APPARATUS FOR FLOTATION CONCENTRATION IN COARSE SIZE RANGE

Original Filed July 2, 1956 2 Sheets-Sheet 1

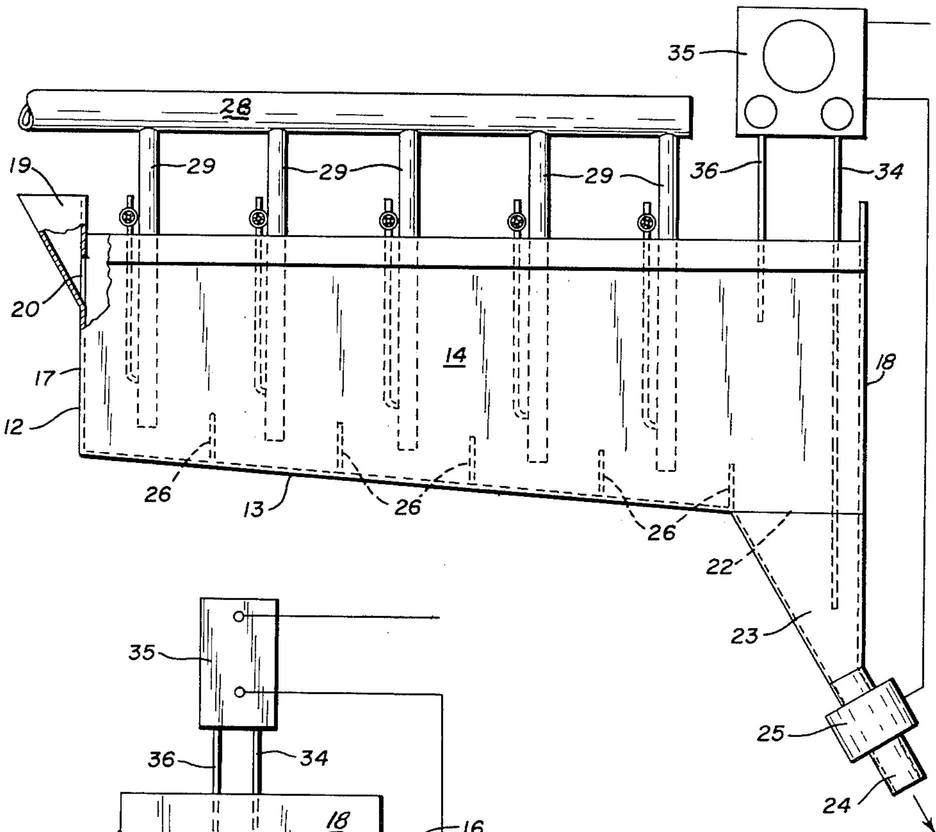

Fig. - 1

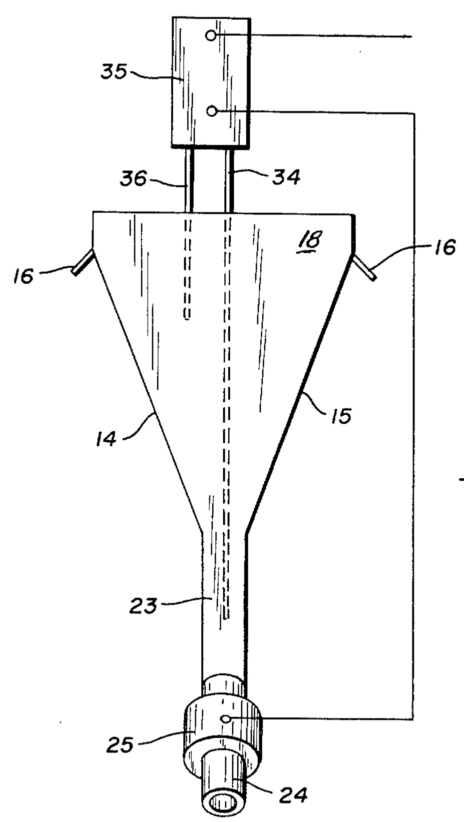

Fig. - 2

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2 Sheets-Sheet 2

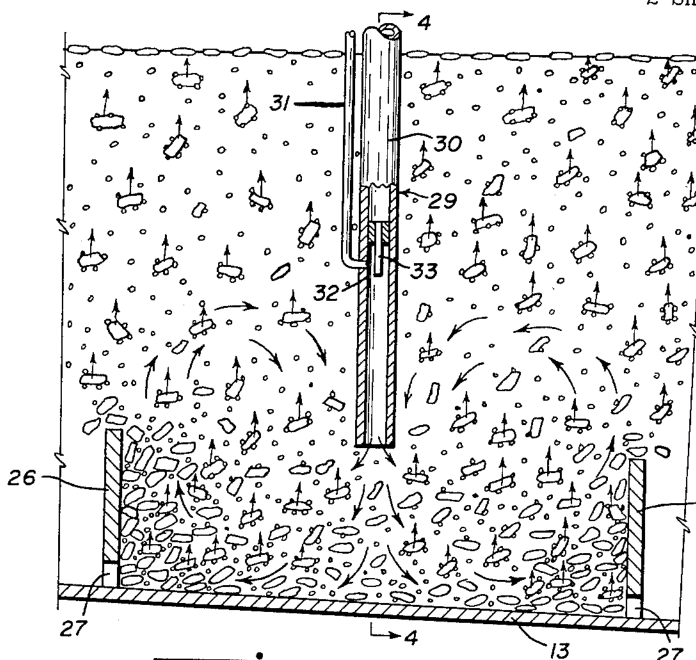

Fig. - 3

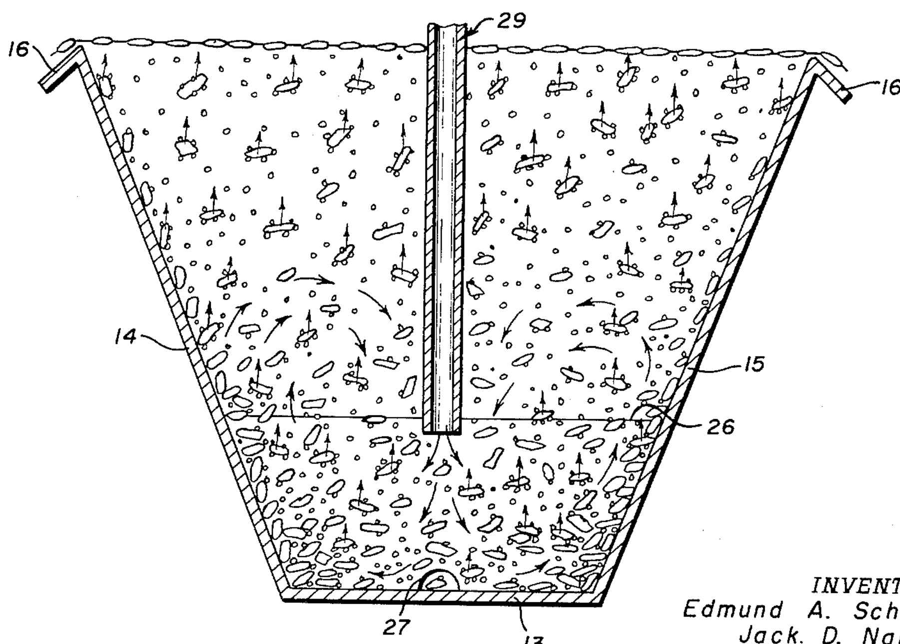

Fig. - 4

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APPARATUS FOR FLOTATION CONCENTRATION IN COARSE SIZE RANGE

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Original application July 2, 1956, Ser. No. 595,500, now Patent No. 2,931,502, dated Apr. 5, 1960. Divided and this application Sept. 8, 1959, Ser. No. 838,544

5 Claims. (Cl. 209—170)

This invention relates to the art of concentrating minerals by a flotation procedure. This application is a division of application Serial No. 595,500, filed July 2, 1956, namely, U.S. Patent No. 2,931,502, issued April 5, 1960.

