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AUTOMATICALLY CONTROLLED FLOATATION APPARATUS AND METHOD

Filed Nov. 21, 1966

FIG. 1.

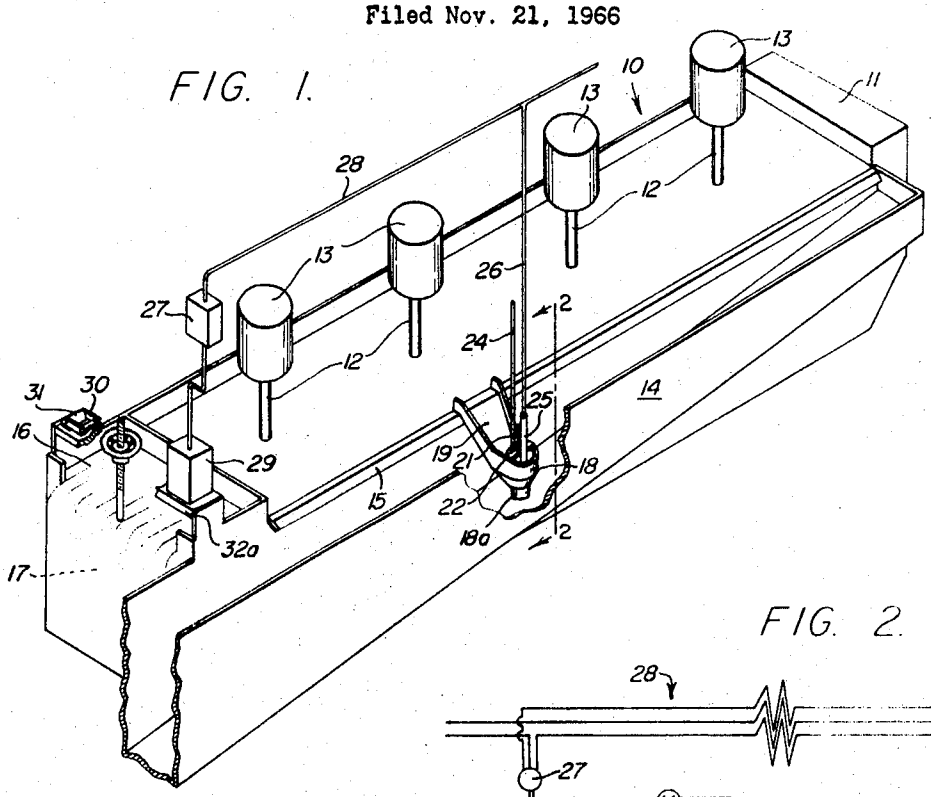


FIG. 2.

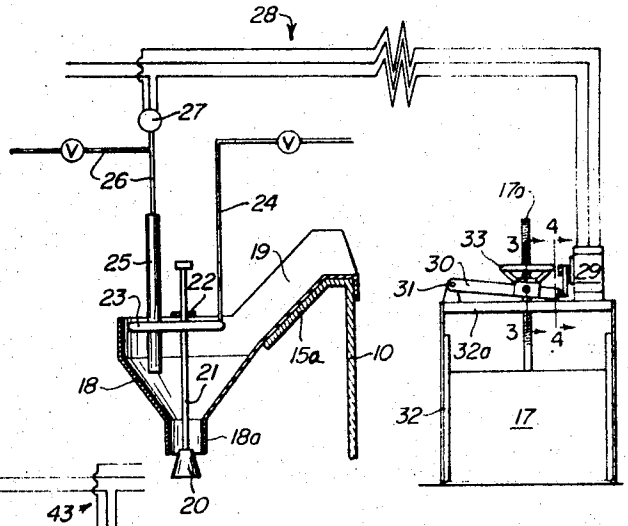


FIG. 3.

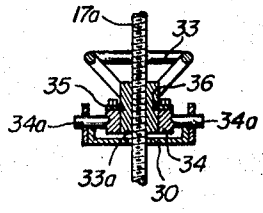


FIG. 5.

