

Dec. 30, 1941.

E. J. LYONS ET AL

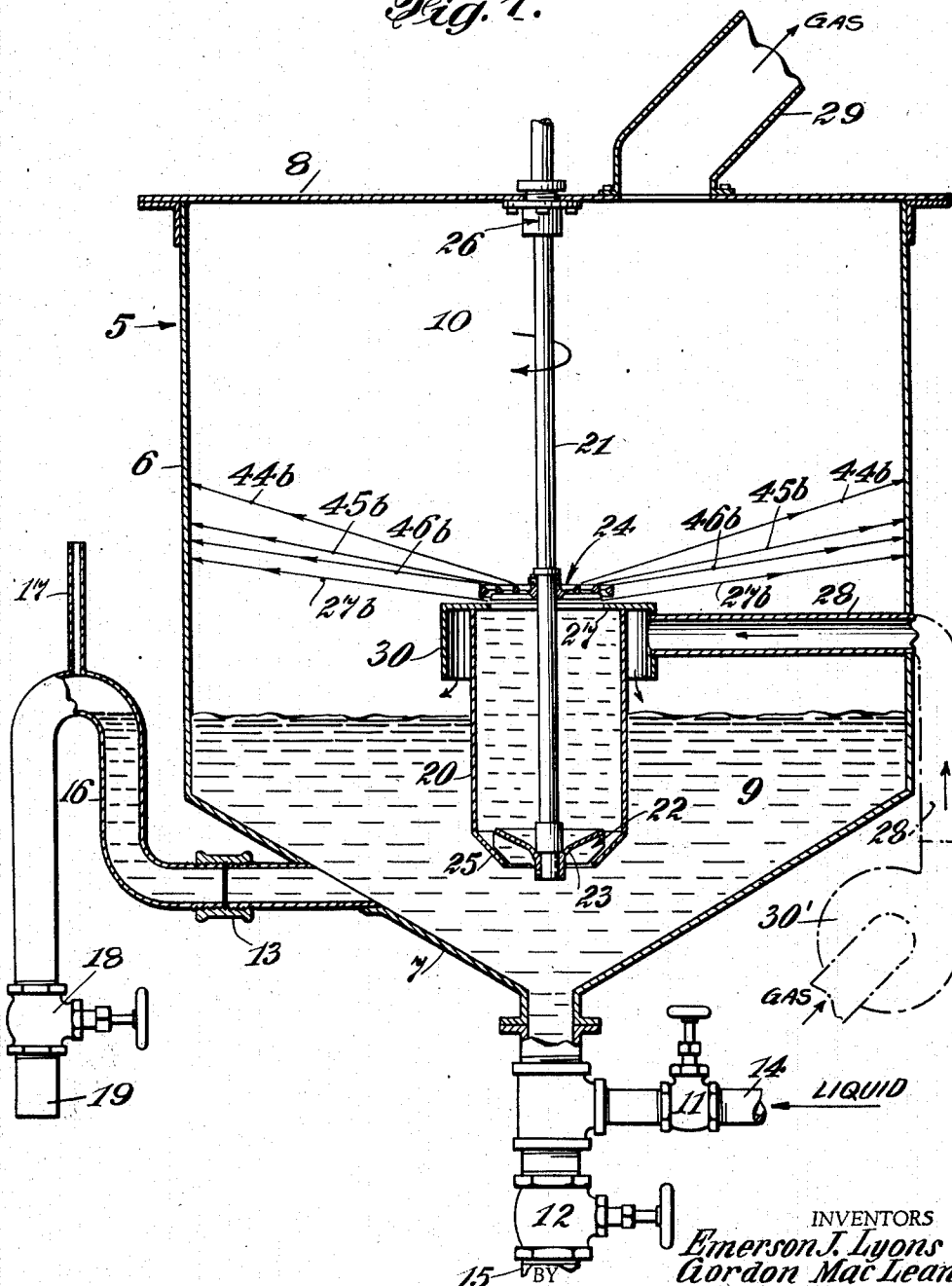
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GAS AND LIQUID CONTACT APPARATUS

Filed March 14, 1940

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Fig. 1.



