

March 15, 1960

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2,928,665

GAS-LIQUID MIXING APPARATUS

Original Filed Sept. 27, 1950

4 Sheets-Sheet 1

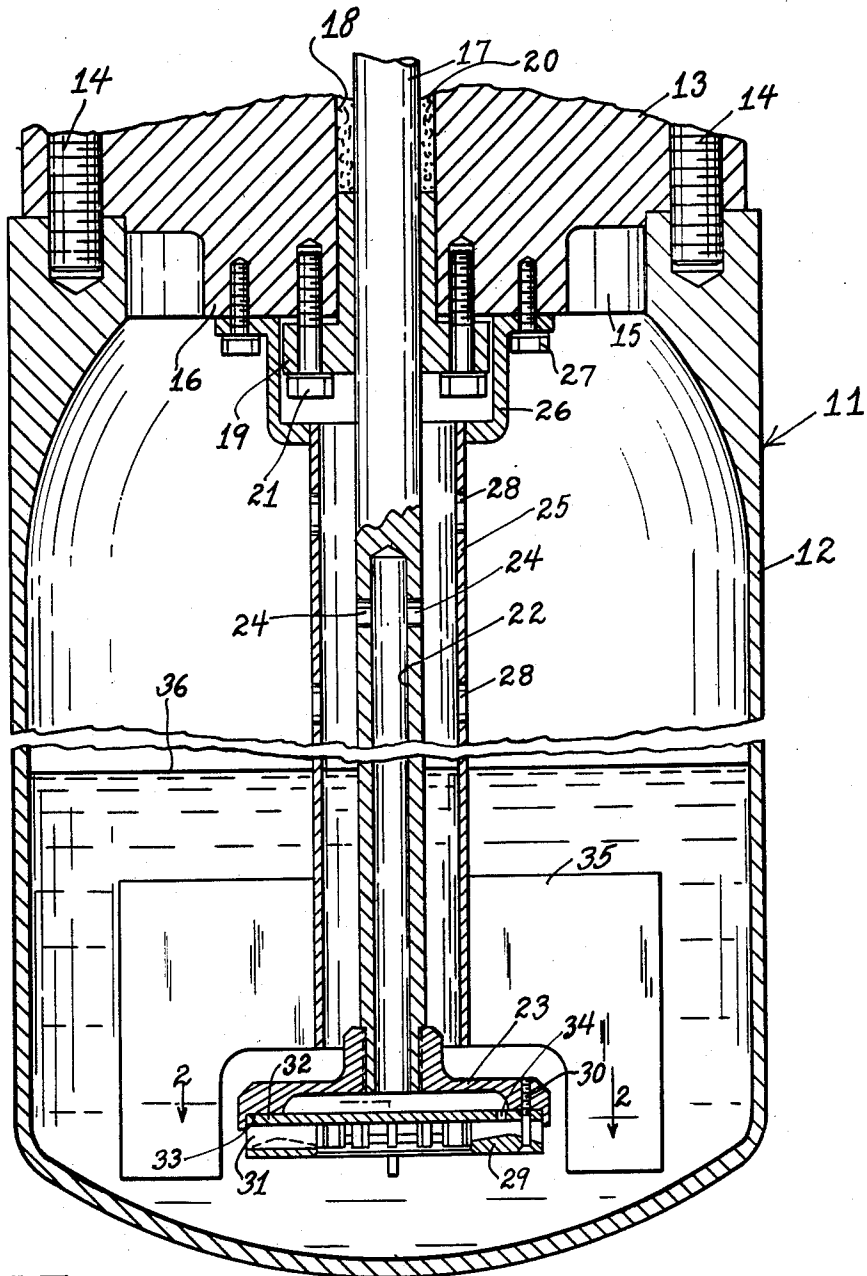


FIG. 1

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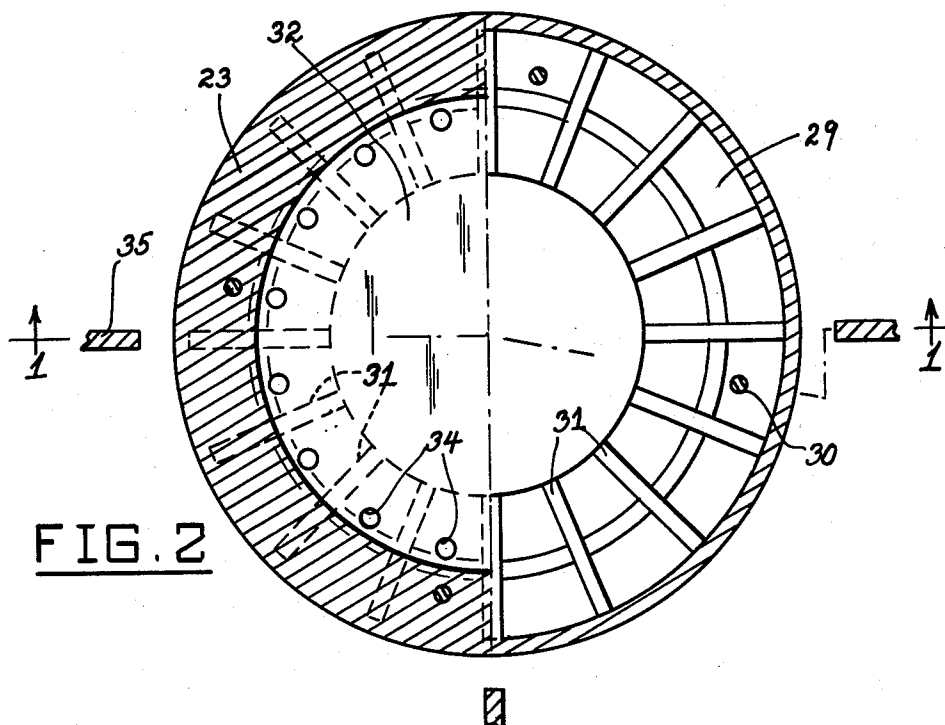


