

April 20, 1943.

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2,316,770

FROTH FLOTATION APPARATUS AND TREATMENT

Filed May 27, 1940

2 Sheets-Sheet 1

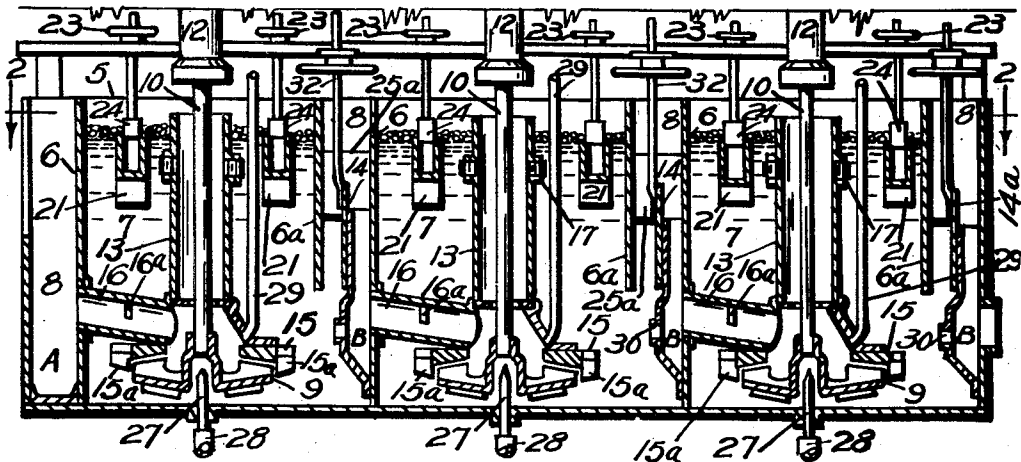


Fig. 1.

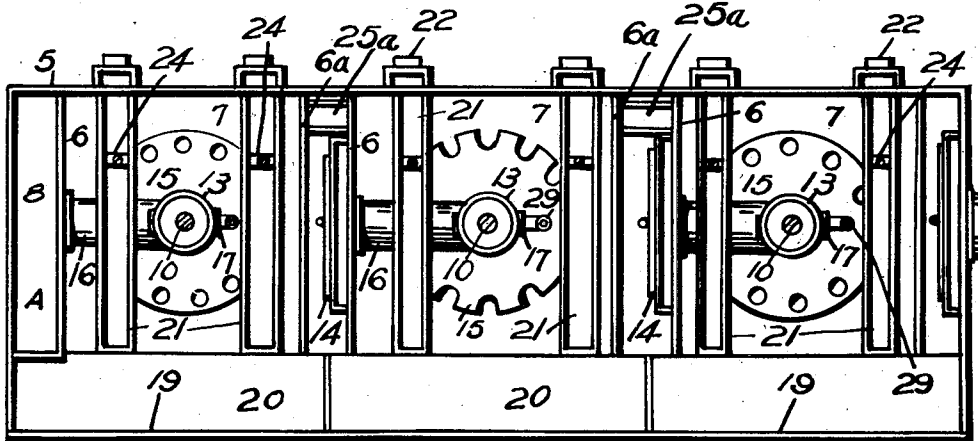


Fig. 2.

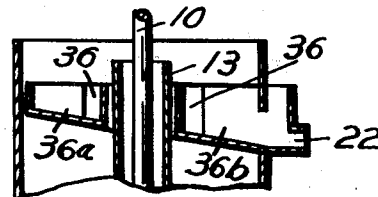
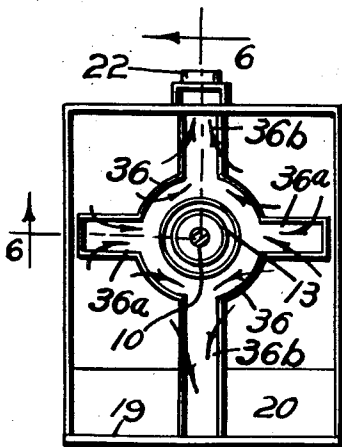


Fig. 6.

