Oct. 23, 1923.

1,471,332

W. E. GREENAWALT

APPARATUS FOR TREATING LIQUIDS WITH GASES

Filed Sept. 26, 1921

3 Sheets-Sheet 1

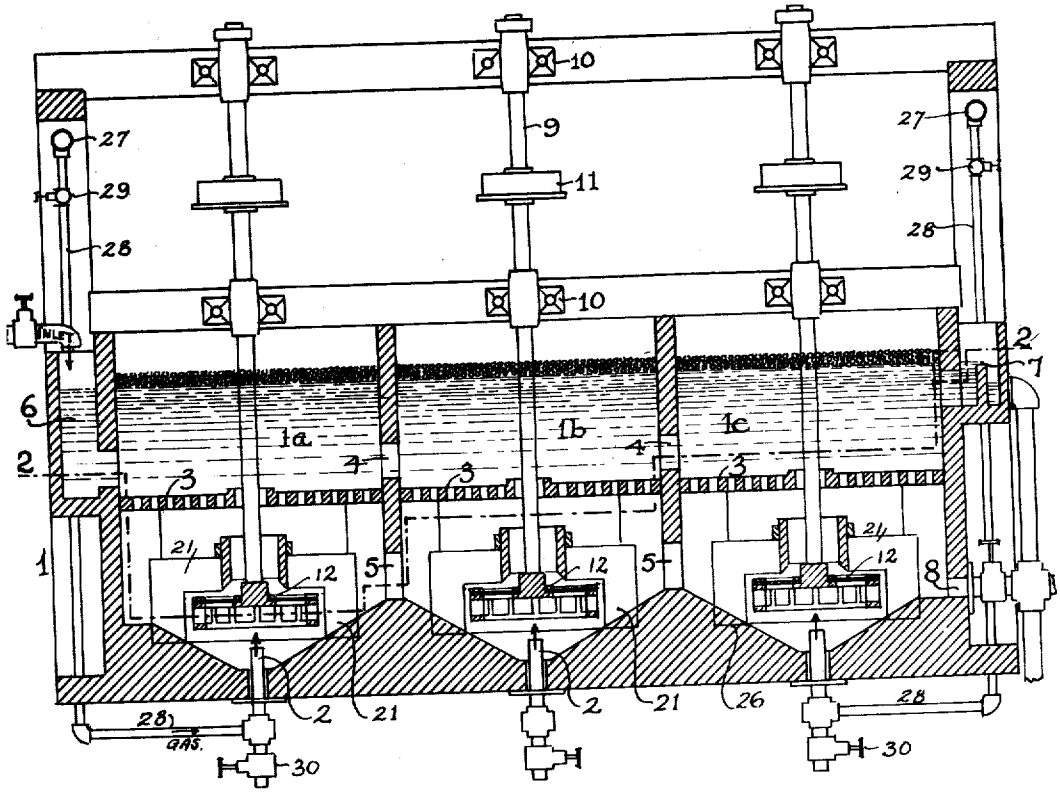

