May 27, 1941. A. C. DAMAN ET AL 2,243,309

FLOTATION APPARATUS

Filed Nov. 25, 1938 3 Sheets-Sheet 1

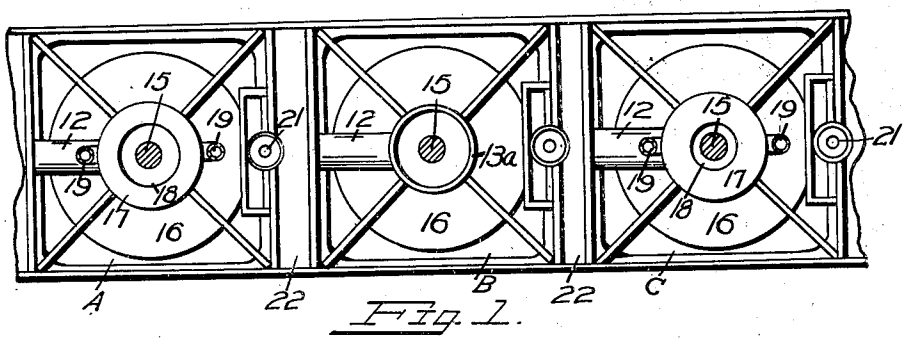



Fig. 1.

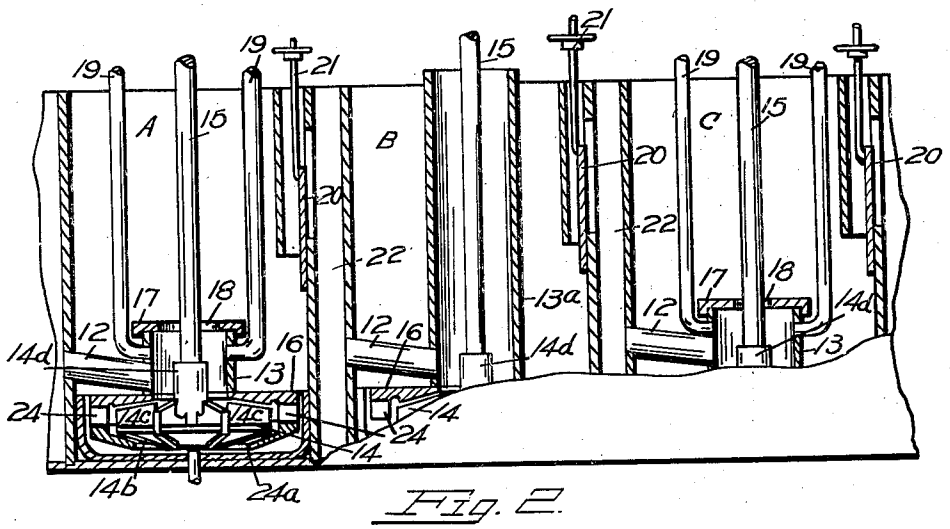



Fig. 2.

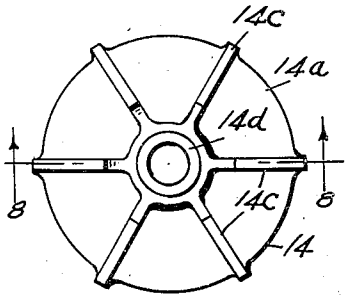



Fig. 3.

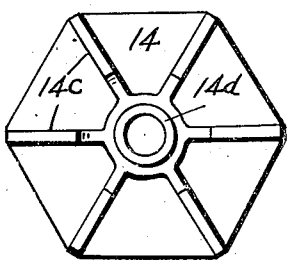



Fig. 4.

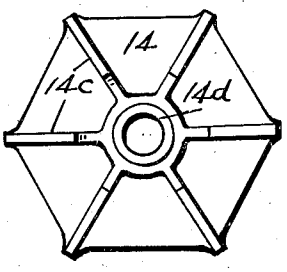



Fig. 5.

INVENTOR.
ARTHUR C. DAMAN and
LELAND H. LOGUE
BY
Rollandet, McGrew & Campbell
ATTORNEYS.