Industrial demand is requiring potash refiners to produce larger tonnages of high-grade sylvite as a coarse product, a minus 6 to a plus 28 size range being representative, and a 60 percent grade in K_2O equivalent is now standard for such product. Consequently, many procedures which would provide a satisfactory product in a standard flotation size range are inadequate for this purpose, since they will not meet grade requirements in treating the coarse material. As an example, flotation of sylvite using an aliphatic amine with a binding agent such as starch or guar flour has been adopted commercially in several plants with good results. However, this procedure when applied to a sized minus 6 plus 28 mesh ore in standard flotation equipment will not make the metallurgical separation.

Mineral, such as sylvite, when properly coated or filmed in the conditioning stage before flotation, attaches to air bubbles and becomes quite buoyant in the brine of the treatment and then will float on the surface without requiring a froth carrier, although aeration is a highly effective means of causing submerged particles to carry to the surface. As the concentrate particles float without a "froth" carrier, this action is what may be termed a frothless flotation.

We have observed the flotation action in a transparent cell and noted the rapid rise of very coarse particles to the surface as soon as air bubble attachment occurs. In addition, we have found that a very effective concentration can be attained by a two-stage flotation treatment using an amount of reagent less than required to float all the sylvite at the first stage, and adding additional reagent before the second stage so as to float substantially all of the sylvite, most of which remains in the form of middlings particles.

An object of the invention is to provide simple, durable and efficient apparatus for performing a novel type of flotation separation on various materials.

Still another object of this invention is to provide a type of flotation cell in which a relatively large volume of material can be treated in a relatively small space and in a relatively short treatment time.

Other objects reside in novel details of construction and novel combinations and arrangements of parts, all of which will be described in the course of the following description.

The practice of the invention will be best understood by reference to the accompanying drawings, and in the drawings in the several views of which like parts bear corresponding reference numerals:

FIG. 1 is a front elevation of a typical cell for practicing the novel flotation treatment, a portion being broken away to show interior arrangements;

FIG. 2 is an end elevation of the cell shown in FIG. 1 and showing the arrangement of the tailings discharge control;

FIG. 3 is a fragmentary vertical section through the cell shown in FIG. 1, drawn to an enlarged scale, and representing the circulation and flotation action of a typical operation; and

FIG. 4 is a section taken along the line 4—4 of FIG. 3.

Where reference is made in the specification to a "coarse ore" or "coarse product," we intend to designate a material having a major portion of its content in sizes substantially larger than minus 28 mesh or standard flotation size. Standard Tyler mesh sizes are designated throughout the specification, and a minus 6 plus 28 mesh product may be considered a typical coarse commercial product by present standards, but it is recognized that even coarser products may become standard at some later date and the present invention is not limited to producing products within such a range.

"Brine" as used herein is intended to designate all the various brines of potash ores which may be formed in a wet treatment of such materials. In a treatment of sylvinite ore, for example, the brine usually will be saturated with respect to the sodium chloride and potassium chloride content, although throughout a portion of the circuit it may be saturated with respect to potassium chloride only. For purposes of the present invention it will be advisable to have the brine saturated with respect to whatever mineral is being floated at the flotation stages, although it is sometimes helpful to have it undersaturated with respect to other soluble constituents at the dewatering stages following the main separation.

"High density pulps" as used herein would apply to any mixtures having a solids content of one part to two parts brine or greater, and usually will be on the order of 1:1. The term "ore" as used herein is intended to designate dry material or material which although wetted does not have enough associated liquid or brine to maintain the particles in a state of substantial suspension. "Pulp" refers to a mixture of ore and brine having sufficient liquid content to act as a carrier vehicle for substantially all of the solids of the ore.

"High velocity" as applied to the gas or brine discharge is intended to designate a rate of flow substantially in excess of that required to obtain aeration or circulation in conventional flotation practice. "Filming" or "coating" of particles as referred to herein is intended to designate a surface attachment of reagent which may partially or totally cover the exposed surface and provides an air-avid surface as well as reducing wettability of the particle.

With this understanding of the terminology employed, the practice of this invention will be described with reference to the accompanying drawings. The novel type of flotation separation of this invention may be performed in a variety of apparatus, but we have shown in FIG. 1 a preferred form of cell for performing the separation.

