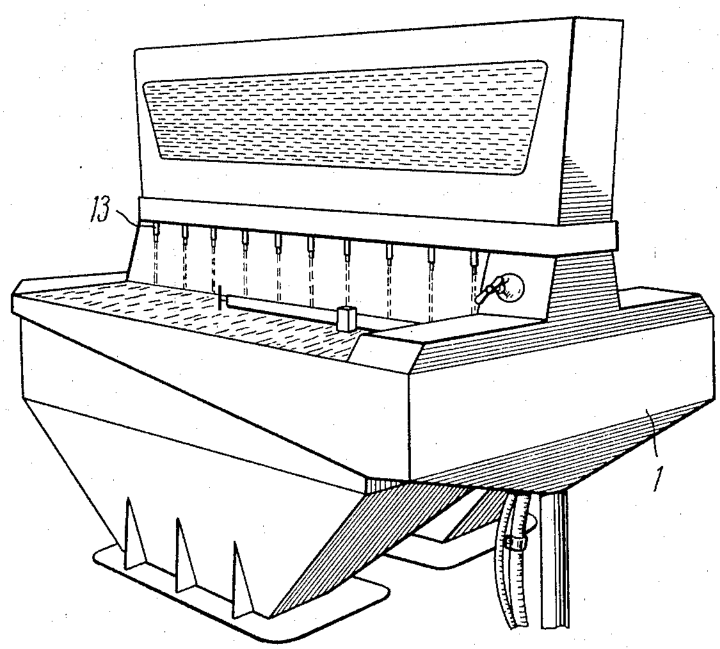

FIG. 1

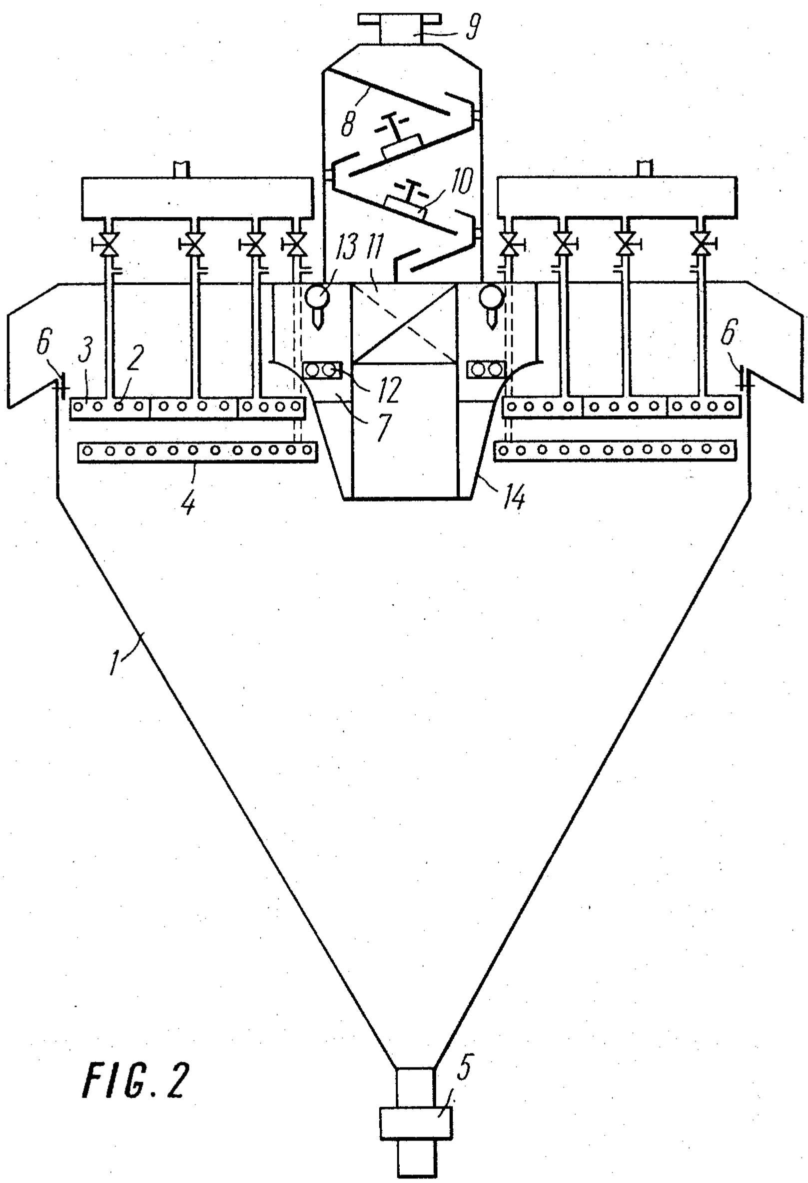

FIG. 2

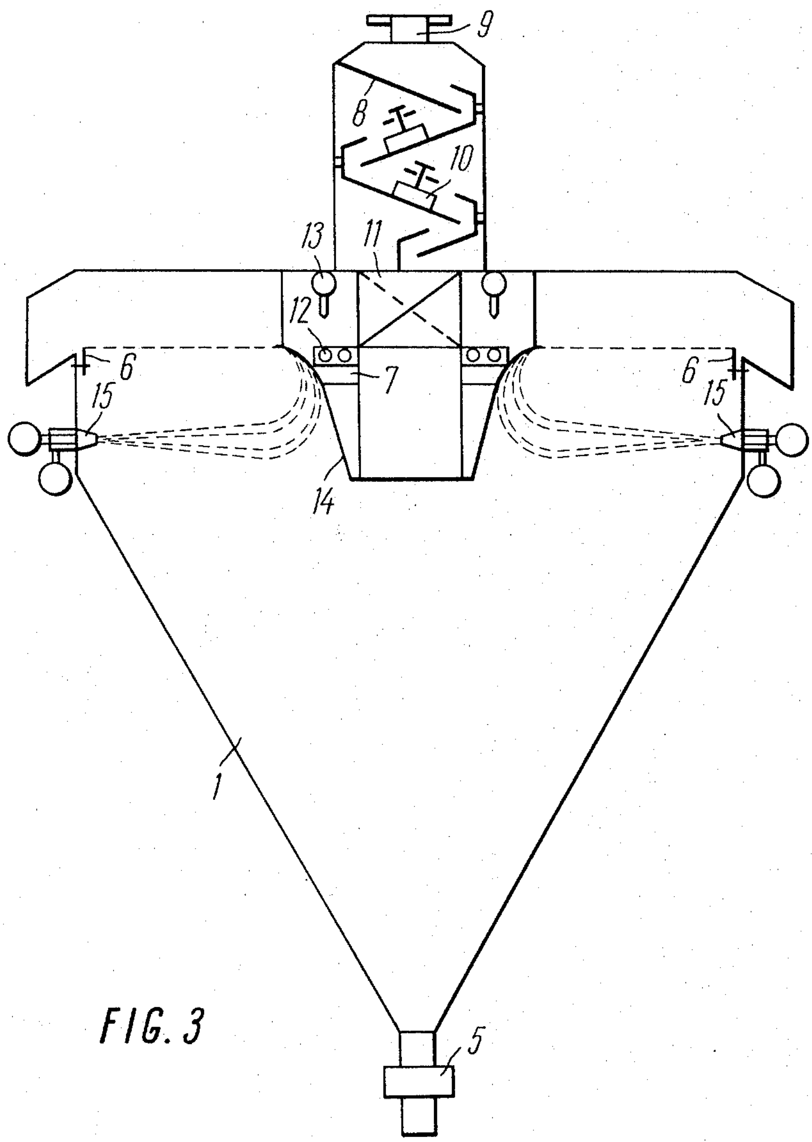

FIG. 3

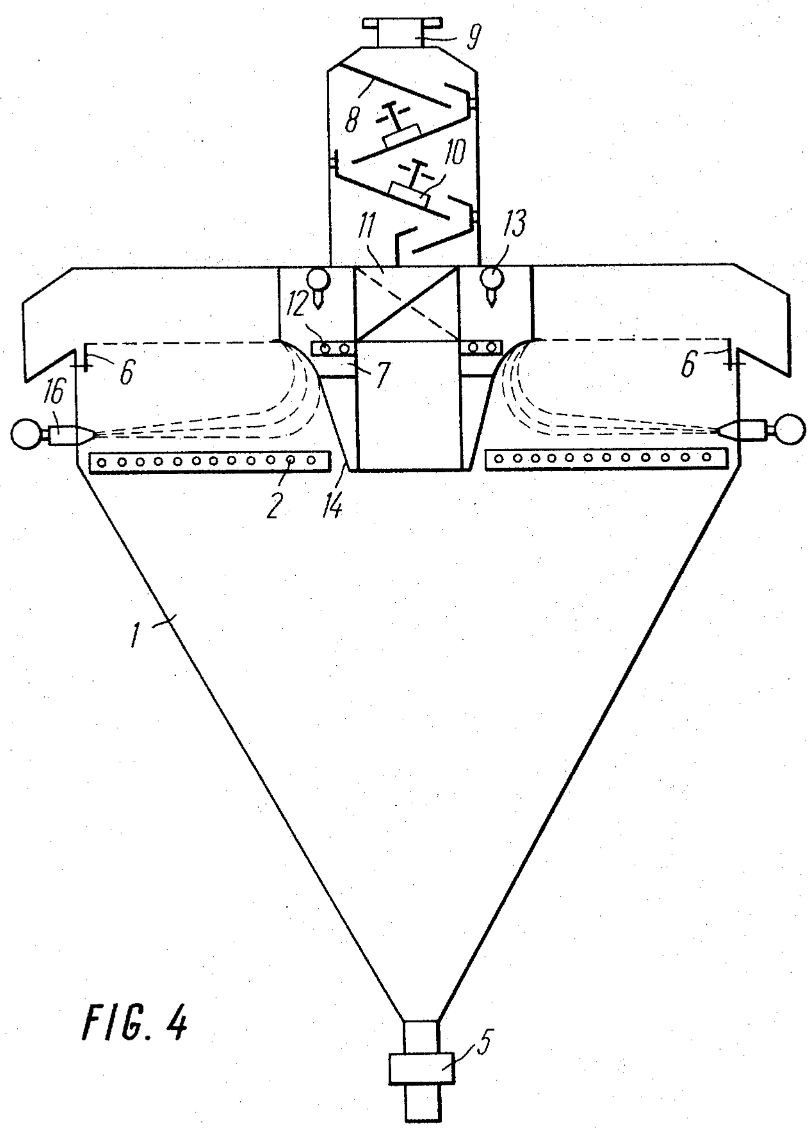

FIG. 4

United States Patent Office

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Patented Mar. 25, 1969

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PREAERATION AND FLOTATION OF MINERAL PARTICLES

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Filed Aug. 29, 1966, Ser. No. 594,953
Int. Cl. B03d *1/14*
U.S. Cl. 209—164 12 Claims

ABSTRACT OF THE DISCLOSURE

Flotation separator including tank with overflow weir has decks arranged in cascade for discharging a thin wide layer of aerated pulp to a splitter which distributes the thin layer into launders provided with compressed air inlet pipes and liquid inlet nozzles. The pulp undergoes frothing in the launder and flows over a curved wall of the launder onto the surface of separating liquid in the tank. Perforate pipes are disposed in the tank and controlled to provide maximum aeration of the liquid in the tank adjacent the launder and minimum aeration of the liquid adjacent the overflow weir.

This invention relates to methods for the separation of mineral particles by flotation particularly coarsely disseminated ores and coals, and to devices used for concentrating minerals.

Prior art methods of concentrating mineral particles by flotation are known, wherein the process is accomplished on shaking tables (table flotation), belts (belt flotation) and spirals.