May 27, 1941. A. C. DAMAN ET AL 2,243,309.

FLOTATION APPARATUS

Filed Nov. 25, 1938 3 Sheets-Sheet 2

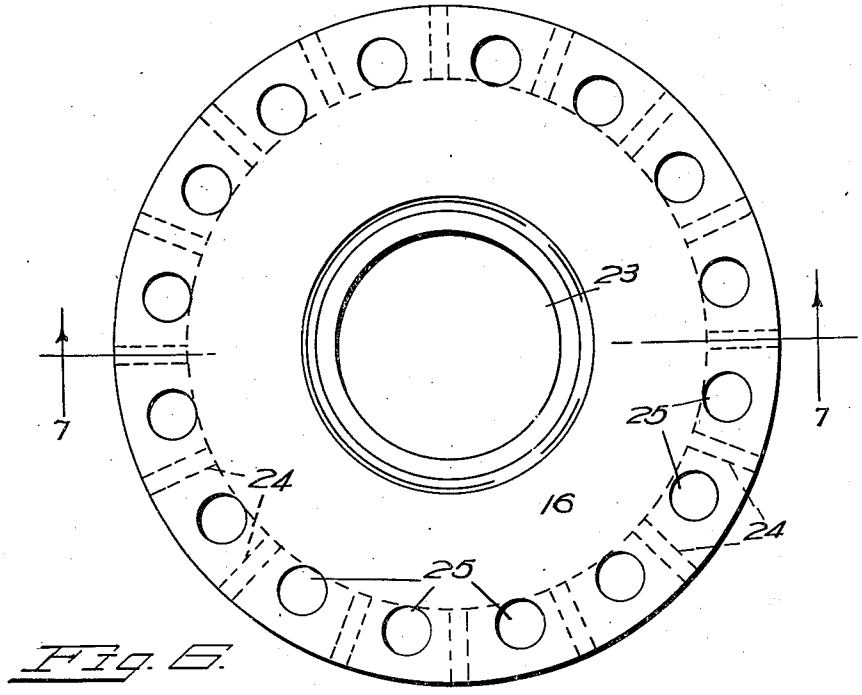



Fig. 6.

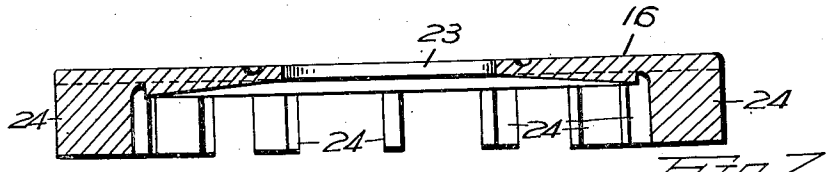



Fig. 7.

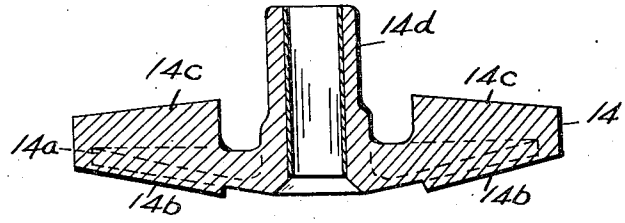



Fig. 8.

INVENTOR.
ARTHUR C. DAMAN and
LELAND H. LOGUE
BY
Rollandet, McGrew & Campbell
ATTORNEYS.

May 27, 1941.