FIG 1

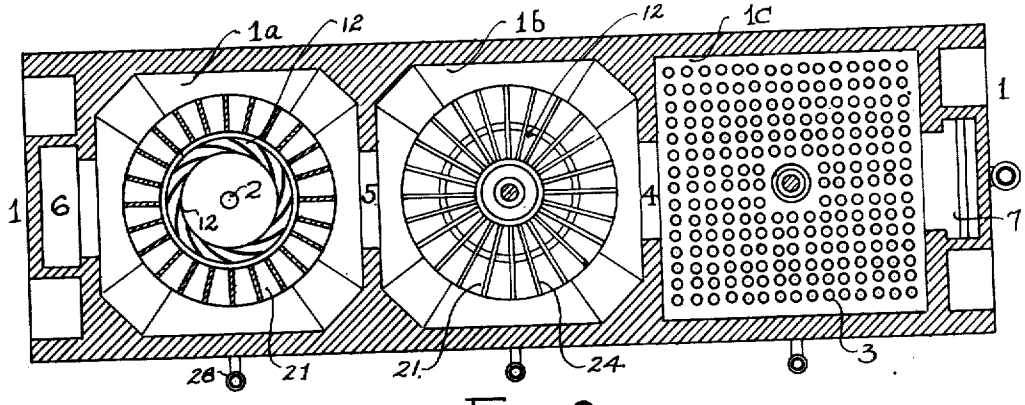

FIG 2

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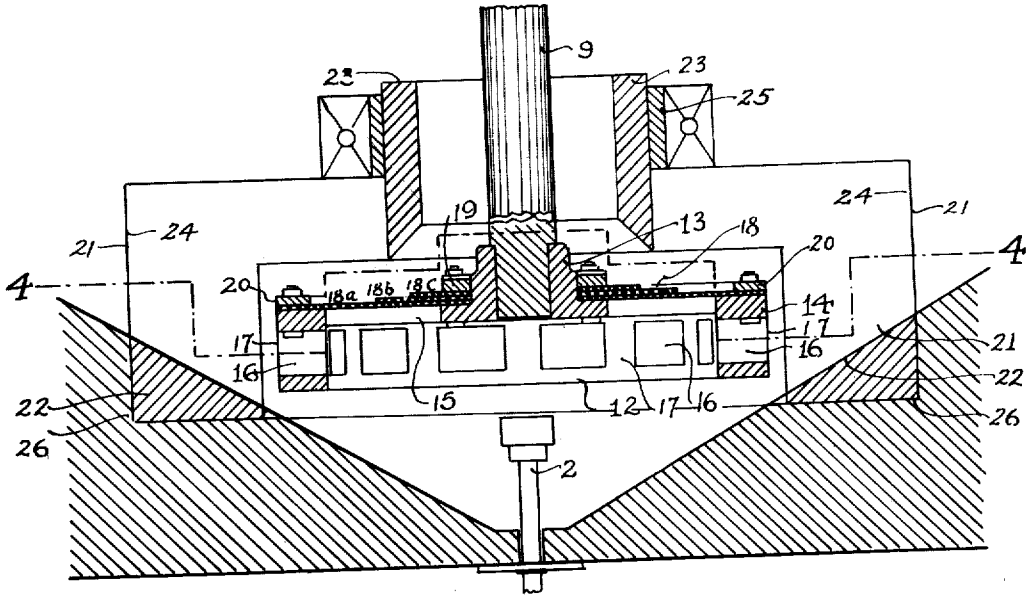