However, said methods and apparatus do not provide the desired efficiency of separation, nor do they achieve high enough throughput when used for separating mineral particles of slightly differing density.

Somewhat better separation of mineral particles has been achieved with an apparatus of the type of a hydraulic classifier, in which a pre-aerated pulp is fed onto the surface of an aerated separating fluid and thus concentrated by flotation. The separating medium is prepared in a separate compartment by saturating the water therein with air delivered under a pressure of 4–5 atm. gauge. The water thus aerated is delivered to the classifier and to a tank for pre-aerating the pulp. Said tank has the shape of a vertical pipe with an air-lift-ejector device at its bottom, by means of which the pulp overflows into the classifier.

However, the throughput of this apparatus is insufficient and it does not enable flotation of particles larger than 1 mm.

The apparatus has a narrow feed zone, as a result of which the gangue particles, contained in large quantities in the feed, entrain large particles of the useful component as they slide down the tank walls into the feed zone. Insufficient aeration and eddy currents existent in the classifier tank result in breakdown of the aggregates formed of particles and air bubbles. Additionally, the water consumption for the process is excessive.

It is an object of this invention to eliminate said disadvantages.

A further and more specific object of the invention is to provide a method of separating mineral particles by flotation, ensuring efficient separation of sufficiently large-size mineral particles, and to a device to carry out this method at a high throughput.

This object has been accomplished by providing a method of separating mineral particles by flotation, consisting in feeding a pre-aerated pulp onto the surface of an aerated separating liquid, in which, according to the invention, the pulp, having been pre-aerated to formation

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of a froth, is fed in the form of a layer over the entire width of the surface flow of the separating liquid, said flow being made ot ascend vertically in a pulp feed zone, become horizontal at the surface and run towards the point of discharge of the froth product, the intensity of aeration of the separating liquid being maintained such that it gradually decreases in the direction of movement of the surface flow.

The method may be accomplished so that before delivering the pulp onto the surface of the separating liquid it is fed in at least one thin stream into the tank wherein it is mixed by streams of air and liquid until a froth is formed.

Before being fed into the tank the pulp may be delivered to at least one flat deck so that it fans out into a thin layer and thus enters the frothing vessel in this form.

The air for aerating the separating liquid may be delivered non-uniformly over the entire tank area, a larger quantity entering at the pulp feed zone, and then less and less towards the end of the horizontal flow.

The water-air mixture may be fed into the separating liquid below the surface of the horizontal flow and counter-current to it.

A liquid, for example, water, may be delivered in streams into the separating liquid below its surface flow and counter-current to it, and dispersed air may be injected below these streams uniformly over the entire area of the separating tank of the machine.

A machine has been built for accomplishing the method, having a tank with devices for aerating the separating liquid and for pre-aerating the pulp, in which, according to the invention, the device for aerating the separating liquid is constructed to enable the creation of a flow in the tank which ascends in the pulp feed zone towards a curved guide baffle installed therein which concentrates the air bubbles and smoothly changes the direction of the flow to horizontal from the pulp feed zone to the froth discharge zone, while the pulp pre-aerating device has a launder for delivering the pulp into the tank onto the surface of the separating liquid over the entire length of the tank, nozzles for feeding water to the launder, pipes for delivering air into the launder and a device for distributing the pulp evenly over the length of the launder.

The curved guide baffle of the tank may be one of the launder walls.

The machine may also be furnished with a device for aerating the separating liquid, said device comprising collectors for differential delivery of air into the perforated pipes in quantities increasing from the tank overflow lip to the pulp pre-aerating launder. Additionally, the machine may have a device for aerating the separating liquid, comprising ejectors built into the tank wall opposite the curved guide wall of the launder of the pulp pre-aerating device, below the overflow lip.

The machine may have a device for aerating the separating liquid, comprising collectors connected to perforated pipes installed below the curved guide wall of the launder, and nozzles for delivering liquid, built into the tank wall between the overflow lip and the perforated pipes.