A. C. DAMAN ET AL

2,243,309

FLOTATION APPARATUS

Filed Nov. 25, 1938

3 Sheets-Sheet 3

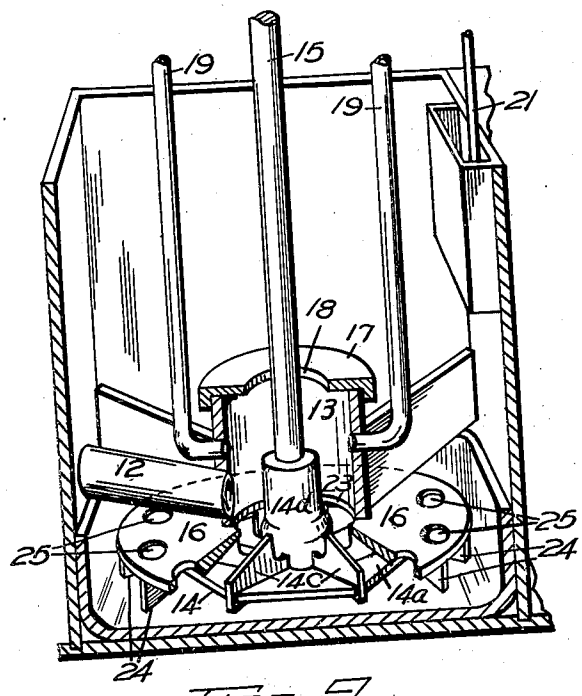



Fig. 9.

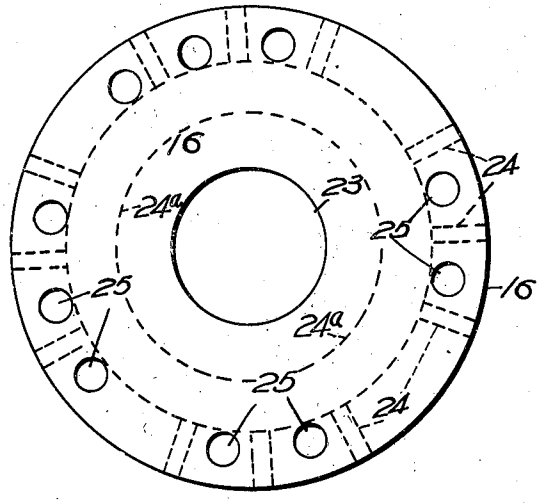



Fig. 10.

INVENTOR.
ARTHUR C. DAMAN and
LELAND H. LOGUE

BY Rollandet, McGrew & Campbell
ATTORNEYS.

Patented May 27, 1941 2,243,309

# UNITED STATES PATENT OFFICE

2,243,309

## FLOTATION APPARATUS

Arthur C. Daman and Leland H. Logue, Denver, Colo., assignors to Mining Process and Patent Company, Denver, Colo., a corporation of Delaware

Application November 25, 1938, Serial No. 242,334

15 Claims. (Cl. 261—93)

This invention relates to improvements in flotation apparatus and more particularly relates to means for controlling the agitation and aeration actions in flotation apparatus employing mechanical agitation.

In flotation machines of this type, agitation of the pulp is effected by rotary impellers and the power consumption of such operations has been found to have a definite and measurable relation to the peripheral surface exposed to the resistance of the pulp.

The impeller design and arrangement of the present invention represents an improvement in the impeller construction disclosed in United States Letters Patent No. 2,031,590, issued to Arthur C. Daman on February 25, 1936, for Flotation apparatus.

It is an object of the present invention to reduce power consumption in apparatus of this character by decreasing the exposed peripheral surface of the impeller, or to utilize the resulting increase in the speed at which such impellers rotate at a given power output to improve agitation and aeration.

Another object of the invention is to control discharge of matter from the impeller of flotation apparatus and thereby improve the mixing and aerating functions of the operation without appreciably increasing boiling and surging influences within the liquid body.

A further object of the invention is the provision of means for controlling the flow of material discharged from the impeller to prevent "sanding" or the settling of heavier particles of the pulp.

Other objects reside in the provision of novel construction and arrangement of parts, as well as novel operating procedure, all of which will appear more fully in the course of the following description.