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2 Sheets-Sheet 2

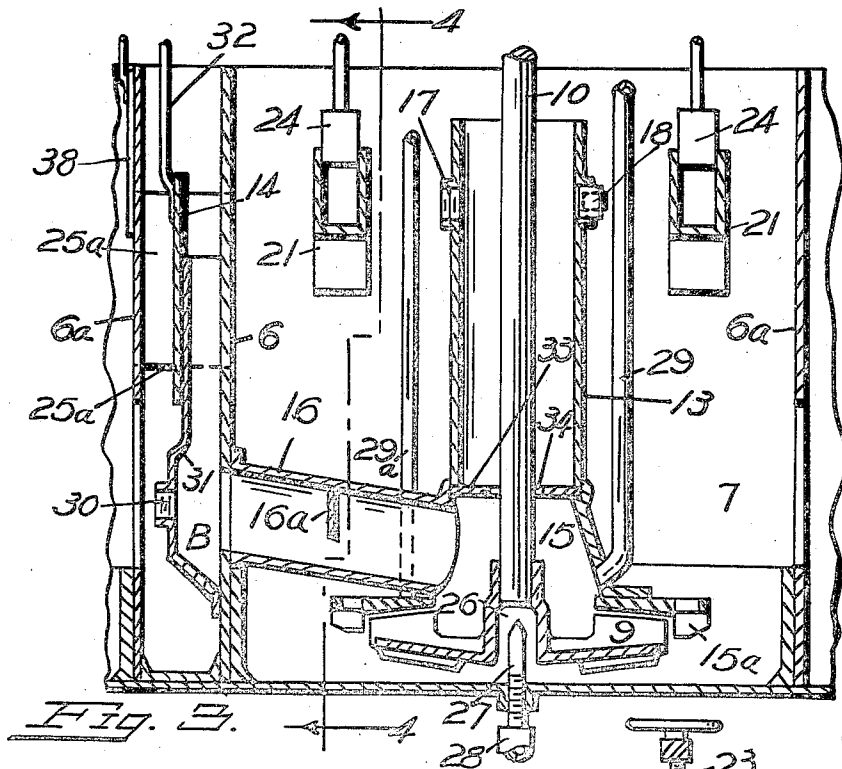


Fig. 3.

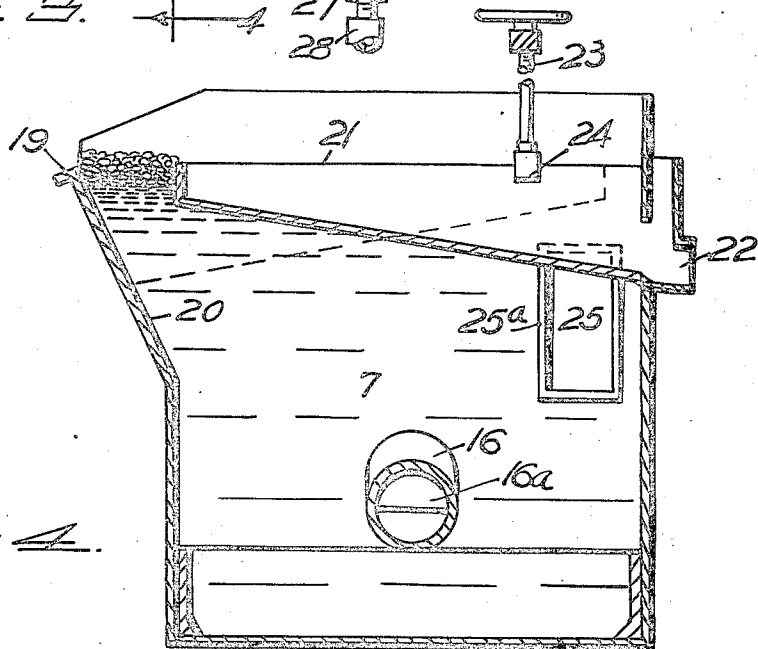


Fig. 4.

