May 18, 1943 S. E. ERICKSON 2,319,394

BENEFICIATION OF LOW GRADE COAL

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FIG. 1.

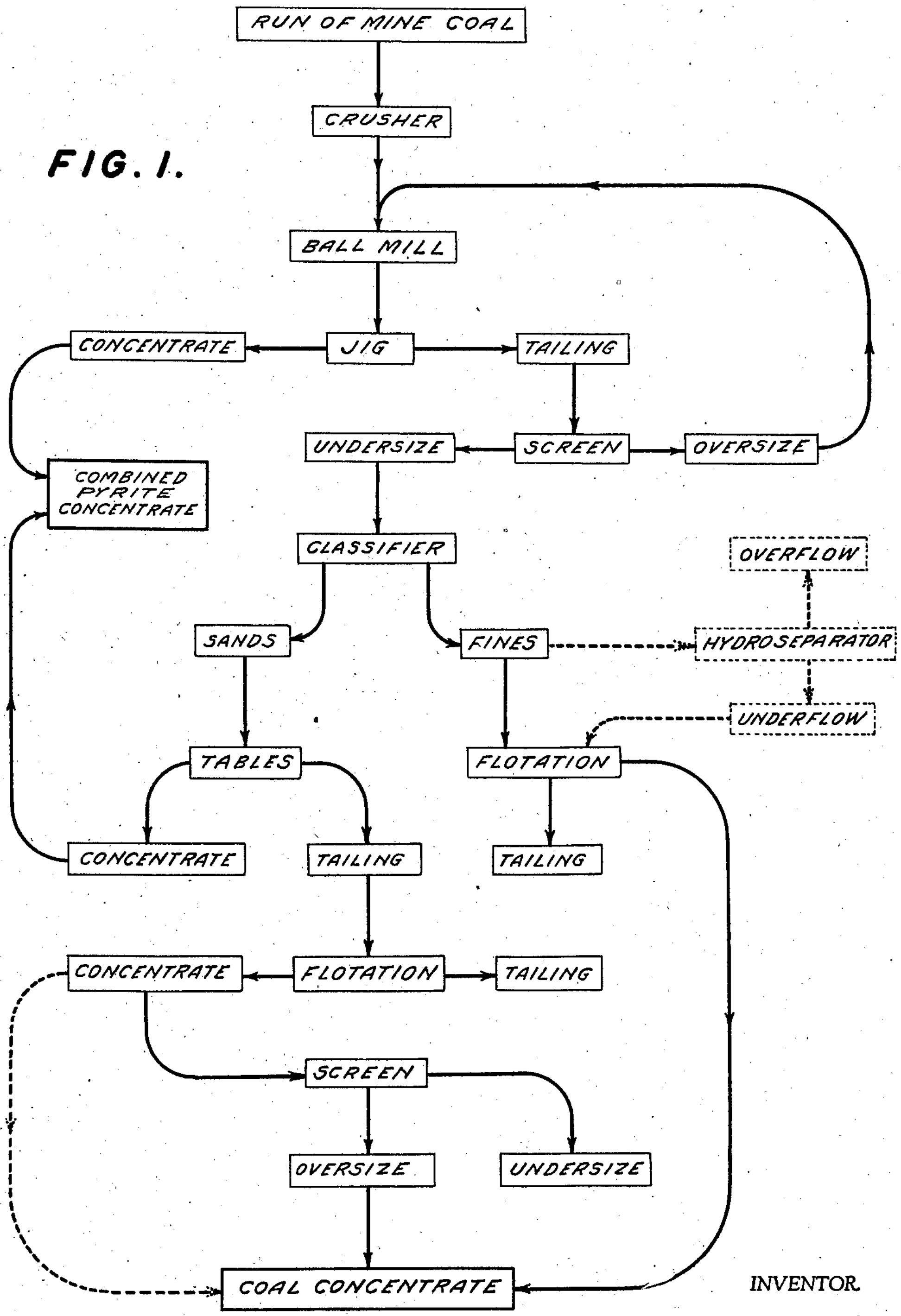

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FIG. 2.

