective pluralities of cyclones to a froth flotation process to give a froth concentrate of low ash coal, combining the tailings from the separate flotation processes with the overflows from the second plurality of cyclones, and flocculating the combined tailings and overflows in a thickener to produce a sludge underflow of waste material.

2. A method for beneficiating coal slurry which comprises dividing said slurry between a first plurality of parallel-connected cyclones, combining the respective overflows from said first plurality of cyclones, dividing the combined overflows between a second plurality of parallel-connected cyclones having smaller diameters than the cyclones in said first plurality, subjecting the underflows from the respective pluralities of cyclones to separate froth flotation processes to give a froth concentrate of low ash coal, filtering said froth concentrate to obtain a cake of metallurgical coal and a filtrate, and recycling said filtrate through said flotation process.

3. A method for beneficiating coal slurry which comprises dividing said slurry between a plurality of parallel-connected cyclones, subjecting the underflows from the cyclones to a froth flotation process to give a froth concentrate of low ash coal, combining the tailings from said flotation process with the overflows from said cyclones, flocculating the combined tailings and overflows in a

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thickener to produce a sludge underflow of waste material and an overflow, filtering the underflow from said thickener to produce a cake of sludge material and a filtrate, and combining the filtrate with the overflow from said thickener.

4. A method for beneficiating coal slurry which comprises dividing said slurry between a first plurality of parallel-connected cyclones, combining the respective overflows from said first plurality of cyclones and dividing the combined overflows between a second plurality of parallel-connected cyclones having smaller diameters than the cyclones in said first plurality, separately subjecting the underflows from the respective pluralities of cyclones to a froth flotation process to give a froth concentrate of low ash coal, filtering the froth concentrate to obtain a cake of metallurgical coal and a filtrate, recycling said filtrate through said flotation process, combining the tailings from said flotation process with the overflows from said second plurality of series-connected cyclones, flocculating the combined product in a thickener to produce an overflow and a sludge underflow of waste material, filtering the underflow from said thickener to produce a cake of waste material and a filtrate, and combining the filtrate from said last-mentioned step with the overflow from said thickener.

5. A method for beneficiating minerals slurry which comprises passing said slurry through a plurality of series-

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connected sets of cyclone separators, each of said sets comprising a number of parallel-connected cyclones with the cyclones in one set having different diameters than those in another set whereby the underflows from the respective sets of cyclones are in different size ranges, subjecting the underflows from the respective sets of cyclone separators to separate froth flotation processes, and combining the froth concentrates from the separate flotation processes.

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