FIG. 2

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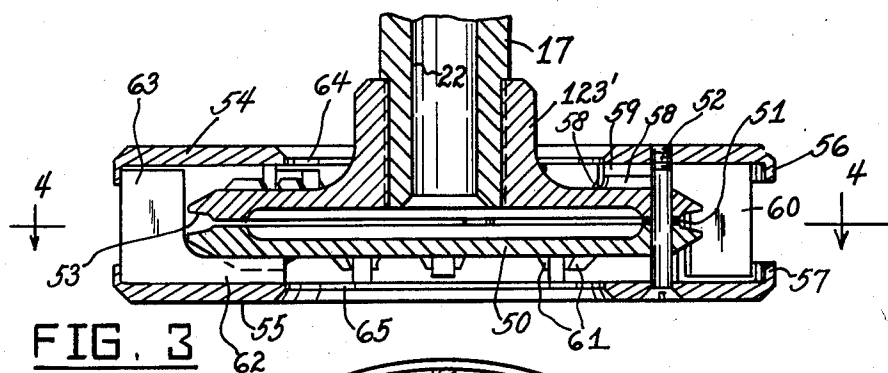
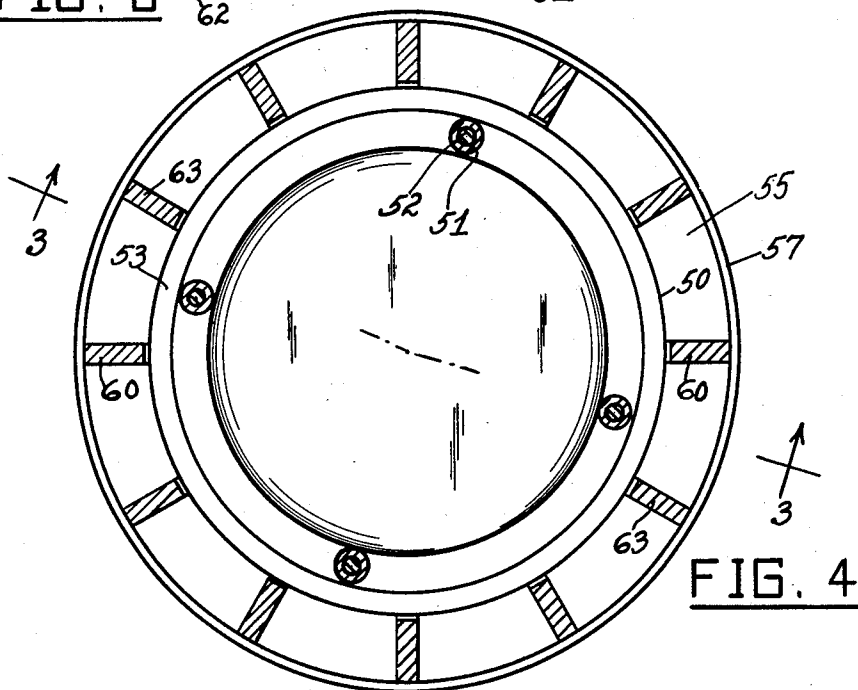
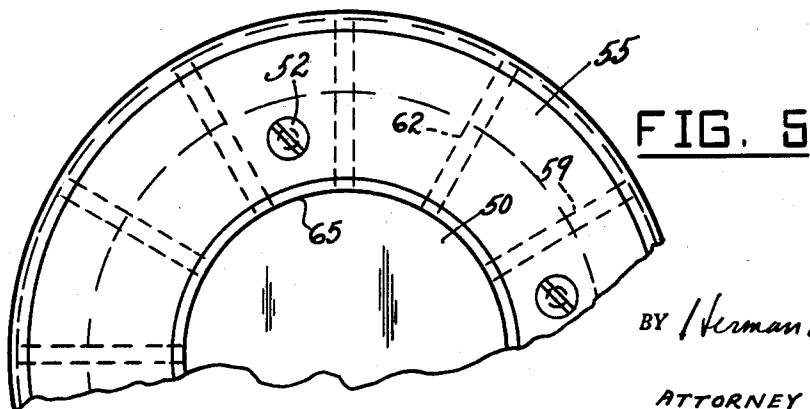
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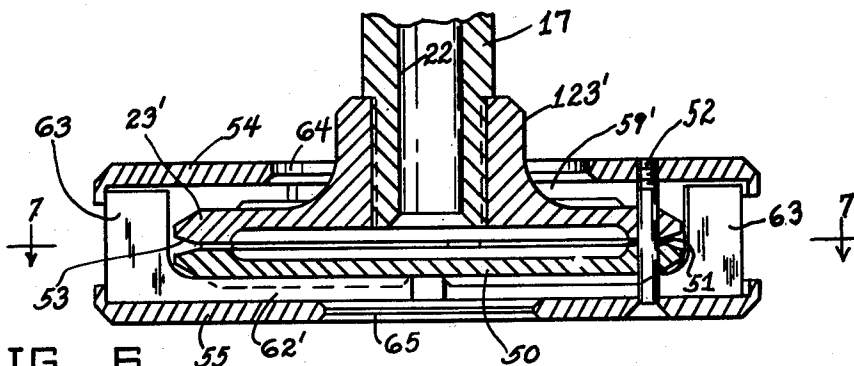


