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CONCENTRATION APPARATUS AND METHOD

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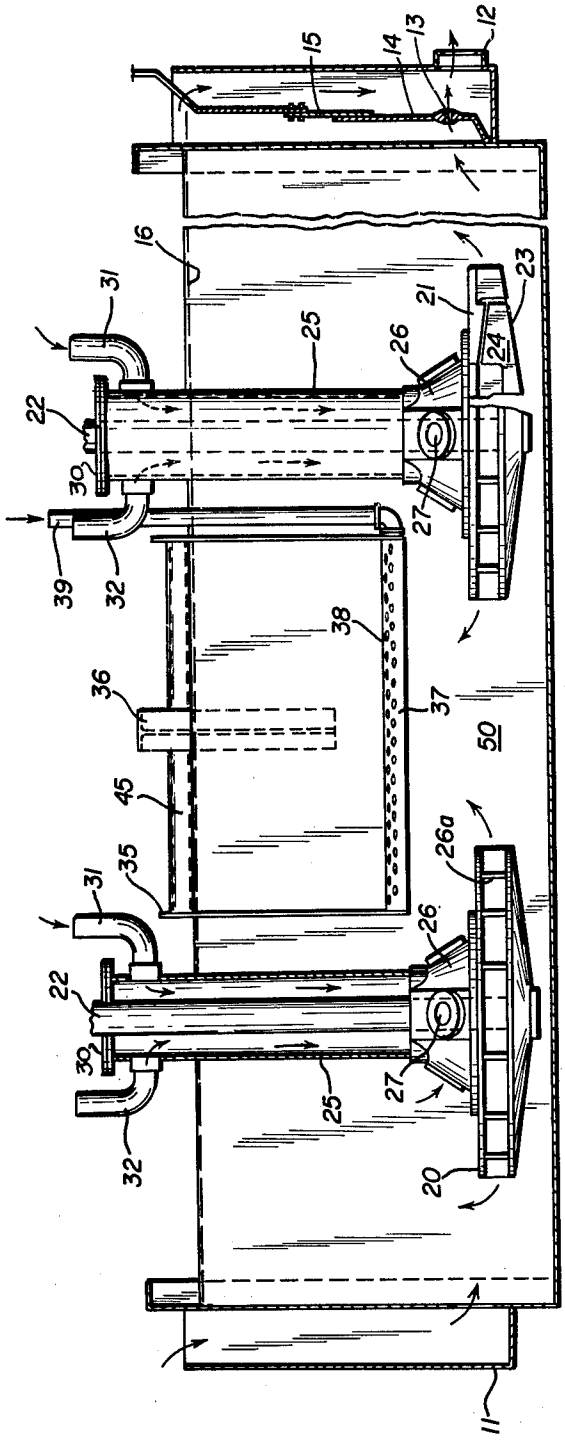

Fig. 1

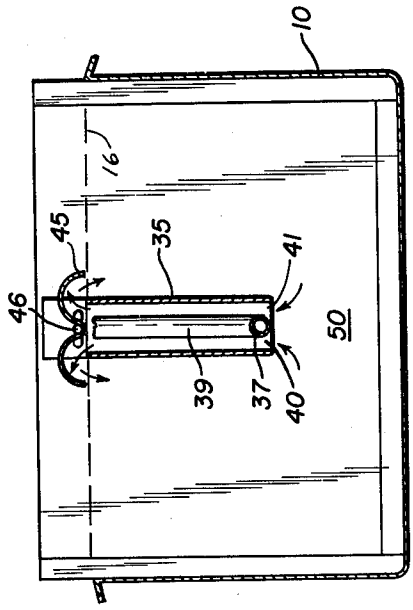

Fig. 3

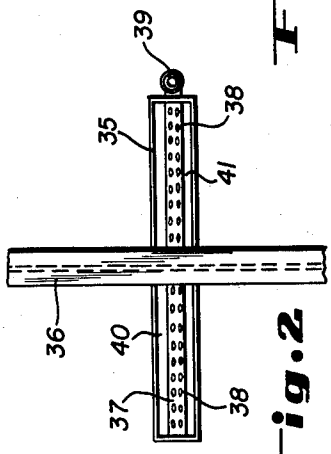

Fig. 2

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CONCENTRATION APPARATUS AND METHOD

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This invention relates to a method and apparatus for concentrating the valuable constituents of a mixture of solids in liquid, and more particularly to froth flotation treatments and apparatus.