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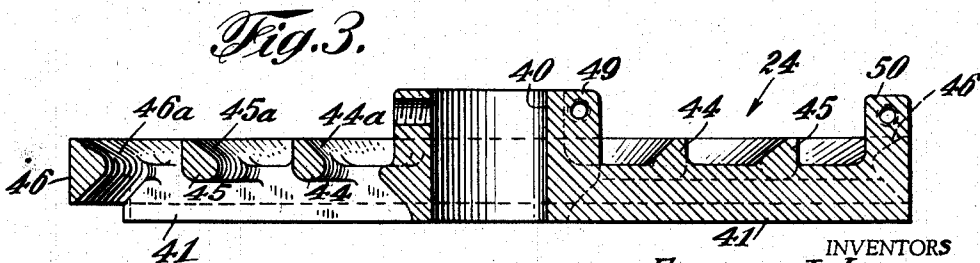
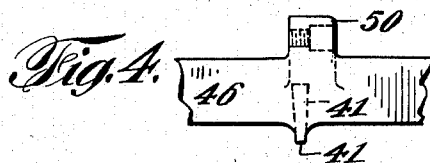
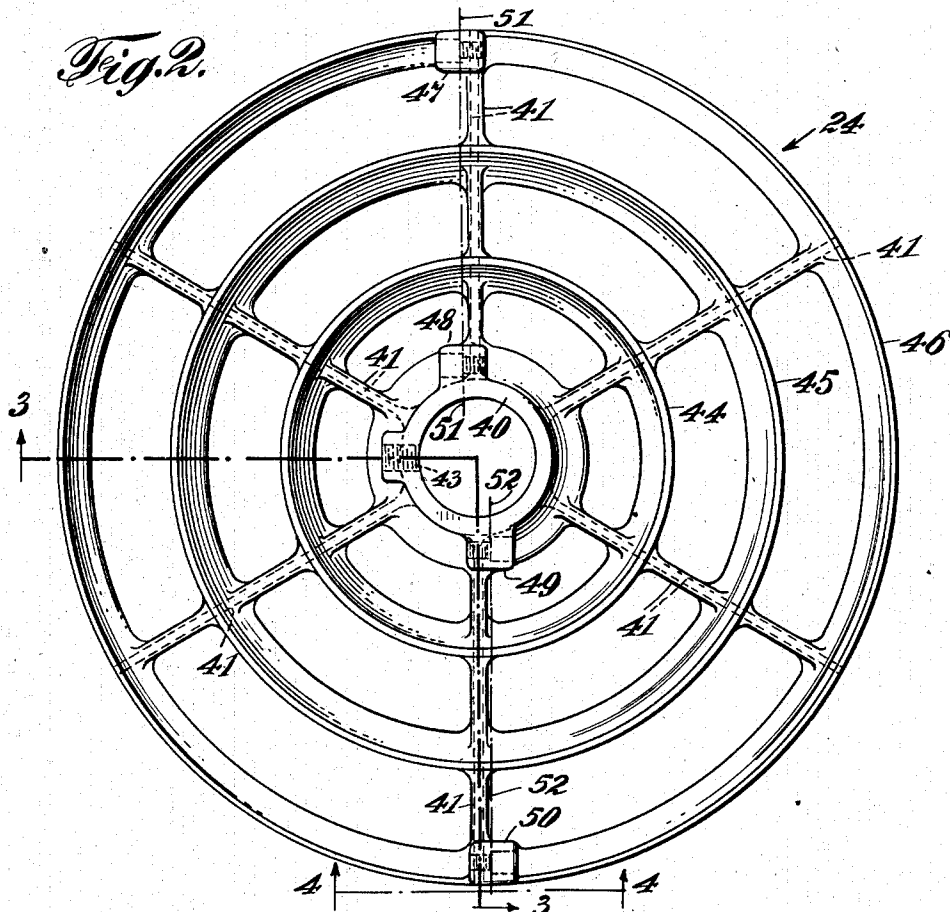
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GAS AND LIQUID CONTACT APPARATUS

