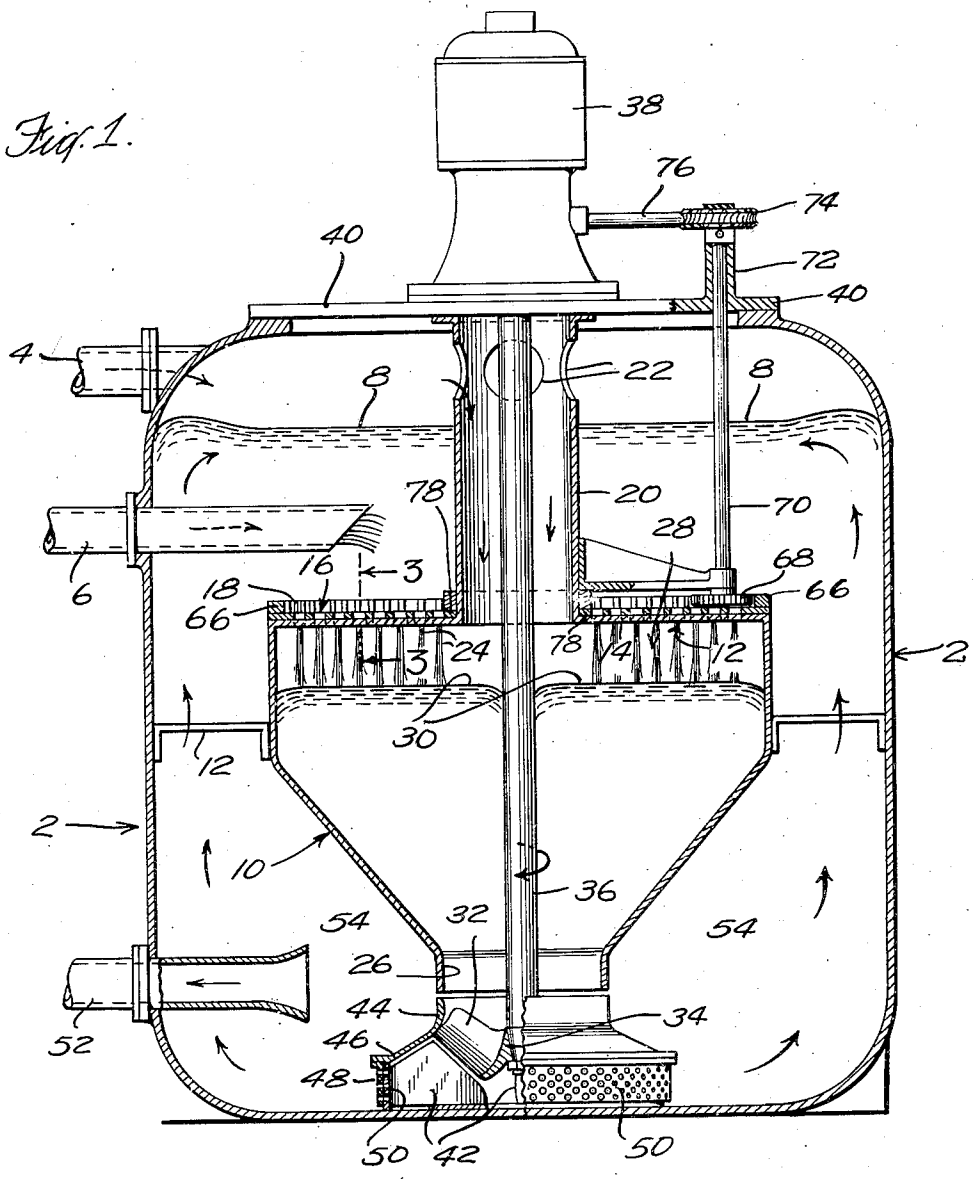
March 8, 1949. J. JOHNSON 2,463,975

APPARATUS FOR CHARGING OR OTHERWISE TREATING LIQUIDS WITH GASES

Filed April 11, 1945 4 Sheets-Sheet 1

Fig. 1.



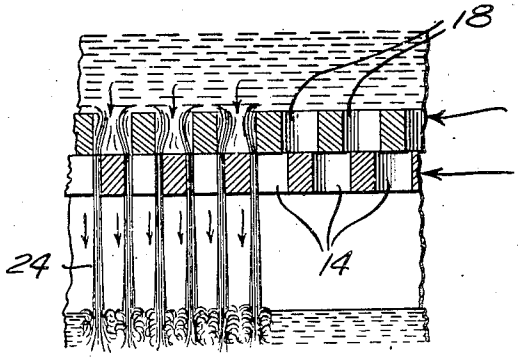


Fig. 3.

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APPARATUS FOR CHARGING OR OTHERWISE TREATING LIQUIDS WITH GASES

Filed April 11, 1945 4 Sheets-Sheet 2

Fig. 2.

