

Aug. 11, 1953

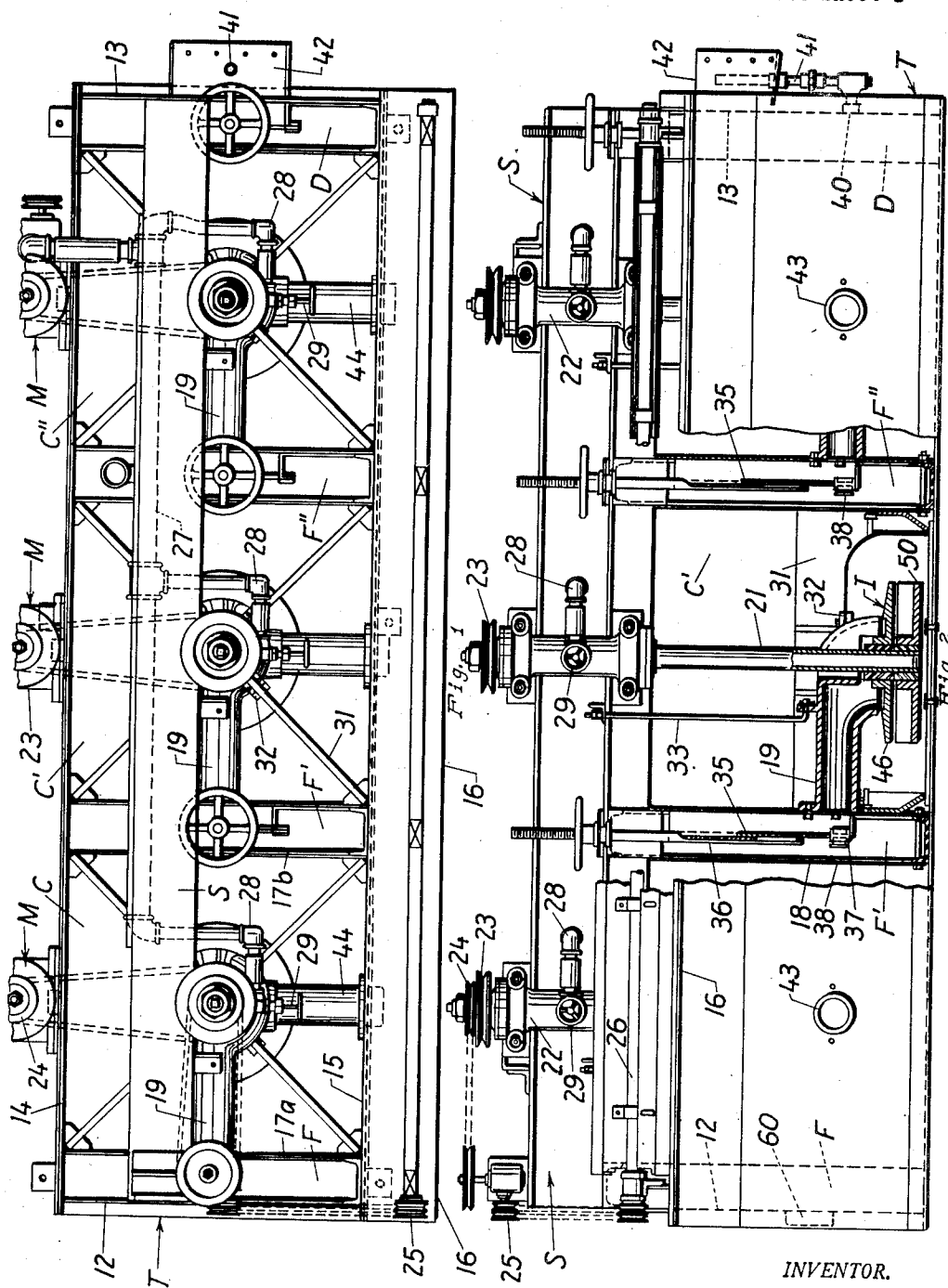
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2,648,529

FROTH FLOTATION APPARATUS.

