

W. E. GREENAWALT.
 APPARATUS FOR TREATING LIQUIDS WITH GASES.
 APPLICATION FILED NOV. 4, 1919.

1,374,445.

Patented Apr. 12, 1921.

3 SHEETS—SHEET 1.

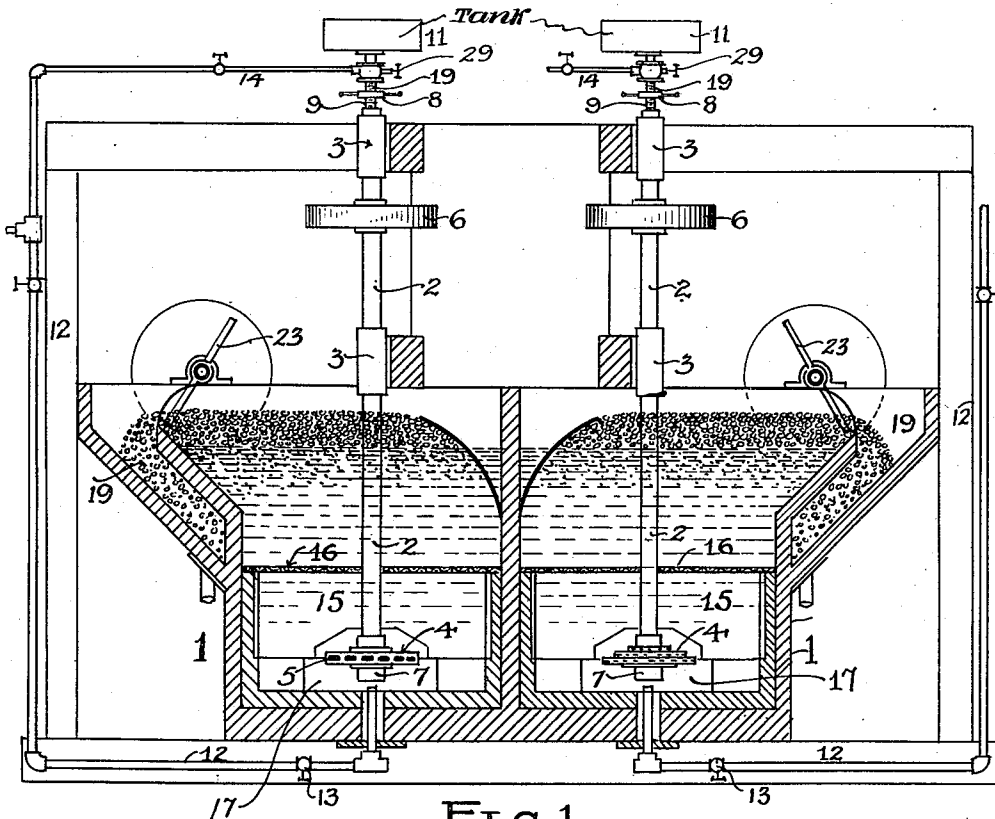


FIG 1

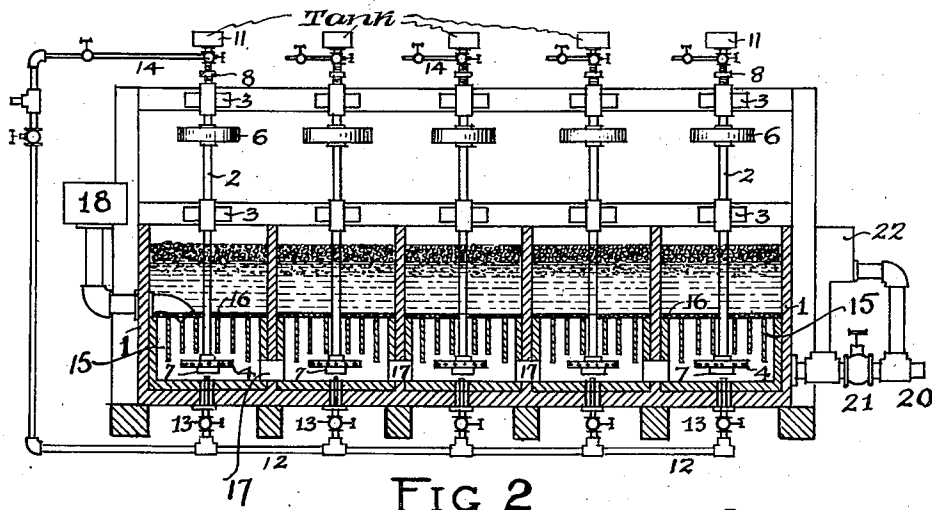


FIG 2