To afford a better understanding of the invention, reference is made to the accompanying drawings, illustrating constructions embodying the several features of the present invention, with like parts designated similarly throughout the several views, and in which:

Figure 1 is a fragmentary plan view of a multicell flotation machine of the mechanical agitation type, embodying the construction of the present invention;

Figure 2 is a fragmentary side elevation of the structure of Figure 1, partially broken away to show details of the invention in section;

Figure 3 is a top plan view of an impeller embodying features of the present invention;

Figure 4 is a top plan view of another form of impeller embodying features of the present invention;

Figure 5 is a top plan view of still another form of impeller embodying features of the present invention;

Figure 6 is a top plan view of one form of hood construction embodying features of the present invention;

Figure 7 is a section taken along the line 7—7, Figure 6;

Figure 8 is a section taken along the line 8—8, Figure 3 and drawn to an enlarged scale to illustrate its relation to the hood shown in Figures 6 and 7;

Figure 9 is a perspective view of a single cell interior showing the relation and arrangement of parts embodying the present invention to conventional parts of a flotation cell; and

Figure 10 is a top plan view of another form of hood construction embodying features of the present invention.

The flotation machine illustrated in Figures 1 and 2 embodies a plurality of cell designs in order to illustrate the adaptability of the present invention for use in conventional machines, and while only two different forms of cells are shown, it will be appreciated that such cells are illustrated as typical examples and in no sense are intended as limiting the use of the invention to such cells alone.

In the machine illustrated, the cells are designated respectively A, B and C for reference, and feed in the form of a pulp enters through an inlet conduit 12 from a preceding cell or other suitable source of supply and discharges into a hollow column 13 and onto an impeller 14.

The hollow column 13 in cell A is relatively short and its upper end terminates within the liquid body at a distance below its surface. A shaft 15 extends through the cell A into the column 13 and carries at its lower end the impeller 14. An annular hood 16 extends from the lower end of the column 13 in overhanging relation to the impeller 14.

At its upper end the column 13 is partially closed by a cover-element 17 having a central aperture to admit the shaft and providing a restricted passage 18 for recirculation of pulp. These passages may be varied in size to satisfy different recirculation requirements, as illustrated in cells A and C, and by removing one and substituting another of preferred size, any given cell can be adapted for different treatment conditions.

Air under pressure from a suitable source of supply enters the column **13** through one or more pipes **19**, to mix with the recirculating pulp and entering feed in passing to the sphere of influence of the impeller.

After treatment in cell A, the pulp passes to cell B by overflowing a weir **20** whose level may be regulated by any suitable means, here shown as a screw **21**, and then flowing through a passage **22** and into inlet conduit **12**.

The central column **13***a* in this form of cell construction extends above the liquid level and air is entrained in the pulp by the pumping influence of the impeller **14**. After treatment in cell B, the pulp overflows weir **20** and progresses in the same manner to cell C for further treatment.

In each of the cells an improved treatment is attained by reason of the design and arrangement of the hood and impeller. The impeller comprises a dished disk **14***a* (Figure 8) carrying a series of radial vanes **14***b* on its under surface to exert a sweeping influence on the cell bottom, while on its upper surface a series of blades **14***c* are spaced from a central hub portion **14***d*. The blades **14***c* taper toward the periphery of the impeller and at their ends have only a small surface exposed to the resistance of the pulp in which they rotate.

Preferably the blades **14***c* extend to or slightly beyond the periphery as illustrated in Figures 3, 4 and 5. Where the blades extend beyond the periphery as in the forms illustrated in Figures 3 and 5, they exert a cutting influence on matter beyond the periphery and thereby serve to promote intermixture of solids, gas and liquids, as well as producing a more widespread diffusion of gas within the liquid.

Overhanging the impeller **14** is the hood **16** having a central apertured portion **23** concentric with the column, and provided at its periphery with a series of downwardly extending vanes or baffles **24**, preferably in radial arrangement, with the inner ends of the vanes **24** positioned adjacent but spaced from the periphery of the impeller **14**.

For some treatments it will be desirable to recirculate matter into the impeller, such as solids tending to collect on the cell bottom, and to this end a flat annular plate **24***a* (Figures 2 and 10) forming an extension at the lower ends of vanes **24** projects inwardly under the impeller **14**. The vanes **14***b* on the impeller cooperate with the flat surface of the plate to produce a pumping action on solids at the bottom of the cell, drawing the same upwardly centrally of the impeller and ejecting them in converging relation to the streams of material passing across the dished periphery of the impeller.