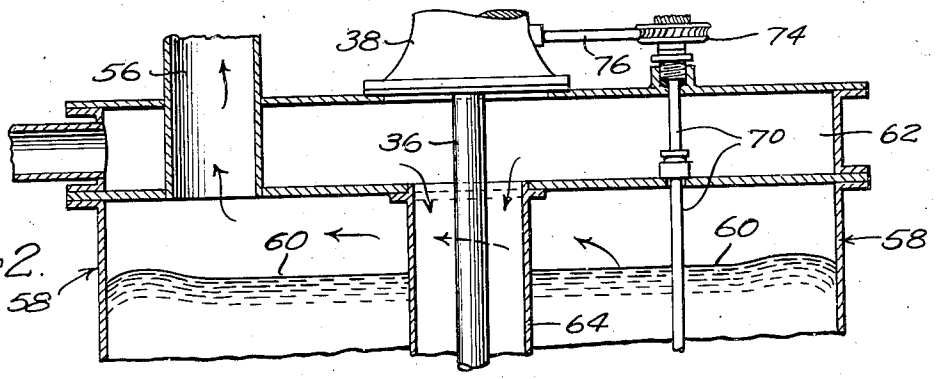
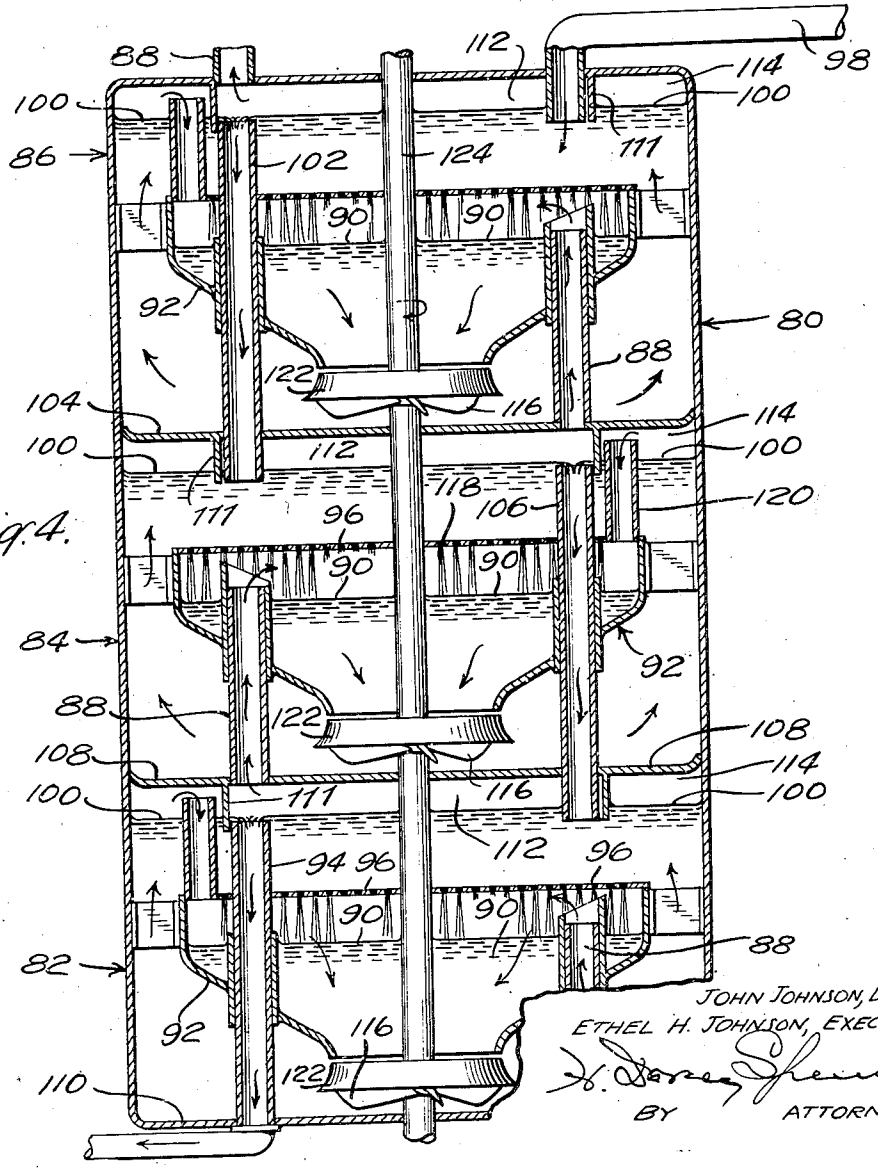


Fig. 4.