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## UNITED STATES PATENT OFFICE

2,316,770

FROTH FLOTATION APPARATUS AND  
TREATMENT

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Application May 27, 1940, Serial No. 337,420

6 Claims. (Cl. 209—169)

This invention relates to improvements in flotation treatments and apparatus, and more particularly relates to improvements in the operation and construction of froth flotation machines of the mechanical agitation type.

It is an object of the present invention to provide a selective control of the aerating action of flotation apparatus to permit its operation under optimum conditions in a wide variety of uses.

Another object of the invention is to provide an accelerated froth removal action to prevent loss of valuable constituents carried into the froth and tending to separate therefrom.

A further object of the invention is to provide a hydraulic balance between the respective cells of a multi-cell machine to the end that pulp will be fed to the several impellers in sufficient quantity to maintain proper overflow levels for a progressively decreasing froth bed in successive cells.

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

To afford a better understanding of the invention, reference is made to the accompanying drawings, in the several views of which corresponding parts have been designated similarly and in which:

Figure 1 is a side elevation partially in section of a multi-cell machine embodying the features of the present invention;

Figure 2 is a top plan view of the apparatus shown in Figure 1;

Figure 3 is an enlarged section of a modified construction embodying the features of the present invention;

Figure 4 is a section taken along the line 4—4 of Figure 3;

Figure 5 is a top plan view of a modified cell construction for accelerating froth removal; and

Figure 6 is a developed section taken along the line 6—6, Figure 5.

Referring first to Figures 1 and 2, the machine illustrated is a three-cell machine, it being understood that any plurality of cells may be similarly arranged. The machine comprises a tank 5 divided by a plurality of partitions 6 into a series of cells 7, each of which is provided with a feed compartment 8.

A rotary impeller 9 is disposed in the lower portion of each cell on a shaft 10 suitably supported in a bearing structure 12, and a hollow column 13 surround the shaft in spaced relation thereto and extends above the liquid level in the

cell determined by an overflow control, in this case an adjustable weir or gate 14, in each cell except the last of the series in which the overflow is controlled by another similar gate 14a.

5 The column 13 is supported upon a flaring hood 15 terminating at its periphery in a series of downwardly projecting vanes 15a in spaced proximity to the impeller 9.

Features of the impeller and hood construction disclosed but not claimed herein have been claimed in the co-pending application of A. C. Daman and L. H. Logue, Serial No. 242,334, filed November 25, 1938, for Flotation apparatus.

A feed intake conduit 16 connects the flaring hood 15 with the feed compartment 8 and preferably is positioned at an inclination as illustrated to permit gravity feeding.

Intermediate the ends of conduit 16, a partition 16a partially closes the passage for purposes that

20 will be explained hereinafter.

In proximity to but slightly below the froth level in the cells, openings 17 are provided in column 13 and preferably are threaded as indicated at 18 to permit adjustment of flow there-  
25 through by the insertion of suitable bushings (Figure 3). A suitable overflow lip 19 extends along one side 20 of the tank 5, and a suitable launder (not shown) extending in front of the overflow lip usually receives froth moved across the same in a manner well known in the art.

In certain flotation treatments, the reagent produces a tender froth of a rather unstable character, and while the collecting action of the reagent is sufficient to elevate the mineral to the surface, a considerable proportion of the mineral will be released and returned to the pulp body unless quickly removed from the treatment.

In conventional practice where the froth is removed by overflow with or without the aid of rotary skimmers, the period of froth retention at the surface is of relatively long duration. Where tough, stable froths are produced, such a condition may be satisfactory, but with tender or brittle froths, such a condition impairs the efficiency of the operation.

To remedy such a condition, there is provided in the present apparatus one or more adjustable launders 21 preferably disposed transversely of the cell with respect to the length of the machine. These launders are located in the cell with their upper edges at an elevation slightly below the uppermost level of the froth bed and receive froth coming in contact therewith, which, upon being collected in the trough, flows by gravity to a discharge outlet 22 from which it can be

conducted in any suitable manner well known in the art to a storage receptacle or another cell for retreatment therein.