As a result of the foregoing action, the cell bottom may be kept substantially clear of settled solids and the provision of another stream of converging material at the periphery of the impeller serves to enhance the mixing function of the operation.

While this construction has been illustrated in Figure 10 as an annular projection about the periphery of hood **16**, it will be understood that if desired, an arrangement may be employed in which the plate **24***a* may be only a segment, and if desired two or more such segments may be located about the cell, suitably spaced to meet the treatment requirements.

Material fed onto the impeller mixes with entrained air and is beaten by the blades **14***c* as it discharges under the centrifugal influence. Also, due to the shape of the disk and hood, streams of material in contact with these surfaces converge at the periphery for further mixing upon discharge.

The depth of the vanes **24** may be varied to satisfy different treatment requirements and good results in improving aeration and agitation, or in reducing power consumption are attained when the lower edges of the vanes are in a horizontal plane slightly higher than the lower peripheral edge of the impeller **14**.

With such an arrangement, the vanes **24** function to restrain and control discharge under the centrifugal influence of the impeller. As a result, the pulp, air and reagent are brought into intimate intermixture, thereby promoting the flotation reaction, while restraining boiling and surging within the cell, which otherwise would tend to increase because of the high speed at which the impeller rotates, thereby interfering with the elevation of the mineral by the aerating influences.

Where more or less restraint of discharge is required, the vanes **24** may be shortened or extended to reduce or enlarge the surfaces of impedance. Likewise, provision is also made to relieve the pressure at the peripheral discharge zone by having a series of apertures **25** at intervals about the hood **16**, which permit escape of the lighter constituents, particularly gas, in an elevating movement, thereby improving diffusion of gas throughout the pulp body.

The restraint of discharge and resulting increase in pressure also cause portions of the gas to enter into solution and such gas as is dissolved in the action travels beyond the zone of restraint before it passes out of solution and rises through the liquid. In this way, a more widespread diffusion of gas is obtained.

In the treatment of certain types of pulps any appreciable impedance of velocity causes a settling and accumulation of solids in the cell, particularly in corners where a rectangular cell is used, and commonly termed sanding, which lessens flotation efficiency and has other deleterious effects.

To avoid such a condition, the vanes may be arranged to provide larger intervals of unrestricted passage toward the corners, and the sweeping movement imparted to the pulp by the impeller serves to maintain in suspension, particles that otherwise would tend to settle.

Also, variation in the size and arrangement of the openings **25**, may be utilized to lessen restraint in portions of the cell. While the preferred arrangement of vanes **24** and openings **25** on the hood **16**, for general operating conditions, is one in which the vanes are in radial arrangement at uniform intervals with openings between the respective vanes, also uniformly spaced as shown in Figure 6, other arrangements may be required for particular treatments.

Thus in Figure 10, an unbalanced arrangement is shown in which one vane and one aperture have been omitted from each ninety degree segment on the left side of the figure, and one vane and two apertures have been omitted from each ninety degree segment on the right side of the figure.

The omission of the openings **25** permits the hood to direct discharge laterally and by omitting one or more vanes **24** a sufficient sweep is imparted to the stream of discharging material

to effectively maintain the constituent solids in suspension.

The foregoing illustrations will serve to clarify understanding of the numerous variations that may be utilized for control purposes and it will be understood that the instances cited are merely typical examples and in no sense intended as defining all the arrangements that may be employed for this purpose.

Referring now to Figure 9, the sequence of treatment in a single cell will be described to better illustrate the operating advantages of the invention.

In such a cell, pulp from a suitable source of supply (not shown) will enter through inlet **12** and flow by gravity aided by the suction influence of the impeller, to discharge into the column **13**. Air under pressure from a suitable source (not shown) enters the column **13** through the pipes **19** and pulp in the cell is recirculated through opening **18** into column **13**.

The several streams of material thus entering the column impinge and entrain the gas in the resulting cascading action. The impeller **14** is rotated at high speed through the medium of the shaft **15**, which may be driven in any suitable manner, and the arrangement of the hood **16** overhanging the impeller permits the latter to forcibly eject the liquid fed thereto from the hollow column **13**, at sufficient velocity to prevent liquid from flowing onto the impeller from beyond its periphery.

