

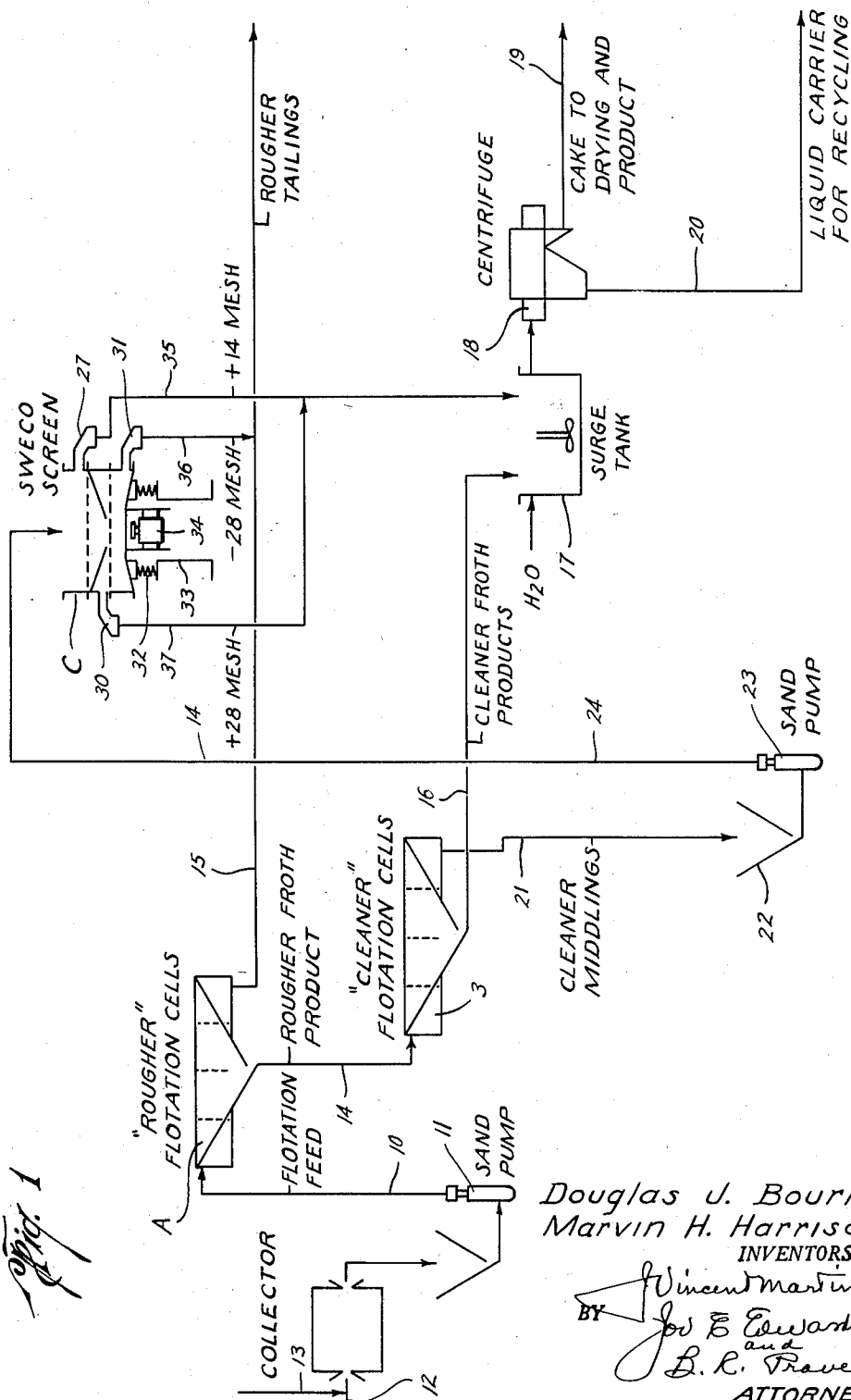
Aug. 26, 1958

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METHODS OF AND MEANS FOR HANDLING FLOTATION MIDDINGS
IN ORE CONCENTRATION PROCESSES