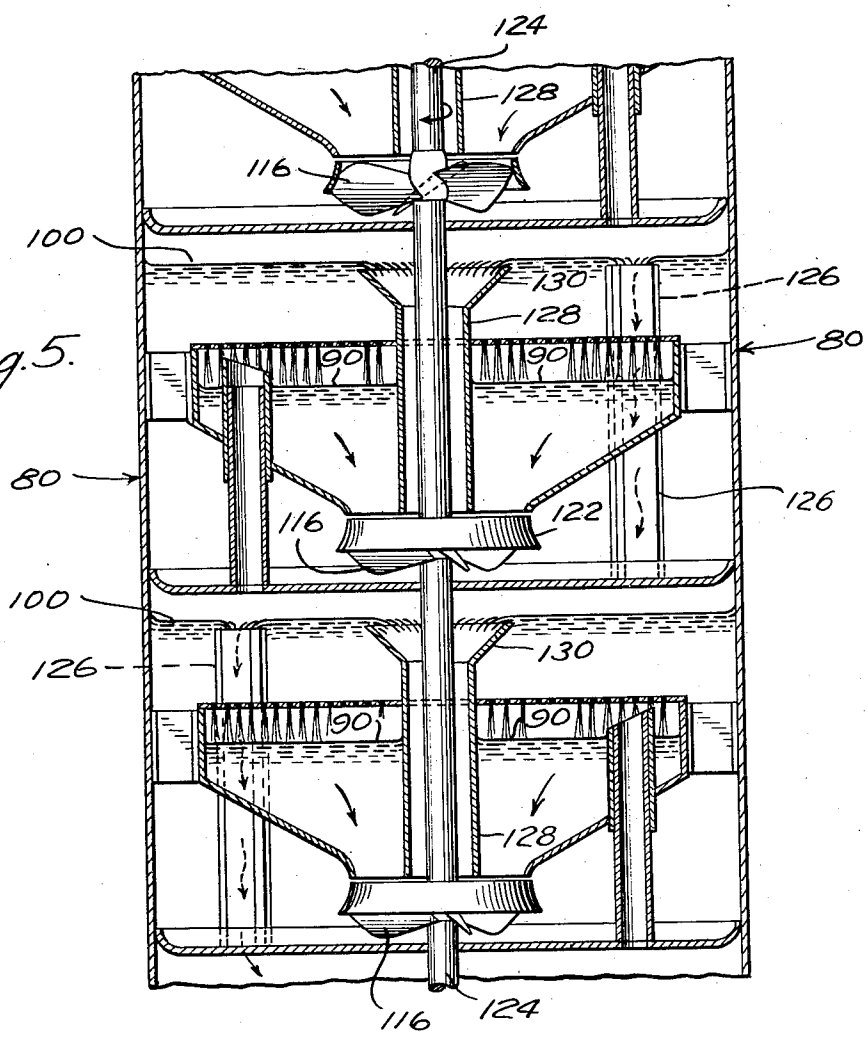
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ETHEL H. JOHNSON, EXECUTRIX.
BY
ATTORNEY

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APPARATUS FOR CHARGING OR OTHERWISE TREATING LIQUIDS WITH GASES

Filed April 11, 1945 4 Sheets-Sheet 3

Fig. 5.



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APPARATUS FOR CHARGING OR OTHERWISE TREATING LIQUIDS WITH GASES

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Fig. 6.

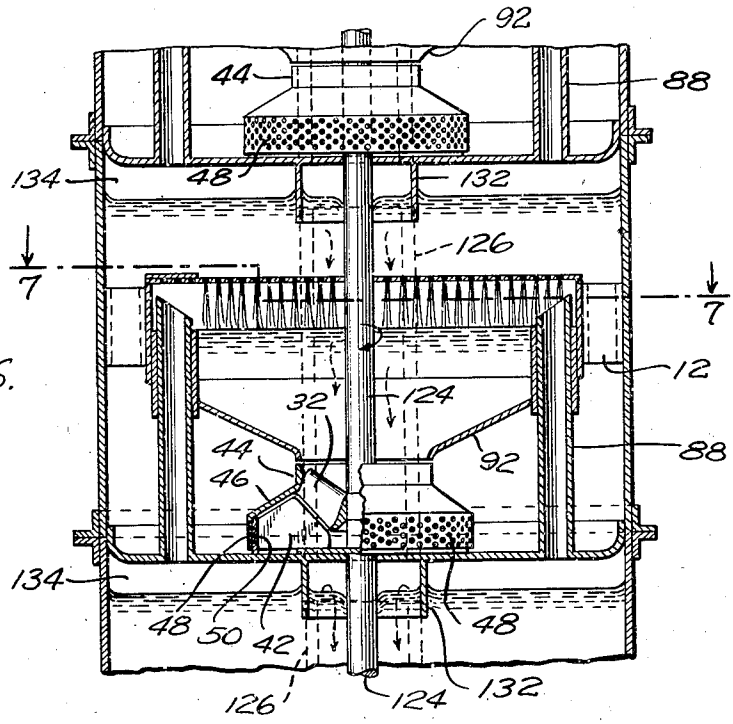
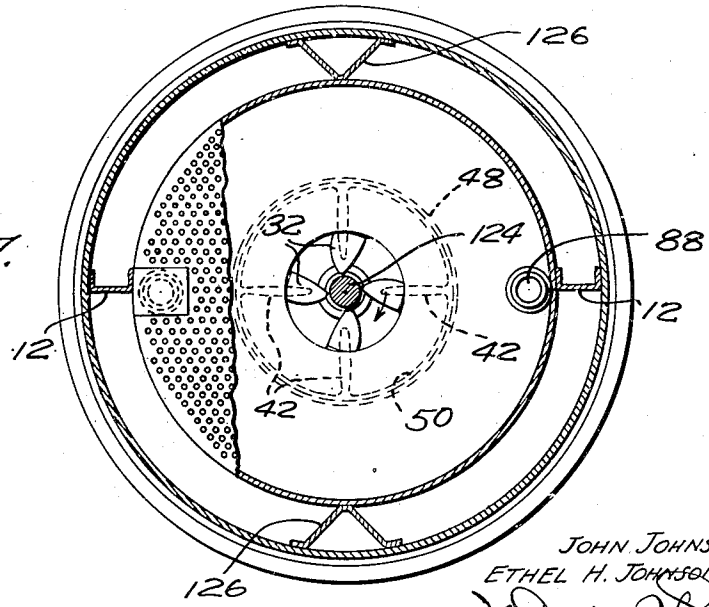