Preferably, the launders 21 extend substantially across the cell and are carried by a screw-actuated member 23 suitably supported from above the tank on its superstructure (Figure 1). The screw member preferably terminates in a foot portion 24 fastened against opposite sides of launder 21. If desired, the fastening means 24 may be a yoke or other equivalent thereof.

As best seen in Figures 2, 3 and 4, the machine of the present invention is provided with a series of openings 25 in the walls 6 and 6a of the respective cells to admit the insertion of conduit members 25a which provide conductive connections between the liquid bodies in the respective cells for purposes that will be explained hereinafter.

To insure adequate aeration under various operating conditions, the present apparatus is designed to utilize introduction of gas under pressure, in addition to atmospheric air drawn in through column 13 by the pumping action of impeller 9. To this end, the impeller 9 has a central recess 26 in its bottom portion into which a gas discharge nozzle 27 connected with a suitable source of supply, such as a header 28, extends in shielded relation so that in the event of shut-downs, the solids separating out of suspension will not reach and enter the nozzle passages.

Provision is also made for introduction of gas into the flaring hub portion 15 through a supply conduit 29 which extends upwardly through the cell and is connected with a suitable source of supply (not shown). Under certain operating conditions, it is preferable to introduce gas nearer the periphery of the impeller, and to this end, there has been shown in Figure 3 an alternate arrangement in which a similarly arranged conduit 29a extends through the cover plate in proximity to the periphery of impeller 9.

Each of the feed compartments 8 other than the compartment of the initial cell, designated in Figure 2 by reference letter B, is provided with a regulatable opening 30 in close proximity to the impeller 9 of its associated cell through which heavy solids not readily maintained in suspension may flow to the succeeding cell in the progressive movement of material through the machine.

The liquid level in each cell is controlled by the adjustable weir 14 movable along passage-defining member 31 to selective elevations. Movement of the weir in the preferred form is controlled by screw-actuated mechanism 32 (Figure 1).

Where it is desired to use gas under pressure in promoting the aerating function of the apparatus and particularly when such gas is introduced through pipes 29 or 29a, it is advantageous to restrict the passage in conduit 13 and this is done by positioning a diaphragm member 33 (Figure 4) across the passage where the flaring hood joins column 13. This diaphragm has a narrow opening 34 about shaft 10 to permit the descent of matter from openings 17 onto the impeller 9. The size of the openings 34 may be varied to suit different treatment requirements and preferably the column 13 is separable from the hood 15 so that diaphragm 33 may be changed and replaced from time to time.

In the usual operation of the machine, pulp is fed into compartment A (Figures 1 and 2)

and feeds by gravity through conduit 16 into the hood enclosure where it descends upon impeller 9. Gas under pressure is introduced to the impeller from the nozzle 27 and pipe 29, the latter mixing with the entering pulp and being subjected to the mixing and compressive action of the impeller 9 before discharge therefrom past the vanes 15a.

While in the usual machine of this character a close control of the positioning of the respective gates 14 would be necessary in order to maintain the proper overflow conditions within the respective cells, the provision of the conduit members 25a in the present construction, in association with other parts, provides a novel means of liquid level regulation of great importance to the metallurgical efficiency of the operation.

In the usual flotation machine of this character, the action of the reagent in the first cell of the series produces a voluminous froth, bringing up relatively large quantities of mineral, which are removed by overflow and pass from the treatment. In succeeding cells of the operation, there is a progressive decrease in froth volume and mineral recovery with pronounced differences in this condition in the first cells of the series and a gradual tapering off thereafter.

As such machines are built with a common froth overflow level, it is necessary to so regulate the pulp overflow from cell to cell in order to give proper elevation to the froth bed in such cells that a desired portion of the froth may be discharged by overflow and removed as a concentrate. In normal operation, there is a progressively decreasing pulp volume coming into the respective cells, due to the removal of a portion of the pulp content from each cell as a concentrate.