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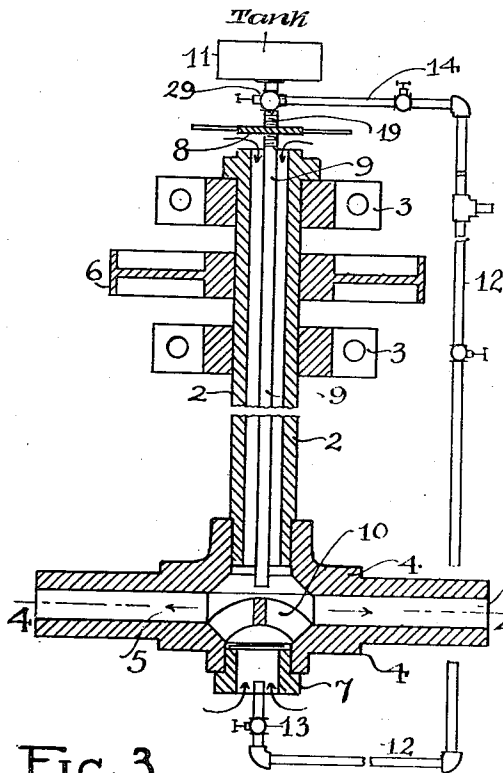


FIG 3

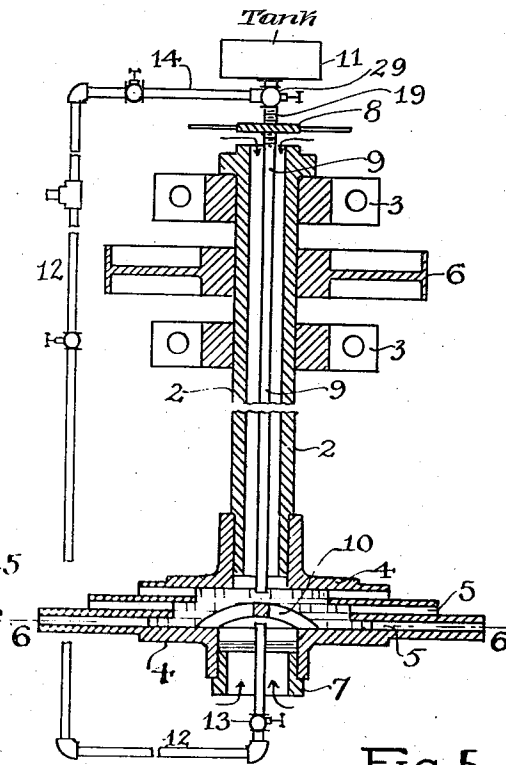


FIG 5

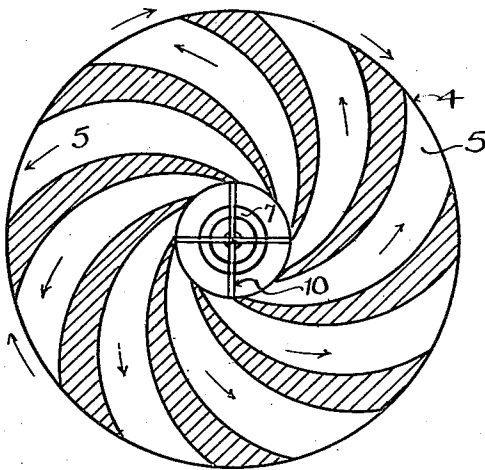


FIG 4

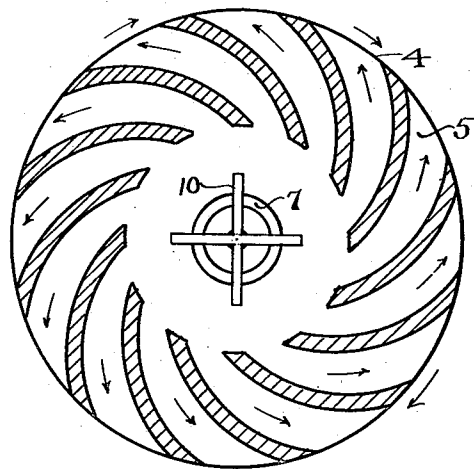


FIG 6

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3 SHEETS—SHEET 3.