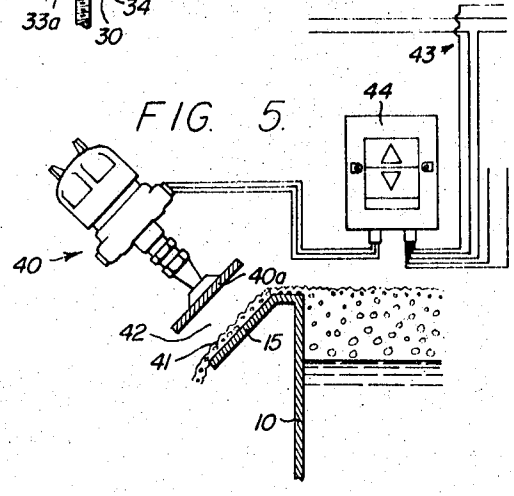
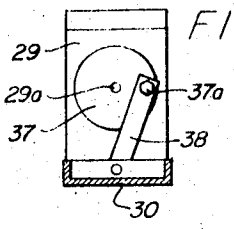


FIG 4.



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AUTOMATICALLY CONTROLLED FLOATATION APPARATUS AND METHOD

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Int. Cl. B03b 13/04
U.S. Cl. 209—1 9 Claims

ABSTRACT OF THE DISCLOSURE

A method of automatically controlling the operation of a flotation machine by continuously sensing the quantity of froth overflow, and apparatus for carrying out the method. One embodiment of the apparatus combines, with a conventional flotation cell, a froth sampling vessel arranged to re-pulp froth flowing thereinto and having means for sensing pressure variations in air supplied to an air-bubbler tube discharging below the fluctuating pulp level in such vessel; another embodiment combines, with such a flotation cell, an electrical capacitance probe arranged above the froth overflow lip of the cell.

The invention

This invention relates to method and apparatus for carrying out flotation procedures in the separation of particles of various materials, such as minerals of different types, by processes of froth flotation, wherein an aqueous pulp of the material particles to be separated is subjected to aeration in a flotation machine to produce a froth overflow carrying certain of the particles and a tailings discharge carrying the other particles.

Flotation machines are normally made up of a series of individual cells, with the feed material flowing from cell to cell. Froth rises in and overflows from each cell to a launder for segregated discharge, while the ailings from one cell flow into the next cell in line as the feed for that cell. It is important that the liquid level in each cell be controlled to maintain optimum conditions for separation of the material particles concerned. This is normally accomplished by means of gates between the individual cells regulating tailings discharge from one cell to a succeeding cell or from the last cell in line, the gates being individually manipulated to effect the desired liquid level control.

In some instances, instead of gates other types of tailings discharge devices are employed, for example, plug valves. Also, in some instances, flotation machines are not divided into cells, in which event a single tailing discharge controls the liquid level along the entire length of the machine.

Liquid levels in flotation machines have been automatically controlled heretofore by devices that sense the varying hydrostatic heads of the liquid pulp in the respective cells and that effect opening or closing of respective gates by feeding signals into motorized power systems for operating such gates.

In accordance with the present invention, however, the quantity of froth overflowing from a flotation cell is sensed continuously, and the tailings discharge gate for such cell is raised or lowered to a greater or lesser extent, or whatever other type of tailings discharge device may be used in the particular instance is appropriately manipulated, in accordance with variations in such quantity.

Continuous sensing of the quantity of froth overflow can be effectively accomplished in various ways, which represent specific aspects of the present invention.

Thus, the froth passing over a small portion of the total length of the overflow lip of a flotation cell may

be continuously conducted into a sensing device, comprising a relatively small sampling vessel having gravity discharge opening such that a body of material, reflecting fluctuations in inflow to such vessel, is maintained in the vessel. A standard type of air bubbler tube detects changes in hydrostatic head of such body of material, which consists of froth repulped in the vessel by a continuous spray of water. By keeping the supply of spray water consistent, the level of the body of repulped froth fluctuates in accordance with fluctuations in the level of froth overflow from the flotation cell, and such changes in level are continuously sensed by the air bubbler tube and used to control a suitable motivating device, such as an electric motor, for the tailings discharge device by means of suitable circuitry which may be of well known type.

Again, a sensing device in the form of a plate-type capacitance proximity probe may be employed, together with standard electrical control circuitry for the actuating motor. The detector plate of the probe is mounted above and in spaced relationship with the froth overflow lip of the flotation cell and extends lengthwise with such lip. It senses variations in froth overflow level by reason of corresponding changes in spacing of the surface of the overflowing froth from the detector plate.

Other suitable types of sensing arrangements may, of course, be used in place of those specifically indicated above, but such specifically indicated arrangements are presently believed to be the best modes of carrying out the invention and are, consequently, illustrated and described in detail.