FIG 3

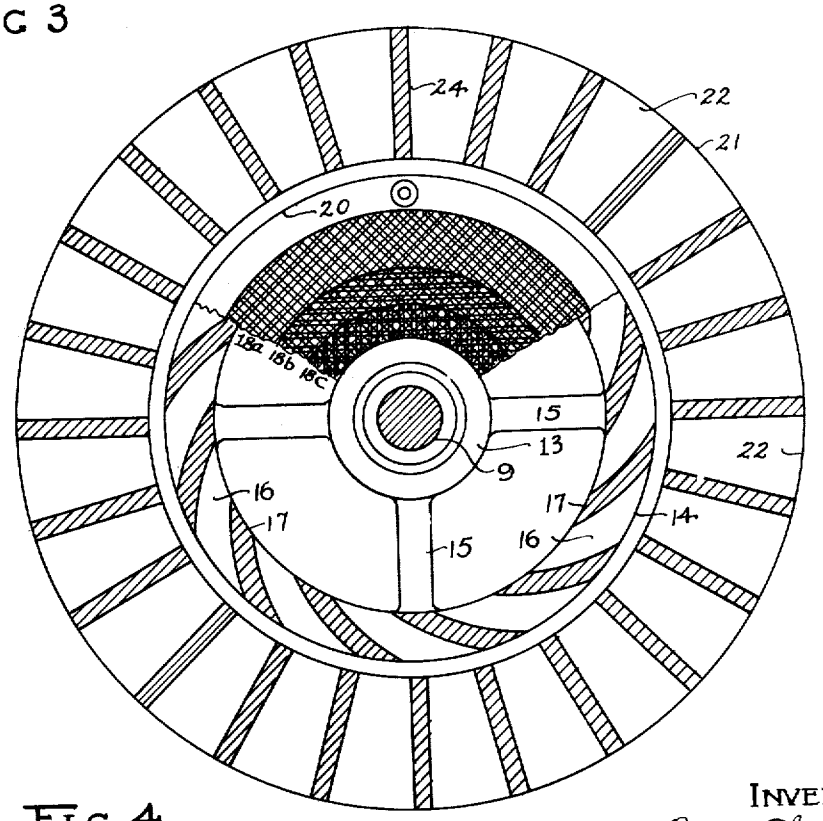

FIG 4

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APPARATUS FOR TREATING LIQUIDS WITH GASES

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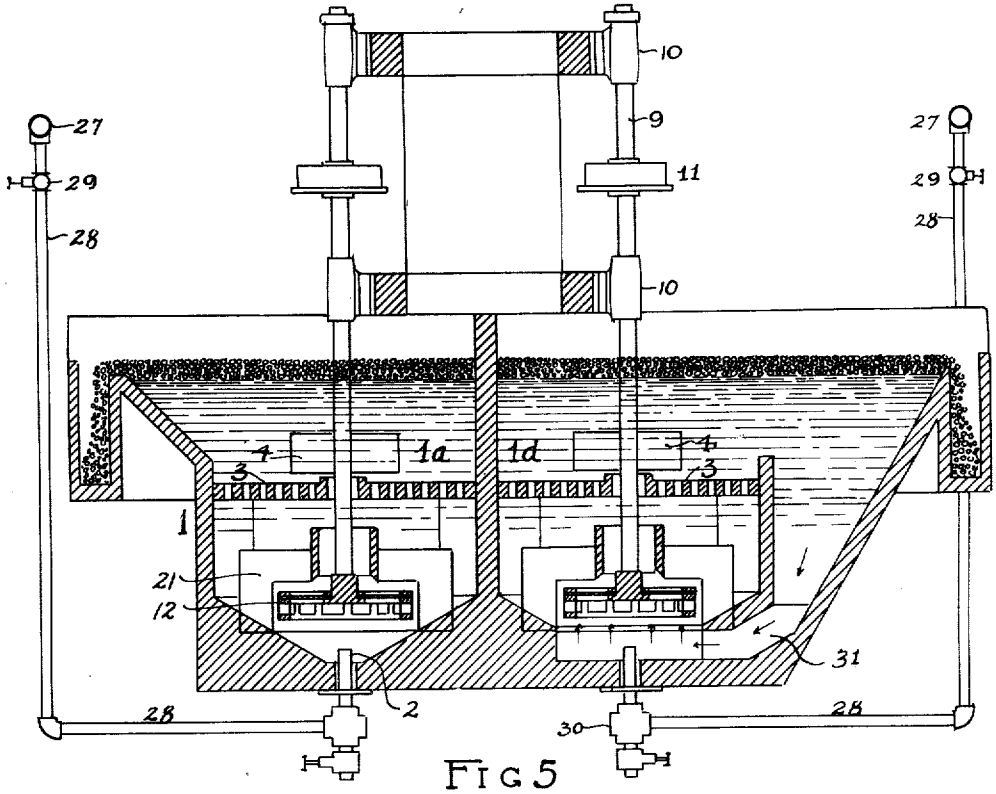