Flotation concentration is employed extensively to recover the valuable constituents of an ore from other minerals and gangue with which it is associated. Flotation treatments are usually preceded by crushing and grinding operations in which mineral particles are freed and reduced to a flotation size. In the flotation process, a pulp is formed with a liquid component, usually water, acting as a carrier vehicle for the crushed and separated particles. The ore is conditioned prior to introduction of the pulp to the flotation stage as by mixing with one or more flotation reagents, which may be collectors, frothers, modifiers and combinations thereof.

In the flotation apparatus, the ground and conditioned pulp is subjected to a series of agitation and aeration stages in one or a series of cells in which the mineral or other valuable constituent responding to the influence of the collector reagent is elevated by the buoyand action of air introduction and collects on the surface in a broth where it is removed by overflow and this action may be assisted by a mechanical skimmer.

Many operations prefer to utilize what is termed a "hog trough" type flotation machine in which the cell arrangement of the unit permits a substantially direct flow of pulp through the machine between its feed inlet and tailings discharge outlet. This provides a more intense sweeping action of solids settling on the bottom of the machine by the centrifugal action of the impellers so that they move progressively to discharge through the tailings outlet. However, some solids tend to accumulate along the bottom of the cell between adjoining impellers, and concentrate material which might otherwise be floated is entrained in a settled bed of solids and gangue material and may be carried from the machine with the tailings discharge even though it is in condition to float.

Not only is there the static buildup of solids on the bottom of the machine between impellers, but there is also a tendency for static spots to occur in the body of pulp itself. Such static spots may occur at various elevations and result in a density buildup. Once such a buildup occurs, there is an impedance to rising particles which would carry to the surface and collect in the froth if the pulp were maintained at normal density.

Accordingly, it is an object of this invention to provide improved flotation apparatus of the hog trough type utilizing a novel method of pulp circulation and flotation concentration.

It is still another object of the invention to provide an efficient and low cost method of flotation concentration under controlled circulation which effectively reduces treatment time.

A distinctive feature of the present invention is the provision of a special type of air lift compartment between successive impellers of the flotation machine so arranged as to dimension and intake and discharge positions as to effectively prevent buildup of high density conditions in the pulp body while at the same time promoting the aeration and flotation, as well as being a factor in the controlled circulation through the machine. This arrangement has the advantage of reducing the work of the impellers in providing the required distribution of aerating gas and pulp circulation in such a way that the total power consumption of the machine is low, while a high capacity circulation and intense aeration is provided. Another innovation of the arrangement is that the air lift compartments are so located that the areas within the pulp body affording the greatest impedance to controlled circulation are altered and undue settling and density buildup are avoided. The features and advantages of this arrangement will be set forth in detail in the following description.

Other details of construction and other objects and features of the method and apparatus of this invention will be set forth in the following description with reference to the appended drawings. In the drawings, in the several views of which like reference numerals are used to designate like parts:

FIG. 1 is a vertical section through a hog trough type flotation machine embodying novel features of my invention;

FIG. 2 is a top plan view of an air lift assembly of the machine shown in FIG. 1; and

FIG. 3 is an end elevation of the air lift assembly of FIG. 2 in operative position in a machine of the type shown in FIG. 1.

The flotation machine shown in FIG. 1 includes an elongated hog trough type cell or tank **10** having a feed inlet **11** at one end and a tailings discharge outlet **12** at its opposite end. The discharge outlet includes a sands relief hole **13** in the stationary wall portion **14** disposed below an adjustable gate or weir **15**. The weir is movable to different elevations for variation in the liquid or pulp level **16** in tank **10**.