2,849,113

Filed Nov. 16, 1953

2 Sheets-Sheet 1



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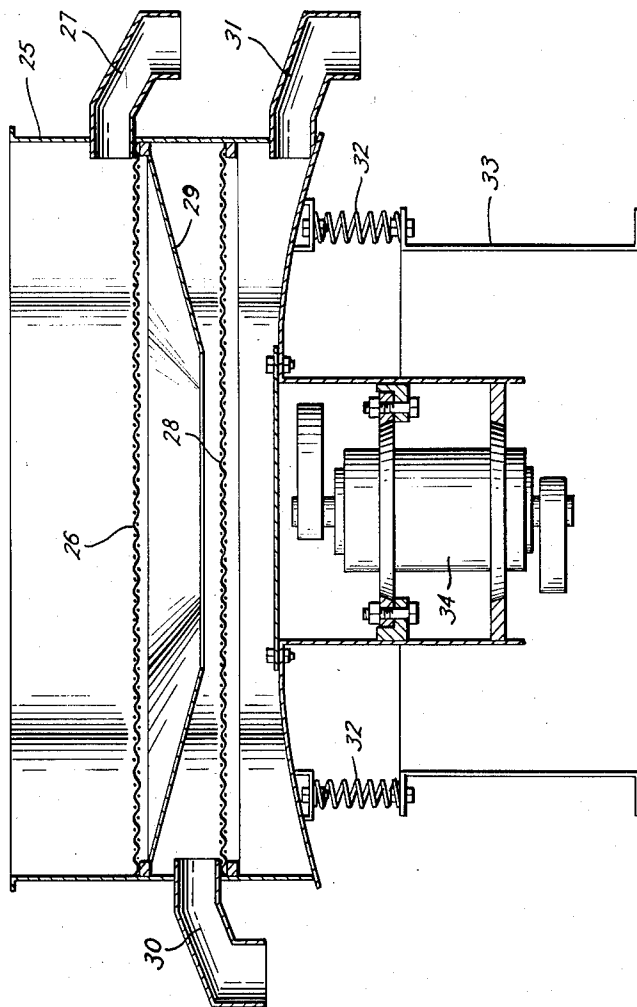


Fig. 2

Douglas J. Bourne
Marvin H. Harrison
INVENTORS

BY *Vincent Martin*
John E. Edwards
B. R. Travel
ATTORNEYS

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METHODS OF AND MEANS FOR HANDLING FLOTATION MIDDINGS IN ORE CONCENTRATION PROCESSES

Douglas Johnston Bourne and Marvin H. Harrison, Carlsbad, N. Mex., assignors to Duval Sulphur and Potash Company, Houston, Tex., a corporation of Texas

Application November 16, 1953, Serial No. 392,178

11 Claims. (Cl. 209—12)

This invention relates to new and useful improvements in methods of and means for handling flotation middlings in ore concentrating processes.

In the conventional froth flotation circuit wherein ore fractions are to be separated, the ore to be concentrated is directed to a first section of flotation cells called "roughers" wherein an initial, crude froth product is separated. Ordinarily, it is necessary to further refine this froth product in a second, and sometimes a third section of flotation cells, called "cleaners" and "recleaners," respectively. The depressed ore constituents comprising the underflow from the "rougher" section are normally a finished material, in that such underflow consists primarily of one of the ore fractions being separated, while underflow constituents from the cleaner and recleaner sections, commonly called "middlings," are not finished material but contain both fractions of the ore. It is therefore necessary to further treat this "middling" fraction before its constituents or fractions which are subsequently separated by such further treatment can join, either the final froth product or the final depressed product.

It has heretofore been the common practice to return the "middlings" from the cleaner and/or recleaner sections to the rougher section, thus recycling these "middlings" in an effort to recover the values therefrom. Such a recycling of the middlings has certain disadvantages and it is the main object of this invention to eliminate the recycling step.

Although the invention may be employed in handling the middling material from any froth flotation circuit, it has been found particularly adapted to those flotation processes wherein the cleaner and/or recleaner sections yield a "middling" consisting principally of (a) relatively coarse particles of the ore constituent which should have reflowed during initial passage through the cleaner circuit and which are not amenable to refloating upon recycling, (b) a fraction consisting of intermediate mesh size material containing locked ore particles—the "true middling," and (c) relatively fine particles of ore constituents which should have been depressed in the rougher section but which were mechanically entrained with the rougher froth product. Such a "middling" is ideally suited to the practice of the invention in that mechanical separation by particle size will yield a coarse and a fine fraction, which without further treatment can join the finished materials and additionally will yield a "true middling" fraction which, if desired, may be refined in methods heretofore practiced.