FIG 5

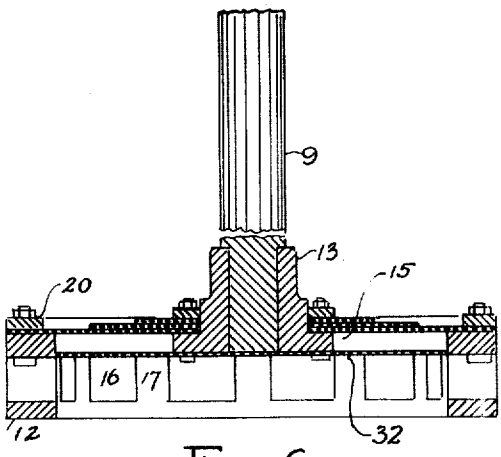

FIG 6

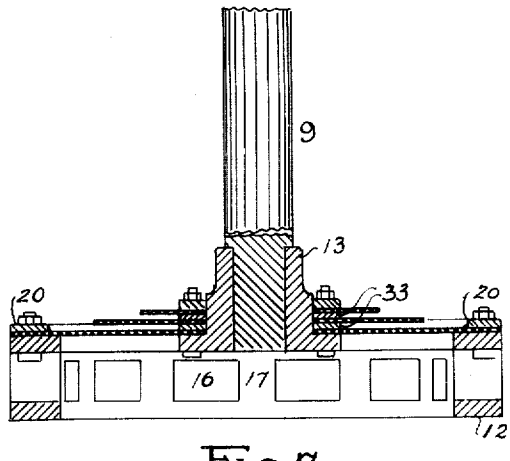

FIG 7

INVENTOR

William E. Greenawalt

Patented Oct. 23, 1923. 1,471,332

UNITED STATES PATENT OFFICE.

WILLIAM E. GREENAWALT, OF DENVER, COLORADO.

APPARATUS FOR TREATING LIQUIDS WITH GASES.

Application filed September 26, 1921. Serial No. 503,463.

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 Apparatus for Treating Liquids with Gases, of which the following is a specification.

The invention has for its more immediate object the effective atomization, or fine subdivision, of gas in liquids to accomplish certain results, as for example, the precipitation of metals from their solutions by a gas such as hydrogen sulphide, the application of sulphur dioxide to a solution of iron salts to reduce the ferric iron to the ferrous condition, or the flotation treatment of certain ores. It is not intended to limit it to any particular use, although in describing the apparatus the above mentioned uses will be kept more or less in mind, and the description will be directed more particularly to the flotation treatment of ores.

This apparatus may be considered as a modification of the apparatus shown in my Patents No. 1,365,034, Jan. 11, 1921: No. 1,374,500, April 12, 1921: No. 1,350,605, Aug. 24, 1920: and No. 1,374,446, April 12, 1921. These patents disclose, in general, apparatus for atomizing gas in a liquid by means of a hollow rotary member submerged in the liquid: the gas being introduced into the interior of the hollow rotary member independent of any mechanical connections, and ejected from the interior of the hollow rotary member through discharge passages into the surrounding liquid, in a fine state of subdivision.

In this apparatus it is intended to overcome certain defects in the apparatus above referred to, and to incorporate certain improvements and modifications which it is believed will give somewhat better results, at least under certain conditions of operation.

In describing the apparatus reference will be made to the accompanying drawings, in which Fig. 1 shows a longitudinal section through the apparatus; Fig. 2, the corresponding plan on the line 2—2 of Fig. 1; Fig. 3, a detail section through the rotary member, or atomizer; Fig. 4, a section on the line 4—4 of Fig. 3, with a portion of the perforated or screen surface removed; Fig. 5, a cross section of two machines, back to back, with the one on the right somewhat modified from the one on the left which is the same as shown in Figs. 1 and 2; Figs. 6 and 7 are sections of modifications of the rotary member, or atomizer.

In the drawings, 1 represents a tank, taken as a whole, containing the liquid and the material to be treated with the gas. The tank is preferably divided into compartments, or cells, 1^a, 1^b, and 1^c, and arranged so that the liquid passes successively through the different compartments. Air or gas is introduced into the compartments and into the rotary atomizers through the gas inlet pipes 2, in the bottom of the tank. The compartments are also preferably divided into an upper and lower portion by a perforated partition 3, which may conveniently be perforated cast iron or sheet iron plates, made in sections so as to be easily inserted and removed. The upper portions of the compartments communicate with one another through the openings 4, and the lower portions through the openings 5. A complete apparatus may consist of one or of any convenient number of compartments. The liquid, or pulp, is flowed into the tank through the inlet 6, and overflows through the weir overflow 7. The lower outlet 8 is provided for matter in suspension which may be too heavy to pass over the weir overflow.