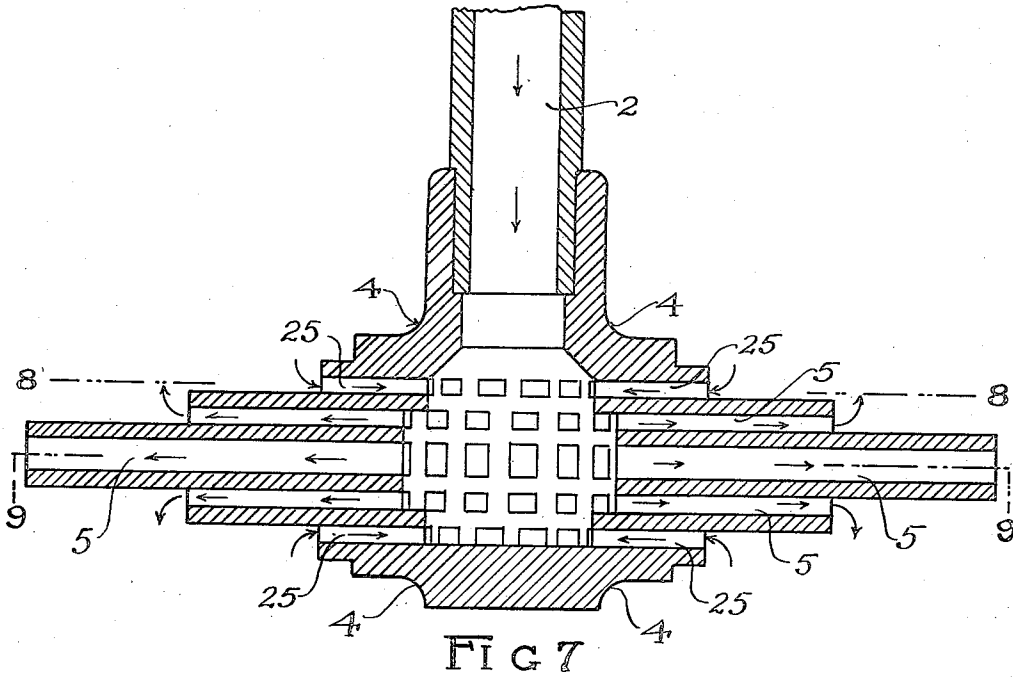
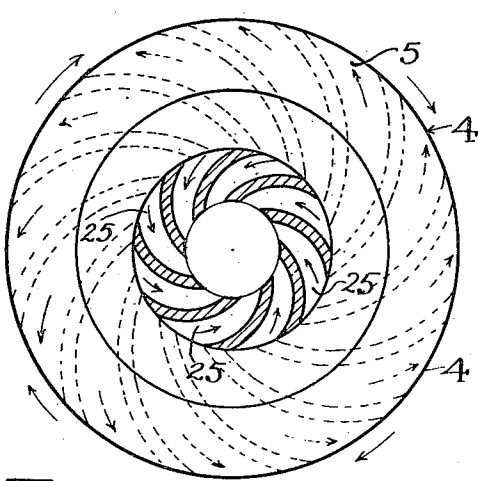


FIG 8

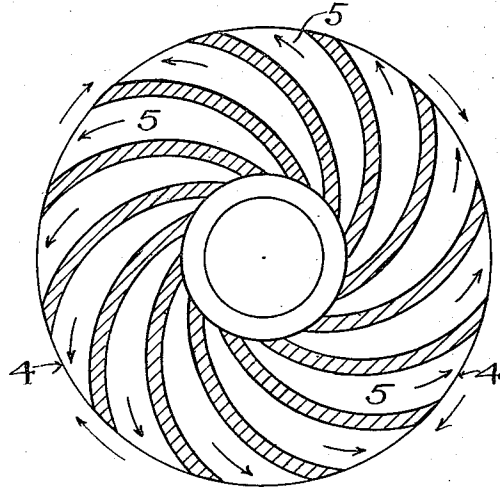


FIG 9

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR TREATING LIQUIDS WITH GASES.