Fig. 7.



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Patented Mar. 8, 1949 2,463,975

UNITED STATES PATENT OFFICE

2,463,975

APPARATUS FOR CHARGING OR OTHERWISE TREATING LIQUIDS WITH GASES

John Johnson, deceased, late of Morristown, N. J., by Ethel H. Johnson, executrix, Morristown, N. J., assignor to John E. Johnson, Morristown, N. J.

Application April 11, 1945, Serial No. 587,798

14 Claims. (Cl. 261—93)

1

This invention relates to apparatus for effecting a thorough charging, impregnation or other mixing or treatment of a liquid with a gas and has for its general object to provide improved means that may be used for the aeration or carbonation of liquids for any purpose or for the hydrogenation or other gaseous treatment of liquids in chemical processes.

In order to bring about effective aeration, carbonation or other charging, impregnation or mixing of liquids with gases and also in order to carry on efficiently those chemical reactions which involve the diffusion of a gaseous reagent throughout a liquid, as in hydrogenation, it is important not only that the distribution of the gas throughout the liquid be as complete as possible, but usually that the gas be disseminated throughout the liquid in as fine bubbles as possible. A particular object of the present invention, therefore, is to provide apparatus in which the bubble size can be so controlled as to secure the desired impregnation or other treatment of a liquid with a gas, the apparatus being particularly adapted to effect a thorough diffusion of a gas, in the form of very fine bubbles, throughout the liquid to be impregnated or treated.

An important feature of the invention is the provision of means for effecting a thorough commingling of the parts of a liquid which has first been charged or impregnated with the desired gas in the apparatus, such treatment not only insuring thorough homogenization of the mixture of liquid and gas but insuring also the separation, for recycling or other disposition, of those bubbles of the gas which may be of a size not suitable for the desired end.

Another important feature of the invention is the provision of means for insuring a recycling, after the commingling or mixing operation, of those parts of the gas which have been introduced into the liquid but not effectively diffused therein.

Other objects and important features of the invention to which specific reference has not been made hereinabove will appear hereinafter when the following description and claims are considered in connection with the accompanying drawings, in which—

Figure 1 is a vertical section through charging or diffusing apparatus embodying the present invention;

Figure 2 is a vertical section through a slight modification of the apparatus shown in Figure 1;

Figure 3 is a detail section on the line 3—3 of Figure 1 showing the arrangement of the two

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perforated plates constituting the jet producing mechanism of the apparatus;

Figure 4 shows the invention embodied in a multiple unit arrangement in which the liquid to be charged or treated with the gas travels in succession through a series of diffusing units in one direction and any unabsorbed or unmixed gas travels through the units in the opposite direction;

Figure 5 is a view similar to Figure 4 showing a modified multiple unit construction;

Figure 6 is another vertical section similar to Figure 4 showing still another modification of the multiple unit construction, and

Figure 7 is a transverse section, on the line 7—7 of Figure 6, showing the overflow arrangement for maintaining the water levels in each of the successive units of the structure.