This unit comprises an elongated tank **12**, having a sloping bottom **13**, upright front and rear walls **14** and **15** respectively, which preferably incline outwardly away from bottom **13** and have overflow lips **16** at the top. An end wall **17** at the feed end and another end wall **18** at the tailings discharge end complete the tank enclosure. A feed box or chute **19** is provided to deliver ore through a large slotted opening **20** in the upper portion of wall **17** as the feed to the cell.

An opening **22** admits the non-floated material or tailings into a depending sump member **23** the outlet **24** of which is regulated by an automatic valve **25**, the functioning and details of which will be described later. A series of submerged partitions **26** located at intervals along the bottom of the tank define a series of treatment stages and regulate the flow of non-floated material along the tank bottom. Preferably each partition has an opening 27 to simplify washing the cell during shutdowns.

A header 28 connected with a suitable source of supply (not shown) delivers brine to a series of downwardly directed nozzles 29, the lower ends of which terminate near but spaced from bottom 13 and substantially centrally of the enclosed area defined by adjacent partitions 26. As shown in FIG. 3 each nozzle comprises a pipe or tubular portion 30 into which a gas supply conduit 31 enters intermediate its ends as indicated at 32. The bore of tube 30 is reduced adjacent the entrance 32, as by the tube 33 of reduced diameter, and provides an aspiration effect to substantially aerate the brine during its passage to the discharge end of nozzle 29 in a high velocity movement.

By reason of the valve control of tailings discharge through outlet 24, the sump 23 functions as a pulp thickener to create a super-elevation pressure in the fluidized pulp. In the automatic control illustrated in FIGS. 1 and 2, a differential pressure controller 35 has an open-ended tube 34 extending down into the lower portion of sump 23 and a second open-ended tube 36 extends below the brine level but near the surface so as to transmit to controller 35 measurements of varying pressure due to changing brine level. The setting of valve 25 is regulated automatically in accordance with the pressure variations and thus maintains a substantially uniform density condition in cell 12.

In operation, ore or pulp may be introduced into tank 12 through feed box 19 and opening 20, while brine and an aerating gas are introduced through nozzles 29. Tailings discharge through outlet 24 is controlled by valve 25 to establish sufficient super-elevation pressure of the pulp to create a high density in the discharge. Unlike the usual flotation treatment, this operation utilizes a high-density pulp with a major portion of the solids content not rising appreciably above the level of the top surfaces of partitions 26, except as the solids are washed over the partitions in their progressive flow through the cell.

The reagentized ore feed is in proper condition for flotation and the high velocity discharge of aerated brine sweeps in and about the submerged body of particles to maintain them in a loose, tumbling condition providing a large amount of air-solids contact. Due to the coarse size of the particles under treatment, a single air bubble attachment may be inadequate to provide an elevating action but we have observed that where several bubbles attach to a particle it rises rapidly to the surface and floats readily without air bubble attachment when exposed to atmospheric air. In fact we have observed many particles coming almost entirely out of the brine and floating with only a minor portion of their mass submerged.

Due to the volume of brine used and overflowing, surface flow is essentially transverse to the progressive flow through the cell, and on reaching the surface the particles are carried rapidly by this flow to one of the lips 16 where they overflow to discharge. In this action, the flotation is so rapid due to the high degree of air-solids contact that the floating particles sometimes cause a jamming of the weirs with some particles being submerged and falling back into the cell. Rising air bubbles frequently attach to such particles and whenever sufficient air is thus encountered they are re-elevated to the surface and thus ultimately discharge as concentrate.

The retention or delaying action of partitions 26 provides substantial recirculation at each treatment stage and floatable mineral not discharged as concentrate in the first stage is subjected to repetitions of the treatment just described in its progress through the cell. As a consequence, about the only floatable mineral passing through opening 22 into the sump thickener stage is true middlings particles which are purposely kept out of the concentrate

to insure grade of product. The features of this control will be described subsequently.