1,374,445.

Specification of Letters Patent.

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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 object the effective application of gases to liquids to accomplish certain results, such, for example, as the precipitation of metals from their solutions by a gaseous precipitant, bringing metals into solution by means of a gaseous reagent, and the treatment of finely ground ores by flotation on the addition of a suitable flotation agent. It is not intended to limit it to any particular use, although in describing the apparatus the flotation treatment of ores will be kept more or less in mind.

This application may be regarded as a modification or improvement of that described in my co-pending applications, Serial No. 58,748, filed October 30, 1915, and Serial No. 68,718, filed December 27, 1915, and Serial No. 845,011, filed June 13, 1914.

The best results in the flotation treatment of ores of metals, under assumed conditions, are obtained when the air, or other gas, is finely subdivided, or atomized, in the liquid. It may be said that the results are more or less proportional to the extent to which the gas is atomized. In subaerating flotation machines in which the air is broken up by rapidly rotating paddles, the atomization is not effectively accomplished, either as to the fineness of the subdivision, or as to the power consumption. In consequence, there is not obtainable either the highest grade concentrate or the highest possible extraction of the mineral from the gangue.

In the present invention, as in my co-pending applications referred to, extremely effective subdivision of the gas is accomplished by passing the gas through ducts, or gas passages, in an atomizer submerged in the liquid and rotating the atomizer at a high speed.

In my co-pending applications referred to, the gas is preferably introduced into the liquid from a stationary gas outlet and delivered into the interior of the atomizer, and ejected into the liquid in the tank either by the pressure of the liquid on the gas, or

by the centrifugal action of the atomizer. This method is preferred in most instances because it admits of easy regulation of the gas within wide limits, and this regulation, in some types of machines, is quite essential for obtaining both a high grade concentrate and a high percentage of extraction. In the apparatus referred to, it is possible to eject only gas through the gas passages, or only liquid; or both, as desired, depending, usually, upon the amount of air used.

It is not always convenient, however, to supply the gas by means of a compressor. The gas may be supplied to the atomizer through a hollow shaft by the suction induced by the atomizer. Much the best results are usually obtained by ejecting a mixture of gas and liquid through the gas passages of the atomizer. In my co-pending applications referred to this is easily accomplished. It is not so easy if the gas is supplied to the atomizer through a hollow shaft by the suction induced by the rotary atomizer. This difficulty is overcome by the present invention as will now be described. Reference may be made to the accompanying drawings in which Figure 1, shows a cross-section of the apparatus. Fig. 2, a longitudinal section. Fig. 3, a detail of the atomizer in ideal vertical section, and Fig. 4, the corresponding horizontal section on the line 4—4 of Fig. 3. Fig. 5, a detail of a modified atomizer in ideal vertical section, and Fig. 6, the corresponding horizontal section on the line 6—6 of Fig. 5. Fig. 7, is another modified atomizer in ideal vertical section, and Fig. 8, is a horizontal section on the line 8—8 of Fig. 7, and Fig. 9, a horizontal section on the line 9—9 of Fig. 7.

In the drawings, 1 is a tank adapted to contain a liquid and the material to be treated; 2 is a hollow shaft vertically mounted in the bearings 3; 4 is an atomizer, suspended within the tank and submerged in the liquid, which, when rotated at a high speed, atomizes the air, or gas, in the liquid, by ejecting the gas, mixed with a portion of the liquid, through the passages 5. The shaft may be belt driven by means of the pulley 6. The speed at which the shaft is rotated will ordinarily vary from 250 to 1000 R. P. M., to get the best results. The degree of atomization of the gas, under assumed conditions, will depend almost entirely on the

speed of rotation. A little experimenting may be necessary in some cases to determine the most desirable speed.

