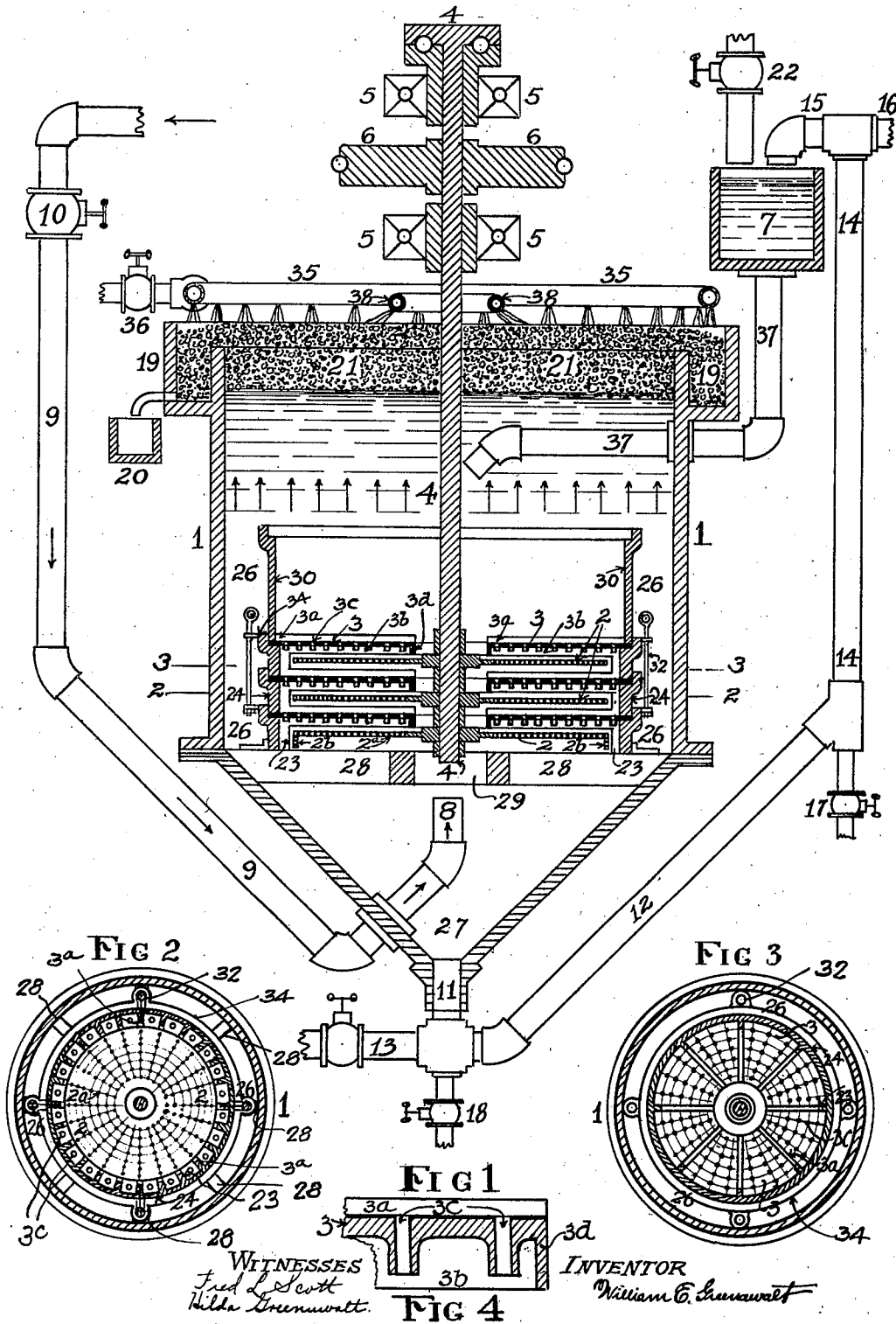


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FLOTATION APPARATUS.

APPLICATION FILED MAY 26, 1916. RENEWED MAR. 22, 1920.

1,374,447.

Patented Apr. 12, 1921.



UNITED STATES PATENT OFFICE.

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Specification of Letters Patent.

Patented Apr. 12, 1921.

Application filed May 26, 1916, Serial No. 100,091. Renewed March 22, 1920. Serial No. 367,829.