FIG. 6

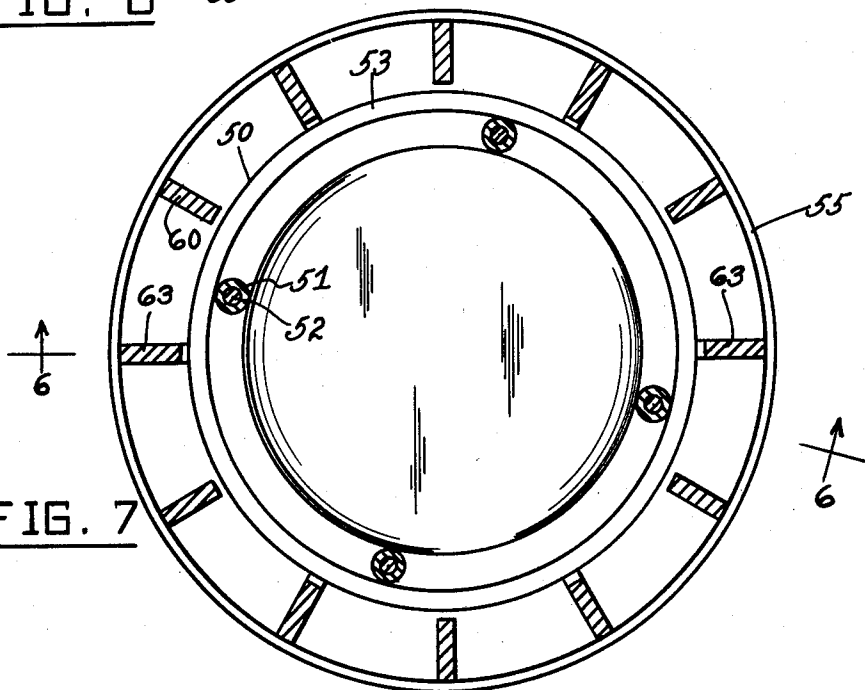


FIG. 7

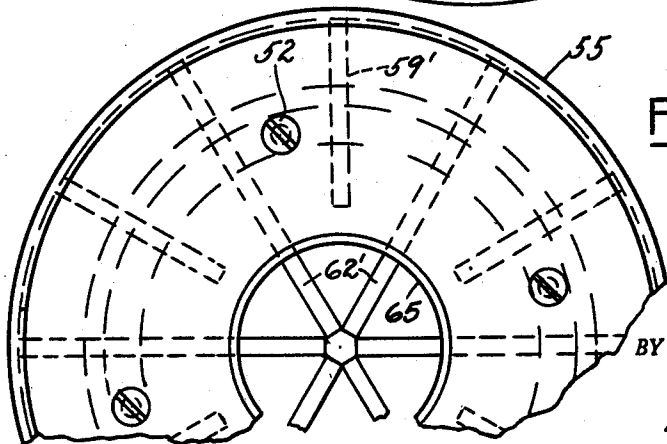


FIG. 8

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GAS-LIQUID MIXING APPARATUS

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Original application September 27, 1950, Serial No. 187,037, now Patent No. 2,743,914, dated May 1, 1956. Divided and this application March 9, 1956, Serial No. 570,557

8 Claims. (Cl. 261-87)

This is a division of my previously filed application, Serial No. 187,037, filed Sept. 27, 1950, and entitled "Gas-Liquid Mixing Apparatus," issued as U.S. Patent No. 2,743,914.

This invention relates to mixing apparatus, and more particularly to improved apparatus for mixing gases with liquids.

A main object of the invention is to provide a novel and improved mixing apparatus which is simple in construction, which is efficient in operation, and which provides homogeneous distribution of a gas through a liquid with which it is to be mixed.

A further object of the invention is to provide an improved mixing apparatus for mixing a gas with a liquid, said apparatus involving relatively inexpensive parts, being very durable in construction, and providing thorough distribution of gas in a liquid with a maximum amount of agitation and mechanical disturbance of the liquid.

A still further object of the invention is to provide an improved mixing apparatus for mixing a gas with a liquid, said apparatus employing an improved and novel arrangement of suction-producing means whereby the gas is aspirated into the liquid continuously during the operation of the apparatus, the suction required for aspiration being produced by moving portions of the apparatus relative to the liquid and providing means which develops reduced pressure in the liquid responsive to such motion.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a vertical cross-sectional view taken through one form of mixing apparatus constructed in accordance with the present invention, said view being taken on line 1-1 of Figure 2.

