ULTRASONIC DEGASSING OF MULTIPLE EMULSIONS IN A VERTICAL UNIT

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This invention relates to an apparatus for the ultrasonic degassing of multiple liquids in which the various elements are associated in an improved arrangement.

Ultrasonic treatment has been used for various purposes such as cleaning, degassing of liquids and emulsification but has as well been suggested for various other uses where the effect of ultrasonic vibrations might be of value such as aging wine, crystallizing sugar, extracting flavoring materials, homogenizing milk, etc. In those previous applications ultrasonic generating elements have been placed at the bottom portion of the tank holding the liquid to which the ultrasonic waves are imparted. Ultrasonic waves have been generated by both crystal transducers and by magnetostriuctive transducers.

One object of our invention is to provide an apparatus for the ultrasonic degassing of multiple liquids providing an arrangement of fluids and transducers so that there is obtained various advantages such as (1) more efficient deaeration (2) ability to deaerate more than one solution in one unit with a common transducer (3) less heat input to the solution in a secondary tank with resulting improvement in temperature control of effluent (4) less stagnation of flow and (5) more stable tuning of the transducer. Another object of our invention is to provide an apparatus for degassing multiple liquids in which the tanks containing the liquids and the transducer element which produces the ultrasonic vibrations are in axial alignment. A further object of our invention is to provide an apparatus for degassing multiple liquids including liquids whose flow rate is low. A still further object of our invention is to provide an apparatus for the ultrasonic degassing of multiple liquids in which the incoming liquids are diffused by baffles thereby distributing incoming fluid velocity across the tank and eliminating channelling. A still further object of our invention is to provide an apparatus in which the liquid-metal and liquid-air interfaces parallel to the transducing element are positioned an anti-nodes thereby imparting optimum efficiency. Further objects of our invention will appear herein.

Referring to the accompanying drawings, FIGURE 1 is a schematic representation and FIGURE 2 is a top view of one form of apparatus in accordance with our invention. FIGURE 3 is a schematic representation and FIGURE 4 is a top view of another form of apparatus in accordance with our invention. FIGURES 5 and 6 are a schematic representation and top view respectively of still another form of apparatus in accordance with the invention.

Referring to FIGURES 1 and 2 the apparatus illustrated therein consists of a bank of magnetostrirector elements, piezoelectric crystals or similar sonic device attached to the side of a vertical deaerating tank 2 through which Solution A which is to be deaerating passes, said solution being introduced by inlet 9 and withdrawn through outlet 19. The air or other gases which are separated from Solution A by the ultrasonic vibrations from element, 1, exit from the tank through outlet 7. If the degassing is carried out under atmospheric conditions, outlet 7 may open directly into the air. However, it is preferred that the air vent on the various degassing tanks be used in conjunction with a special pressure relief, air-operated diaphragm valve for in-line closed tank deaeration, such valves not being shown in the drawings. Thus equipping the air vents separately provides relief from excessive pressures and an air bleed for air accumulated during operation. It is advantageous to equip the deaeration tank with a baffle such as an inverted cone directly beneath the inlet 9 to distribute the incoming fluid velocity within the tank, which assists in eliminating channeling therein.

Immediately adjacent deaerating tank 2 is a second deaerating tank 6 provided with an inlet 11 and an outlet 12, through which a second liquid to the deaerating tank is passed. This tank 6 is separated from tank 2 by means of a sheet or diaphragm 4 which transmits ultrasonic vibrations from the liquid in tank 2 to that in tank 6. The diaphragm is held by a gasketed flange 5 to avoid leakage. The second deaeration tank 6 is provided with an air vent 8 to relieve gas pressure and with a diaphragm 4 and an inverted cone 3 to distribute the incoming fluid in the tank. Although in FIGURES 1 and 2 the primary tank is arbitrarily shown larger than the secondary tank, these tanks might be of equal or reversed dimensions. Additional tanks might well be attached to the primary of the secondary tank in like manner as tank 6 is attached to tank 2 to form a combination of apparatus for the deaeration of 3 or more solutions depending on the degassing characteristics of the solutions. In generating two different solutions by using the apparatus illustrated in FIGURE 1, it is desirable to introduce that solution having the higher flow-rate in the primary tank next to the transducer to carry away the heat generated by the electrical resistance in the transducer and the lower flow-rate liquid into the secondary tank. If on the other hand two solutions of equal flow-rate are to be deaerated but one solution is much more sensitive to the effects of an elevated temperature than the other, it would be preferable to deaerate the more sensitive liquid in the secondary tank. By contrast whereas solutions with concentrations of entrained air of 0.05% or more by volume flowing at 9 pounds per minute and having 60 cps. viscosity would not be deaerated in an open trough ultrasonic unit, if this liquid were put through a vertical tank of the same capacity in a combination of apparatus as pictured in FIGURE 1 the liquid would be successfully deaerated either in the primary or the secondary tank even if the solution had double the specified concentration of entrained air.