In the form of the invention shown in Figure 1, which shows a single unit with provision for recycling the unabsorbed or unmixed part of the gas and a part of the liquid, the diffusing apparatus comprises means, including a liquid container and a multiple jet producing device, for causing the liquid, which is to be charged, impregnated or treated with a gas, to travel in numerous intimately spaced jets through an atmosphere of said gas into a body of the said liquid in said container; means for maintaining a constant head upon the jets; means for maintaining the atmosphere through which the jets travel, and means for maintaining a constant level of the body of liquid, all in combination with means for effecting a thorough commingling of the parts of the charged liquid. As herein shown, the jet producing means and the means for effecting a commingling of the parts of the charged liquid are all contained within a main container 2 provided with a gas intake 4 and a liquid intake 6. No substantial head is required on the gas flowing into the chamber 2 through the gas intake 4 or on the liquid flowing into said container 2 through the liquid intake tube 6. The hydraulic head for producing the jets hereinafter to be described is provided by maintaining in the chamber 2 a constant liquid level 8—8.

Located within the container 2, which may be cylindrical, is a hopper-like diffuser structure 10, preferably concentric with the wall of the container 2 and supported therein by any suitable braces or brackets 12, welded to the inside wall of the container and to the outside wall of the hopper-like diffuser structure 10. The upper end of the diffuser casing 10 is covered with a stationary perforated plate 12 having preferably

hundreds of jet-producing openings 14 therein. There is preferably superimposed upon the plate 12 a second movable perforated plate 16, the perforations 18 in which are preferably of approximately the same size as the perforations 14 in the stationary plate 12 and may be moved into and out of complete register with the perforations 14 in the plate 12 for cleaning purposes. The plate 16 is rotatably mounted on the gas conduit 20 extending upwardly from the center of the perforated plate 12 and having, near its upper end, intake openings 22 through which gas to supply a gas atmosphere above the liquid in the diffuser casing 10 can pass into the conduit 20 and therethrough into the casing 10.

In one position of the plate 16 its holes 18 will be in full register with the holes 14 of the plate 12 so that liquid can flow freely therethrough and remove any material that may have clogged the jet openings. Preferably, however, the jet openings will be smaller than either the holes 14 or the holes 18 and therefore the plate 16 is preferbaly turned into a position so that only relatively narrow slits are left through which the liquid can pass to form the jets 24.

In order that the jets 24 may travel through an atmosphere of the gas, before striking the liquid in the diffuser casing 10, a liquid circulating rotor is connected with the outlet 26 at the reduced end of the casing 10 in such manner that it tends to draw down the level of the liquid in the casing 10 to provide a space 28, between the perforated plate 12 and the liquid level 30, in which the gas to be mixed with and diffused throughout the liquid can be brought into intimate relation to the jets 24.

The means for withdrawing the liquid through the outlet 26 from the diffuser housing 10 at such a rate as to create the gas space 28 above the liquid in the casing 10 is preferably associated with means for insuring a thorough commingling or mixing of the different parts of the charged liquid with each other as they are withdrawn from the casing 10 and discharged into the body of the liquid in the container 2. This mixing means is preferably of the general type of those disclosed in the co-pending application of John Johnson, deceased, Serial No. 569,719, filed December 26, 1944, the particular form shown in Figure 1 of this drawing being that disclosed in Figure 1 of the drawings of said co-pending application and comprising a rotor, having propeller blades 32 mounted on a hub 34, carried on a shaft 36 depending from a driving motor 38 mounted upon a cover 40 for the container 2. Cooperating with the propeller blades 32 are stator blades 42 which may be attached as shown to the bottom of the container 2.

The propeller blades 32 carry at their outer ends a flow directing shroud 44 which extends over the stator blades 42 and carries, attached to a flange 46 on its periphery, a cylindrical perforated plate or screen 48. The screen 48 is substantially contiguous to an inner cylindrical perforated plate or screen 50, the perforations in which are adapted to register with the perforations in the screen 48 in certain parts of the relative movements of the two screens. The screen 50, as shown, is attached to the stator blades 42 and therefore the screen 48 moves over the screen 50 as the rotor turns.

From the foregoing description it will be seen that the propeller blades 32 of the rotor, as the rotor turns, create a down flow of the liquid through the rotor, which, by reason of the shape

of the propeller blades, is a combined downward and outward flow, and that the liquid, as it strikes the stator blades 42, is subjected to a thorough mixing action even before it is discharged through the screens 50 and 48. After passing through the spaces between the stator blades 42 the liquid first strikes the screen 50 and passes through the perforations therein and then passes through the perforations in the screen 48, which is moving over the screen 50, so that the size of the resultant jet producing openings in the two screens varies constantly, the liquid being thus subjected to a hydraulic shearing action as it is withdrawn from the diffuser casing 10 and discharged into the body of the liquid in the container 2.