The intermixture cascading onto the impeller from the column initially surrounds the hub **14*d*** and due to the centrifugal action and inclination of the disk surface thereafter assumes a lateral movement having an elevating component. This change in direction effects further intermixture after which the material is subjected to repeated engagement with the blades **14*c*** in its progress to the periphery. Each such engagement serves to break up the liquid mass, producing further intermixture and tending to cause more widespread diffusion of the gas.

This breaking-up action results in the creation of two streams of material moving under the centrifugal influence. One of these moves along or parallel with the surface of the disk, subject to interruption by the blades **14*c***, while the other travels along or parallel to the under surface of the hood and is also subject to interruption by impingement of matter elevated by the blades **14*c***.

Because the under surface of the hood is downwardly inclined, while the dished surface of the disk imparts an upward component to matter deposited thereon, the respective streams are in converging relation at the point of their engagement and further intermixture and diffusion is attained in this manner.

Upon discharge across the periphery, the stream of material enters a zone of pressure exceeding the normal hydrostatic pressure at that level in the cell, caused by the impedance to escape provided by the overhanging hood and the projecting vanes, and the extension plates **24*a*** when used.

In this compression zone the stream so discharged is broken up and forced to take different and divergent courses with resulting decrease in velocity. A portion of the gas is caused to enter into solution and after being subject to such breaking-up action, the material escapes from the compression zone in a plurality of streams, some of which move upwardly through openings **25** while others strike and bound away from vanes **24**.

The circuitous paths of escape provide a more widespread diffusion of gas, both dissolved and undissolved, throughout the cell, and due to the repeated and intimate contact of solid and gas, the mineral content is subjected to a high degree of aeration.

Increased impeller speed is thus utilized in improving agitation and aeration within the zone of agitation in the cell, but due to the control exercised over the material in moving from the agitation zone into the separation zone, the increased speed of the impeller has no deleterious effects on separation.

The provision for variation in size and relation of parts comprising the hood and impeller structure serves as a means of regulation to satisfy different treatment requirements, and while the hood has been illustrated as particularly adapted for association with the impeller structure herein described and illustrated, it will be appreciated by flotation operators that the provision of a compression zone encompassing the impeller and the utilization of other control factors may be carried out in apparatus employing rotary impellers of all types; the variety of impellers here illustrated making such fact readily apparent.

Changes and modifications 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. In flotation apparatus, a rotary shaft, an impeller disc on the shaft, radial blades on the upper surface of the disc having their top surfaces downwardly inclined toward the periphery of the disc, a hood overhanging the impeller with its under surface inclined in converging relation to the periphery of the disc, and radially disposed vanes on the hood depending in the plane of the impeller.

2. In flotation apparatus, a rotary shaft, an impeller disc on the shaft, radial blades on the upper surface of the disc having their top surfaces downwardly inclined toward the periphery of the disc, a hood of larger diameter than the impeller in overhanging relation thereto, and radial vanes projecting from adjacent the periphery of the hood in the plane of rotation of the impeller and in proximity thereto.

3. In flotation apparatus, a rotary shaft, an impeller disc on the shaft, blades on the upper surface of the disc having their top surfaces downwardly inclined toward the periphery of the disc, a hood of larger diameter than the impeller in overhanging relation thereto and apertured in the peripheral portion extending beyond the disc for the escape of matter from the hood enclosure, and vanes projecting downwardly from such peripheral portion in proximity to the disc.

4. In flotation apparatus, a rotary shaft, an impeller disc on the shaft, blades on the upper surface of the disc having their top surfaces downwardly inclined toward the periphery of the disc, a hood of larger diameter than the impeller in overhanging relation thereto, and apertured at uniform intervals in the peripheral portion extending beyond the disc for the escape of matter from the hood enclosure, and vanes projecting downwardly from such peripheral portion at uniform intervals and in proximity to the disc.