It is one object of this invention to provide an improved method of handling the middling material in a froth flotation process which produces an increased recovery of the desired ore constituent.

An important object of the invention is to provide an improved method of handling middling material in a froth flotation circuit which does not require the return of said middling through the rougher section of the circuit,

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whereby all of the disadvantages incident to such recycling step are obviated.

A particular object of the invention is to provide an improved method of handling the middling material from the cleaner and/or recleaner sections of a froth flotation circuit which includes mechanically separating the middling material according to mesh size whereby a relatively coarse fraction of said material can be conducted directly to the final froth product and whereby a relatively fine fraction can be conducted directly to the final depressed product.

A further object is to provide an improved means for handling middlings in a froth flotation circuit which includes a wet screen apparatus for separating the middling material in accordance with mesh size; the separation preferably being a three fraction split on fourteen and twenty-eight mesh screens whereby particles of the desired ore constituents in said middling material may be recovered.

Other objects will appear hereinafter.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part hereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a flow diagram of a froth flotation ore concentrating process and illustrating the improved method and apparatus constituting the present invention, incorporated in said process, and

Figure 2 is a transverse sectional view of the screening apparatus.

The invention will be described herein as applied to the usual froth flotation circuit which is employed in the concentration of ores containing potash, but it is pointed out that the invention is applicable to processes involving the concentration of other ores.

In the drawings (Figure 1), the letter A designates the usual "rougher" section of flotation cells, which section forms part of the usual froth flotation circuit. The flotation feed is conducted to the section A through an inlet conductor 10, said feed being pumped by a suitable pump 11. The feed is directed to the pump 11 through an inlet line 12 and in the case of a process for concentrating ore containing potash, a suitable collector reagent is introduced into the feed through line 13. It is pointed out that the feed is actually a slurry consisting of ground ore admixed with a carrier medium which is a brine saturated with the ore constituents.

An initial separation of the potassium chloride values from the sodium chloride-clay slime gangue is effected in the "rougher" flotation cell section A, and the potassium chloride froth product is conducted through a conductor 14 to a "cleaner" section of flotation cells B. The sodium chloride-clay slime tailings from the "rougher" section are discharged through an outlet line 15. As is well known, the "cleaner" section of flotation cells is for the purpose of effecting final separation and the froth product containing refined potassium chloride is conducted from this "cleaner" section through line 16 to a surge tank 17, from which it passes to a centrifuge 18, the latter functioning to separate the liquid carrier medium from the valuable ore constituent. The solids from the centrifuge are then conducted through line 19 to a suitable drying unit (not shown) and becomes the final product. The effluent from the centrifuge 18 is discharged therefrom through line 20 for reuse in the process as the carrier medium.

The foregoing comprises the usual type of froth flotation circuit which is employed in concentrating ores containing potash, and actually the circuit as such forms no part of the present invention.

The underflow from the "cleaner" section of flotation

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cells B is generally identified as "middlings," and it has heretofore been the practice to conduct this middling material back into the inlet line 10 so as to recycle said material through the "rougher" flotation section A. It has been found that the middling material contains one fraction consisting primarily of coarse particles of the potassium chloride, an intermediate or "true middling" fraction consisting of potassium chloride and sodium chloride, and a third fraction consisting primarily of fine particles of sodium chloride-clay slime gangue.

When the middling material is recycled back through the "rougher" section of flotation cells A, it produces certain disadvantages. In the first place, the potassium chloride particles are relatively coarse and usually because of their size were not refloatated in their initial passage through the cleaner circuit; therefore, these particles are not amenable to refloating upon a recycling thereof, and this ultimately results in escape of such particles from the "rougher" section A with the tailings whereby overall recovery is reduced. When the finer fraction of the middling material which consists principally of sodium chloride and clay slime particles is recycled back through the rougher section, the clay slime particles are again contacted with the collector reagent and since, as is well known, such particles have an avid appetite for collector reagents, the slime particles become coated with the reagent, thereby further increasing reagent consumption. Furthermore, the excessive coating on the slime particles deters slime settling, whereby said slimes may be continually carried over with the froth product and recycled and also whereby increased quantities of flocculating agent are required to effect subsequent settling of the slime particles in other portions of the process.