Filed May 24, 1949

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

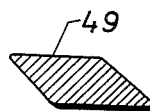
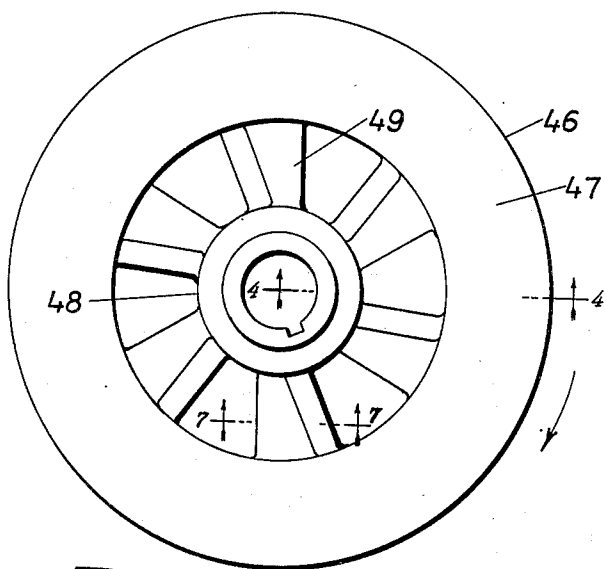


Fig. 7

Fig. 3

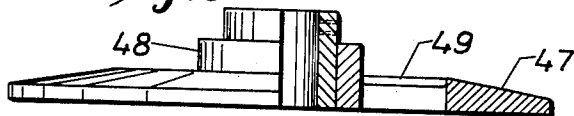


Fig. 4

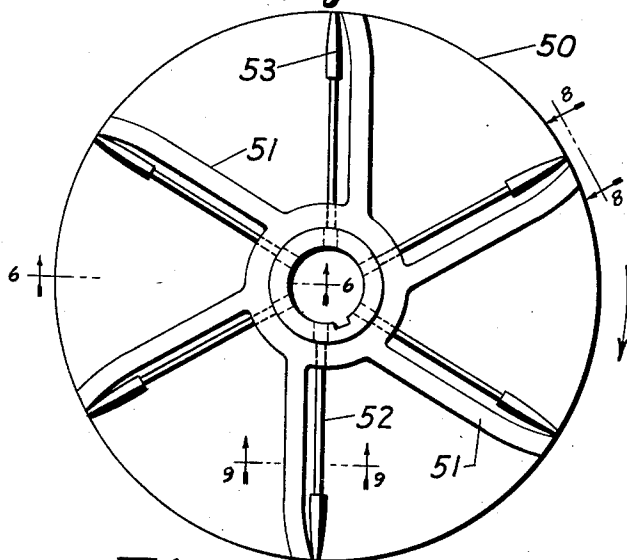


Fig. 5



Fig. 6



Fig. 8

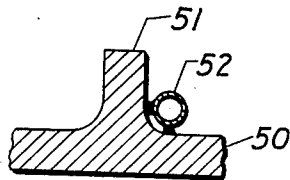


Fig. 9

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3 Sheets-Sheet 3

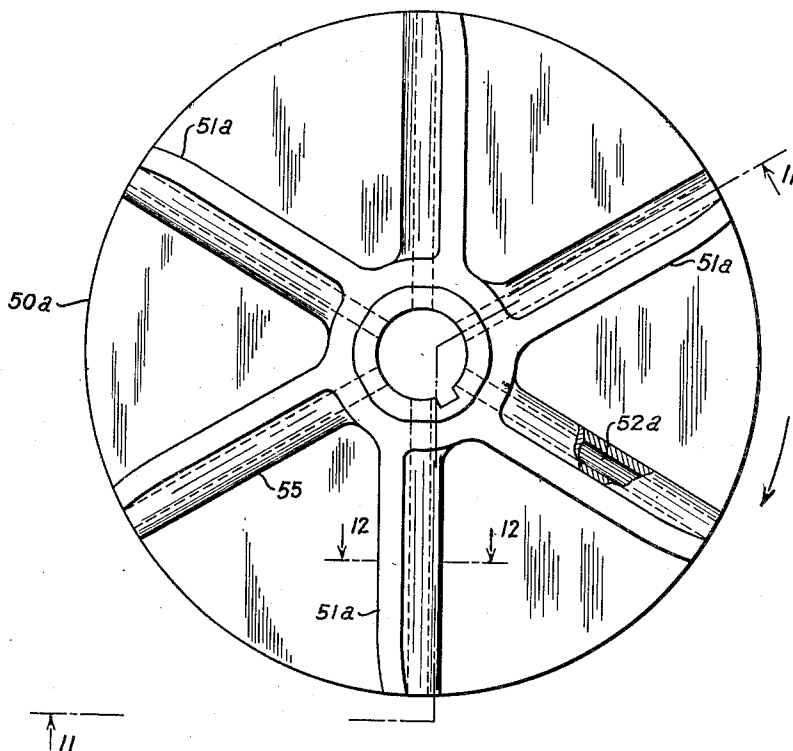


Fig. 10

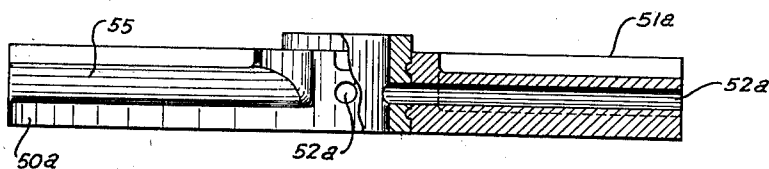


Fig. 11

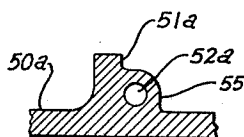


Fig. 12

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2,648,529

FROTH FLOTATION APPARATUS

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Application May 24, 1949, Serial No. 95,095

6 Claims. (Cl. 261—93)

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This invention relates to froth flotation apparatus and, more particularly, relates to improvement in flotation apparatus of the type shown in my copending application, Serial No. 557,968, now Patent 2,502,497, dated April 4, 1950. Features disclosed but not claimed in this application have been made the subject of claims in said copending application.

It has been customary in the past to supply air or other aerating gas in such volume and at such pressure that dispersion of the gas throughout the pulp after discharge from the impeller is assured. However, excessive pressures tend to create undue turbulence in the cell and an excessive volume of air puts an undue cost on the operation.