Figure 2 is an enlarged cross-sectional view taken on line 2-2 of Figure 1.

Figure 3 is a fragmentary vertical cross-sectional view taken through the lower portion of a still further modified form of mixing rotor according to the present invention, said view being taken on line 3-3 of Figure 4.

Figure 4 is a cross-sectional view taken on line 4-4 of Figure 3.

Figure 5 is a fragmentary bottom plan view of the modified form of mixing rotor of Figures 3 and 4.

Figure 6 is a fragmentary vertical cross-sectional view taken through the lower portion of a still further modified form of mixing rotor according to the present invention, said view being taken on line 6-6 of Figure 7.

Figure 7 is a horizontal cross-sectional view taken on line 7-7 of Figure 6.

Figure 8 is a fragmentary bottom plan view of the modified form of mixing rotor shown in Figures 6 and 7.

Referring to the drawings, and more particularly to Figures 1 and 2, 11 generally designates a mixing apparatus constructed in accordance with the present invention, said apparatus comprising a mixing chamber 12, which may be in the form of a conventional autoclave,

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secured to a supporting body 13 by means of bolts, shown for example at 14. As shown in Figure 1, the vessel 12 has a circular top opening 15 and the body 13 has a boss portion 16 which projects through the opening 15.

5 Designated at 17 is a shaft member which extends axially through a bore 18 in the member 13, a suitable sealing gland 19 being provided in the boss portion 16, said sealing gland being forced against suitable packing 20 in the bore 18 by means of bolts 21 which extend through a flange on the gland member 19 and are threaded into the boss portion 16, as shown. The shaft 17 is thereby sealingly and rotatably engaged in the member 13.

As shown in Figure 1, the shaft member 17 is formed with an axial bore 22. Secured to the lower end of the shaft member 17 is the dome-like member 23 whose interior communicates with the bore 22, as shown in Figure 1. The shaft member 17 is formed adjacent the upper end portion of the bore 22 with a plurality of openings 24 which provide communication between the space external to the shaft 17 and the interior of the bore 22. Designated at 25 is a cylindrical sleeve which is disposed around the shaft 17 and is coaxial therewith, said sleeve being secured to an annular drum-shaped member 26 which is bolted to the boss member 16, as by the bolts 27. The upper portion of the sleeve member 25 is formed with apertures 28 which establish communication between the interior of the sleeve member and the space in the upper portion of the vessel 12.

Designated at 29 is an annular disc member which is secured to the rim portion of the dome-like member 23 by a plurality of spaced bolts 30, said bolts being arranged at equal angular distances around the axis of the shaft member 17. The annular disc member 29 has secured thereto a plurality of evenly spaced radial vertical wall elements 31, defining radial passages. Designated at 32 is a circular disc which is interposed between the top radial edges of the wall members 31 and the annular surface of a recessed seat 33 formed in the bottom rim of the dome-like member 23.

As shown in Figures 1 and 2, the disc 32 is formed with respective apertures 34, each aperture being located adjacent the intermediate portion of a respective passage defined between an adjacent pair of wall members 31. As will be further seen from Figure 1, the annular disc 29 is substantially flat on its bottom surface but is formed with a top surface which is bevelled both inwardly and outwardly from its intermediate portion to define a generally venturi-shaped cross-section with respect to the disc 32, the aperture 34 associated with each above-mentioned radial passage being located adjacent the constricted intermediate portion of the passage.

In operation, the liquid and gas to be mixed are first introduced into the vessel 12 in any suitable manner, and the body 13 is sealingly secured to the top rim of vessel 12, as by the bolts 14. The shaft 17 is connected to a suitable driving means, for example, the output shaft of a slow-speed motor. As the rotor defined by the shaft 17 and the elements secured thereto revolves, liquid flows inwardly through the central opening of the annular disc member 29 and enters the radial passages defined between the radial wall elements 31. The liquid flows outwardly through said radial passages by centrifugal force, and as the liquid passes through the venturi-like portions of said radial passages, reduction in pressure is developed adjacent the constricted passage portions as the liquid is moved radially outwardly therethrough. This reduction in pressure provides a substantial degree of suction which causes gas from the upper portion of the vessel 12 to be aspirated into the liquid as said liquid is moved outwardly through the passages. The gas in the upper portion of the vessel flows through the openings 28 and through the apertures 24 into the bore 22, and then flows downwardly