In carrying out the present invention, the underflow product or middlings of the cleaner section B of the flotation circuit is not recycled through the rougher section A, as has been the usual practice. Instead, the middlings are conducted through a discharge conductor 21 to a suction box 22, and from this box the middling material is pumped by means of a pump 23 through a line 24 which discharges into a separator unit C. The separator unit may be of standard construction, and as illustrated is a well known commercially available "Sweco" separator. It is pointed out, however, that other separator units could be employed, such as a "Dorrclone," "Dorrco Hydrosizer," standard screens or a rotary strainer.

The particular separator which has been found adaptable to the present invention is more completely illustrated in Figure 2 and comprises an annular housing or casing 25 which has an open upper end. A screen or cloth 26 which is preferably of a size to separate all plus 14 mesh material is disposed to extend across the housing 25 and the plus 14 fraction escapes through a discharge spout 27. A second screen or cloth 28 which is preferably constructed to separate all plus 28 material is located below the screen 26, the throughput of screen 26 being guided onto the center of the screen 28 by an annular inclined deflector 29. The plus 28 fraction from screen 28 is conducted from the screen through a discharge outlet 30 and the minus 28 fraction which passes through the screen escapes through a discharge 31. The housing 25 is mounted by means of springs 32 on a base 33, and a motor 34 which is mounted to set up a vibration in the housing is located within the base.

When the separator unit is operating, the housing 25 is constantly vibrated and the screens 26 and 28 serve to accomplish a three-way split of the material which is introduced therein through line 24. It is pointed out that although two screens which separate the material at plus 14 and plus 28 mesh have been found satisfactory, the invention is not to be limited to this number of screens or to a separation of material at this mesh. Obviously, any number of screens of any mesh size desired may be employed.

The discharge spout 27 through which the plus 14 mesh

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material is discharged is conducted through a line 35 to the surge tank 17 of the system. The minus 28 mesh material which is separated in the separator C is discharged through a line 36 into the rougher flotation tailings outlet line 15 and is disposed of as a tailing. The coarse particles are thus conveyed directly to the finished froth product while the fine fractions are conveyed directly to the final flotation tailings.

The intermediate fraction, which comprises the minus 14 plus 28 mesh material, is discharged through line 37 and is conducted to line 35 which extends to the surge tank. It has been found that by eliminating the recycling of the middling material through the "rougher" section A, the purity of the flotation froth product is so improved that the intermediate fraction from the screening device may be transferred directly to the surge tank without the loss of overall product purity. In some instances it may be desirable to further treat this fraction after it is withdrawn from the separator and before it is directed to the surge tank.

From the foregoing it is evident that the method completely eliminates the recycling of the middling material through the flotation circuit and contemplates the passage of said middling material directly to a mechanical separator. The method has actually been applied to a process wherein the mineral sylvite is floated from sylvinite ore and as an example, the underflow or "middlings" from the cleaner section B represents about 5 to 10 tons of solids per 100 tons of ore feed. A typical analysis of the solids is as follows:

Table I

Mesh Size Tyler Standard	Percent By Weight	Percent KCl
14	30	95
20	20	76
28	6	48
35	3	24
-35	41	5

A consideration of the foregoing table illustrates that the plus 14 mesh fraction, amounting to 30% of the middling solids, is of acceptable purity to join the final froth product. All minus 28 mesh material, comprising 44% of the total solids and assaying 6% potassium chloride, has been sufficiently cleaned of values to warrant rejection to the "rougher" flotation tailings. The remaining intermediate fraction amounting to 26% by weight of solids and analyzing 70% of potassium chloride is essentially a "true middling" and may be transferred directly to the "cleaner" froth product without affecting the overall product purity.

Actual plant operation has been conducted in connection with a process of concentrating sylvite ore, and the following table indicates the improvement in the concentrate or froth product and the reduction in tailings loss:

Table II

Period	Concentrate, Percent KCl	Tailings, Percent KCl
Two full months prior to operation of separator	96.0	2.22
Two full months subsequent to separator installation	96.5	1.50

The improved method which eliminates recycling of the middling material through the flotation circuit and which handles the middling material by a mechanical separation produces an unexpected result in that it improves the recovery and chemical and physical quality of the valuable ore constituent; apparently, the recycling of middlings through the flotation circuit as heretofore practiced did not produce recovery of the values in the

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middling flow at the level which was assumed or suspected to be produced by such recycling.