The liquid level 8—8 in the container 2 is maintained by providing an outlet pipe 52 in the container 2 through which charged liquid is withdrawn at a rate substantially equal to the rate of its introduction through the intake pipe 6. It will be seen, however, that, by reason of the action of the liquid circulating rotor, a considerable part of the liquid in the container 2 will be re-circulated and again pass through the jet-producing openings 14 and 18 in the plates 12 and 16, thus passing again through the gas atmosphere in the space 28 in the diffuser casing 10. It will further be seen that the outlet pipe 52 extends into the container 2 a sufficient distance so that the liquid discharged from the container will be that in the relatively inactive zone 54 between the upper surface of the shroud 44 and the conical lower surface of the hopper-like diffuser casing 10. The liquid thus discharged through the discharge pipe 52 will be that which has had the gas thoroughly diffused throughout it in the form of small bubbles, any large bubbles having a chance to escape and pass along up to the upper part of the container 2, where the bubbles are again discharged into the incoming stream of gas and recycled.

The rate of withdrawal of the charged liquid through the discharge pipe 52 is, as above stated, gauged so that it will maintain a constant level 8—8 in the container 2. The speed of rotation of the rotor propeller blades 32 is so determined that, with the head provided by the liquid level 8—8 and the rate of flow of the liquid through the jet openings 14 and 18 in the plates 12 and 16, the level of the liquid in the casing 10 will be maintained at the level 30—30. It has been found in practice that, with a head of about 12" from the plates 12 and 16 to the liquid level 8—8 and with a drop of 3" to 4" from the plate 12 to the liquid level 30—30, the jets 24 will carry the gas from the space 28 into the liquid in the casing 10 in the form of a very large number of very fine bubbles, e. g., about $\frac{1}{32}$" in diameter. These bubbles are then drawn into the rotor of the mixer or homogenizer hereinabove described and forced through the screens or perforated plates 50 and 48, which further tend to reduce the bubble size and to diffuse the gas thoroughly throughout the liquid. The fine bubbles, which are mixed with or absorbed by the liquid, as above stated, will be those which are eventually carried out through the discharge pipe 52 with the liquid. Also, as above stated, the large bubbles will rise through the liquid level 8—8 where they will break and the gas thus released will be recycled through the openings 22 in the gas conduit 20, through which they are led back into the gas atmosphere in the space 28 in the diffusing casing 10.

In the form of the invention shown in Figure 2 the gas, instead of being recycled as in the form shown in Figure 1, is passed only once through the diffuser and homogenizer, any gas not mixed with or absorbed by the liquid passing out through the gas discharge 56. In this form of the apparatus, which is well adapted for treating a batch of liquid, as in hydrogenation, the container 58 is provided with a batch of the liquid to be treated up to the level 60—60 and this liquid is passed through the diffuser and homogenizer and recycled in the same manner as in the form of the invention shown in Figure 1, but new liquid is not constantly introduced and charged liquid withdrawn, as in the invention shown in Figure 1. The gas with which the liquid is to be charged or treated is introduced into a gas compartment 62, superimposed upon the container 58, this compartment being connected with the gas atmosphere in the upper part of the casing 10 by a gas conduit 64 and the gas space above the level 60—60 of the liquid in the container 58 being connected with the gas discharge 56.

When liquid, containing material which is liable to cause clogging of the jet openings in the plates 12 and 16, is being charged or otherwise treated in the apparatus shown in Figure 1 or in that shown in Figure 2, provision is made, as hereinabove pointed out, for effecting a relative movement of the plates 12 and 16 to bring their openings 14 and 18 into complete register to effect a cleaning out of these openings and for then again adjusting them to provide the desired narrow slits for producing the jets 24 of small cross section. This adjustment may be effected from outside the casing in any suitable manner as, for example, by providing the perforated plate 16 with an annular, or segmental, rack 66 engaged by a pinion 68 on a shaft 70 extending through a bearing 72 on the cover 40 of the container 2. This shaft 70 may be turned by hand to effect the cleaning adjustment of the plates 12 and 16 or, if desired, when the annular rack is employed, it may be turned constantly to effect intermittent cleaning operations by means of a worm and worm gear drive 74 from a horizontal shaft 76 intergeared with the main propeller shaft 36 in any suitable manner, as by means of bevel gears not shown. The worm and worm gear drive 74, not shown in detail, will effect a slow turning of the plate 16 which, as above pointed out, has its hub 78 mounted on the gas conduit 20. This slow turning of the plate 16 will gradually vary the effective jet openings through the plates 12 and 16 from very small narrow jet-forming openings to full openings when the openings 14 and 18 come into register with each other.