The fact that the main solids charge of the feed remains substantially submerged except as elevated by air bubble attachment permits a much higher volume of feed to be circulated than would be possible with any other type of flotation separation. The submerged particles are not suspended in the usual sense, in that no appreciable quantity of the non-floated material is swept into the upper portion of the pulp body by the aerated brine agitation, although the submerged body is suspended sufficiently so that the circulating brine flows readily between the particles and carries entrained air into all areas adjacent the cell bottom. Floatable particles begin their rise at all elevations within the pulp body, whenever adequate air adherence is attained, and the rate of rise is independent of the rate of ascending brine flow.

The velocity of discharge of aerated brine may be varied in accordance with the volume of ore under treatment and the overflow requirements of the operation. When large volume, high velocity discharge is attained, the sweep of the brine may cause a slight vortex condition at the surface, whereas under reduced input the surface will be relatively quiescent except for the activity of the bubbles rising to and breaking up on the surface. In any event, there are distinct up and down currents at all times during operation with the discharging brine spraying out along the bottom, then rising, and a portion of same swinging back toward the nozzle and moving downwardly.

A major portion of the brine rises, and on reaching the surface flows directly to and over the lips 16, and it is this flow that sweeps the floating concentrate to discharge. FIGS. 3 and 4 show a representation of this action with the arrows indicating the general flow pattern. The surface flow divides substantially along the center line of the cell and flows in substantially equal volume to the overflow lips of the front and rear walls 14 and 15. In addition to the up and down brine flow at each stage, there is also a pronounced flow lengthwise of the machine towards the tailings discharge.

The provision of the partitions 26 and the regulation of discharge through outlet 24 keep this flow from becoming too intense as otherwise a substantial amount of floatable mineral may be entrained and discharged with the tailings when it is in proper condition to float. By having the last nozzle 26 at some distance forward from the outlet opening 22, the thickened pulp in sump 23 is not disturbed by the agitation and the measurements of controller 35 are a true indication of the pressure differentials.

Again referring to FIGS. 3 and 4, the distribution of solids, gas and floating particles is representative of observed conditions and while more schematic than actual scale depicts the relation of particle size to air bubbles, and the distribution of floating and non-floating material in the cell, as well as the circulatory flows previously described. Dash line arrows indicate particles actually floating, except on the surface, whereas a single bubble attachment represents a particle which is merely suspended or sinking.

The partitions 26 of the present application insure sufficient retention time at each aeration stage to provide adequate air-solids contact for all mineral ready to float and by having repetitions of the delayed movement, mineral not floating at one stage is exposed at subsequent stages due to the tumbling movement provided and eventually receives the required air attachment to elevate it to the surface.

Similarly, the density control of the tailings discharge in conjunction with the partition arrangement adapts the flotation unit to treat a greater tonnage of ore on a more efficient basis. Comparative test operations before and after incorporating the partitions and the density control established that tonnage treated could almost be doubled with improved concentration and reduction in tailings losses. The change also resulted in the brine requirement being held at a minimum due to the reduction in brine discharge with the tailings by reason of the increased density at the tailings discharge.

In the form of cell shown in FIGS. 1 and 2, we have provided a single nozzle for the discharge of aerated brine at each treatment stage, but for some treatments it will be preferable to have a plurality of nozzles to effect a more widespread distribution of the areating gas at each such stage. For example, in a pilot plant test with a cell substantially as shown in FIGS. 1 and 2, we provided two nozzles to each stage between the end wall at the fed end and the first baffle, and between each set of successive baffles. These nozzles were positioned along a line approximating the lengthwise center line of the cell.

This cell was six feet long, eighteen inches wide at the top, three inches wide at the bottom, eighteen inches deep at the feed end and twenty-four inches deep at the discharge end. Seven baffles were positioned lengthwise of the cell, each being six inches in height, and a total of 14 nozzles were provided, arranged as described above.

Operation of this plant on the date of test gave composite analyses of:

	Percent KCl
Ore feed (sylvinite)	41.6
Granular concentrate (−6 +28 mesh)	97.0
Granular middlings	10.7
Granular tailings	1.6

The rate of ore feed to the coarse concentrate cell was approximately 100 tons per day. From the foregoing it will be apparent that the present invention, in addition to satisfying grade requirements, provides a high capacity treatment in small volume equipment requiring little operator control.

While the invention has been described with reference to particular embodiments, there is no intent to limit the concpt to the precise details so illustrated except insofar as set forth in the following claims.