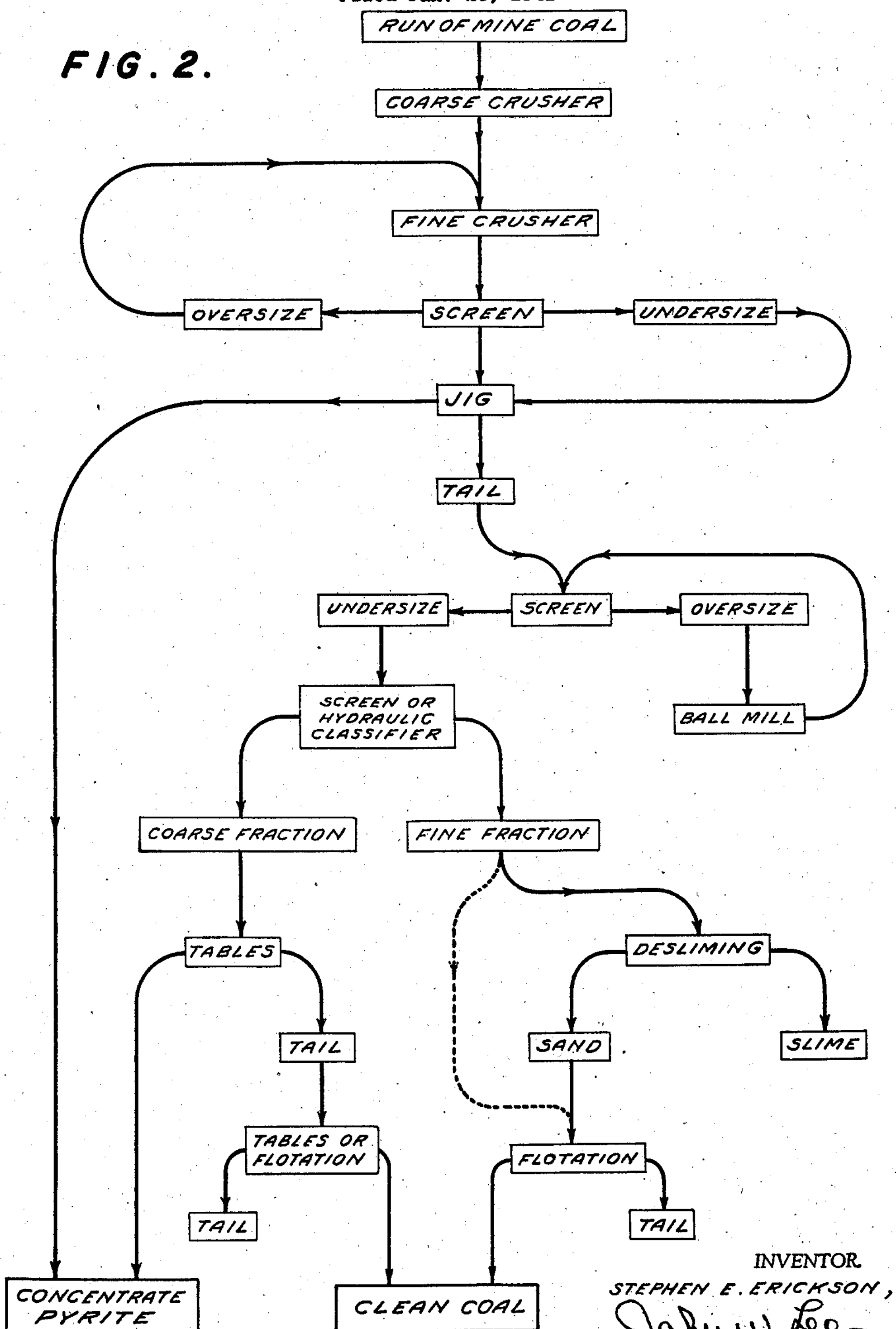

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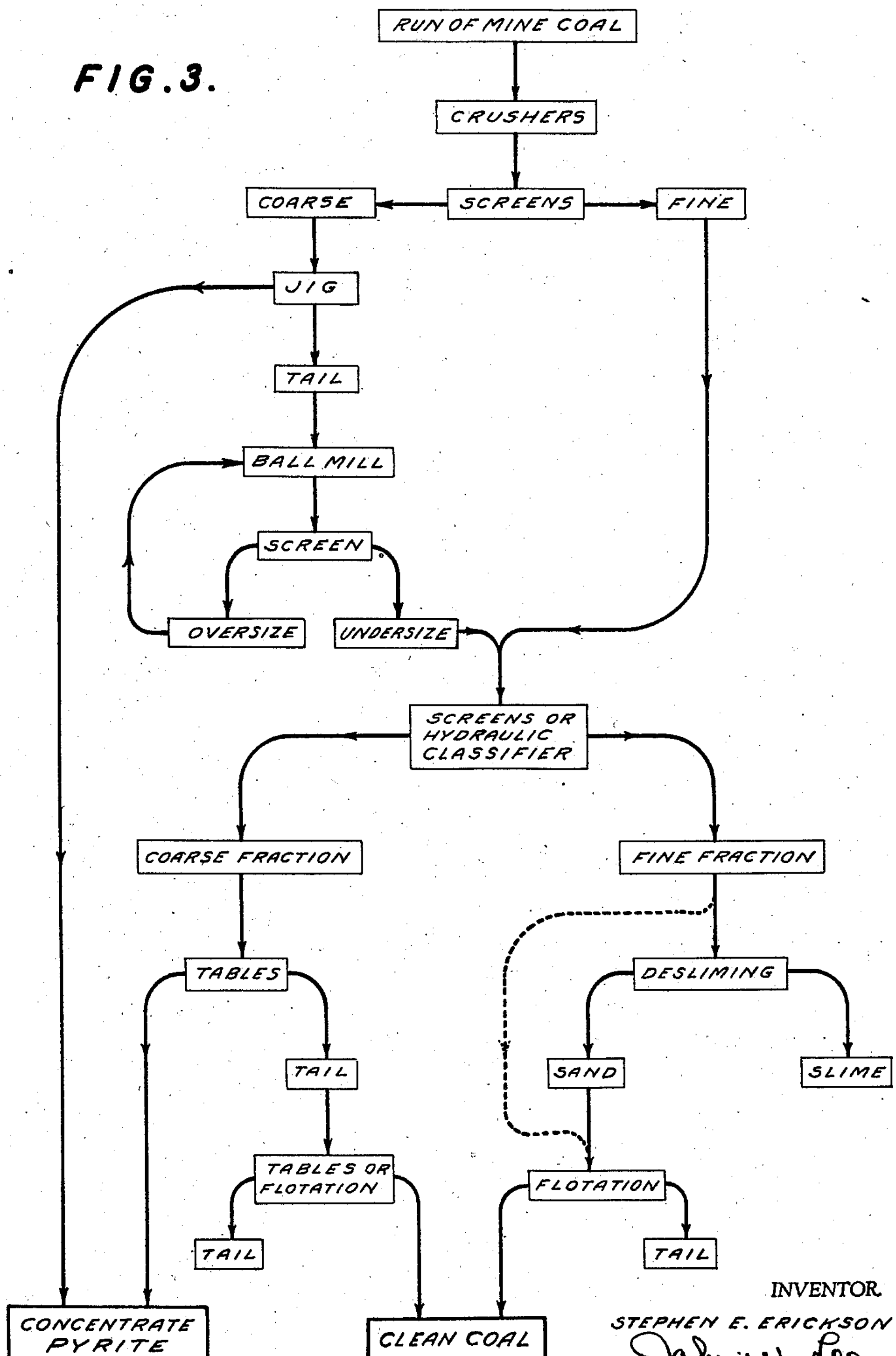
FIG. 3.



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BENEFICIATION OF LOW GRADE COAL

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Application January 29, 1941, Serial No. 376,448
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3 Claims. (Cl. 83—94)

This invention relates to the beneficiation of low grade coal. More particularly the invention relates to the recovery of both coal and pyrite values from a low grade coal composed of good coal, bone coal, slate, and pyrite. In particular this invention relates to the treatment of low grade coal in which the good coal occurs in fine grains and therefore, requires crushing to a comparatively fine degree in order to liberate the good coal from the accessory material.