Referring more particularly to Figs. 3, 4, 5, and 6, it will be observed that the atomizer 4 has a circular periphery and a smooth exterior surface so that when the atomizer is rotated at a high speed the friction with the liquid will not be excessive and the agitation reduced to a minimum. The atomizer is provided with gas passages 5 extending, preferably, from its interior central portion toward the periphery. These gas passages communicate with the atmosphere above the liquid through the hollow shaft 2, and with the liquid in the tank through the aperture in the plug 7, so that when the atomizer is rotated with sufficient speed both air and liquid may be ejected through the gas passages. It is evident, also, that if the aperture in the plug 7 is sufficiently large, liquid would be ejected to the exclusion of the air. To overcome this difficulty the plugs are made with different sized apertures. A little experimenting will determine the best plug to use. The idea is to constrict the opening in the plug so that the suction in the gas passages will also be sufficient to cause a flow of both gas and liquid through the gas passages. Having determined on the plug with the most suitable aperture for the conditions of speed of rotation of the atomizer and the depth of the atomizer in the liquid, the inflow of air can be regulated by the valve 8, above the opening in the shaft. This valve may be in the nature of a plate or disk 8 mounted on the pipe 9, a portion of which, 19, is threaded. By turning the disk on the stationary pipe 9, any desired regulation of air may be obtained, and by having a series of plugs with different size apertures any desired proportion of air and liquid may be obtained and ejected through the gas passages.

Within the central portion of the atomizer 4 are cross pieces 10 which rotate with the atomizer and thoroughly mix and distribute the gas and liquid before it is ejected through the gas passages 5. Much of the effectiveness of the aeration depends on the proper ejecting of a mixture of air or gas and the liquid. It is difficult to effect a thorough mixture after the air or gas has once been ejected through the gas passages into the liquid. The ejecting of a mixture of gas and liquid also gives a better distribution of the atomized gas in the liquid in the tank than when the gas is ejected alone through the gas passages.

It is frequently desirable to introduce other substances besides air and liquid into the atomizer. If the substance is a liquid, as for example a flotation agent, it may be put into the small tank 11 above the hol-

low shaft and, by means of the stationary pipe 9, introduced into the central portion of the atomizer where it may be atomized with the gas and tank liquid and ejected with the mixture. The flow of the substance passing through the pipe 9 may be regulated by the valve 29. The outlet to the pipe 9 should be below the surface of the liquid in the tank, and should preferably be in the central portion of the atomizer, as shown in the drawings.

Similarly, if some other gas beside air is to be used, such for example as sulfur dioxide, ammonia, or a vaporized flotation agent, it may be introduced through the pipe 12 and through the aperture in the plug 7, and its flow may be regulated by the valve 13. The pipe outlet is stationary, and the gas once delivered to the atomizer or into the liquid in the tank, is forced by the pressure of the liquid, and by the suction of the atomizer, into the central portion of the atomizer and ejected with the mixture of air and liquid. If desired the gas could be introduced through the stationary pipe 9 in the hollow shaft, through the pipe 14, as shown in detail in Figs. 3 and 5.

It is evident that air, as well as any other fluid, may be introduced through the pipe 14, and this may be desirable in the event that the submergence of the atomizer is too deep or the rotary speed too slow to create sufficient suction to cause a flow of air through the hollow shaft.

Referring now more particularly to Figs. 1 and 2, the application of the invention to the flotation treatment of ores will be described. The ore pulp is delivered to the box 18 and flowed into the first compartment, or cell, of the two series, back to back, of five cells each. The atomizers, driven at a rotary speed of from 250 to 1000 R. P. M. cause a flow of air and liquid into the interior central portion of the atomizers, and the mixture of air and liquid is ejected through the gas passages into the liquid in the tank. In this way the gas is finely subdivided or atomized in the liquid. The flotation agent is placed in the tank 11 and is introduced into the atomizer through the pipe 9 in the hollow shaft and its amount is regulated by the valve 29. If some other gas besides air is to be used, it is introduced into the atomizer through the pipe 12 or the pipe 14 and its amount regulated as desired.