The method definitely increases overall potassium chloride recovery. This increase results from a reduction in tailings loss inasmuch as those relatively large sylvite crystals which are extremely difficult to refloat are no longer recycled to the roughers and subsequently lost to tailings. Since the fine sodium chloride-clay slime particles are not recycled back to the rougher section A, these particles are removed from the flotation circuit after one pass therethrough and this eliminates the possibility of said particles ultimately being carried over with the froth and appearing in the final product.

A noticeable reduction in collector reagent consumption is produced because the over dose of collector, which is used where middling material is recycled in an attempt to refloat the recycled coarse sylvite, is obviated; also, the clay slime gangue which has an avid appetite for the collector is not recycled through the "rougher" section. As has been noted, the principal deterrent to slime settling is the collector coating on the clay slime particles, and by eliminating recycling of the slime particles, said slime particles have little or not chance to adsorb the collector. This results in improved slime settling characteristics and appreciably reduces the quantity of flocculating reagent which is required.

In addition, the elimination of the recycled middling material reduces flotation feed to the "rougher" section by several percent without allowance for the build-up of a circulating load whereby increased capacity and improved flotation control is provided. Also, observation of the solids on the upper screen 26 provides an ideal check on plant operation because fluctuation in the particle size or quantity of these solids is indicative of a necessary correction in the grind or in the quantity of reagents.

Another advantage of the method is to produce improved product quality. The addition of the coarser middling fractions to the product, coupled with the removal of fine gangue particles from the froth product obviously improves the physical quality of the final product. As above noted, the sodium-chloride-clay-slime fines in the middling material are removed from the circuit and do not appear in the froth product, and this advantage more than off-sets any down grading caused by the addition of the "true middlings" or intermediate fraction to the final product.

It is pointed out that the use of the mechanical separator permits the production of a granular product in those processes where the valuable constituents are floated. In such processes, those coarse particles which are difficult to float are concentrated in the middling material from the "cleaner" or "recleaner" operation. The selection of the proper mesh screen in the separator device will remove these coarse particles and yield a uniform production of high purity.

The method and apparatus of the present invention have been described herein as applied to a process for concentrating sylvite from sylvite ore and in connection with the description it has been presumed that the sylvite is contained in the froth product. It is, of course, evident that so long as the middling material is such that mechanical separation may be effected substantially in the manner herein described, said method and apparatus may be used in processes for concentrating other ores or for concentrating sylvite ore wherein the sylvite is depressed as distinguished from being floated.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

Having described the invention, we claim:

1. In an ore concentrating process wherein the ore is subjected to froth flotation in flotation cells and wherein

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a middling material is produced which consists partially of coarse particles of the collected ore constituent which are difficult to refloat and partially of relatively fine particles of the depressed ore constituent which were mechanically entrapped in the froth, the method of handling middling material which includes, conducting said middling material from the flotation circuit and subjecting the same to mechanical separation to separate said material into at least two fractions according to mesh size, conducting one fraction directly to the final froth product from the flotation cells, and conducting the other fraction to the depressed product which is discharged from said flotation cells.

2. An ore concentrating process including, subjecting the ore to froth flotation in a first flotation section to separate the major portion of one ore constituent from a second ore constituent, thereafter subjecting the first ore constituent flowing from the first flotation section to a second froth flotation step in a second froth flotation section to further separate the second ore constituent therefrom, conducting the middling material, which consists of a first fraction comprising coarse particles of the collected ore constituent and a second fraction comprising relatively fine particles of the depressed ore constituent, from said second froth flotation section, subjecting said middling material to mechanical separation to separate said material according to mesh size, and conducting the collected ore constituent which has been separated by the mechanical separation step directly to one of the final ore products.

3. In an ore concentrating process wherein the ore is subjected to froth flotation in flotation cells to yield a middling material consisting of a mixture of coarse particles of the collected ore constituent and relatively fine particles of the depressed ore constituent, the method of handling middling material which includes, conducting said middling material from the flotation circuit and subjecting the same to mechanical separation to separate said material into three fractions according to mesh size, conducting two of said fractions directly to the final froth product from the flotation cells, and conducting the other fraction to the depressed product which is discharged from said flotation cells.

4. In an ore concentrating process wherein the ore is subjected to froth flotation in flotation cells and wherein the valuable ore constituent is concentrated in the froth product and further wherein a middling material is produced which consists of a mixture of coarse particles of the valuable ore constituent and relatively fine particles of the depressed ore constituent, the method of handling the middling material, which includes, conducting the said middling material from the flotation circuit and subjecting same to mechanical separation to separate the material according to mesh size, and removing therefrom a relatively coarse fraction as a granular product.