The flotation of coal using standard flotation reagents which are for the most part hydrocarbons such as kerosene accompanied if necessary by suitable frothers has been used on a rather large scale in the past for reducing the ash content of the coal. More recently flotation procedures have been used to recover the coal values from waste slush or culm, such procedures being described in the Crawford and Grine U. S. Patent 2,136,074 in which the culm is separated into two or more size fractions and each size floated separately using different flotation procedures for each of the sizes. The Hedley U. S. Patent 2,136,341 describes a process for recovering coal values from a slush culm by flotation which comprises flotation of the coal fines followed by screening or classification of the flotation tailing, rejecting the fine sizes and then subjecting the coarse portion to flotation to recover a low ash coal concentrate.

Various gravity separation methods have also been employed in the past for recovering coal values from coal contaminated with high ash material. Among such specific gravity concentration methods are those such as tabling, jigging, and float and sink methods.

The primary purposes of the above coal treating processes were for the purpose of obtaining a clean coal concentrate having a low ash value and were not concerned with the recovery of materials other than coal that might be present, as for example the pyrites. While many of these past procedures are commercially successful in obtaining a high grade coal concentrate from certain types of coal, they are not at all successful in recovering the coal and pyrite values from a low grade coal containing good coal, which is present in relatively fine-size particles, bone coal, slate and a relatively high percentage of pyrite.

The beneficiation of such low grade coal has been a serious problem in the coal industry heretofore as there has been no economical method for recovering the values therefrom. While the problem is of little economical importance in the United States it is of very great importance in countries that do not have an abundance of high grade coal such as, for example, Brazil, but do have large amounts of low grade pyrite containing coal.

Large deposits of this type coal are found in Brazil. For some time attempts have been made to produce a low ash coal suitable for locomotive fuel from this low grade material but ordinary coal washing methods on this type coal do not give a satisfactory low ash coal and also do not permit the recovery of the pyrite as a secondary product which is suitable for use in acid manufacture. When the procedure of the present invention is applied to crude coal of this type, a relatively high grade coal, suitable for combustion purposes, and a pyrite by-product which can be used for acid manufacture are readily produced. The term "pyrite" as used in this application refers to any or all sulfide bearing materials occurring in low grade coal.

In accordance with the present invention a coal treating process is provided which is particularly useful for the beneficiation of low grade coals containing pyrite. The flow sheet employed in the present invention results in the recovery of a clean coal product having a relatively low ash content and also the recovery of a pyrite product suitable for acid manufacture.

In carrying out the present invention a low grade coal containing good coal, bone coal, slate, and pyrite is subjected to a crushing operation and the crushed coal is subjected to a gravity concentration process followed by froth flotation of the gravity concentration tails. The gravity concentrate represents a product having relatively a high percentage of pyrite. The flotation concentrate resulting from flotation treatment of the gravity concentration tails produces a clean coal concentrate, having a low ash content and hence suitable for fuel.

The present invention is not concerned with any particular type of flotation reagent and it is an advantage of the invention that it is applicable to the standard reagent combinations. Similarly the invention may be used with various types of flotation equipment.

The invention is also not broadly concerned with the particular type of crushing equipment that is employed to crush the coal, nor in any particular type of screen or classifier that may be used to effect sizing of the crushed coal. The invention likewise is not particularly concerned with a particular type of gravity concentration apparatus which is employed.

The invention will be described in greater detail in conjunction with typical flow sheets which have been found to result in good recovery of clean coal and pyrite products from low grade coals.

Figure 1 is a diagrammatic flow sheet of a process in which the crushed coal is subjected to a jigging operation followed by classification into a coarse and a fine fraction. The fine fraction is then subjected to flotation resulting in the production of a clean coal concentrate. The coarse fraction is subjected to a gravity concentration treatment (tabling) to produce a pyrite concentrate and a tailing which upon treatment by flotation results in the production of a clean coal concentrate.

The flow sheets of Figures 2 and 3, represent optional flow sheets in accordance with the present invention. The broad principle in each of these proposed flow sheets is the same but there are some minor differences in the details.