In the modified form of the invention shown in Figure 4, the relatively movable shearing or homogenizing perforated plates 48 and 50, associated with the liquid circulating propeller, are omitted and the maximum impregnation or treatment is brought about by passing the liquid, in one direction, through a series of diffusers and mixers and the gas, in the other direction, through the same series. As shown in Figure 4, a series of three combined diffusers and mixers are arranged in a vertical column or stack, one above the other, in a common casing 80 in such manner that the charged liquid is withdrawn from the bottom compartment 82 and the gas is introduced into this bottom compartment 82, while the liquid is introduced into the top compartment 86 and spent gas is withdrawn from the said top compartment. As above suggested, the gas is introduced into the lowermost compartment 82 through a gas intake 88, above the level 90—90 of the liquid in the diffuser casing or housing 92 in this compartment, and the charged or otherwise treated liquid is withdrawn from this compartment 82 through the outlet pipe 94. The diffuser casing or housing 92 is of a construction substantially the same as that of the diffuser casing 10, shown in Figure 1, except that only a single jet forming perforated plate 96 is shown at its top and the gas intake pipe 88 passes through the conical wall of the casing 92 to discharge the gas in the space above the liquid level 90—90 in said casing. There is likewise provided in each of the diffuser casings 92 in each of the chambers 82, 84 and 86, a passage through the conical wall thereof for the overflow liquid from each of the upper compartments.

As shown, the liquid to be treated is introduced into the top compartment 86 through an intake pipe 98, which extends a slight distance below the surface 100—100 of the liquid in this compartment, this surface or liquid level 100—100 being maintained by the discharge pipe 102, which passes through the conical wall of the diffuser casing 92 in this compartment, through the bottom 104 of the compartment and then below the surface 100—100 or liquid level in the compartment 84. The liquid level in the compartment 84, like that in the compartment 86, is maintained by an overflow pipe 106 passing through the perforated top 96 of the diffuser, through the conical wall of the housing 92 and then through the bottom 108 of this compartment 84 into the compartment 82 and below the liquid level 100—100 in said compartment 82. The liquid level of the liquid in the compartment 82 is maintained by the discharge pipe 94 which can either have a discharge rate substantially equal to the intake rate through the intake pipe 98 or it can, as herein shown, like the overflow pipes 102 and 106, extend up through the bottom 110 of the compartment 82 through the conical wall of the diffuser housing 92 in said compartment 82 and to the level 100—100 of the liquid in the compartment 82.

In order that the gas bubbles which are not absorbed by or thoroughly mixed with the liquid may be recycled in each compartment, each compartment is preferably provided with a gas separator ring 111 which divides the space above the liquid level 100—100 in the compartment into a central circular space 112 and an annular space 114 surrounding it. It will be seen that the liquid which is recirculated by the rotor 116 will first come up on the outside of the diffuser casing 92 and enter the annular space 114, the gas ring 110 projecting slightly below the level 100—100 of the liquid in each compartment. This permits the bubbles of gas which have not become thoroughly mixed with or absorbed by the liquid to break in the annular space 114 and be again drawn into the atmosphere in the space 118 above the liquid level 90—90 in the casing 92, the gas passing down through the intake tube 120 projecting up into the space 114.

Those bubbles of gas which have been absorbed by or thoroughly mixed with the liquid will pass under the gas ring 111 and be recirculated. Some of these bubbles, however, particularly when the liquid has become thoroughly charged, will be released into the space 112 and pass up through the gas tube 88 into the next chamber above where they will be discharged

into the gas atmosphere maintained in the space 118 in said chamber.

It will be noted that the means for effecting the circulation and maintaining the level 90—90 in the casing 92 in the form of the invention shown in Figures 4 and 5 is a simple propeller rotor 116 of the type shown in Figure 1 of the co-pending application of John Johnson, deceased, Serial No. 563,500, filed November 15, 1944 now Patent 2,450,802 dated Oct. 5, 1948, this rotor having a flow-directing shroud 122 connected to its propeller blades but having no stator blades associated therewith. This rotor, like that shown in Figure 1 of the present application, may be driven from a driving shaft 124 connected to any suitable motor, not shown, mounted upon the top of the multiple unit structure.

In the form of the invention shown in Figure 5, which shows another multiple unit structure, the means for maintaining the liquid level in each compartment comprises a pipe 126 extending to the desired level 100—100 in each compartment and draining any excess liquid in this compartment either into the next compartment below or to the outside of the apparatus. In this form of the invention there is also provided a second down pipe 128, surrounding the driving shaft 124 and having a funnel-like top 130 into which foam accumulating on the surface of the liquid above the level 100—100 can be drawn by the rotor 116 and recirculated to insure its diffusion throughout the liquid.

As shown, the down pipe 126 may be formed by welding a strip, V-shaped in section, to the inner wall of the casing 60. Since the apparatus shown in Figure 5 is provided with a foam collector the gas separator ring 110 is omitted from this apparatus.

In the form of the invention shown in Figure 6 the circulating unit is provided with the dispersing or homogenizing means shown in Figure 1, in order further to break up and diffuse the gas bubbles. In this form of the invention, as in Figure 6, the overflow or liquid level maintaining pipes in each compartment are of the form shown in Figure 5. This form of the invention differs from that shown in Figure 4 in that the gas separating ring 132, shown in Figure 6, is of much smaller diameter and the gas conductor 84, leading the gas to the next compartment above, opens into the space above the liquid in the annular space 134 outside the gas ring 132.