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GAS AND LIQUID CONTACT APPARATUS

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12 Claims. (Cl. 261-91)

This invention relates to apparatus for treating liquid with gas or vice versa. One example of the treatment of liquid with gas is the hydrogenation of vegetable oil, i. e. the treatment of vegetable oil with hydrogen to effect a chemical combination of the hydrogen with the vegetable oil. One example of the treatment of gas with a liquid is the washing of air to remove dust particles suspended in the air or to remove soluble vapors which may be present in the air.

Gas and liquid contact apparatus is old and well known and is used for many industrial purposes of which the ones mentioned above are merely specific examples. While apparatus is available which is satisfactory in a sense for some purposes, certain disadvantageous limitations in such apparatus have persisted. Among these limitations are inefficient use of the gas in treating liquid, so that large quantities of the gas are wasted; long time of treatment required to reach the desired result either when treating a liquid with gas or vice versa; and large consumption of power required to effectively contact the liquid with the gas or vice versa.

General objects of the present invention are to provide apparatus which so effectively contacts liquid with gas, or vice versa, that the materials are effectively and efficiently utilized, and that reaction or operating time is diminished.

Another object is to provide gas and liquid contact apparatus which, with relatively large size liquid drops (when such is desirable) can nevertheless rapidly and effectively contact the liquid with the gas or vice versa.

A further object of the invention is to provide apparatus applicable for effectively treating a large volume of gas with a relatively small volume of liquid, thereby reducing the requirements as to amount of liquid in use, as to liquid replacement, and as to power consumed.

An additional object is to provide gas and liquid contact apparatus which automatically maintains optimum operating conditions despite a measure of variation in the liquid level in the apparatus.

Various additional and specific objects of the invention will be apparent to those skilled in the art from the accompanying disclosure.

Fig. 1 of the drawings is a partly diagrammatic central vertical section of an apparatus embodying the present invention;

Fig. 2 is a plan view of a disseminating impeller shown in Fig. 1;

Fig. 3 is a vertical section taken approximately on the line 3-3 of Fig. 2; and

Fig. 4 is a detail view in elevation, looking from the line 4-4 in Fig. 2.

Reference will first be had to Fig. 1. A closed tank designated as a whole by 5 has a cylindrical wall portion 6, a hopper-shaped bottom portion 7, and a removable cover 8. This tank is arranged to have liquid space 9 at the bottom and gas space 10 at the top. Piping with associated valves 11 and 12 provides for admission of liquid into the tank and also draining of the tank. With valve 12 closed and valve 11 open, liquid is admitted to the tank from inlet 14, it being understood that the liquid supply is under pressure or at a higher level. With valve 11 closed and valve 12 open, the tank is drained through outlet 15.

If desired, a broken siphon device 16 may be used to prevent accidental filling of the tank with liquid to more than a desired level. Tube 17 is open to the air; and with valve 18 standing open, the liquid level in the tank is limited to that shown in the drawings, any excess liquid passing out through outlet 19. By turning the gooseneck is coupling 13 the broken syphon device 16 can be set on an incline and thereby limit the liquid level in tank 5 to lower values than shown in the drawings. In case it is desired to fill the tank with liquid to a level higher than shown in the drawings, valve 18 can be closed and tube 17 (when made of glass) can be used as a gauge glass indicating the level of liquid in the tank. Some processes require heating or cooling of the contents of the tank. For this purpose the tank may be provided with a jacket or with coils (or both) through which heating or cooling fluid is circulated, as is well understood in the art.