Suspended within the lower portion of the cells, by means of the shaft 9 and bearings 10, are the atomizers 12, which are rotated by means of the pulleys 11. These atomizers are preferably composed of a skeleton portion consisting of a hub 13, (see Figs. 3 and 4) a cylindrical peripheral wall 14, and radial arms 15, joining the hub with the peripheral wall. The peripheral wall portion is provided with openings, or discharge passages 16, formed by deflecting blades, or partitions, 17. These blades are preferably inclined, as shown, so as to create a positive flow of liquid and gas through the discharge passages and eject the liquid and gas into the surrounding liquid in the tank. The upper portion of each atomizer is preferably made of a number of screens 18 of various diameters, bolted to the hub 13 by means of the ring 19, and to the peripheral wall by means of the ring 20. The ring 20 also acts as a deflector to give a slight upward movement of the gas and liquid discharged through the screens. The number of screens bolted to the top of the skeleton member will be determined principally by

the desired degree of atomization of the gas. The screens may be the ordinary woven wire cloth or perforated sheet metal. It is evident, with only one sheet of screen, that the gas will not be as finely divided near the hub as toward the periphery, owing to the difference in linear speed, which very largely determines the degree of atomization. To compensate for the difference in linear speed the screen may be made denser or the perforations smaller toward the hub. This effect is conveniently obtained by a series of superimposed screens of gradually diminishing diameter toward the hub, as shown by 18ª, 18ᵇ, and 18ᶜ. The screens may be the ordinary wire mesh screening or perforated metal sheets of regular manufacture, cut out in the form of an annulus, and bolted to the skeleton member as described. When one set of screens is worn out it may be quickly and cheaply replaced by another set. The mesh of the screen will depend on the material to be treated and the results desired: fine screens, especially if a number of them are superimposed, will give a finer atomization of the gas than coarse screens; on the other hand, the speed of rotation is quite as important a factor in determining the degree of atomization as the fineness of the screens. Under ordinary conditions, a strong wire or perforated screen of moderate mesh will be used in connection with moderate speed of rotation. In the flotation treatment of ores the mesh should be large enough to avoid clogging by the ore particles.

Surrounding the atomizers are baffle cages 21, preferably sectionally constructed, and supported from below, and consist essentially of a lower ring 22, an upper ring 23, and radially disposed baffles 24 connecting the rings to form a cage-like structure, supported by the lower ring, and surrounding the rotary atomizers. The baffle cage is preferably constructed in sections so that it can be conveniently inserted in the tank and removed therefrom without interfering with the atomizer or shaft or being hampered by them. The ring 25 serves to hold the baffle cage together and a recess 26 in the bottom of the tank serves to keep it in place.

The gas is introduced into the tank and into the atomizers through the stationary gas inlets 2, which connect with the compressed gas main 27, by means of the individual pipes 28 going to the various cells. The flow of gas is regulated by the valves 29, and the operator can immediately see the effect of varying quantities of gas by observing the surface of the liquid. The flow of gas can be regulated at will for the different cells. The gas need only be compressed sufficiently to overcome the static head of the liquid: usually it need not be more than three or four ounces for flotation treatment of ores. The valves 30 are provided to remove obstructions from the inlet pipe 2 should any occur. The method of introducing the gas into the interior of the atomizer is immaterial, but the method shown is preferred since it is simple and admits of wide variation while the apparatus is in operation.

Fig. 5 shows a cross section of two cells, back to back. The cell, shown on the left, will be preferred in most cases since it provides for a simple circulation without any definite channel for return flow. If, however, a definite circulation and return flow is desired, the arrangement, shown on the right, will give good results. The blades of the atomizers will give a positive circulation in either case, and the degree of circulation will depend largely on the speed of rotation and the length and inclination of the blades. Ordinarily a violent circulation and agitation is to be avoided, but sufficient circulation should always be provided to avoid clogging of the apparatus, in the treatment of ore pulp and the like.

Fig. 6 shows a modified atomizer, in that a screen or perforated sheet 32 is bolted to the under side of the radial members 15. The radial members 15, without a bottom sheet 32, tend to mix the gas and liquid before the gas is ejected from the interior of the atomizer. Ordinarily this will be the preferred arrangement. If, however, a smooth surface should be preferred for the interior underside of the atomizer, it can be obtained by bolting a perforated metal sheet to the radial members, as shown. This arrangement will enclose a portion of the liquid between the upper and lower screens, or perforated metal sheets, and this will tend to help subdivide the gas in passing through the upper portion of the atomizer.