The operation of the present invention will be readily apparent by referring specifically to the flow sheet of Figure 1, in which a run of mine low grade coal containing pyrite, from a Brazilian coal deposit, in which the good coal particles were −35 mesh in size and in which the pyrite was satisfactorily liberated from attachments by crushing to −10 mesh is fed into a suitable crushing circuit which may consist of a coarse jaw crusher followed by a roll-crusher or rod-mill, if desirable, which results in the production of a −10 mesh material. The crushed coal is then subjected to a jigging operation which results in the production of a concentrate rich in pyrites. The jig tails are subjected to a suitable classifying operation to produce a coarse fraction approximately plus 35 mesh which is returned to the crushing circuit and a −35 mesh fraction. This classification may be accomplished by any suitable classifier, preferably, however, a screen is used because of the more desirable size control obtained. The −35 mesh material is then further classified into sands and fines. The sands are subjected to a tabling operation producing a pyrite concentrate and dirty coal tails which upon treatment by flotation result in the production of a clean low ash concentrate. The classifier fines are subjected to a direct flotation treatment to produce a clean low ash coal concentrate. These froth flotation operations may be carried out in the presence of any suitable collector and frothing reagents such as, for example, fuel oil and an alcohol frother. The amount of reagents and reagent combinations may of course be varied to obtain best results from each particular size range of feed.

It is to be noted also that the fine fraction may be deslimed by a hydroseparator or the like prior to the froth flotation. The flotation concentrate obtained from the course fraction or sands, if desired, may be subjected to a screening operation to produce a coal concentrate of higher fuel value. The combined pyrite concentrates from the jigging and tabling operations represent a high percentage of pyrites which were present in the run of mine coal feed. This pyrite product is suitable for use in acid manufacture. The combined coal concentrates represent a good recovery of coal which is sufficiently low in ash to be suitable for combustion purposes.

The following example illustrates in greater detail the operation of the present invention in accordance with the flow sheet of Figure 1.

Example

A Brazilian crude coal was crushed to approximately −10 mesh and subjected to a jigging operation producing a pyrite concentrate and a low grade coal tailing.

These jig tails were screened on a 35 mesh screen the oversize being returned to the crushing circuit and the undersize further classified into sands and fines.

The sands were tabled producing a pyrite concentrate and low grade coal tails. These low grade coal tails were then subjected to a froth flotation operation producing a rougher concentrate which was then screened on an approximately 50 mesh screen to produce a low ash coal concentrate.

The fines were subjected to froth flotation to produce a recleaner concentrate of a low ash coal.

The conditions under which the flotation operations were carried out are summarized as follows:

Rougher flotation—(Sands) Coarse feed (−35 mesh)—*Procedure*
- Per cent solids 22
- Time of float .... minutes .. 4½

Reagents—Lbs./ton flotation feed
- Kerosene—1.08—conditioned 2 minutes prior to float
- Alcohol frother—0.07—conditioned 2 minutes prior to float
- Alcohol frother—0.07—to float

Rougher conc. screened on 50 mesh. No cleaning.

Total reagents—Per ton of original run of mine coal.
- Kerosene 0.32
- Alcohol frother 0.04

Fine float—(95%—100 mesh)—*Procedure*
- Per cent solids 14.8

Time of float—
- Roughing .... minutes .. 6
- Cleaning .... do .. 6
- Recleaning .... do .. 6

Reagents—Lbs./ton flotation feed

Reagent	Rougher	Cleaner	Recleaner	Total
Kerosene	0.95	0.0	0.0	0.95
Alcohol frother	0.31	0.17	0.13	0.61

Total reagents—Per ton of run of mine coal
- Kerosene 0.48
- Alcohol frother 0.31

The data in the following table represent the results obtained in Example 1.

Table

Product	Tons	Sulfur	Ash	Carbon
		Per cent	*Per cent*	*Per cent*
Run of mine coal	1000	12.36	34.51	--------
Coarse classified feed (sands)	500	--------	--------	--------
Table concentrate	200	47.07	--------	4.34
Table tail	300	2.42	23.61	--------
Rougher flotation concentrate	237	2.55	22.00	--------
Rougher flotation tail	63	2.17	35.46	--------
50 mesh screen oversize	93	1.40	16.13	--------
50 mesh screen undersize	144	3.30	25.76	--------
Fine classified feed (fines)	500	--------	--------	--------
Rougher flotation concentrate	400	4.29	17.96	--------
Rougher flotation tail	100	8.16	66.1	--------
Cleaner flotation concentrate	365	3.82	14.8	--------
Cleaner flotation tail	35	9.43	52.54	--------
Re-cleaner flotation concentrate	345	3.52	13.26	--------
Re-cleaner flotation tail	20	8.66	38.86	--------
Combined coal concentrate	438	3.08	13.84	--------
	Weight Per cent		*Total Per cent*	
Recoveries:				
Pyrite concentrate	20.0		76.16	
Coal concentrate	43.8		82.43	