A plurality of rotary impellers is mounted at intervals lengthwise of the cell to aerate and circulate the pulp. For simplicity in illustration, I have shown only two impeller mechanisms **20** and **21** in cell **10**, but it will be understood that any plurality may be provided to meet the requirements and length and treatment capacity of the cell.

The two impeller mechanisms shown are similar and include a drive shaft **22** suitably interconnected at its upper end to a power source (not shown) and carrying at its lower end a dished impeller **23** having a plurality of impeller blades **24** on its upper surface. A hollow column **25** encompasses shaft **22** and has a hood assembly **26** at its lower end including a plurality of pulp recirculating apertures **27** formed therethrough. The top of the column may be closed by annular plate **30** as shown, below which a pair of air lines **31** and **32** extends into column **25** to deliver an aerating gas, usually air, which discharges downwardly into the enclosure formed by hood **26** and impeller **23**. One or more of the openings **27** may be plugged and the remainder will recirculate pulp for additional mixing and aeration within the impeller enclosure.

An air lift assembly **35** is disposed between successive impellers and comprises a narrow hollow body having an open top and bottom which is suspended in cell **10** by the downwardly opening U-shaped partition **36**. The lengthwise axis of hollow body **35** is substantially coincident with the lengthwise axis of cell **10**. A gas supply header or conduit **37** extends the entire length of the open bottom of cell **35** and includes a plurality of apertures **38** formed through approximately the entire upper 180° surface to direct the gas discharge upwardly in a series of fine jets. Conduit **37** is interconnected through a line **39** with an exterior source of air (not shown).

Header **37** has an outside diameter occupying a substantial part of the area of the bottom entrance opening in compartment **35**, and defines with the walls of compartment **35** a pair of intake passages **40** and **41**. These

passages are subjected to the hydrostatic head of pulp in the cell, as indicated by level **16** in FIG. 1, and the release of a large volume of gas in high velocity jet flow directed upwardly adjacent thereto results in an intense elevation effect, drawing pulp from the lower portion of the pulp body through said entrance passages in an upward movement, and subjects it to an intense aeration effect in the passage through the hollow body.

A deflector **45** comprised of two downwardly facing arcuate sections interconnected at their adjoining edges to a rod **46** which is supported by opposite end portions of body **35** is arranged to direct the discharge of pulp passing upwardly through passages **40** and **41** and body **35** under the elevating action therein so that it impinges on the surfaces of the deflector which force the aerated pulp downwardly into the pulp body. In a typical installation, the intake through passages **40** and **41** of body **35** is higher than the top surface **26A** of the hood assembly and the discharge course from deflectors **45** is slightly higher than the pulp level **16** in the machine.

From the foregoing, it will be apparent that the structural arrangement of the present invention provides a series of centrifugal agitation and aeration stages in the lower portion of the cell which intercept or converge and tend to create a high density zone within the pulp body in the immediate area of such convergence. By having the air lift compartment adjacent the normal location of said high density zone with its entrance in a position to draw the high density material into the hollow body, the inducted pulp is elevated and distributed so as to prevent density buildup in the cell.

In operating a flotation machine according to the practice of my invention, a zone of intermingling centrifugal flows **50** is formed between the two impeller assemblies **20** and **21**, directly below the air lift **35**. Under the elevating influence of high pressure air or aerating gas passing upwardly through compartment **35**, pulp from the zones of intermingling is drawn through the compartment and discharged on the surface in a spreading movement. Particles ready to float will remain on or near the surface and collect in the bed of froth externally of deflector **45** and other particles which are not floatable spread out and distribute in the pulp body under the suspending influence of the agitation.

The circulation in the cell is from inlet to outlet with the impellers spreading the pulp at the bottom of the compartment **35** in their centrifugal action. The air lift compartment entrains solids elevated above the main sweep of the impellers and distributes them, together with a large volume of gas on the surface, through a relatively narrow zone. The remainder of the pulp body adjacent the surface of the liquid is substantially quiescent and affords little impedance to the ascent of floating particles.