Suitably mounted within the tank is a vertical conduit 20 having its lower end open to the liquid space 9 and its upper end open to the gas space 10. Depending co-axially into this conduit is a rotatable shaft 21 carrying liquid-feeding impeller 22 and a disseminating impeller 24. Impeller 22 is of a well known type but may be provided with a drain hole 23, so that liquid will not be held on top of it when the tank is drained. Adjacent to impeller 22 the conduit 20 is provided with a throat 25. Between impeller 24 and the top of the conduit there is a flow directing and controlling restriction 27 which is preferably large enough to pass impeller 22 during assembly or disassembly.

When the shaft 21 is rotating the impeller 22 continuously draws liquid from the liquid space 9 and causes it to be discharged from the

upper end of the conduit 20. Thus, the action is to keep conduit 20 in constantly overflowing condition. As the liquid overflows from the conduit, it is disseminated in the gas space 10 by impeller 24 as will be more fully discussed later. Shaft 21 may pass into the tank through a stuffing box at 26, and the shaft may be supported and driven in any suitable manner. To support and drive the shaft we prefer to use mechanism such as shown in U. S. Patent to Petry 2,151,146, issued March 21, 1939.

Gas may be continuously circulated through the gas space, entering through pipe 28 and leaving through pipe 29. The incoming gas may be fed in any suitable way as by a blower 30', and it is preferably discharged downwardly against the liquid surface and in an annular zone surrounding conduit 20. To this end, pipe 28 communicates with an annular hood 30 which surrounds conduit 20 and from which the gas is discharged downwardly against the surface of the liquid.

Reference will now be had to Figs. 2, 3 and 4 which show the details of the disseminating impeller 24. This impeller may be cast in one piece, and it comprises a hub 40 from which radiate equal spaced radial blades 41 (six shown). Merging with the upper portions of the blades, and extending above the tops of the blades, are radially spaced concentric rings 44, 45 and 46. At 43 the impeller is drilled and tapped to receive a set screw for locking the impeller to the shaft. If desired the impeller may be cast with lugs or enlargements at 47, 48, 49 and 50 so that the impeller can be cut in two and then bolted together. This makes it possible to insert the two impeller halves through a relatively small manhole in the treatment tank and then bolt them back together again on the drive shaft. If the impeller is to be severed, it is cut along dot dash lines 51 and 52; and in conjunction therewith the lugs 47, 48, 49 and 50 are drilled and tapped as indicated to receive cap screws for holding the two halves together.

In operation the impeller 24 so rapidly and thoroughly disseminates the liquid that an exceedingly large effective surface area of gas and liquid contact is produced. It should be noted that the different rings of impeller 24 act in different degrees upon the different annular components of the column of liquid flowing upwardly through conduit 20. This is because the peripheral speed of the various rings 44, 45 and 46 (as well as the intervening sections of blades 41) is different. Liquid which passes out between hub 40 and ring 44 will have imparted to it a trajectory which involves the factors of (a) vertical velocity in tube 20, (b) radial velocity imparted by the section of blades 41 between hub 40 and ring 44, and (c) the tangential velocity of ring 44. Of course this trajectory is a locus, rather than a single geometrical surface as all of the liquid will not leave from the same radius on ring 44. For liquid passing between rings 44 and 45, passing between rings 45 and 46, and passing between ring 46 and the top of restriction 27, the factors corresponding to (b) and (c) are increased, with resultant shifting of the trajectory loci. The shifting is toward flattening of the trajectories as the discharge point shifts outwardly of impeller 24; and for this reason the surfaces 44a, 45a, and 46a of the respective rings are set at progressively less inclination as shown in Fig. 3.

In all cases the trajectories are annular ones

which extend circumferentially around impeller 24. The net result is that the liquid is discharged in a series of pseudo conical or funnel-like loci, the funnel formations being concentric but with different angles of slope. The boundaries of each locus are two pseudo frusto-conical surfaces that are coaxial and have different slopes; and the various loci or funnel formations are also coaxial and have different shapes. The geometrical shapes are not truly conical because they are modified by the action of gravity on the flying drops, as well as by lifting effect of gas passing to exhaust 29. Of course the lifting effect varies with the size of the liquid drops and the rate of gas flow.