An analysis of the above results show that 57.63% of the combusible material is obtained in a good coal product which has only 13.84% ash present and hence entirely satisfactory for combustion purposes. Likewise 76.16% of the sulfides are obtained which are suitable for use in acid manufacture.

Results similar to those of Example 1 are obtained when the present invention is carried out in accordance with the flow sheets of either Figure 2 or Figure 3, which differ only in detail from the flow sheet of Figure 1.

Referring specifically to the flow sheet of Fig. 2 a run of mine low grade coal containing pyrite is fed into a coarse jaw crusher thence through a roll-crusher and onto a screen of approximately 10 mesh. The oversize or plus 10 mesh material is returned to roll-crusher. The undersize or −10 mesh material is subjected to a jig treatment to produce a pyrite concentrate and a low grade coal tail. This tailing is then screened on an approximately 35 mesh screen the oversize being recrushed and returned to the screen. The undersize −35 mesh material is subjected to a suitable sizing to produce a coarse fraction and a fine fraction. The coarse fraction is tabled producing a pyrite concentrate and a low grade coal tail which can then be tabled or floated to obtain a low ash coal product. The fine fraction may be deslimed and the sand floated to produce a low ash coal concentrate or in many cases can be floated directly without desliming.

Referring now to the flow sheet of Figure 3 the run of mine coal is crushed and fed onto a double deck screen of approximately 10 and 35 mesh. The −10 plus 35 mesh material is fed to a jig, a pyrite concentrate is produced and a high ash coal tail obtained. This tail is further crushed and fed onto a 35 mesh screen, the oversize being returned to the crusher, the undersize −35 mesh is combined with the −35 mesh material from the double deck screen and classified into a fine and a coarse fraction. The remaining steps are the same as those outlined in connection with the fine and coarse fractions of Figure 2.

Essentially the three flow sheets illustrated all comprise the steps of crushing the coal subjecting to a jigging operation, classifying the jig tails into a coarse and fine fraction, subjecting the coarse fraction to a tabling operation followed by froth flotation of the table tails and subjecting the fine fraction to flotation without tabling. Various coals, however, differ in the degree to which they must be crushed to liberate the coal and pyrite values and hence it is desirable that the crushing and classifying operations may be varied as indicated in the flow sheets to obtain the best results.

What I claim is:

1. A method of recovering pyrite and coal values from a low grade coal containing pyrite which comprises crushing the coal to −10 mesh, subjecting the crushed coal to a gravity concentration operation to produce a pyrite concentrate and a low grade coal tail, classifying the tails into a coarse and a fine fraction, subjecting the coarse fraction to a gravity concentration operation followed by froth flotation of the coal values from the gravity concentration coarse fraction tails, and recovering the coal values from the fine fraction by froth flotation.

2. A method of recovering pyrite and coal values from a low grade coal containing pyrite which comprises crushing the coal to −10 mesh, subjecting the crushed coal to a jigging operation to produce a pyrite concentrate and a low grade coal tail, classifying the tails into a coarse and a fine fraction, subjecting the coarse fraction to a tabling operation followed by froth flotation of the coal values from the table coarse fraction tails, and recovering the coal values from the fine fraction by froth flotation.

3. A method of recovering pyrite and coal values from a low grade coal containing pyrite which comprises crushing the coal to −10 mesh, subjecting the crushed coal to a jigging operation to produce a pyrite concentrate and a low grade coal tail, crushing the tails to −35 mesh and classifying into a coarse and a fine fraction, subjecting the coarse fraction to a tabling operation followed by froth flotation of the coal values from the table coarse fraction tails, and recovering the coal values from the fine fraction by froth flotation.

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