This arrangement of circulatory actions effectively prevents any density buildup of consequence in any portion of the body of pulp, provides a high degree of aeration and gas-solids contact, and releases a considerable quantity of floatable material on the surface of the liquid where it discharges with the froth. Heavy and large unfloatable solids which tend to settle are maintained in a circulatory flow which progresses through the machine to its discharge outlet, entrainment of floatable material in the tailings is substantially eliminated, and a highly efficient flotation concentration under low power consumption is provided.

While I have shown only a single structural embodiment in describing the practice of my invention, substantial variations in construction and arrangement of parts and in operating procedures may be included within the scope of the invention. The centrifugal agitation stages are shown as utilizing a standard type "Denver Sub-A" impeller and cover assembly, but it will be understood that any type of open or closed impeller may be provided, and the impellers may be a bladed type as shown, or a

squirrel cage or other type in general use in flotation machines.

Variations in size and capacity of the air lift chambers may be availed of but best results will be attained if the aspirated pulp is directed downwardly into the pulp body as shown and the area of such return flow is restricted so as to occupy only a small portion of the total surface on which the froth is formed.

As a result of such novel arrangements, the method of operation will comprise treating a body of conditioned pulp, subject to continuous feed and discharge, in a progressive flow between the feed inlet and discharge outlet of the elongated machine. The hog trough arrangement provides a common overflow level through the machine, and the mechanical agitation and aeration stages provide the progressive circulation through the machine. A portion of the discharge of one said stage moves in opposition to a portion from an adjoining stage and some of the intermingling flows are drawn into the air lift chamber by the aspirating effect of the large volume gas discharge. The discharge of the aspirated pulp is directed downwardly onto the surface along a narrow course determined by the shaping of the deflectors and such circulation controls maintain an efficient froth discharge and prevent any substantial density buildup in the pulp body.

I claim:

1. The froth flotation process, which comprises treating a body of conditioned pulp, subject to continuous feed and discharge, in a progressive flow through an elongated confined zone with the surface of the pulp maintained at a common level throughout said zone, subjecting pulp in the lower portion of said body to a succession of at least two adjoining stages of contrifugal agitation and aeration with a portion of the pulp discharge from one stage converging in opposition to a portion of the pulp discharge from an adjoining stage, withdrawing a portion of the intermingling discharge from said agitation and aeration stages upwardly through an upper superposed confined zone under the elevating action of a large volume of aerating gas introduced in fine, upwardly-directed streams at the bottom of said superposed zone, and discharging the entrained pulp along a narrow path on the surface of said pulp.

2. The froth flotation process, which comprises treating a body of conditioned pulp, subject to continuous feed and discharge, in a progressive flow through an elongated confined zone with the surface of the pulp maintained at a common level throughout said zone, subjecting pulp in the lower portion of said body to a succession of at least two adjoining stages of centrifugal agitation and aeration with a portion of the pulp discharge from one stage converging in opposition to a portion of the pulp discharge from an adjoining stage, withdrawing a portion of the intermingling discharge from said agitation and aeration stages upwardly through an upper superposed confined zone under the elevating action of a large volume of aerating gas introduced in fine, upwardly-directed streams at the bottom of said superposed zone, discharging the entrained pulp along a narrow path on the surface of said pulp, and shielding froth formed on the surface of the pulp from said discharge of said pulp.

3. The froth flotation process, which comprises treating a body of conditioned pulp, subject to continuous feed and discharge, in a progressive flow through an elongated confined zone with the surface of the pulp maintained at a common level throughout said zone, subjecting pulp in the lower portion of said body to a succession of at least two adjoining stages of centrifugal agitation and aeration with a portion of the pulp discharge from one stage converging in opposition to a portion of the pulp discharge from an adjoining stage, withdrawing a portion of the intermingling discharge from said agitation and aeration stages upwardly through an upper superposed confined zone under the elevating action of a large volume of aerating gas introduced in fine, upwardly-directed streams

at the bottom of said superposed zone, and discharging the entrained pulp downwardly onto the surface of said pulp in a narrow area extending lengthwise of said treatment zone.