FIGURES 3 and 4 illustrate a multi-component water bath deaerator composed of a number of tanks mounted in a water bath. The apparatus illustrated as provided with one bank of piezoelectric crystals 21 can instead be provided with more than one ultrasonic wave generating transducer which in many cases would increase the efficiency of deaeration.

The water bath is provided with a water inlet 38, a water outlet 37 and a constant level device 39. Electricity from the water bath is a group of three tanks each of which is provided with means for feeding in solution 29, 31 and 33 and means for withdrawing solution from the bottom of the tanks 22, 26 and 24. The outlets being 30, 32 and 35. The tanks are each provided with inverted cones 23 to distribute the velocity of incoming liquids and with air vents 27, 28 and 34 which air vents here would be profitably fitted with diaphragm valves particularly should the air vents be situated below the level of the water in the water bath. The water bath serves both to transmit the ultrasonic vibrations to the liquids in the tanks and to control temperature such as by dissipating the heat generated by the transducers. If desired the water introduced into the water bath can be cooled to a lower temperature prior to introduction thereto. If for some reason the water bath should be maintained at a constant temperature, thermostat control is desirable provided with the
water bath reservoir jacketed to provide temperature regulation all as is well-known in the art. FIGURES 5 and 6 illustrate a double pipe vertical deaerator composed of a central pipe used for deaerating one solution and an outer pipe for deaerating another, the outer pipe being provided with a transducer to provide the ultrasonic vibrations for deaerating the solutions. Outer pipe 42 is fitted with inlet 46 and outlet 49 so that the liquid to be deaerated can be passed through the outer pipe. Inner pipe 43 is provided with inlet 47 and outlet 48 enabling passage of liquid through the central pipe. Both the central and outer pipes are provided directly beneath their inlets with inverted cones 44 for the purposes stated above. Both the central and outer pipes are provided with air vents to discharge air or gas which has been separated from the liquid passing through the apparatus.

In the apparatus illustrated by FIGURES 5 and 6, the transducer might be at the core of the concentric pipes instead of on the outer wall of the outermost pipe, the sonic device being inside of the central pipe surrounded by a plurality of pipes concentric with the central pipe. In this type of apparatus the walls should of no more than a certain thickness to transmit the ultrasonic vibrations. Twenty-gauge stainless steel pipe (.038 in. thickness) has been found to be quite suitable for this purpose but for good results no thicker than 16 gauge pipe (.062 in.) should be used. In the case of the water bath type of apparatus the liquid to be deaerated should have walls of no more than 16 gauge thickness and preferably 20 gauge thickness or less. An advantage of the water bath type deaerating equipment is in keeping halide ions away from the walls of the transducer particularly where material susceptible to corrosion is used. In the water bath type deaerator the tanks in the water bath may be in staggered relationship to each other rather than in line if desired.

In deaerating liquids with the apparatus as described the rate at which the liquids are passed through the various tanks will depend in some measure on the viscosity of the solution to be deaerated, the height of the tanks and the effectiveness of the transducing element employed.

It is desirable that the liquid-metal and liquid-air interfaces which are parallel to the transducer face should be positioned at distances from the transducer face which are anti-nodes for optimum efficiency. In FIGURE 1 it is desirable that the diaphragm separating Solution A from Solution B and the side of the secondary tank parallel to the transducer should each be established at an anti-node distance. In FIGURE 3 each of the 6 walls parallel to the transducer element of the back wall of the water tank should be positioned at an anti-node distance. These distances can be calculated by using the velocity of sound and the vibration frequency. For example, with the velocity of sound through air free water=5000 feet per second at 35° C. and using a transducer frequency of 40 kc./per second.

\[
\text{Wave length} = \frac{5000 \text{ feet per second} \times 12 \text{ inches per ft.}}{40000 \text{ ey. per second}} = 1.50 \text{ inches}
\]

As an anti-node exists at the point of propagation of sound, other anti-nodes exist at every half length for the sound path perpendicular to the face of the transducer. In accordance with the example, these points would occur at the following intervals:

\[
34, 116, 214, 3, 3\times4, 4, 5\times4, 6, 6\times4, 7\times4, 8\times4, 9 \text{ inches etc.}
\]

Where transducers are opposed such as on opposite sides of a tank, it would be desirable to skip every other point in determining optimum points for walls to reside such as 34, 214, 3, 3\times4, 4, 6\times4, etc. inches.