5. A hood for use in flotation apparatus, com-

prising a disc having a central aperture for the admission of feed to an impeller covered by the hood, the under surface of the hood being dished, and radial vanes projecting from the dished surface thereof at intervals about its periphery.

6. A hood for use in flotation apparatus, comprising a disc having a central aperture for the admission of feed to an impeller covered by the hood, the under surface of the hood being dished, and there being apertures at intervals about the periphery of the disc.

7. A hood for use in flotation apparatus, comprising a disc having a central aperture for the admission of feed to an impeller covered by the hood, vanes projecting from the under surface of the hood at intervals about its periphery, and a plate-member extending inwardly and downwardly from the periphery at the lower ends of the vanes.

8. Froth flotation apparatus comprising a tank having a feed inlet and a discharge outlet determining a pulp level therein, a rotary impeller positioned in the lower portion of the tank at a distance from the tank bottom and having impelling vanes on its upper and lower surfaces, a hood element overhanging the impeller, with a central opening admitting feed thereto, and depending vanes at the periphery of the hood providing a partial closure for the periphery and bottom of the impeller, whereby settled solids on the bottom of the tank will be subjected to a controlled suction influence of the impeller.

9. Froth flotation apparatus comprising a tank of rectangular shape, having a feed inlet and a discharge outlet determining a pulp level therein, a rotary impeller positioned in the lower portion of the tank at a distance from the tank bottom and having impelling vanes on its lower surface, a hood element overhanging the impeller with a central opening admitting feed thereto, and a series of vanes disposed in radial arrangement at intervals on the hood and depending into the plane of the impeller at its periphery, with the intervals between the vanes located adjacent the corners of the tank being of sufficient extent to permit the impeller to exert a sweeping action thereagainst.

10. Froth flotation apparatus comprising a tank of rectangular shape, having a feed inlet and a discharge outlet determing a pulp level therein, a rotary impeller positioned in the lower portion of the tank at a distance from the tank bottom and having impelling vanes on its upper and lower surfaces, a hood element overhanging the impeller with a central opening admitting feed thereto, and a series of vanes disposed in radial arrangement at intervals on the hood and depending into the plane of the impeller at its periphery, with the intervals between the vanes located adjacent the corners of the tank being of sufficient extent to permit the impeller to exert a sweeping action thereagainst.

11. In flotation apparatus, a tank for pulp, a rotary impeller in the tank, means for delivering an aerated pulp onto the impeller by gravity, restraining means about the impeller to induce compression of matter acted upon by the impeller, and means for dividing the compressed matter into separate streams, some of which move laterally and others of which move upwardly away from the impeller.

12. In flotation apparatus, a tank for pulp, a rotary impeller in the tank, means for delivering an aerated pulp onto the impeller by gravity, restraining means about the impeller to induce compression of matter acted upon by the impeller, means to induce a mixing of pulp and gas while subject to compression, and means for dividing the compressed matter into separate streams, some of which move laterally and others of which move upwardly away from the impeller.

13. In flotation apparatus, a tank for pulp, a rotary impeller in the tank, means for delivering an aerated pulp onto the impeller by gravity, restraining means about the impeller to induce compression of matter acted upon by the impeller, means for mixing pulp, gas and reagent while subject to compression, and means for dividing the compressed matter into separate streams, some of which move laterally and others of which move upwardly away from the impeller.

14. In flotation apparatus, a tank for pulp, a rotary impeller in the tank, means for delivering an aerated pulp onto the impeller by gravity, restraining means about the impeller to induce compression of matter acted upon by the impeller, and means for dividing the compressed matter into separate streams, some of which move laterally and others of which move upwardly away from the impeller at reduced velocity.

15. In flotation apparatus, a tank for pulp, means in the tank for mixing a flotation pulp, gas and recirculated pulp of the treatment in a cascading action, a rotary impeller in the tank, means for delivering such intermixture onto the impeller by gravity, restraining means about the impeller to induce compression of matter acted on by the impeller, and means for dividing the compressed matter into separate streams during movement away from the impeller.

ARTHUR C. DAMAN.
LELAND H. LOGUE.