The decreasing amount of concentrates to be removed from successive cells, combined with the reduced tonnage passing through the machine, causes a shallower froth bed, necessitating a higher pulp level in each successive cell. These conditions, coupled with feed fluctuations, require much operating control with continual attention to the individual gates to maintain the shallow froth beds at the correct elevation to produce the continuous overflow.

With the present structural arrangement, an initial setting of the gates 14 is made to overflow a volume of feed into the next cell which is in excess of the initial flow of feed to the machine.

Due to the fact that the impellers are operated to accommodate a capacity much in excess of the actual capacities encountered in operation, this does not create an overloaded condition.

The impellers function at all times as pumps in the circulatory movement of the pulp through the machine to force pulp overflowing from the preceding weir into the cell in which the impeller operates and from which it passes into a succeeding cell in the series.

Under operating conditions such as hereinbefore described, the impellers function to deliver to their respective cells a quantity of pulp in excess of the amount normally passing to them from the preceding cells.

Because of the provision of the passages 25a, a quantity of pulp from a given cell will flow back to the preceding cell in an amount sufficient to make up the deficiency of the original feed.

As a hydrostatic head is necessary to cause the

reverse flow through the passage 25a, the pulp level in each succeeding cell is maintained at a higher elevation than the pulp level in the preceding cell. As a consequence, the present structural arrangement induces a counterflow in the upper portion of such cells opposed to the normal flow of pulp through the machine.

The gate 14a in Figure 1 controls the pulp levels of the preceding group of cells and may be either the final gate control of the machine, or merely a gate control for a given number of cells within a machine.

Feed fluctuations or changes in the rate of flow through the machine only require an operation of the weir or gate setting 14a and such regulation controls the preceding cells as a group, while the differentials in pulp levels between the cells of the group are maintained by reason of the initial setting of the gates 14, coupled with the return flow through the passages 25a between the cells.

Thus, it will be seen that after the initial setting, the control of individual cells is automatic with a progressively higher pulp level provided in successive cells creating a successively shallower froth bed, allowing continuous overflow of froth without attention to the individual gates or weirs 14.

While the novel features of the present invention, namely, the improved aeration, the rapid removal of froth and consequent reduction in the interval of froth retention at the surface and the flow regulation within the pulp body, particularly as it applies to the maintenance of froth beds with respect to froth overflow, are factors which jointly improve metallurgical efficiency, each of such improvements may be employed separately where desired.

In addition, the aforesaid flow regulation simplifies operating procedure and reduces to a large degree the extent of operator control necessary to the maintenance of such a machine in continuous operation.

When the machine of the present invention is operating under conditions as hereinbefore described, pulp enters the respective conduits 16 and flows to the hood enclosure of the impeller 9. At the same time, a small portion of pulp admitted through bushings 18 will remain on diaphragm member 33 due to the restricted character of the passage 34 and thus provides a seal to prevent escape of gas delivered to the impeller under pressure.

Such gas may be delivered to the impeller through the nozzle 27 or either of the supply conduits 29 or 29a, as best seen in Figure 3, and after mixing with the pulp and reagent is subjected to the mixing and compressive action of the impeller and its vaned hood.

After discharge by the impeller, a portion of the pulp passes across weir 14 and descends into compartment B of the next cell from which it passes through conduit 16 onto the impeller 9 of the succeeding cell. Sands too heavy to rise across the weir and tending to collect in the lower portion of the cell are moved through opening 30 into compartment B and thence through conduit 16 into the succeeding cell.

Froth forming on the surface in the respective cells passes across overflow lip 19 and also overflows the sides of launders 21 and is moved by gravity to the discharge outlets 22. Because there is a relatively large superficial area in each of the cells devoted to the collection and removal of froth, the period of retention of the froth

in the cell is materially reduced, permitting use of tender, brittle froths when necessary without impairment of metallurgical function.

At the same time, the conduits 25a perform their equalizing function in conjunction with the action of the impellers to maintain the froth bed at the desired elevation with reference to the overflow level and following the initial setting of the gates 14, regulation of the controls of the individual cells other than the last of the series controlled by gate 14a is not required except in the event of extraordinary circumstances, such as shut-downs and the like.