For a better understanding of the present invention an exemplary embodiment of the machine for accomplishing the method of the invention is described below with due reference to the accompanying drawings in which:

FIGURE 1 is a general perspective view of the machine according to the invention;

FIGURE 2 is a cross-sectional view of said machine;

FIGURE 3 is an embodiment of the machine with ejectors in the tank wall, according to the invention; and

FIGURE 4 is an embodiment of the machine with perforated pipes and nozzles arranged in the tank, according to the invention.

The machine comprises a tank **1** (FIGS. 1 and 2) with a device for aerating a separating liquid therein and a device for pre-aerating the pulp.

The device for aerating the separating liquid has two rows of perforated pipes **2**, arranged horizontally over the whole area of the tank. The pipes are connected to collectors **3** and **4**. The upper collector **3** has three sections each of which is connected individually to a source of compressed air in such a way as to provide differential delivery of compressed air into the separating liquid by setting up a maximum head at the feed zone, said head decreasing to a minimum at overflow lip **6** at the outlet of the tank.

An automatic valve **5** is provided at the bottom of the tank for discharging the settled fraction. The valve operates depending on the level of the liquid in the tank with respect to overflow lip **6**. The automatic system of the valve comprises a liquid level pickup in the tank and an actuating mechanism which closes the outlet valve. This system is a conventional one and is not shown in the drawing.

The pulp pre-aerating device includes an attachment for spreading the pulp into a thin wide layer over the entire length of a launder **7**.

Said attachment comprises inclined flat decks **8** arranged in cascade, over which the pulp fed through pipe **9** spreads; the decks have guide strips **10** on them.

To provide two-sided operation of the machine, a splitter **11** is installed under the attachment for spreading the pulp, said splitter dividing the original pulp flow into two streams in two launders and distributes the streams evenly over the entire length of each launder.

Each launder is fitted with perforated pipes **12** for delivering air to the pulp and with nozzles **13** for feeding liquid to the pulp.

The nozzles and perforated pipes are arranged along the launder parallel to splitting **11** to provide aeration of the pulp which passes into the launder in the form of a thin layer. The thin layer of pulp undergoes frothing as a consequence of the aeration and it overflows, after frothing, over wall **14** of launder **7**.

Wall **14** of the launder is curved and faces the overflow lip **6**. The shape of wall **14** is such that its inside surface ensures passage of the aerated pulp into tank **1** in a layer onto the surface of the separating liquid. The outer surface of the curved launder wall is shaped so as to provide concentration of the air bubbles rising upwards in the tank, and their smooth emergence from under the wall at the point where the layer of frothed pulp is fed onto them.

The method is accomplished in the machine as follows. The reagent-conditioned pulp is fed along pipe **9** onto inclined decks **8** arranged in cascade, on which the pulp fans out into a wide thin layer, cascading from deck to deck. This is necessary not only to ensure uniform distribution of the pulp in a thin layer over the entire length of each launder **7**, but also to simultaneously contact the hydrophobized mineral particles with the oxygen of the air, thus improving aeration of the pulp and flotation separation of the mineral particles. The pulp splitter **11** installed under the lower deck distributes the pulp evenly into the two launders **7** of the machine. The pulp gravitates into the launder in a thin continuous layer, or in a layer consisting of a number of streams. Compressed air is delivered into the same launder under pressure for aeration, and liquid is streamed in to mix the pulp and dilute it as required. Due to the small cross-sectional area of the launder, the thin flow of pulp in it is broken up by the thin streams of liquid and air, mixed thoroughly and saturated with finely dispersed air bubbles, as a result of which it is rapidly whipped into a froth.