It is an object of the present invention to provide simple, durable and efficient froth flotation apparatus in which air pressures and volumes may be reduced from customary standards with an improvement in metallurgical result. Another object of the invention is to provide a novel type of gas discharge within the confines of a rotating impeller so as to cause a greater dispersion of gas in the pulp body in which the impeller rotates. A further object of the invention is to provide a novel type of impeller for froth flotation apparatus, or the like, in which the blade arrangement effects high velocity discharge at relatively low power consumption. Other objects reside in novel combinations and arrangements of parts and in novel details of construction, all of which will be fully described in the course of the following description.

In the apparatus of the present invention I prefer to use a two-part impeller consisting of a lower plate or disc having a series of blades on its upper surface and an overhanging cover member in the form of an annulus, with a spider type hub portion mounted in the inner openings of the annulus. Each of said members is mounted for rotation on the shaft and the blades of the spider portion of the upper member are so positioned and shaped as to contact and break up pulp descending onto the impeller in the vortex action, while at the same time drawing the broken pulp stream into contact with the following blade of the lower member.

In conjunction with the aforesaid action I also provide for discharge of the aerating gas at the periphery of the impeller so that it is broken up, entrained and discharged in one and the same action. Because of this arrangement the impeller speed can be reduced substantially below the standard of prevailing practice and the

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mixing action, as aforesaid, still results in thorough and widespread dispersion of the gas through the pulp with high metallurgical efficiency in the operation.