5. In the process of concentrating soluble potash ores wherein a brine liquor is utilized as a carrier medium in a closed flotation circuit which includes a "rougher" section and a "cleaner" section and also wherein a collector is employed in the flotation treatment, the improved method of handling the middling material which comprises, conducting the middling material which includes both desirable ore constituents and undesirable constituents from the "cleaner" section of the flotation circuit, and subjecting said material to mechanical separation to separate the material according to size.

6. In the process of concentrating soluble potash ores, wherein a brine liquor, essentially saturated with ore constituents, is utilized as a carrier medium, in a flotation circuit which includes a rougher section and one or more cleaner sections, and also, wherein a collector selective to the potassium mineral value is employed, the improved method of handling the middling material which comprises conducting the middling material which includes both desirable and undesirable ore constituents from the

cleaner section or sections, and subjecting said material to mechanical separation to separate the material according to particle size.

7. In the process of concentrating soluble potash ores wherein a brine liquor, essentially saturated with ore constituents, is utilized as a carrier medium, in a flotation circuit which includes a rougher section and one or more cleaner sections, and also, wherein a collector selective to the potassium mineral value is employed, the improved method of handling the middling material which comprises conducting the middling material which includes both desirable and undesirable ore constituents from the cleaner section or sections, and subjecting said material to mechanical separation to separate the material according to particle size, conducting a relatively coarse fraction directly to the final froth concentrate, and conducting a relatively fine fraction directly to the rougher tailings.

8. In the process of concentrating soluble potash ores wherein a brine liquor is utilized as a carrier medium in a closed flotation circuit which includes a "rougher" section and a "cleaner" section and also wherein a collector is employed in the flotation treatment, the improved method of handling middling material which comprises, conducting the middling material which includes both desirable ore constituents and undesirable ore constituents from the "cleaner" section of the flotation circuit, subjecting the same to mechanical separation to separate the material according to mesh size, and withdrawing a selected relatively coarse fraction of the desirable ore constituent as a granular product.

9. In the process of concentrating soluble potash ores, the improved method of handling middling material as set forth in claim 5, together with the additional steps of conducting the separated particles of desirable ore constituents to the final desirable product from the flotation circuit, and conducting the separated particles of undesirable ore constituents to discharge.

10. An ore concentrating apparatus comprising, in combination, a "rougher" section of flotation cells having a desirable ore constituent discharge line and an undesirable ore constituent discharge line, a "cleaner" section of flotation cells having a desirable ore constituent discharge conductor and a middling material discharge

conductor, means connecting the desirable ore constituent discharge line of the "rougher" section to the "cleaner" section whereby said desirable ore constituent from the "rougher" section is directed through the "cleaner" section to produce a middling material consisting partially of coarse particles of the desirable ore constituent and partially of relatively fine particles of undesirable ore constituent, a mechanical separator unit connected with the middling material discharge conductor, whereby the middling material is conducted to said separator unit, means in said separator unit for mechanically separating the particles of desirable ore constituent from the undesirable constituent, and means extending from the separator unit for conducting the desirable ore constituent to the final ore product which is discharged from the desirable ore discharge line extending from the "cleaner" section.

11. In the process of concentrating soluble potash ores wherein a brine liquor is utilized as a carrier medium in a closed flotation circuit and wherein the ore is subjected to froth flotation in flotation cells and an intermediate product material is produced which consists partially of coarse particles of the desirable ore constituents which are difficult to re-float and partially of other particles of the ore constituents of a size smaller than said coarse particles which smaller particles were mechanically entrapped in the froth, the method of handling said intermediate product material which includes, conducting said intermediate product material from the flotation circuit and subjecting the same to mechanical separation to separate said material into at least two fractions according to mesh size, one of said fractions comprising the coarse particles of the desirable ore constituent, and conducting said desirable ore constituent, which has been separated by the mechanical separation step directly to one of the final ore products.

References Cited in the file of this patent

UNITED STATES PATENTS

1,842,400	Hahn	Jan. 26, 1932
2,136,341	Hedley	Nov. 8, 1938
2,222,728	Tartaron	Nov. 26, 1940
2,668,617	Houston	Feb. 9, 1954