All this promotes flocculation of the hydrophobized mineral particles in launder **7** prior to their flotation. Flocculation is caused by the streams of liquid fed through nozzles **13** and the dispersed air fed through perforated pipes **12**. The liquid fed under pressure through nozzles **13** also saturates the pulp with minute air bubbles which promote the formation of primary flotable aggregates. From pre-aerating launder **7** the frothed pulp gravitates steadily in a broad thin layer onto the surface of the separating liquid in tank **1**. The separating liquid is aerated by air delivered through perforated pipes **2** arranged in tank **1** in two rows over the entire separating area. The degree of aeration of the separating liquid is maintained higher in the pulp feed zone and decreases gradually towards the froth product discharge end. Such non-uniform delivery of air gives rise to an intensive vertically upward flow of liquid and air bubbles in the feed zone. At the top the flow encounters wall **14** of launder **7**, streamlines it and changes its direction to horizontal. The curved launder wall **14** crosses the vertical flow of bubbles in the pulp feed zone in the tank and concentrates them under itself, while a thin but wide layer of mineralized froth flows along the inside wall of launder **7** and runs off it quiescently onto the concentrated flow of air bubbles and separating liquid emerging from under the launder wall **14** over its entire length in a wide horizontal flow running in the direction of the overflow lip **6** of the machine. The curved wall **14** of launder **7** ensures: smooth change of the direction of flow of the aerated separating liquid from vertical to horizontal, concentration of air bubbles in the pulp feed zone and smooth slippage of the aerated pulp onto the surface of the flow of separating liquid which transports the hydrophobized particles to the point of discharge.

The flow rate may be regulated between 0 and 40 cm./sec. by redistributing the amount of air delivered for aeration through the perforated pipes **2** of the tank.

Separation of the mineral particles occurs at the surface of the horizontal flow of aerated liquid. The conditioned flotable aggregates formed in the pre-aerating launder and fed onto the surface of the aerated separating liquid remain on its surface and are carried with it to the overflow lip, while the hydrophilic mineral particles sink and settle at the bottom of tank **1**, from which they are removed through valve **5**.

The sharpness of separation of the mineral particles can be controlled by regulating the rate of transport of the froth product, which depends on the difference in head between the perforated pipe sections.

Optimum conditions have been created in the machine for accomplishing the method of the present invention, ensuring high metallurgical efficiency and performance. For instance, the following results were obtained on commercial-scale treatment of a silvinite ore:

Throughput per 1 $m.^3$ of overall dimensions of the machine—13 t./hr. of feed;
Flotation time—2-3 sec.;
Floatable particle size—5 mm. max.;
Power consumption for the separation—not over 0.2 kwh./t. of feed.

Changing the throughput and pulp dilution from zero to the rated value has practically no effect on the quality characteristics of the process.

In another embodiment of the machine (FIG. 3) a device is provided for aerating the separating liquid, comprising ejectors **15**, built into the tank wall below the overflow lip **6** opposite the curved guide wall **14** of launder **7** of the pulp pre-aerating device.

A stream of water-air mixture is delivered through ejectors **15** into the separating liquid under the curved guide wall **14** of launder **7**. This causes a flow in the separating fluid, running from the ejectors **15** to the curved guide wall **14**, along it up to the surface of the separating liquid and horizontally from the pulp feed zone to the froth discharge zone.

Thus, a surface flow is created by a flow of water-air mixture running parallel to the surface flow with the froth, below it and in the opposite direction.

Still another embodiment of the machine (FIG. 4) has a device for aerating the separating liquid, comprising collectors which are connected to perforated pipes **2** arranged horizontally below the curved guide wall **14** of launder **7**, and nozzles **16** for delivering the liquid, built into the wall of tank **1** between the overflow lip **6** and perforated pipes **2**.

Though air is delivered uniformly into perforated pipes **2**, the water fed from nozzles **16** deflects the air bubbles towards the curved guide wall **14** which concentrates the air bubbles in the pulp feed zone. Thus, operation of nozzles **16** and pipes **2** of the device for aerating the separating liquid causes a flow in it which ascends in the pulp feed zone towards the curved guide wall **14** and changes to horizontal at the surface of the separating liquid, running from the pulp feed zone of tank **1** to the zone where the froth is discharged over overflow lip **6**.