The apparatus of the present invention will be best understood by reference to the accompanying drawings. In the drawings in the several views, on which like parts have been designated similarly,

Fig. 1 is a top plan view of a multi-cell flotation machine embodying features of the present invention;

Fig. 2 is a front elevation, partially broken away, to show the arrangement of interior parts of the multi-cell machine shown in Fig. 1;

Fig. 3 is a top plan view of the upper plate member of the impeller assembly shown in Fig. 2, and drawn to an enlarged scale;

Fig. 4 is a side elevation partially in section corresponding to the line 4—4 of Fig. 3;

Fig. 5 is a top plan view of the lower impeller plate member of the aforesaid assembly showing a preferred arrangement of blades;

Fig. 6 is a side elevation of the structure shown in Fig. 5, partially in section, corresponding to the line 6—6 of Fig. 5;

Fig. 7 is an enlarged section taken along the line 7—7 of Fig. 3;

Fig. 8 is an end view of one of the gas discharge nozzles taken approximately in the position of the line 8—8 of Fig. 5;

Fig. 9 is an enlarged fragmentary section taken along the line 9—9 of Fig. 5;

Fig. 10 is a top plan view of another form of impeller, partially broken to show the arrangement of interior parts;

Fig. 11 is a developed section taken along the line 11—11 of Fig. 10; and

Fig. 12 is a fragmentary section taken along the line 12—12 of Fig. 10.

The flotation machine shown in Figs. 1 and 2 comprises a tank T, consisting of end walls 12 and 13, a rear wall 14 and front wall 15, with the latter inclining forwardly in its upper portion to provide a froth overflow lip 16. The interior of the tank is divided by a series of partition members 17^a and 17^b, into a series of flotation cells which are shown as a first cell C, and second or intermediate cell Cⁱ, and a discharge or end cell C¹¹.

In the series of cells a partition member 17^b of a preceding cell cooperates with the partition member 17^a of a succeeding cell to form a feed compartment to the succeeding cell, and a first partition member 17^a in the series cooperates

with end wall 12 to form a feed compartment F for cell C, while the final partition member 17^b cooperates with end wall 13 to form a discharge control box D for the machine. The intermediate feed boxes of the machine shown in Fig. 1 have been designated Fⁱ and Fⁱⁱ corresponding to the cells with which they are associated. The partition members 17^b are suitably apertured at 18 to provide a discharge outlet for the flow of pulp from the cell into the next feed box in the series. Each of the partitions 17^a is suitably apertured to receive the intake end of a feed conduit 19, and in this way circulation of pulp through the successive cells is provided.

Suitable superstructure S is mounted on the top walls of the tank and provides the supporting structure for a plurality of shafts 21, journaled in bearing members 22, each having a pulley or sheave 23 mounted at its upper end in driving connection with a motor M or other prime mover. The shaft 21 for cell C carries another sheave 24 which drives a transmission assembly 25 to actuate a scraper assembly 26 journaled for rotation, adjacent froth overflow lip 16. A gas supply header 27 supplies the aerating gas to a series of branch lines or conduits 28 which connect with the housing structure of the bearing unit 22 and deliver gas from the header into the hollow portion of shaft 21. Suitable valves 29 are provided for individual regulation of the gas admission to each such shaft.

A rotary impeller unit I is mounted at the lower end of each of the shafts 21, and the details of such member will be fully described with reference to other views of the drawing. The inner end of each feed conduit 19 terminates as an enlarged downwardly flaring extension of the conduit and in overhanging relation to the opening in the upper portion of the impeller unit. In order to maintain the feed conduit free from vibration a series of baffle members 31 are suitably connected to the flaring portion as shown at 32, and in addition a rod 33 suspended from superstructure S attaches to the upper surface of feed conduit 19 to provide stabilizing support. Due to the relatively low speed of rotation of the impeller and the low pressure gas introduction, I prefer to substantially space the baffles from the bottom of the tank as clearly shown in Fig. 2 since their restraining influence above the impeller level is all that is required to create the demarcation between the agitation and separation zones required in this type of flotation apparatus.