In order to insure a thorough distribution of the atomized gas and to maintain a quiescent surface of the liquid, baffles, 15, are placed in proximity to the atomizers. A screen 16 may be placed on top of the baffles to further insure quiescence. The tops of the baffles are kept below the surface of the liquid and the bottoms of the baffles some distance above the bottom of the cells.

The pulp flows from one cell to the next of the series through the openings 17, at or near the lower portion of the cells. There is, preferably, no other liquid connection

5 between the cells.

When the ore pulp is introduced into the first cell of the series, some of the mineral froth is floated to the surface of the liquid and overflows into the froth launder 19. The

10 tailings from the first cell are passed into the next through the opening 17, and their passage is facilitated by the rotary motion of the pulp in the lower portion of the cells, below the baffles. If it were not for this

15 rotary motion of the liquid in the lower portion of the cell there might be danger of clogging due to the rapid settling of coarse tailings in a quiescent liquid. The tailings from the first cell are given a further treat-

20 ment in the second, and from the second in the third, and so on for the entire series of cells. The pulp is then wasted through the outlet 20. This outlet is arranged with a valve 21 to take a portion of the flow con-

25 taining the coarser material, and an overflow 22 by means of which the height of the liquid in the tank, or in the entire series of cells, may be regulated at will. The open-

30 ings between the cells are intended to be large enough so that there will be no appreciable difference in the liquid level of the various cells due to the rotary atomizers. Skimmers 23 may be used to assist in removing the mineral froth from the surface of the

35 liquid.

Manifestly, by the arrangement in this apparatus, any particle of mineral which has a tendency to float will be floated above the level of the atomizers, while the tailings which have no mineral particles attached

40 and have no considerable tendency to float are worked very quickly through the entire series of cells. It will be observed that in this apparatus a mineral particle once float-

45 ed cannot escape without first descending against the ascending highly atomized gas, to the openings 17 and the outlet 20. The entire tendency is to keep mineral particles which have a tendency to float in the appa-

50 ratus as long as possible, and expel the totally barren gangue as quickly as possible. It is possible also, to get various floating conditions in the different cells by varying the speed of rotation of the atomizers which

55 can be done by having various size pulleys on the main driving shaft, (not shown). The mixture of gas and liquid may also be varied in the different cells, as also the flotation agent, or gas other than air introduced

60 through the pipe 12.

Referring to Figs. 7, 8 and 9, which show a modified form of atomizer, the gas flows into the interior of the atomizer through the hollow shaft 2. The atomizer has two sets

65 of passages extending from its interior to-

ward its periphery: one set is indicated by 25 through which liquid from the tank is introduced into the interior of the atomizer: the other set is indicated by 5 and also extends from the interior toward the periph-

70 ery, through which the gas introduced through the hollow shaft 2 and the liquid introduced through the passages 25 are ejected into the body of the liquid in the tank. The

75 passages 25 are preferably inclined toward the direction of rotation of the atomizer, as shown in Fig. 8, in order to cause a pressure of liquid inwardly, and the passages 5, as shown in Fig. 9, are preferably inclined

80 away from the direction of rotation of the atomizer in order to eject the liquid and gases from the interior of the atomizer outwardly into the liquid in the tank and also create a suction inwardly through the hol-

85 low shaft. The liquid inlets 25, as shown in Figs. 7 and 8, are restricted in area the same as the inlets shown in Figs. 3 and 5, in order that gas may be sucked through the hollow shaft and in order that gas and liquid may be ejected through the passages 5.

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I claim:

1. In apparatus for treating liquids with gases, a tank adapted to contain a liquid, a rotary atomizer having gas passages extending from its central portion toward its periphery suspended within the tank and submerged in the liquid, means for causing a flow of gas to the central portion of the atomizer, means for causing a flow of liquid in the tank to the central portion of the atomizer, rotary means for mixing the gas and the liquid, means for ejecting the mixture of gas and liquid through the gas passages of the atomizer from its central portion toward the periphery and into the liquid in

95 the tank, and means for rotating the atomizer about its vertical axis.