In the aerating action, various forms of gas delivery may be employed. Where the intake of atmospheric air is sufficient to satisfy aerating requirements, the diaphragm 33 is removed from column 13 and atmospheric air is delivered to the mixing zone through column 13 under the suction influence of the impeller.

Where additional gas for aeration is required, the column 13 may be left open and additional gas supplied through jet 27. However, if it is preferred to add substantial quantities of gas under pressure directly to the mixing zone, the diaphragm 33 is placed in column 13 in the manner illustrated in Figure 3 and sufficient pulp is recirculated through bushings 18 to provide a liquid column above opening 34, thereby sealing the hood enclosure against the escape of gas from the mixing zone. Similarly, the partition 16a extends downwardly in passage 16 for a distance sufficient to submerge it in the pulp stream passing to the impeller from compartment B and the consequent sealing of this passage prevents escape of gas in that direction.

As a result, all gas delivered within the hood is subjected to mixing with pulp and reagent under the beating action of the impeller and subsequent compression, with the result that it is entrained in the fluid body discharging from the impeller in a widely diffused condition promoting greater efficiency of the flotation reaction.

As illustrated in Figure 2, the openings adjacent the periphery of the hood portion 15 may comprise a series of apertures as illustrated in cells 1 and 3 or they may be a series of peripheral slots as illustrated in cell 2.

In Figures 5 and 6 a modified form of froth collecting launder is shown comprising a central annular portion 36 and radial extensions 36a and 36b communicating therewith.

The extensions 36b extend to or beyond the upright walls of the cell and provide discharge outlets at their ends for the removal of froth from the treatment. The extensions 36a terminate adjacent the walls of the cell and within the same with their bottoms inclined, but at an elevation above the elevation of the annular portion 36.

Similarly, the bottom elevation of the portions 36b is at a lower elevation than the bottom elevation of annular portion 36 to induce a continuous flow of collected froth from the portions 36a through 36 and along 36b to the final discharge outlets such as 22 (Figures 5 and 6).

With such an arrangement, substantial quantities of the froth forming on the surface will be collected and quickly removed from the treatment without being required to flow to and across overflow lip 19. This arrangement insures a rapid froth removal action particularly suited for operations requiring the production of tender froths.

From the various forms of a launder construc-

tion illustrated as being suitable for the froth removal function of the present operation, it will be apparent that various structural modifications thereof may be resorted to, and the provision of one or more launders carrying collected froth to the front or back side of the machine for discharge from the treatment is within the contemplation of the present invention.

In this connection, the dotted line in Figure 4 is intended to illustrate the reversed position of the launder 21 in a typical cell to provide two separated froth discharges at the same side of the cell.

The provision of the recessed impeller illustrated in Figures 1 and 3, in conjunction with a gas delivery means such as 27, is particularly advantageous in the case of shut-downs to keep the discharge orifices of jet 27 from being closed or impaired by settling sands. The various forms of gas delivery conduits illustrated in the present invention are intended to show the variety of operating methods that may be employed, and while under some circumstances it may be desirable to have a plurality of such conduits in a single cell, in usual practice a single gas delivery conduit will be sufficient and it may be located and operated in any of the various ways illustrated herein.

The provision of the bushings 18, in conjunction with the diaphragms 33, permits a selective control of the amount of recirculating pulp required to maintain the proper seal of passage 34. Likewise, it is obvious that where desired the openings 17 and bushings 18 may be utilized for controlling the recirculation of a middlings product for additional aeration in the mixing zone.

The provision for adjusting the elevation of the various launders 21, 36, etc., insures the collection of the desired amount of froth forming on the surface. The features of the mixing and compressing action of the present invention have not been emphasized in the present description, as they are described and claimed in the co-pending application of Daman and Logue, Serial No. 242,334.

While the launders 21 and 36 have been described as used in conjunction with an overflow lip 19, which is the preferred operating arrangement, it will be understood that where desired the overflow lip may be dispensed with and the launders then will be the exclusive froth collecting and removing means. In regulating the elevation of the launders in their various usages, it is possible to locate them at any predetermined elevation with respect to the froth bed, and where a plurality of such launders are located in a single cell, obviously such launders may be elevated differentially where desired.