From the foregoing description it will be seen that the apparatus for charging or otherwise treating a liquid with gas of the present invention provides simple and efficient means for insuring a thorough dissemination of the gas throughout the liquid in the form of very fine bubbles and that the apparatus is of such a simple construction and nature that it is practically self-cleaning and cannot readily get out of order.

Although the homogenizing or dispersing means which is combined with the rotating propeller or liquid circulator of the illustrative embodiment of the invention is of the form shown in Figure 1 of the drawings of the copending application of John Johnson, deceased, Serial No. 569,719, filed December 26, 1944, it will be understood that other forms of homogenizing or dispersing means, such as shown in other figures of said copending application, may be combined with the liquid circulator without departing from the spirit of the invention and that other forms of liquid circulating means may also be employed.

What is claimed as new is:

1. Diffusing apparatus comprising, in combination, a container completely enclosing the liquid to be treated, a multiple jet producing device including a casing located in said container below the normal liquid level therein and having a jet producing top wall, a bottom discharge and liquid withdrawing means connected to said bottom discharge for maintaining a liquid level in said casing sufficiently below said jet producing top wall so that liquid in said container, which is to be charged, impregnated or treated with a gas, may travel in numerous intimately spaced jets through an atmosphere of the said gas into said liquid, and a gas intake into said casing through which gas may be introduced to maintain the gas atmosphere therein, said liquid withdrawing means including means for effecting a thorough commingling of the parts of said charged liquid with each other during withdrawal, said liquid container being shaped to provide recycling of said liquid through the jet device and said gas intake having openings therein above the liquid level in said container to receive and cause the reintroduction into the gas atmosphere in said casing of gas carried out of said casing by said liquid that has not become diffused therein.

2. Diffusing apparatus according to claim 1 in which said commingling means includes means for breaking the charged liquid up into many individual streams and effecting a mechanical shearing action on each of said streams.

3. Diffusing apparatus according to claim 1 in which the withdrawing means comprises jet producing screens interrupting the discharge to cause said charged liquid to stream therefrom in numerous intimately spaced jets.

4. Diffusing apparatus according to claim 1 in which the withdrawing means includes both means for effecting a thorough commingling of the parts of the charged liquid and means for causing the charged liquid to stream therefrom in numerous intimately spaced jets.

5. Diffusing apparatus in which the apparatus of claim 1 comprises one of a series of like devices which are so arranged that the liquid to be impregnated or treated travels in succession therethrough in one direction.

6. Diffusing apparatus in which the apparatus of claim 1 comprises one of a series of connected like devices so arranged one above the other that the unabsorbed or unmixed impregnating or treating gas may travel in succession upwards therethrough.

7. Diffusing apparatus in which the apparatus of claim 1 comprises one of a series of connected like devices so arranged one above the other that the liquid to be impregnated or treated may travel in succession downwardly therethrough in one direction and the unabsorbed or unmixed impregnating or treating gas may travel in succession upwardly therethrough.

8. Diffusion apparatus according to claim 1 in which the multiple jet producing device comprises means arranged for actuation from outside the apparatus for simultaneously varying the cross-sectional area of each of said jets.

9. Diffusing apparatus according to claim 1 in which the multiple jet-producing device comprises perforated plates, one superimposed upon the other and constructed to be moved relatively from a position in which the perforations of the two plates register into various perforation restricting

relations, and means for effecting such relative movements of said plates automatically.

10. Diffusing apparatus according to claim 1 in which the multiple jet-producing device comprises perforated plates, one superimposed upon the other and constructed for angular relative movement from a position in which the perforations of the two plates register into various perforation restricting relations.

11. Diffusing apparatus according to claim 1 in which the multiple jet-producing device comprises perforated plates, one superimposed upon the other and constructed for angular relative movement from a position in which the perforations of the two plates register into various perforation restricting relations and in which there are means extending to the exterior of the apparatus for effecting such relative movement.

12. Diffusing apparatus according to claim 1 in which the commingling means comprise substantially contiguous screens arranged in the path of flow of the liquid from the withdrawing means and relatively movable to bring the openings in each gradually into and out of complete register with openings in the other as the charged liquid is driven therethrough by the withdrawing means.

13. Diffusing apparatus according to claim 1 in which the withdrawing means comprise a liquid propelling rotor and in which stator blades adjacent to the rotor constitute a part of the commingling means.

14. Diffusing apparatus according to claim 1 in which the withdrawing means comprise a liquid propelling rotor and in which stator blades adjacent to the rotor constitute a part of the commingling means, substantially contiguous screens, one connected to said stators and the other to said rotor being so constructed and arranged that the relative movement thereof thus produced gradually brings the openings in each into and out of complete register with the openings in the other as the charged liquid directed thereto by the stator blades is driven therethrough by the propelling rotor.

ETHEL H. JOHNSON.
Executrix of the Estate of John Johnson, Deceased.

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