To all whom it may concern:

Be it known that I, WILLIAM E. GREENAWALT, a citizen of the United States, residing in the city and county of Denver and State of Colorado, have invented certain new and useful Improvements in Flotation Apparatus, of which the following is a specification.

My invention relates to flotation apparatus, and has for its object the effective separation of minerals from their gangue by introducing a gas into the flotation liquid and atomizing the gas in the liquid. It is not intended, however, to limit the apparatus to this use alone.

The gas, introduced into the liquid, is brought into a fine state of sub-division by means of rapidly rotating perforated disks in its ascent through the liquid, and the atomized gas, rising to the surface, effectively floats the floatable mineral particles in the presence of a frothing agent.

This method of applying the gas is particularly effective in flotation operations. It is most effective when the gas bubbles are brought into a very minute state of sub-division, and it is best accomplished when the relative motion between the liquid and atomizer of the gas is as great as possible. In the present application the best effect is obtained when the perforated disks rotate at a comparatively high speed while the liquid remains comparatively stationary or quiescent. It is also desirable to have the surface of the liquid as quiescent as possible, under the conditions, so that the mineral froth may be floated more effectively and a high grade of flotation concentrate obtained.

The apparatus can best be described by referring to the accompanying drawings, in which Figure 1, represents a vertical section through the apparatus; Fig. 2, a horizontal section on the line 2-2, Fig. 1, on a reduced scale; Fig. 3, a horizontal section on the line 3-3, Fig. 1, on a reduced scale; and Fig. 4, a detail of the perforated plates.

In the drawings, 1 represents a tank adapted to contain a liquid and the material to be treated. 2 represents perforated disks, suspended within the tank and submerged in the liquid, and having perforations 2^a through which gases may pass in their ascent through the liquid when introduced into the tank 1. 3 represents plates, interposed between the disks 2, and having perforation 3^a, through which the gas may pass

as it ascends through the liquid. Attached to these perforated plates 3, are baffles 3^a, on the upper side, and 3^b, on the lower side. The baffles retard the circulatory motion of the liquid, induced by the rapidly rotating perforated disks 2. 4 is a shaft rotating in the bearings 5; the disks 2, are suspended and rotated within the tank 1, when the shaft is driven by the pulley 6. 7 is a feed hopper by means of which the material to be treated is fed into the tank through the pipe 37. This pipe, preferably, passes through the sides of the tank so as to deliver the material to be treated below the surface of the liquid, and in the vicinity of the rotating shaft. It is desirable to deliver the material to be treated close to the shaft. The rotary motion of the liquid in the immediate vicinity of the shaft will just about give the material the desired distribution. 8 is a pipe, preferably stationary, through which air or other gases may be delivered to the submerged rotating perforated disks 2, communicating with the source of gas supply through the pipe 9, and having a gas regulating valve 10. The gas, delivered into the liquid in the tank through the submerged pipe 8, will, by its own buoyancy ascend through the liquid and pass through the perforations in the disks and the plates. 11 is an opening in the bottom of the tank through which the gangue may be removed and wasted through the pipe 13. If desired, the material may be returned to the tank for re-treatment through the pipes 12, 14, and 15, or passed on to a similar apparatus, for further treatment, through the pipe 16. Air or other gas is introduced into the pipe 14 through the pipe 17, thus making an air lift of the pipe 14. Clogging in the opening 11, in the bottom of tank 1, is removed or prevented by an air or water jet introduced through the pipe 18. 19 is a launder into which the mineral froth 21 may overflow and be removed from the tank and delivered into the trough 20. 22 is a feed pipe for the fresh ore or material delivered into the hopper 7 to be introduced into the tank for treatment. 24 is a casing, preferably built in sections, surrounding the disks and plates, and having baffles 23, around the inner surface. The sections of the casing may be bolted together by the rods 32, and these rods may also be used to lift the casing out of the tank when it becomes necessary.