We claim:

1. An elongated tank for pulp of substantial depth, having a feed inlet at one end, a concentrate overflow along at least one side wall positioned lower than other walls of said tank, and a lower discharge outlet at the opposite end of the tank, said inlet and outlet determining a liquid level at an elevation substantially higher than said concentrates overflow, means disposed at intervals lengthwise of said tank for directing streams of brine and aerating gas in downwardly sweeping movements toward the bottom of said tank for aerating and floating concentrate material of the pulp and for moving non-floating solids of said pulp in a progressive flow from inlet to outlet, and a control mechanism for said discharge outlet, including means for measuring pressures indicative of pulp density in an upper portion and a lower portion of the outlet end of said tank, and arranged to change the discharge capacity of said outlet in accordance with the pressure differential of said measurement.

2. An elongated tank for pulp of substantial depth, narrow at its bottom and wider at its top and having a bottom sloping from an inlet at one end to an outlet at the opposite end of said tank, a concentrate overflow along at least one side wall positioned lower than other walls of said tank, said inlet and outlet determining a liquid level at an elevation substantially higher than said concentrates overflow, means disposed at intervals lengthwise of said tank for directing streams of brine and aerating gas in downwardly sweeping movements toward the

bottom of said tank for aerating and floating concentrate material of the pulp and for moving non-floating solids of said pulp in a progressive flow from inlet to outlet, and a control mechanism for said discharge outlet, including means for measuring pressures indicative of pulp density in an upper portion and a lower portion of the outlet end of said tank, and arranged to change the discharge capacity of said outlet in accordance with the pressure differential of said measurement.

3. Frothless ore flotation apparatus comprising an elongated tank for pulp narrow at its bottom and wider at its top having a feed inlet at one end and a bottom outlet at its opposite end for tailings discharge and determining an overflow level in said tank, said bottom sloping from the feed inlet end to the tailings outlet for gravitational movement for settled solids through the tank, said tank having a concentrates overflow along at least one of its sides at an elevation below its end walls, whereby to establish a large volume liquid discharge carrying concentrates on its surface while passing over said concentrates overflow at a higher elevation, means including a series of aerator nozzles disposed at intervals lengthwise of said tank arranged to effect multiple stage aeration of the pulp by discharging streams of aerated pulping liquid in a downwardly sweeping flow into the bottom of said tank so as to form air bubble attachment with settled solids of the pulp, and means within the pulp body constructed and arranged to measure superelevation pressure and to vary the outlet discharge relative to said superelevation pressure to control the rate of overflow discharge.

4. High overflow frothless ore flotation apparatus comprising an elongated tank for pulp narrow at its bottom and wider at its top having a feed inlet at one end and an automatically variable bottom outlet at its opposite end for tailings discharge, said tank having a concentrates overflow along at least one of its sides at an elevation below its end walls, means including a series of aerator nozzles disposed at intervals lengthwise of said tank arranged to direct the discharge of a plurality of streams of aerated pulping liquid in a downwardly sweeping flow into said tank to effect positive movement to the pulp and air bubble attachment with the solids of the pulp, and means within the pulp body adjacent the outlet end of the tank constructed and arranged to measure superelevation pressure in said pulp to operate said automatically variable outlet to maintain a high density tailings pulp and to maintain the surface of the material in said tank at an elevation higher than the lowest side.

5. Apparatus as defined in claim 4 wherein the tailings outlet is automatically controlled in accordance with variations in superelevation pressure which is measured by the difference in density between the tailings discharge and the density of the pulp in an upper portion of the tank.

References Cited in the file of this patent

UNITED STATES PATENTS

1,269,150	Armstrong	June 11, 1918
1,380,650	Hebbard	June 7, 1921
1,380,665	Lyster	June 7, 1921
1,401,598	Gahl	Dec. 27, 1921
1,440,129	Borcherdt	Dec. 26, 1922
1,912,630	Forrester	June 6, 1933
2,143,669	Weinig	Jan. 10, 1939
2,184,115	Coke	Dec. 19, 1939

FOREIGN PATENTS

612,368	Germany	Mar. 28, 1935