Each of the feed compartments other than initial compartment F and also the final discharge compartment D are provided with weirs 35. The effective overflow level of each is regulated by a screw-actuated gate member 36 to provide individual level regulation for cells C, Cⁱ, and Cⁱⁱ. A sands relief opening 37 is provided at the lower end of each weir and may be closed when desired as by a plug member 38 in the manner shown in Fig. 2. The final discharge from compartment D is through a spigot member 40 inclusive of an ascending column 41 terminating in a discharge box 42, and the effective overflow elevation of column 41 may be varied by the addition to or removal of rings from its upper end.

The machine of the present invention is intended for all-purpose operation inclusive of rougher-cleaner operations in which a froth concentrate of one cell is recirculated through another cell of the series. To this end, openings 43 are provided in the front wall of each cell and

connect through return conduits 44 with the impeller. When these openings are not connected for return circulation as aforesaid, suitable plug members, not shown, may be screwed into same to close them.

Referring next to the structure shown in Figs. 3 through 9, the upper impeller member 46 comprises an outer rim portion 47 of tapering section, an inner hub 48 suitably drilled and keyed for fastening to the shaft and an interconnecting spider portion 49. The members constituting the spider assembly of portion 49 are of uniform section but with their forward and rear sides substantially inclined, as will be best understood by reference to Fig. 7. Through this arrangement pulp descending through the openings between rim 47 and hub 48 is engaged by the pointed forward end of the spider members and broken by the cutting action resulting from its relatively high speed movement through the pulp, while at the same time the inclination of the contacting surface forces a substantial portion of the broken pulp in a declining movement onto the surface of lower plate member 50 in the region immediately forward of the following blade member 51 on disc 50.

As will be best understood by reference to Fig. 2, the upper member 46 is spaced from, but in close proximity to, the surface of the blades on the lower member 50. This limited clearance prevents any substantial outflow of pulp between the adjoining surface of the members with the result that substantially all the pulp discharged in front of a given blade 51 is forced in the ensuing rotation to travel out and cross the periphery of disc 50. As shown in Fig. 5 a series of tubes or pipes 52 are located immediately behind, and preferably are attached to, the blades 51 as by brazing, welding, or the like. Rubber nozzles 53 preferably are located at the end of pipes 52 and have their outer ends flattened and normally closed, except as they are spread open by the pressure of the discharging gas.

The discharge of the gas at the periphery and in close proximity to the blades 51 serves to create a trailing zone of highly gasified matter at the end of each such blade, and the pulp discharging across the periphery under the centrifugal influence is thrown into this gasified zone at relatively high velocity to break up and disperse the gas components. In this action outflow from the impeller is restricted to a substantial degree by the more or less static body of pulp encompassing the impeller, so that the initially highly gasified zone becomes a crossroads or thoroughfare through which portions of the pulp traveling at relatively high speed pass in indiscriminate order.

The indiscriminate movement and bombardment effect of this type of mixing prevents or substantially impedes any large bubble effect. As a consequence the aerated pulp passing from the mixing zone of the impeller into the agitation zone at the lower portion of the cell is thoroughly aerated without creation of excessive velocities and resulting turbulence. Any tendency toward eddy currents is restrained or broken up by the baffle formation and as a result the aerated mineral is free to travel through a substantially quiescent zone thoroughly filled with small gas bubbles to effect the necessary elevation of the mineral to the surface. In the operation of the machine hereinabove described, pulp passing from each of the weirs 35 creates a hydraulic head above the intake of the conduit

19, but due to the absence of high pressure gas introduction it is only necessary to maintain a slight head above each intake opening in order to insure the most efficient aeration. As a consequence substantial fluctuation in feed to the machine can be accommodated without material change in operating efficiency.