The trajectories of the liquid cannot be adequately shown on a two dimensional drawing; and moreover there are a multitude of possible effects depending upon the rate of upward feed of the column of liquid in tube 20, the increase in vertical velocity imparted by restriction 27, the speed and size of impeller 24, and the number of rings in impeller 24. In Fig. 1 there is shown trajectory lines 44b, 45b, 46b, and 27b which are merely hypothetical two dimensional trajectory lines to indicate the progressive flattening of the trajectories.

If the speed of impeller 24 is relatively high and the rate of vertical flow to the impeller is relatively low, the liquid will be very finely subdivided and thereby produce a large total surface of gas and liquid contact in space 10. To adjust the rate of vertical flow to impeller 24, a number of variables are available, including construction and speed of impeller 22, length of throat 25 in overlapping relation with the blades of impeller 22, amount of restriction established by member 27, level of liquid in tank 5, and other factors. If a high rate of gas flow is to be used, very fine liquid drops may be undesirable because such may be easily carried into exhaust 29, even if the exhaust pipe be made large to reduce entrainment. However, the present construction also produces large area of effective gas and liquid contact with relative large liquid drops. Large drops are produced by increasing the rate of vertical flow to impeller 24, which means more rapid recirculation of the liquid and greater speed of the flying drops. The increase in speed of the flying drops reduces the tendency for dead gas to collect about them; and the repeated and rapid breaking of the drops as they strike the tank wall, prevents stale conditions from developing either within or without the surface of the drops. By stale conditions we mean either a surrounding layer of gas which has had its potency reduced through the reaction with the drop, or a surface layer within the drop which has had its absorption capacity reduced through the reaction with the gas. Thus, even with relatively large drops, the effective surface of gas and liquid contact is very high.

In addition to the large surface of gas and liquid contact created in the main gas space, there is the surface contact of the gas with the liquid running down the tank walls and the contact of the incoming gas with the top of the main body of liquid. Since tube 20 is kept in overflowing condition, impeller 24 operates under optimum conditions despite variations in the main liquid level. The over all contact surface is so large as to provide efficient utilization of the gas and liquid, short reaction or treatment time, and often small power consumption.

In compliance with the patent statutes we have

disclosed the best form in which we have contemplated applying our invention, but it will be understood that the disclosure is illustrative of the invention without limiting the scope of the invention.

What we claim is:

1. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the bottom and gas space at the top; means to conduct liquid into the vessel; separate means to circulate gas into and out of the vessel; a stationary conduit located within the vessel and extending upwardly from the liquid space into the gas space; means to circulate the liquid in the vessel, the circulation taking the liquid upwardly through the conduit and discharging it into the gas space; and a rotary device separate from the conduit and operative to disseminate the liquid as it is discharged into the gas space.

2. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the bottom and gas space at the top; means to conduct liquid into the vessel; separate means to circulate gas into and out of the vessel; a conduit located within the vessel and extending upwardly from the liquid space into the gas space; means to circulate the liquid in the vessel, the circulation taking a column of liquid upwardly through the conduit and discharging it into the gas space; and a rotary device adjacent to the top of the conduit to disseminate the column of liquid as it is discharged from the conduit, said device including means to impart different trajectories to the different annular components of the column of liquid, such trajectories varying progressively from the center portion of the column to the peripheral portion of the column.

3. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the bottom and gas space at the top; means to conduct liquid into the vessel; separate means to circulate gas into and out of the vessel; a conduit located within the vessel and extending upwardly from the liquid space into the gas space; means to circulate the liquid in the vessel, the circulation taking the liquid upwardly through the conduit and discharging it into the gas space; a horizontal rotary impeller above the top of the conduit and operative to disseminate the liquid as it is discharged from the conduit; and annular means positioned adjacent to the top of the conduit to direct the flow from the conduit to the disseminating impeller, said annular means having an internal diameter smaller than the internal diameter of the conduit.

4. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the bottom and gas space at the top; means to conduct both gas and liquid into the vessel; a broken syphon device to automatically limit the level of liquid in the vessel; a conduit located within the vessel and opening bottom and top into the liquid space and gas space, respectively; means to establish flow of liquid from the liquid space, through the conduit, and out into the gas space; and a rotary device adjacent to the top of the conduit and operative to disseminate the liquid as it is discharged into the gas space.

5. Apparatus as in claim 1 in which the rotary device is an impeller having outwardly extending blades and also having spaced concentric rings.

6. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the

bottom and gas space at the top; means to conduct both gas and liquid into the vessel; a stationary conduit within the vessel and extending upwardly from the liquid space into the gas space, the lower end of the conduit having an annular inwardly extending portion providing a restricted throat; a rotary shaft depending longitudinally into the conduit; an impeller mounted on the shaft adjacent to said restricted throat in the conduit and in overlapping relation to said inwardly extending portion, said impeller operating to keep the conduit overflowing with liquid; and a rotary device mounted on said shaft above said conduit and operative to disseminate the overflowing liquid.

7. Apparatus as in claim 6 in which the rotary device is an impeller having outwardly extending blades and also having spaced concentric rings.

8. Gas and liquid contact apparatus comprising: a closed vessel having liquid space at the bottom and gas space at the top; a stationary conduit located within the vessel and extending upwardly from the liquid space into the gas space; means to conduct both gas and liquid into the vessel, the gas conducting means discharging the incoming gas downwardly in an annular zone surrounding said stationary conduit; means to circulate the liquid in the vessel, the circulation taking the liquid upwardly through the conduit and discharging it into the gas space; and a rotary device separate from the conduit and operative to disseminate the liquid as it is discharged into the gas space.

9. In gas and liquid contact apparatus of the type in which there is a liquid space, a gas space above the liquid space, a conduit extending upwardly from the liquid space into the gas space, flow producing means to keep the conduit in overflowing condition, and a rotary impeller at the top of the conduit to disseminate the overflowing liquid; the improvement which comprises: said impeller having at different radii from its axis of rotation spaces through which the liquid flows upwardly, and having adjacent to said spaces means located at substantially the same level to throw the liquid outwardly from points located in a common horizontal plane but at different radii from the axis of rotation.

10. In gas and liquid contact apparatus of the type in which there is a liquid space, a gas space above the liquid space, a conduit extending upwardly from the liquid space into the gas space, flow producing means to keep the conduit in overflowing condition, and a rotary impeller at the top of the conduit to disseminate the overflowing liquid; the improvement which comprises: said impeller having a series of concentric rings between which the liquid flows upwardly and from the tops of which the liquid is thrown outwardly, the tops of said rings being at substantially the same level.

11. In gas and liquid contact apparatus of the type in which there is a liquid space, a gas space above the liquid space, a conduit extending upwardly from the liquid space into the gas space, flow producing means to keep the conduit in overflowing condition, and a rotary impeller at the top of the conduit to disseminate the overflowing liquid; the improvement which comprises: said impeller having a series of concentric rings between which the liquid flows upwardly and from the tops of which the liquid is thrown outwardly, the tops of the rings being at substan-

tially the same level, and the impeller also having outwardly extending blades running from ring to ring.

12. In gas and liquid contact apparatus of the type in which there is a liquid space, a gas space above the liquid space, a conduit extending upwardly from the liquid space into the gas space, flow producing means to keep the conduit in overflowing condition, and a rotary impeller at the top of the conduit to disseminate 10

the overflowing liquid; the improvement which comprises: said impeller having a series of spaced arcuate members between which the liquid flows upwardly and from which the liquid is thrown outwardly; the upper surfaces of said members being inclined upwardly and outwardly, and the tops of said members being at substantially the same level.

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