4. The froth flotation process, which comprises treating a body of conditioned pulp, subject to continuous feed and discharge, in a progressive flow through an elongated confined zone with the surface of the pulp maintained at a common level throughout said zone, subjecting pulp in the lower portion of said body to a succession of at least two adjoining stages of centrifugal agitation and aeration with a portion of the pulp discharge from one stage convering in opposition to a portion of the pulp discharge from an adjoining stage, withdrawing a portion of the intermingling discharge from said agitation and aeration stages upwardly through an upper superposed confined zone under the elevating action of a large volume of aerating gas introduced in fine, upwardly-directed streams at the bottom of said superposed zone, discharging the entrained pulp along a narrow course on the surface of said pulp, circulating pulp in the lower portion of said treatment zone from feed to discharge under the impelling influence of said centrifugal agitation stages, and restricting agitation in the upper portion of the treatment zone by confining the downward direction of elevated pulp into the pulp body along a narrow course between said feed and discharge.

5. In a hog trough type flotation machine, including at least two rotary impellers submerged in the pulp body therein at spaced intervals between an inlet at one end and an outlet at the other end and disposed to direct their centrifugal discharge in converging flows, the improvement comprising a narrow aerating gas lift chamber open at its top and bottom and extending lengthwise of the machine and suspended in the pulp between successive impellers, the lower opening of said chamber comprising an intake disposed above the direct sweep of the centrifugal action and converging flow of said impellers, and aerating gas distributing means in said intake arranged to entrain and elevate material from the converging flows and discharge it along a narrow path on the surface of the pulp in the machine.

6. In a hog trough type flotation machine, including at least two rotary impellers submerged in the pulp body therein at spaced intervals between an inlet at one end and an outlet at the other end and disposed to direct their centrifugal discharge in converging flows, the improvement comprising a narrow aerating gas lift chamber open at its top and bottom and extending lengthwise of the machine and suspended in the pulp between successive impellers, the lower opening of said chamber comprising an intake disposed above the direct sweep of the centrifugal action and converging flow of said impellers, and aerating gas distributing means in said intake arranged to entrain and elevate material from the converging flows and discharge it along a narrow path on the surface of the pulp in the machine, and means at the top of said chamber for directing the discharge downwardly onto the surface of the pulp.

7. In a hog trough type flotation machine, including at least two rotary impellers submerged in the pulp body therein at spaced intervals between an inlet at one end and an outlet at the other end and disposed to direct their centrifugal discharge in converging flows, the improvement comprising a narrow aerating gas lift chamber open at its top and bottom and extending lengthwise of the machine and suspended in the pulp in overlapping relation to surfaces of successive impellers, the lower opening of said chamber comprising an intake disposed above and in proximity to the direct sweep of centrifugal action and converging flow of said impellers, and aerating gas distributing means in said intake arranged to entrain and elevate material from the converging flows and discharge it along a narrow path on the surface of the pulp in the machine.

8. In a hog trough type flotation machine, including at least two rotary impellers submerged in the pulp body therein at spaced intervals between an inlet at one end and an outlet at the other end and disposed to direct their centrifugal discharge in converging flows, the improvement comprising a narrow aerating gas lift chamber open at its top and bottom and extending lengthwise of the machine and suspended in the pulp in overlapping relation to surfaces of successive impellers, the lower opening of said chamber comprising an intake disposed above and in proximity to the direct sweep of centrifugal action and converging flow of said impellers, and aerating gas distributing means in said intake arranged to entrain and elevate material from the converging flows and discharge it along a narrow path on the surface of the pulp in the machine, and a deflecting member at the top of said chamber above the pulp level of the machine for directing the elevated pulp downwardly onto the surface of the pulp along a plurality of narrow paths adjoining said chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

1,180,089	Thompson et al.	Apr. 18, 1916
1,843,696	Pudan	Feb. 2, 1932
1,847,659	Maclennan	Mar. 1, 1932
2,258,507	Hoag	Oct. 7, 1941
2,259,243	Daman	Oct. 14, 1941
2,687,213	MacLeod	Aug. 24, 1954
2,892,543	Daman	June 30, 1959