Fig. 7 shows another modification of the atomizer, in that the screens are separated by annular rings 33, so that while the gas is passing from one screen to the next through the intermediate liquid, there will be a tendency also to further subdivide the gas and to eject the mixture of gas and liquid toward the periphery of the atomizer. In this modification, the screens are preferably perforated metal sheets of sufficient thickness for the required strength and stability to maintain them in position when separated by the rings 33. This arrangement of the screens will give a very good distribution of the atomized gas, especially in connection with the deflector ring 20, which also serves to hold the lower screen in position, about the periphery of the atomizer.

The operation of the apparatus, in its application to flotation, may be briefly described as follows: The finely pulverized ore, mixed with the desired amount of water and frothing agent to form a suitable pulp, is

flowed into the tank through the inlet 6. The general stream of pulp will flow through the upper portion of the cells toward the weir overflow 7, but some of the heavier particles of ore will have a tendency to pass through the perforated plate 3 and enter the lower portion of the cells. The gas is introduced into the rotary atomizer in the amounts desired, as can be judged by looking at the surface of the pulp in the tank and noticing the effect with varying quantities of the gas. The gas introduced into the interior of the atomizer, is ejected in a fine state of subdivision mixed with a portion of the liquid, and is thoroly distributed in the liquid in the lower portion of the cells. The atomized gas ascends through the perforated plate 3, into the relatively quiet upper portion of the cells, where the mineral particles are effectively floated toward the surface as a mineral froth. The froth overflows into a launder as shown in Fig. 5. It will be seen that the mineral, once floated, will have to sink against the current of ascending atomized gas to escape from one cell to the next through the openings 4 and through the weir overflow 7. The larger portion of the gangue descends to the lower portion of the cells, where it is kept in motion and gradually worked toward the outlet 8 in the lower portion of the last cell. A stream, somewhat less than the inflowing stream, is kept flowing through the outlet 8, while the weir overflow takes the difference and maintains a constant liquid level in the cells. The blades in the peripheral wall circulate the pulp, prevent the gangue particles from settling and packing, and serve to eject streams of gas and pulp against the baffles, which still further subdivides the gas and prevents too violent agitation of the pulp in the lower portion of the cells.

The baffle-cage, which enclosed the atomizer, also tends to distribute the atomized gas, so that the atomized gas is quite uniformly disseminated in the upper portion of the tank above the perforated plate.

The speed of rotation of the atomizer will depend largely on its diameter. With an atomizer from twelve to fifteen inches in diameter, a speed of from 250 to 450 R. P. M. will be found to give good results.

A relative slow movement may be used if the atomizer is made fairly large. If a large atomizer is used the top would be composed of a number of superimposed screens with their number increasing from the periphery toward the center of rotation. The relatively slow movement of the atomizer would greatly help to subdivide the gas, distribute the subdivided gas in the liquid, and prevent settling of ore particles on the top of the atomizer. Under such conditions a relatively coarse wire fabric will give about the same results as a fairly tightly woven cloth fabric used in the ordinary stationary porous bottom flotation apparatus. The wire fabric will outwear many cloth fabrics and give a more uniform distribution of the atomized gas in the liquid in the tank.

The operation of the machine may continue indefinitely, or until some part is worn out. The perforated plates 3, as also the baffle-cages 21, are preferably made in sections so that they can be removed easily and quickly to get at the atomizers 12. The atomizers may also be easily removed from the shaft without removing the shaft from the bearings. The idea would be to have extra atomizers and as the wire screens become worn out, unscrew the atomizer from the shaft and immediately insert a new one, while the used one may be repaired at leisure.

I claim:

1. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary skeleton member suspended within the tank and submerged in the liquid, said rotary skeleton member being comprised of a hub attached to the shaft, a peripheral cylinder or ring and radial arms connecting the hub with the peripheral cylinder, a fluid permeable member attached to the hub and to the peripheral cylinder in removable relation thereto, and means for supplying gas to the interior of the tank through a submerged stationary gas inlet.

2. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary skeleton member suspended within the tank and submerged in the liquid, said rotary skeleton member being comprised of a hub attached to the shaft, a perforated peripheral cylinder and radial arms connecting the cylinder to the hub, a fluid permeable member secured to the upper portion of the skeleton member in removable relation thereto, and a gas inlet in the lower portion of the tank arranged so that the gas in its ascent through the liquid in the tank will pass through the permeable member.

3. In apparatus for treating liquids with gases, a tank adapted to contain liquid divided into compartments by vertical partitions arranged with communicating passages in their lower portions, hollow rotary members journaled in the various compartments, baffles attached to a horizontal member surrounding the respective rotary members and arranged so that fluid ejected from the hollow rotary member of one compartment will pass between the baffles and through the communicating passages of the partitions into the adjoining compartment, and means for supplying gas to the interior of said rotary members.

4. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a skeleton rotary member within the tank,

fluid permeable members attached to the skeleton member in spaced relation and arranged to confine some of the liquid between them, and means for introducing gas into the tank and passing it through the permeable members and the liquid enclosed by them and into the surrounding liquid in the tank.

5. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a skeleton rotary member suspended within the tank and submerged in the liquid, said skeleton rotary member being open at the bottom and arranged with a removable top composed of a plurality of screens, and means for supplying gas to the interior of said rotary member.

6. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary member journaled within the tank, said rotary member having a plurality of perforated sheets of various diameters arranged about the rotating axis, and means for supplying gas to the tank from a submerged inlet to rise through the perforated sheets of the rotary member in its ascent through the liquid in the tank.

7. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary member journaled within the tank, said rotary member having a number of perforated plates of various diameters arranged about the rotary axis and spaced apart, and means for supplying gas to the tank from a submerged inlet to pass through the rotary member in its ascent through the liquid in the tank.

8. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a horizontal perforated partition within the tank dividing the tank into an upper and lower portion, a hollow circular rotary atomizer open at its bottom in the lower portion of the tank and adapted to eject fluid from its interior toward its exterior into the surrounding liquid, baffles supported from below arranged about the rotary atomizer so as to allow fluid ejected by the atomizer to pass horizontally between the baffles, and means for supplying gas to the interior of the rotary atomizer.

9. In apparatus for treating liquids with gases, a tank comprising a series of compartments adapted to contain liquid, a perforated horizontal partition dividing the compartments into upper and lower portions and having communicating passages between the compartments in both the upper and lower portions, rotary members in the lower portions adapted to subdivide gas in the liquid, and means for introducing gas into the lower portions of the compartments to be subdivided by the rotary members.

10. In apparatus for treating liquids with gases, a tank for containing liquid divided into compartments by vertical partitions, perforated horizontal plates dividing the compartments into upper and lower portions said lower portions of the compartments communicating with one another through openings in the vertical partitions, rotary members in the lower portion of the compartments adapted to subdivide gas in the liquid, and means for introducing gas into the lower portion of the compartments to be subdivided by the rotary members.

11. In apparatus for treating liquids with gases, a tank adapted to contain liquid divided into compartments by vertical partitions, perforated horizontal plates dividing the compartments into upper and lower portions said lower portions of the compartments communicating with one another through openings in the vertical partitions, hollow rotary members in the lower portion of the compartments adapted to eject fluid from their interiors into the surrounding liquid, and means for introducing gas into the interior of said rotary members.

12. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary gas diffusing member journaled within the tank and submerged in the liquid, means for introducing gas into the lower portion of the tank to be atomized and diffused by the rotary gas diffusing member, and a baffle cage arranged about the rotary gas diffusing member, said baffle cage being comprised of a horizontal member with vertically attached baffles arranged about the rotary gas diffusing member.

13. In apparatus for treating liquids with gases, a tank adapted to contain liquid, a rotary gas diffusing member journaled within the tank and submerged in the liquid, means for introducing gas into the lower portion of the tank to be atomized and diffused by the rotary gas diffusing member, and a baffle cage arranged concentrically with the peripheral circle of the rotary gas diffusing member, said baffle cage being composed of upright baffles resting on and attached to a horizontal member, said horizontal member being supported and maintained in place from below.

WILLIAM E. GREENAWALT.