The support for the casing and plates is preferably in the shape of a spider 28 having an opening in the center, 29, through which the gas issuing from the pipe 8 passes to the rotating disks 2. The casing is preferably made in sections, both vertically and horizontally, to facilitate the assembling of the apparatus. It will be seen that by this arrangement of the casing a space 26 is formed between the casing and the sides of the tank, in which the liquid is more quiescent than in the space within the casing, in which the disks rotate. This arrangement allows the coarser ground ore to pass down through and between the plates and disks into the hopper 27, while the finer ore, or slimes, may pass through the more quiescent space 26 to the hopper 27. It will be noticed that the plates 3 have lips 3^a projecting downwardly at the bottom: this is to allow the finely ground ore to pass over the plates and on the rotating disks near the shaft, to be worked toward the periphery, while the gas, issuing from the pipe 8, passes through the perforations in the rotating disks and to the plates, where it is prevented from short-circuiting up through the middle by the lips 3^a on the plates 3. The perforations on the disks are arranged so that the gas passing through the disks will be delivered to the plates to be trapped by the lip 3^a. For this reason there are preferably no perforations in the space toward the center of the disks. The projections 34 on the casings, are lugs through which pass bolts 32 to hold the plates in place. The upper section 30 of the casing may be made as high or as low as desired to get the results sought for. As the section 30 is made higher more material, or ore, being treated will pass through the disks and plates into the hopper 27; if the casing 30 is made very low much of the coarser material will pass through the space 26 into the hopper 27. The best height for each particular case can only be determined by experimenting.

35 is a water pipe over the launder 19, by means of which jets of water wash the mineral froth from the overflow launder 19 to the trough 20, which conveys the froth away from the apparatus. 38 is an air pipe having air jets arranged so as to blow the froth toward the periphery of the tank and into the launder 19.

In operating the apparatus, the tank 1 is filled with a liquid and the material to be treated, which may be assumed to be a floatable ore pulp ground, say, to 80 mesh, and mixed with suitable frothing agents. The shaft and disks are then rapidly rotated, say, several hundred or several thousand revolutions per minute, driven by the pulley 6. The air, or gas, valve 10 is then opened and the gas introduced into the tank 1 through the pipe 9 and the stationary pipe

8, and its amount is regulated so as not to be in excess of that capable of passing through the perforations either in the disks 2 or the plates 3. There is no mechanical connection between the rotating disks 2 and the stationary gas delivery pipe 8, so that the disks can conveniently be rotated at any speed desired.

The gas, in passing through the perforations of the rapidly rotating disks, is atomized in contact with the liquid, and the atomized gas, in ascending through the liquid having the finely ground ore in suspension, floats the mineral particles to the surface, as shown by 21, while the gangue passes downwardly into the hopper 27. The heavier particles of gangue pass downwardly within the casing and over and through the rotating disks, while the gangue slimes pass downwardly through the more quiescent space 26, between the casing and the tank. The amount of separation between the sands and the slimes with a constant supply of gas, depends largely on the height of the section, 30, and regulation may be controlled within fairly wide limits. In this way the apparatus may also act as a classifier, or pulp thickener, and once the most desirable gravity having been obtained by adjusting the height of the casing, this condition can always be maintained, no matter what the proportion of solid to liquid is on entering the tank. The sands and slimes, although somewhat separated during treatment, are again brought together in the hopper 27, below the disks and plates, and are drawn from the hopper through the opening 11, and may be wasted through the pipe 13, or returned for re-treatment through the pipes 12 and 14, into the same apparatus through the pipe 15, or a similar apparatus through the pipe 16. The mineral froth 21 rises to the surface and overflows into the launder 19. It may be assisted toward the periphery of the tank by air jets from the pipe 38. The froth is broken up and washed out of the launder 19, by water jets from the pipe 35, placed directly over the launder.

It is intended to maintain a high rotary speed for the disks, while the baffles between the disks prevent the liquid from circulating with the disks. In this way, the gas, passing from the disks to the plates becomes thoroughly atomized and in the best condition for flotation, and only a minimum amount of air is required. The atomizing effect will be confined to the spaces between the disks and plates, and the surface of the liquid will be fairly quiescent with only a moderate circulatory motion which tends to work the froth toward the periphery of the tank. The best number of plates and disks to use for each particular ore can only be determined by experimenting: usually three will be sufficient.

The ore, or material to be treated, is pref-

erably introduced through a pipe 37, submerged in the liquid, just below the froth. This leaves the surface entirely free and facilitates the removal of the froth from the liquid.

The thickening of the pulp in the tank may be accomplished, either by the speed of rotation of the disks, the amount of gas introduced into the liquid, or the height of the casing above the disks. Usually all of these factors will be operative at the same time.

The perforations in the plates and disks are made somewhat larger than the size to which the ore is ground so that there will be no danger of the perforations becoming clogged, and experience has proved that they do not become clogged under the conditions.