Results from one run showed complete entrained air removal of 0.10% air by volume of fluid flowing through the apparatus when the interfaces were established at anti-nodes distances but where the interfaces were established at a node or low intensity point only 0.06% air removal was obtained using the same conditions otherwise.

Deaeration in accordance with our invention removes the entrained air but not dissolved air in the liquid being treated. However if the temperature of the liquid increases, the dissolved air is converted to entrained air hence heating up of the liquid being deaerated should be avoided as much as possible.

Our invention is particularly of value in the deaerating of photographic emulsions, or photographic colloidal solutions generally, particularly where there are solutions affected adversely by the heat from the transducer, for example sizing or overcoating solutions. In these cases it is desirable that the higher flow rate material such as the photographic emulsion be used in the tank next to the transducer to carry away the conducted heat and the more sluggish solution or solutions be passed through the secondary or successive tanks so as to avoid undue temperature rise resulting from the slow speed at which they pass through the deaerating chamber. It is also useful for deaerating latex coating solutions or any other liquid coating compositions of elevated viscosity particularly prior to coating onto a surface.

The following examples illustrates the use of apparatus in accordance with our invention for deaerating multiple liquids by means of ultrasonic vibrations:

**Example I**

An apparatus as illustrated by FIGURES 1 and 2 comprising three 6" x 6" x 20" vertical compartments served by a bank of eight 28-watt piezoelectric transducers was fed with a gelatin solution having a viscosity of 18 cps. The solution was rendered entrained air-free at a flow rate of 8 lb./min. for entering entrained air concentrations of:

- Primary tank ———— up to 0.8% air by volume.
- Secondary tank ———— up to 0.5% air by volume.
- Tertiary tank ———— up to 0.4% air by volume.

**Example II**

An apparatus illustrated by FIGURE 1 was used composed of two 5" x 9" x 18" tanks served by 12 10-watt piezoelectric transducers. An aqueous solution of gelatin having 60 cps. viscosity was rendered entrained air-free when introduced at a flow rate of 12 lb./min. for entering entrained air concentration up to 0.15% by volume in the primary tank and 0.10% by volume in the secondary tank. The solutions were freed of entrained air so as to be useful for applying gelatin coatings to surfaces from bubbles, crescents, and other defects.

**Example III**

A water bath type of apparatus as illustrated by FIGURES 3 and 4 comprising a 2" x 2" x 26" primary tank and a 4\(\times\frac{1}{4}\)" x 4\(\times\frac{1}{4}\)" x 26" secondary tank served by twenty-four 10-watt piezoelectric transducers was used. There was fed thereto a colloidal solution of 18 cps. viscosity at a flow rate of 3 lb./min. through the primary tank and 6 lb./min. through the secondary tank for entering entrained air concentrations of up to 0.15% by volume in the primary tank and 0.30% in the secondary tank. The colloidal solution was rendered air-free and formed coatings free of bubbles and other like defects.

We claim:

1. An apparatus for removing entrained gas from liquids comprising a vertical chamber having a body of liquid therein and provided with a vertical deaerating tank having a body of liquid therein and a vertical wall, common to both said tank and said chamber, capable of transmitting ultrasonic vibrations from said liquid in said chamber to said liquid in said tank, vents at the top of said tank and of said chamber to release gas pressure, outlets from said tank and from said chamber below and significantly spaced from said vents and inlets to said
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5 tank and said chamber, and extending a substantial length of said chamber and spaced from said vertical wall common to both said chamber and said tank, an ultrasonic vibration device attached to a substantial height of a side wall of said chamber, which provides means for transmitting ultrasonic vibrations from said device through the liquid in said chamber, said common vertical wall, and finally into the liquid in said tank.

2. An apparatus for removing entrained gas from liquids comprising a plurality of concentric vertical tanks each having a body of liquid therein and each having a vertical wall common to another of said tanks, capable of transmitting ultrasonic vibrations from said body of liquid in one tank to said body of liquid in the other, vents at the top of each of said tanks to relieve gas pressure, outlets from each of said tanks, below and significantly spaced from said vents, and inlets to said tanks, and attached to a substantial height of a vertical outer wall of the outermost tank, an ultrasonic vibration device, which provides means for transmitting ultrasonic vibrations from said device through said body of liquid in said outermost tank, said common walls and said bodies of liquid in said concentric vertical tanks from said outermost tank to the innermost tank of said plurality of concentric tanks.

References Cited by the Examiner

UNITED STATES PATENTS

816,560 4/1906 Cooley 209—146 X
2,093,898 9/1937 Taplin 209—170 X
3,044,236 7/1962 Bearden 55—277 X
3,076,544 2/1963 Bodine 209—1
3,103,424 9/1963 Hosking 55—277 X

FOREIGN PATENTS

846,395 8/1952 Germany.

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