In the drawing:

FIG. 1 is a schematic perspective view of a typical single cell flotation machine, with which is combined a sampling vessel and air-bubbler tube type of froth overflow level sensing arrangement;

FIG. 2, a schematic view showing the sampling vessel and a fragment of the froth overflow lip of the flotation machine in vertical central section, with parts of a standard wiring diagram connecting sensing components of such sampling vessel with actuating mechanism for raising and lowering the tailings discharge gate of the flotation machine, which mechanism and gate are shown in elevation.

FIG. 3, a fragmentary vertical section taken on the line 3—3 of FIG. 2 and drawn to a larger scale;

FIG. 4, a similar view taken on the line 4—4 of FIG. 2; and

FIG. 5, a view similar to that of FIG. 2 but showing a different form of the apparatus of the invention, wherein a plate-type capacitance probe is utilized to sense changes in the level of froth overflowing the froth-overflow lip of the machine.

Referring to the drawing:

In the embodiment of FIGS. 1–4, the single cell flotation machine illustrated schematically is typical of standard installations. It comprises an elongate tank **10** into which flotation pulp is fed through a usual feed box **11**. As is common, a plurality of impellers (not shown) are mounted for rotation at the lower ends of respective impeller shafts **12** powered by respective electric motors **13**. Mineral-laden froth rises to the surface of the body of pulp in tank **10** and discharges into lounder **14** over an elongate froth overflow lip **15**. As usual, the tailings pass into tailings box **16** through submerged outlet openings (not shown) and discharge over tailings gate **17**, either into a next succeeding cell (not shown) at a lower level, for repeated flotation treatment, or directly to waste if the flotation pulp is sufficiently impoverished at this stage.

For controlling the pulp level in tank **10** in accordance with this invention, a froth sampling vessel **18**, provided with continuously operating discharge means of predeter-

mined capacity, which in this instance, is a valved, gravity discharge opening **18***a*, is fed with a continuously flowing sample of the over-flowing froth by means of a sampling launder **19**. The vessel **18** is advantageously of inverted frusto-conical formation, converging to a bottom opening, **18***a*, and such opening is advantageously valved by means of a plug **20** at the end of a stem **21** that is movable upwardly and downwardly in a supporting arm **22**. Thus, the size of discharge opening **18***a* can be predetermined as desired for any given operation of the machine, and a body of material can be established and continuously maintained in the vessel **18** to reflect variations in quantity of froth inflow from time to time.

Provision is made for re-pulping the froth samples as they pass through sampling vessel **18**. In the illustrated instance, a spray ring **23** is positioned over the interior of the sampling vessel, being supplied with water through pipe **24** under the control of a valve, as indicated.

In order to automatically control the raising and lowering of tailings gate **17** in accordance with fluctuating froth overflow levels from the flotation tank **10**, a bubble tube **25**, supplied with low-pressure air from valved air supply lines **26**, is positioned to dip below the normal liquid level in sampling vessel **18** and to detect changes in hydrostatic head of the body of re-pulped froth maintained in such vessel.

Pressure differentials are used in well known manner to control an electrical switch **27** of standard type, which regulates the supply of electricity through circuit **28** to a reversible motor **29** that is adapted to raise or lower tailings gate **17**, depending upon the direction of operation of such motor on any given activation thereof. The particular direction of operation, either forward or reverse, will, of course, depend upon whether the hydrostatic pressure in vessel **18** is either lowered or raised to trip switch **27**.

As here illustrated, the mechanism by which motor **29** either raises or lowers tailings gate **17** comprises a lever **30**, fulcrumed at one end by a pivot mounting **31** positioned on top frame member **32***a* of tailings gate frame **32**, and an eccentric drive connecting the output shaft **29***a* of the motor to the free end of the lever.

The usual handwheel mechanism for normally raising or lowering the gate is modified by rotatably mounting the hub, **33***a*, of such handwheel, **33**, in a bearing mount **34** that is swiveled by stub pins **34***a* in lever **30**. A split ring **35**, FIG. 3, fits into a circumferential groove **36** of handwheel hub **33***a* and holds the handwheel in place as it is turned to screw the threaded stem **17***a* of gate **17** either upwardly or downwardly, such split ring being bolted to bearing mount **34**, and the swivel mounting of pins **34***a* being sufficiently loose to accommodate the small amount of arcuate movement occurring as lever **30** is raised and lowered.

As illustrated, the eccentric drive between motor **29** and lever **30** comprises a disk **37**, FIG. 4, secured to motor shaft **29***a* and provided with a crank pin **37***a*, which is connected to the free end of lever **30** by means of a connecting rod **38**.