Referring again to the blade arrangement shown in Fig. 5, I prefer to have the blades extend in non-radial arrangement but offset only slightly from the radius so as to substantially parallel a true radial line. Also in the preferred apparatus the blades adjacent the periphery are curved slightly to a trailing position as I have found that I can obtain reduced power consumption and wear by such an arrangement and with an appreciable improvement in the mixing action. However, when a greater pumping action is required than would be produced by the foregoing arrangement straight line blades may be used and, if desired, these can be in true radial arrangement. Likewise it is unnecessary to provide the rubber nozzles at the ends of the gas discharge pipes, but I have found the use of such members beneficial, particularly in preventing sanding up of the openings during shutdowns.

Impellers in the forms hereinabove described and illustrated may be made in a variety of materials. For the treatment of many corrosive and abrasive materials the use of rubber impellers will be preferred, and to simplify fabrication of such designs it may be preferable to move the blades 51 to a substantially radial position and mold the pipes 52 within the blade formation throughout most of its length, but providing a bend in the pipe near the periphery of the impeller which brings it to the trailing surface of the blade at or near the periphery. In the case of iron or other metallic impellers, it will be preferable to drill the hub portion in alignment and in proximity to the blade on its trailing side and then insert the pipe into such opening and fasten it by brazing at the opening, or by a tack weld lengthwise along the blade as indicated in the sectional view, Fig. 9.

Another form of impeller has been illustrated in Figs. 10 through 12. The plate section 50^a of this form, preferably is in the form of a disc, and has a series of blades 51^a, preferably extending from the central hub portion to the periphery and slightly curved rearwardly with respect to the direction of rotation adjacent the periphery.

An outlet passage 52^a extends through a fillet or web 55 on the trailing side of each of the blades 51^a and preferably is in radial arrangement. Air delivered through the hollow shaft passes through the hollow hub and into passages 52^a from which they discharge at the periphery of the impeller at the trailing side of blades 51^a. This impeller is adapted for use with the upper impeller member 46.

Nozzles similar to nozzles 53 (Fig. 5) may be inserted in passages 52^a, if desired, and will be effective in preventing clogging of the passages during shutdowns. However, it has been found that if the blower air is left on for a sufficient period after the impellers stop rotating to permit the sands to settle, the passages will be kept clear and in proper condition to resume operation.

In the operation of the machine illustrated in the drawings a suitable flotation pulp is in-

troduced through an inlet nipple 60 to feed box F, from which it passes into the feed conduit 19 of cell C and discharges through the enlarged opening thereof and through the opening in the upper impeller member 46 onto the lower disc 50. The enlarged end of feed conduit 19 is of bifurcated form as will be understood by reference to structure shown in cell C¹ on Figure 2, and thus the incoming pulp to the impeller is subjected to mixing with recirculating pulp drawn into the top opening of the impeller by the vortex action.

This intermingling of pulp produces a partial aeration which is further enhanced by the resulting beating action, resulting from contact with spider members 49. Following this the pulp is subjected to further aeration in its centrifugal movement to the periphery of the impeller where it penetrates the highly gasified zone previously described and attains the final degree of mixing and dispersion. Usually the pulp fed to flotation cells of this type will be preconditioned, but if additional reagent introduction to the individual cells is required it may be fed through reagent feeders, of either the wet or dry type, mounted at the top of each such cell, or it may be fed under pressure into the branch lines 28, and conducted by the aerating media into the mixing zone. The setting of the gates 36 relative to the weirs 35 determines the rate of outflow from each cell and also establishes an effective liquid level in such cell. Froth forming at the surface of the respective cells is moved across the overflow lip 15 by the scrapers 26 and may be collected in launders (not shown) or in any other suitable receptacle. Where a gritty pulp is being treated, portions of which will not readily overflow the weirs, the plugs 38 may be removed from the sands relief opening 37 to permit a direct passage of such content from a preceding cell into the feed conduit of the next succeeding cell. In this way there is a progressive movement of pulp through the series of cells from the first to last, except as such flow may be diverted by recirculation of concentrate from a succeeding cell to a preceding cell in the manner previously described.

Mixing and recirculation of pulp through the impeller as heretofore described occurs in each of the cells and the individual regulation of the respective weirs permits a level setting properly proportioned to the depth of the froth bed in each such cell. The final discharge from the machine is through the ascending column 51, which being subject to regulation of its effective overflow level gives an overall level control for the machine.