2. In apparatus for treating liquids with gases, a tank adapted to contain the liquid, a rotary atomizer having gas passages extending from its interior toward its exterior suspended within the tank and submerged in the liquid, means for causing a flow of gas toward the interior of the atomizer, means for causing a flow of liquid in the tank toward the interior of the atomizer, rotary means for mixing the gas and liquid, means for ejecting the mixture of gas and liquid through the gas passages of the atomizer from the interior toward the exterior and

110 into the liquid in the tank, and means for rotating the atomizer about its vertical axis.

3. In apparatus for treating liquids with gases, a tank adapted to contain the liquid, a rotary atomizer having gas passages extending from its central portion toward its periphery suspended within the tank and submerged in the liquid, a hollow shaft communicating with the atmosphere above the liquid and with the gas passages of the

125 130

atomizer, a stationary pipe passing through the hollow shaft with its outlet in proximity to the central portion of the atomizer, and means for rotating the atomizer about its
5 vertical axis.

4. In apparatus for treating liquids with gases, a tank adapted to contain a liquid, a rotary atomizer having gas passages extending from its interior toward its exterior
10 suspended within the tank and submerged in the liquid, a hollow shaft communicating with the atmosphere above the liquid and with the gas passages of the atomizer, a stationary pipe extending downwardly within
15 the hollow shaft with its outlet extending below the normal surface of the liquid in the tank, and means for rotating the atomizer about its vertical axis.

5. In apparatus for treating liquids with
20 gases, a tank adapted to contain a liquid, a rotary atomizer having gas passages extending from its central portion toward its periphery suspended within the tank and submerged in the liquid, a hollow shaft communicating with the gas passages of the
25 atomizer, a stationary pipe extending downwardly within the hollow shaft and arranged for introducing a fluid substance through the stationary pipe and delivering
30 it to the atomizer and ejecting it with the gas through the gas passages into the liquid in the tank, and means for rotating the atomizer about its vertical axis.

6. In apparatus for treating liquids with
35 gases, a tank adapted to contain a liquid, an atomizer mounted on a hollow rotary member and communicating with the atmosphere above the liquid suspended within the tank and submerged in the liquid, said atomizer
40 having a set of passages extending from its interior toward its periphery and inclined toward the direction of rotation and restricted in area so as to cause a flow of gas and liquid into the interior of the atomizer,
45 and another set of passages extending from its interior toward its periphery and inclined away from the direction of rotation through which a mixture of gas and liquid is ejected into the liquid in the tank.

50 7. In apparatus for treating liquids with

gases, a tank adapted to contain a liquid, a centrifugal atomizer mounted on a hollow rotary member and communicating with the atmosphere above the liquid and with the liquid in the tank and suspended within the
55 tank and submerged in the liquid, said atomizer having two sets of passages extending from its interior toward its periphery and oppositely inclined in reference to the direction of rotation of the atomizer. 60

8. In apparatus for treating liquids with gases, a tank adapted to contain a liquid, a gas impregnator suspended within the tank and having its interior in communication with the liquid in the tank, means for causing
65 a flow of liquid in the tank into the interior of the impregnator, means for causing a flow of gas into the interior of the impregnator, rotary means in the interior of the impregnator for mixing the liquid and the
70 gas, and means for ejecting the mixture of liquid and gas into the liquid in the tank.

9. In apparatus for treating liquids with gases, a tank adapted to contain the liquid, a hollow rotary member having discharge
75 passages in the walls thereof suspended within the tank and submerged in the liquid, a hollow shaft communicating with the interior of said rotary member, and a stationary pipe extending downwardly
80 within the hollow shaft, and means for admitting a regulable quantity of gas under pressure through the stationary pipe to the interior of said rotary member.

10. In apparatus for treating liquids with
85 gases, a tank adapted to contain the liquid, a rotary member having discharge passages extending from its interior toward its exterior suspended within the tank and submerged in the liquid, a hollow shaft communicating with the interior of the discharge passages of the rotary member, a
90 stationary pipe passing through the hollow shaft with its outlet in the interior of said rotary member, and means for admitting a
95 regulable quantity of fluid through the stationary pipe into the interior of said rotary member.

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