A different type of sensing arrangement is shown in FIG. 5, where an electrical capacitance proximity probe **40** is employed to directly detect changes in level of froth **41** overflowing lip **15**. The changes in froth level produce corresponding changes in capacitance by reason of increase or decrease of the dielectric space or air gap **42** between an elongate detector plate **40***a* and the superficial surface of the overflowing froth **41**. Such detector plate should, for best results, extend along substantially the entire length of a portion of overflow lip **15** that is subject to the action of an impeller unit represented by a shaft **12** and motor **13**. In the particular cell illustrated, this is approximately one-quarter the length of lip **15**, and the detector plate advantageously extends symmetrically at opposite sides of such shaft **12** and motor **13** and parallel with the superficial surface of the overflowing froth, as indicated in FIG. 5, to provide a control for the entire cell. It is obvious that the mineral content in the froth will play a part in the electrical output of the sensing device as well as changes in the froth levels.

The detector plate **40***a* should extend over a representative area of the overflowing stream of froth. The usual downwardly-sloping apron **15***a* of the overflow lip of the flotation cell provides an effective detection surface for the overflowing froth. It is preferable that the width of detector plate **40***a* be commensurate therewith, as illustrated. Both the capacitance probe **40** and the electrical control circuit therefor (merely indicated at **43**), may be of standard type, such as provided by the commercial level measuring and indicating system manufactured and sold by Aeronautical and Instrument Division, Robertshaw Controls Company, Anaheim, Calif., as detailed in its Bulletin 30 under the trade designation "Level-Tel" Model 305, which advantageously includes a visual display unit **44** to indicate how the system is operating and to house various circuit components, which need not be detailed here.

We claim:

1. Automatically controlled flotation apparatus, including in combination:

a flotation cell, comprising a tank having an elongate froth overflow lip, pulp feed, and variable tailings discharge means;

power means for varying said tailings discharge means;

means for continuously sensing variations in the quantity of froth overflowing said lip of the flotation cell; and

control circuitry between the sensing means and the power means for translating sensed changes in froth quantity into related changes in power applied to said power means, whereby the tailings discharge will be varied in accordance with variations in froth quantity.

2. Apparatus as recited in claim **1**, wherein the means for sensing variations in the quantity of froth overflowing the lip of the flotation cell comprises:

a froth sampling vessel having continuously operating discharge means of predetermined capacity for material flowing into said vessel;

a sampling launder leading from a localized area along said lip of the flotation cell into said sampling vessel;

means for continuously mixing a re-pulping liquid with samples of froth in said sampling vessel;

an air-bubbler tube in said sampling vessel, with its discharge end disposed below the normal level of re-pulped froth therein and below the lowest point of variation of said level;

means for supplying air under pressure to said bubbler tube; and

wherein the control circuitry between the sensing means and the power means includes electrical switch means responsive to changes in pressure of the air being supplied said bubbler tube.

3. Apparatus as recited in claim **2**, wherein the sampling vessel is of inverted frusto-conical formation, with the discharge means being a valved opening at the downwardly-directed, convergent bottom of said vessel.

4. Apparatus as recited in claim **2**, wherein the means for continuously mixing a re-pulping liquid with samples of froth in the sampling vessel comprises a spray nozzle directed inwardly of said vessel, and means for supplying water under pressure to said spray nozzle.

5. Apparatus as recited in claim **1**, wherein the means for sensing variations in the quantity of froth overflowing the lip of the flotation cell comprises:

an electrical capacitance probe having an elongate detector plate spaced above said lip of the flotation cell and extending along the length thereof.

6. Apparatus as recited in claim **5**, wherein the detector plate has a width substantially equal to the width of the apron portion of the overflow lip.

7. A method of automatically controlling the operation of a flotation machine, comprising

continuously sensing the quantity of froth overflow during operation of the machine to produce signals indicative of variations in said quantity; and

utilizing said signals to control the quantity of tailings discharged from the machine so as to keep the pulp level in the machine substantially constant.

8. A method as recited in claim 7, wherein the quantity of froth overflow is sensed by continuously repulping a portion of the normal froth overflow from the machine, and by sensing variations in pressure of air discharged below the fluctuating surface of the repulped portion of said froth overflow.

9. A method as recited in claim 7, wherein the quantity of froth overflow is sensed on the basis of variations in

electrical capacitance brought about by variations in froth discharge across the froth overflow lip of the machine.

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