The spider support for the casing and baffles, as shown by 28, is a convenient arrangement. The pipe 8 delivers the gas to the disks, while the arms of the spider support the casing, and the space between the spider arms allows both the sands and the slimes to pass into the hopper 27. The spider arms also act to retard the circulatory motion of the liquid in the hopper below the disks.

It is desirable to have a flange 2^b projecting downwardly around the periphery of the lower disk. This acts as a hood to confine the gas and give it an equal distribution by forcing it to pass through the perforations 2^a, and thus preventing its escape in large bubbles around the periphery. Similarly, it is desirable to arrange the perforations with projections downwardly so that air will be trapped on the under side of the plates, as shown in detail in Fig. 4.

The operation of the apparatus is not dependent upon the agitation of the liquid—for that is a detriment—but upon the atomizing of the gas in the liquid, and this is most effective when the liquid is as nearly quiescent as possible, although, of course, some movement of the liquid is inevitable. A good idea of the operation of the apparatus may be obtained from the following illustration: Suppose the disks rotate at a speed of 400 R. P. M. A perforation, say, $\frac{1}{2}$ inch in diameter, and 0.8 foot from the center, will travel a distance of 5 feet per revolution and a total distance of 2000 feet per minute. It is evident that the gas escaping, per minute, through the $\frac{1}{2}$ inch perforation, is distributed through a linear distance of 2000 feet of the liquid, if the liquid is stationary. If the liquid rotates with the disks it will be less. The maximum efficiency is obtained, therefore, by having the relative motion between the disks and liquid as great as possible, and this condition is best realized in my apparatus when the liquid is as nearly stationary

as possible, under the conditions. To best accomplish this, baffles are preferably interposed between the disks, and the disk machined, or the surface of the disks otherwise made as smooth as possible. This is the preferred arrangement.

I claim:

1. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, a shaft rotatably mounted suspended within the tank, a plurality of perforated disks mounted on said shaft, a plurality of perforated stationary plates interposed between the disks and alternating with them, means for rotating the shaft and disks, and means for introducing a gas into the liquid in the tank and by its own buoyancy passing it upwardly through the perforated disks and plates, and thus by atomizing the gas in contact with the liquid causing the floatable material to rise to the surface of the liquid.

2. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, a shaft rotatably mounted suspended within the tank, a plurality of perforated disks mounted on said shaft, a plurality of perforated stationary plates interposed between the disks and alternating with them, means for rotating the shaft and disks, means for introducing a gas into the liquid in the tank and by its own buoyancy passing it upwardly through the perforated disks and plates, means for introducing the material to be treated into the tank to be acted upon by the atomized gas, and means for withdrawing the gangue from below the disks in the tank.

3. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, a plurality of perforated disks mounted on a vertical shaft, plates having baffles interposed between the disks, means for introducing a gas into the liquid to be atomized in the liquid by the disks and plates, and means for rotating the disks.

4. In apparatus for separating minerals from their gangue by flotation, a plurality of disks mounted on a vertical shaft, plates and baffles interposed between the disks, means for rotating the disks, and means for introducing a gas into the liquid in the tank to be atomized by alternately bringing it in contact with the disks and plates, and thus floating the floatable mineral particles.

5. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, a plurality of perforated disks mounted on a vertical shaft and suspended within the tank, perforated plates interposed between the disks, means for rotating

the disks, means for introducing a gas into the liquid in the tank to be atomized by the disks and plates, and means in connection with the disks and plates for preventing the short-circuiting of the gas in the vicinity of the shaft in its ascent through the liquid.

6. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, means for introducing a gas into the tank and into the liquid from a submerged opening, a plurality of disks having means for atomizing the gas mounted on a vertical shaft suspended within the tank and submerged in the liquid, means for rotating the disks, and plates having means to retard the circulatory motion of the liquid induced by the rotating disks interposed between the disks.

7. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, means for introducing a gas into the tank and into the liquid from a submerged opening to rise by its own buoyancy, disks having means for atomizing the gas mounted on a vertical shaft suspended within the tank and submerged in the liquid, means for rotating the disks, and means interposed between the disks for retarding the circulatory motion of the liquid induced by the rotating disks.

8. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, means for introducing a gas into the tank and into the liquid from a submerged opening to rise by its own buoyancy, atomizers for the gas mounted on a vertical shaft suspended within the tank and submerged in the liquid, means for rotating the atomizers, and means interposed between the atomizers for retarding the circulatory motion of the liquid induced by the rotating atomizers.

9. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain the liquid and the material to be treated, means for introducing a gas into the tank and into the liquid from a submerged opening to rise by its own buoyancy in the liquid, atomizers for the gas mounted on a vertical shaft suspended within the tank and submerged in the liquid, means for rotating the atomizers, means interposed between the atomizers for retarding the circulatory motion of the liquid induced by the rotating atomizers, and a casing interposed between the atomizers and the sides of the tank.

10. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, means for introducing a gas into the tank and into the liquid from a submerged opening to rise by its own buoyancy

in the liquid, atomizers for the gas mounted on a vertical shaft suspended within the tank and submerged in the liquid, means for rotating the atomizers, means interposed between the atomizers for retarding the circulatory motion of the liquid induced by the rotating atomizers, a hopper for the gangue located below the atomizers, and means for withdrawing the gangue from the hopper.

11. In apparatus for gasifying a pulp, a tank adapted to contain the pulp, means for introducing a gas into the tank and into the pulp from a submerged opening to rise by its own buoyancy in the pulp, rotary means having perforations for atomizing the gas in its ascent through the liquid, means for maintaining a relatively quiescent surface of the pulp, and means for creating a current of air over the relatively quiescent surface of the pulp toward the periphery of the tank.

12. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid, a shaft rotatably mounted suspended within the tank, a plurality of perforated disks mounted on said shaft, a plurality of stationary plates interposed between the disks and alternating with them, and a casing surrounding the disks and supporting the plates, and means for introducing a gas into the liquid in the tank and by its own buoyancy passing it upwardly through the rotating perforated disks and stationary plates.

13. In apparatus for treating liquids with gases, a tank adapted to contain the liquid, a shaft rotatably mounted suspended within the tank, a plurality of perforated disks mounted on said shaft, means for retarding the circulatory motion of the liquid interposed between the disks, a casing interposed between the disks and sides of the tank thus forming a relatively quiescent space between the casing and the tank, means for introducing a gas into the liquid in the tank to be acted upon by the rotating disks, and means for creating a current of air over the surface of the liquid toward the periphery of the tank.

14. In apparatus for treating liquids with gases, a tank adapted to contain the liquid to be treated, a plurality of rotatably mounted parallel disks having means for subdividing a gas in the liquid, a plurality of stationary baffles having means for subdividing the resulting mixture of gas and liquid alternating with the disks, submerged means for injecting a gas into the liquid, and means for rotating the disks.

15. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, means for introducing a gas into the liquid in the tank, and stationary and rotating surfaces having gas passages

arranged so that the gas in its ascent through the liquid will alternately pass through the gas passages of the rotating and stationary surfaces.

5 16. In an apparatus for treating liquids with gases, a tank adapted to contain the liquid to be treated, a plurality of perforated disks mounted on a vertical shaft suspended in the tank and submerged in the
10 liquid, means for rotating the disks, means for introducing a gas into the liquid to be atomized by the rotating disks, and means interposed between the disks for retarding the circulatory motion of the liquid induced
15 by the rotating disks.

17. In apparatus for separating minerals from their gangue by flotation, a tank adapted to contain a liquid and the material to be treated, a plurality of atomizers
20 having gas passages suspended within the tank and submerged in the liquid, means for causing a flow of gas through the gas passages of the atomizers, means for rotating the atomizers about a central axis, and
25 means interposed between the atomizers for retarding the circulatory motion of the liquid induced by the rotating atomizers.

18. In apparatus for treating liquids with gases, a tank adapted to contain the liquid

to be treated, a plurality of perforated disks 30 arranged with a space between them mounted on a shaft within the tank submerged, means for injecting a gas into the liquid, means for rotating the disks, and means for effecting an intimate mixture be- 35 tween the gas and the liquid.

19. In apparatus for treating liquids with gases, a tank adapted to contain the liquid to be treated, a plurality of rotatably mounted perforated disks suspended within 40 the tank, a plurality of stationary perforated baffles alternating with the disks submerged, means for injecting a gas into the liquid, and means for rotating the disks.

20. In apparatus for treating liquids with 45 gases, a tank adapted to contain a liquid, a stationary casing within the tank having a gas inlet and a gas outlet and a liquid inlet and a liquid outlet communicating with the liquid in the tank, a rotary shaft within 50 said casing, a series of rotary members mounted on said shaft, and a series of stationary members interposed between the rotary members.

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Witnesses:

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