In preferred practice I have found that I can operate the impellers at from 1400 to 1600 feet peripheral speed with best results, but I have been able to reduce the volume of air introduced into the machine to approximately one-half the volume of that required for best results in the operation of a machine of equivalent size and of the type shown in my aforementioned Patent No. 2,502,497.

What is claimed is:

1. An impeller for flotation apparatus comprising a disc-like body having a hollow hub portion adapted for attachment to a rotary shaft, a series of non-radial blades disposed on the upper surface of the body at uniformly spaced intervals and extending from the hub to the periphery, a radial conduit extending from the hollow hub to a point adjacent the periphery at

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the trailing side of each blade, and a flexible nozzle at the end of each conduit having a normally closed discharge opening at its outer extremity expansible by pressure of the gas to effect its discharge at the periphery.

2. An impeller structure for flotation machines and the like comprising an upper disk member having a hub portion for attachment to a shaft, a concentric peripheral portion, and a plurality of radially extending arms connecting the hub and the periphery, the leading edges of each of said arms sloping downwardly, a lower disc-like member having a relatively flat upper surface and a hub for attachment to said shaft in close proximity to, but spaced from said upper disc, a plurality of straight radially disposed gas conduit structures on the upper surface of the lower disc each having an inlet in the hub and an outlet at the disc periphery, and blades on the upper surface of the lower disc, each blade being disposed immediately ahead of one of said conduits with respect to the direction of impeller rotation and extending continuously from the hub to the disc periphery and having a rearwardly curved portion adjacent the periphery of the disc.

3. An impeller for flotation apparatus comprising a disk-like body having a hollow hub portion for attachment to a rotary shaft, a plurality of radial conduits extending outwardly from the hub to the periphery of the impeller, each of said conduits having an inlet through the hub and an outlet at the periphery of the body, and upwardly extending blades on the upper surface of the impeller along the leading side of each conduit, said blades being substantially straight throughout a majority of their extent and terminating at the periphery immediately ahead of the conduit outlet in a rearwardly curved portion, and means for connecting each of the conduits with a source of gas.

4. An impeller for flotation apparatus comprising a disk-like body having a hollow hub portion for attachment to a rotary shaft, a plurality of radial conduits extending outwardly from the hub to the periphery of the impeller, each of said conduits having an inlet through the hub and an outlet at the periphery of the body, and upwardly extending blades on the upper surface of the impeller along the leading side of each conduit, each of said blades including a straight hub portion and an end portion inclined rearwardly with respect to the direction of impeller rotation, each of said blades terminating

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immediately ahead of the corresponding conduit outlet in a rearwardly curved portion, and means for connecting each of the conduits with a source of gas.

5. An impeller for flotation apparatus and the like comprising a disc-like body having a hollow hub for attachment to a hollow rotary shaft, a substantially flat upper surface, and a plurality of elongated projections extending upwardly from said upper surface and laterally from the hub to the periphery thereof, each of said projections including a radial fillet portion extending from the hub portion to the periphery and a continuous integral blade portion substantially coextensive with the fillet portion, said blade portion extending upwardly from the fillet portion and being disposed ahead of the fillet portion with respect to the direction of impeller rotation.

6. In a froth flotation machine of the type having a tank, a submerged impeller, and an upright hollow shaft for driving the impeller, the improvement which includes an upper impeller disc secured to the shaft and having a plurality of radial vanes for forcing the pulp in the tank downwardly, a lower impeller disc on the shaft in close proximity to, but spaced from the upper disc, the lower impeller disc having on its upper surface a plurality of radial gas conduits extending outwardly to the disc periphery, and a blade immediately ahead of each of the conduits with respect to the direction of impeller rotation, each of said blades being continuous and terminating at the periphery of the disc, and a plurality of upright fixed baffles in the tank spaced from the impeller and extending outwardly from a level above the impeller and downwardly to a level below the impeller.

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