Another feature of importance in the present design is the flow regulation through conduits 25a. As best seen in Figure 3, an adjustment means is provided, such as the gate 38, which varies the area of the opening 25 at the end of the conduit 25a. Preferably, this gate is screw-actuated to permit precise adjustments, but it will be understood that any means for varying the flow through the opening 25 will be satisfactory for this purpose.

Changes and modifications in the construction and operation may be availed of within the spirit and scope of the invention as defined in the hereunto appended claims.

What we claim and desire to secure by Letters Patent is:

1. Froth flotation apparatus comprising a cell

having a feed inlet and a discharge outlet determining a liquid level therein, a froth overflow adjacent the liquid level in the cell, a rotary impeller in the lower portion of the cell, a hood covering the impeller, a hollow column supported on the hood and extending above the liquid level in the cell, said column having a pulp intake opening below the liquid level in the cell, means for delivering gas under pressure into the hood enclosure of the impeller, and a diaphragm member separating the hood enclosure from the hollow column and having a restricted passage for the delivery of matter from the hollow column to the impeller.

2. Froth flotation apparatus comprising a cell having a feed inlet and a discharge outlet determining a liquid level therein, a froth overflow adjacent the liquid level in the cell, a rotary impeller in the lower portion of the cell, a hood covering the impeller, a hollow column supported on the hood and extending above the liquid level in the cell, means for delivering gas under pressure into the hood enclosure of the impeller, a diaphragm member separating the hood enclosure from the hollow column and having a restricted passage for the delivery of matter from the hollow column to the impeller, and adjustable means controlling recirculation of material under treatment in the tank into the hollow column to provide a liquid seal for the diaphragm passage.

3. Froth flotation apparatus comprising a cell having a feed inlet and a discharge outlet determining a liquid level therein, a froth overflow adjacent the liquid level in the cell, a rotary impeller in the lower portion of the cell, a hood covering the impeller, a hollow column supported on the hood and extending above the liquid level in the cell, means for delivering gas under pressure into the hood enclosure of the impeller, a diaphragm member separating the hood enclosure from the hollow column and having a restricted passage for the delivery of matter from the hollow column to the impeller, and adjustable means in the column below the liquid level in the cell controlling recirculation of material under treatment in the tank into the hollow column to provide a liquid seal for the diaphragm passage.

4. Froth flotation apparatus comprising a cell having a feed inlet and a discharge outlet determining a liquid level therein, a froth overflow adjacent the liquid level in the cell, a rotary impeller in the lower portion of the cell, a hood covering the impeller, a hollow column supported on the hood and extending above the liquid level in the cell, means for delivering gas under pressure into the hood enclosure of the impeller, a diaphragm member separating the hood enclosure from the hollow column and having a restricted passage for the delivery of matter from the hollow column to the impeller, and adjustable means in the column adjacent the liquid level in the cell controlling recirculation of material in the tank into the hollow column to provide a liquid seal for the diaphragm passage.

5. The combination with a flotation cell containing a body of pulp under treatment, of a launder disposed in the cell in the position to receive froth forming on the surface of the pulp body, said launder comprising an annular portion and a plurality of portions projecting therefrom toward the sides of the cell, one of said portions terminating in a discharge outlet outside the cell and the bottoms of the respective por-

tions being progressively inclined toward said discharge outlet for the gravitational movement of collected froth out of the cell.

6. Froth flotation apparatus comprising a cell having a feed inlet and a discharge outlet determining a liquid level therein, a froth overflow adjacent the liquid level in the cell, a rotary impeller in the lower portion of the cell, a cover for the impeller inclusive of a hollow column extending above the liquid level in the cell, said column having a pulp intake opening within the

liquid body in the cell, means for delivering gas under pressure between the impeller and the cover, and a diaphragm member separating the hollow column from other portions of the cover and having a restricted passage for the delivery of matter from the hollow column to the impeller.

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