The required flow may also be created in the separating fluid by using unions for the collectors of the perforated pipes **2**, with holes in each (not shown in the drawings) of gradually increasing diameter from one end of the union to the other. These unions should be arranged with their larger holes at the launder end and perpendicular to the launder. In this case the air fed to the air collector, after passing through perforated pipes **2**, will be distributed non-uniformly over the tank area, more air emerging in the feed zone, and this will give rise to a flow of the shape and direction indicated.

Other changes may be made in the design of the machine. For instance, the machine may be one-sided and have only one launder **7**, in which case a splitter is unnecessary.

In the conical part of the machine the valve for discharging the hydrophobic sink particles may be replaced by various transporting devices, e.g., a screw or belt conveyor.

Though the present invention has been described in accordance with a preferred embodiment, various changes and modifications may be made in carrying out the present invention without departing from the spirit and scope thereof, as will be understood by those skilled in the art. These changes and modifications are to be considered as falling within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A flotation method for separating mineral particles from a pulp, said method comprising spreading said pulp in the form of a broad thin layer, subjecting said layer of the pulp to aeration to attain froth formation, feeding the thus aerated pulp layer onto the surface of a liquid in a tank in which the upper region of the liquid is aerated and a froth layer is formed on the surface thereof, whereat mineral particles in the pulp are separated into hydrophobic particles remaining in the froth layer and hydrophilic particles which settle into said liquid, directing the froth layer to flow towards a discharge outlet, diminishing the aeration of the upper region of the liquid in the direction of flow of the froth layer, and separately discharging the froth layer and entrained particles and the settled particles from said tank.

2. A method according to claim **1**, wherein the pulp is spread into the broad thin layer by flowing along at least one inclined surface.

3. A method as claimed in claim **1**, wherein the aeration of the pulp is effected by mixing the pulp with pressurized liquid and compressed air.

4. A method according to claim **1**, wherein the upper region of the liquid is aerated by feeding dispersed compressed air in the liquid, the major portion of said air being fed to the liquid in the region where the aerated pulp layer flows onto the froth layer.

5. A method according to claim **1**, wherein the aerating of the liquid in the tank is effected by feeding an air liquid mixture below the froth layer in a direction in opposition to the flow of said froth layer.

6. A method according to claim **1**, wherein the aerating of the liquid in the tank is effected by simultaneously and separately feeding compressed air and liquid below the froth layer in a direction in opposition to the direction of flow of the froth layer, the air being fed below said liquid.

7. Flotation apparatus for the separation of mineral particles in a pulp, said apparatus comprising a tank filled with a liquid and having an upper part with at least one overflow weir for discharging froth-entrained material and means at the bottom of the tank for discharging settled material; an inlet at the upper part of the tank for charging pulp; a distribution means disposed below said inlet and including at least one inclined surface for spreading the pulp into a broad, thin layer; at least one launder disposed below the inclined surface of said distribution means for receiving the pulp layer and having an upper edge positioned for overflow of pulp layer onto the liquid in said tank, means for aerating the pulp layer in said launder; and means for aerating the liquid at the surface thereof in said tank to produce a froth layer on the surface of said liquid, the latter said means being disposed below the upper edge of said launder.

8. Flotation apparatus according to claim **7**, wherein said distribution means includes a plurality of inclined decks disposed in cascade one above another.

9. Flotation apparatus according to claim **7** comprising a second launder and a splitter disposed below said distribution means for dividing the total pulp stream leaving the last deck into two equal parts and directing said parts to the launders for aeration therein.

10. Flotation apparatus according to claim **7**, wherein said means for aerating the pulp comprises a plurality of nozzles disposed along and above said launder and connected to a source of liquid.

11. Flotation apparatus according to claim **7**, wherein said means for aerating the pulp comprises a plurality of perforated pipes connected to a source of compressed air, said pipes being disposed along said launder and submerged in the pulp.

12. Flotation apparatus according to claim **8**, wherein said means for aerating the pulp comprises a plurality of nozzles disposed along and above said launder and connected to a source of liquid, and a plurality of perforated pipes connected to a source of compressed air, said perforated pipes being disposed along said launder and submerged in the pulp.

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U.S. Cl. X.R.

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