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through said bore into the space defined within the dome-like member 23. The gas then flows through the respective apertures 34 into the aspirator passages, wherein the gas is mixed into the liquid as the liquid flows outwardly through said passages. It will be readily apparent that the rotary motion of the shaft causes liquid to move outwardly from the bottom portion of the rotor through said passages by centrifugal force, the flow of the liquid through the above-mentioned aspirator passages providing the necessary reduction in pressure to produce the aspirating action.

In order to increase turbulence and mechanical agitation of the liquid, a plurality of radial baffle plates 35 are secured to the lower end portion of the sleeve member 25, said baffle plates serving to prevent the formation of a vortex around the sleeve member as the shaft 17 rotates.

As will be evident from Figure 1, the liquid which is to be treated, designated at 36, is disposed in the vessel 12 to a depth sufficient to cover the lower portion of the rotor and the lower portion of the sleeve 25, whereby the dome-like member 23 and the elements carried thereby are completely immersed in the liquid. The gas which is to be mixed with the liquid fills the upper portion of the vessel 12 and is freely accessible to the interior of the bore 22 through the openings 28 and 24. As the gas is distributed through the liquid the level of the mixture rises until finally a completely homogenous mixture of gas and liquid is produced.

Referring now to Figures 3, 4 and 5, a further modification of a rotor according to the present invention is disclosed. Secured to the end of the shaft 17 is a dome-like member 123', and secured to the rim of said dome-like member in opposing relation thereto is the circular dished member 50, the opposing surfaces of the members 123' and 50 being separated by suitable washers 51 encircling the fastening bolts, shown at 52. As shown in Figure 3, the rim portions of the members 123' and 50 are tapered so as to define outwardly flaring annular spaces 53 between said rim portions. Designated at 54 and 55 are respective annular flat ring elements which are disposed respectively above and below the dome-like member 123' and the dished member 50 in the manner shown in Figure 3. The member 54 is formed with a peripheral flange 56 and the member 55 is similarly formed with a peripheral flange 57. The upper surface of the member 123' is formed with respective pairs of radial lugs 58 which receive therebetween the radial leg portions 59 of generally L-shaped radial partition elements 60. The outer portions of the elements 60 depend adjacent the peripheral edges of the members 123' and 50, and define radial partitions beyond the peripheries of members 123' and 50. Similarly, the bottom surface of the member 50 is formed with respective pairs of radial lugs 61 which receive the leg portions 62 of generally L-shaped wall elements 63, the outer portions of said wall elements 63 rising vertically adjacent the peripheral edges of the members 123' and 50, and defining radial partitions similar to the partitions 60. The partitions thus defined by the members 60 and 63 alternate in sequence. The clamping bolts 52 exert force on the members 54 and 55 which causes the leg portions 62 of the members 63 and the leg portions 59 of the members 60 to be firmly clamped between the respective pairs of retaining lugs 61, 61 and 58, 58, as well as forcing the dished member 50 upwardly toward the member 123'. However, the rim portions of the members 123' and 50 are maintained separated by the washers 51, thereby defining passages through which gas may emerge from the hollow shaft 17 into the liquid. The central apertures 64 and 65 of the members 54 and 55 define inlet passages for the liquid, and the respective leg elements 59 and 62 define radial passages whereby the liquid may flow into the space between the annular members 54 and 55 past the peripheral portions of the members 123' and 50. As the liquid flows past said peripheral portions, the passages for the liquid become substantially

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increased in area, whereby a reduction in pressure is produced adjacent the flaring space 53 at the gas escape apertures. This reduction in pressure produces aspiration of the gas into the liquid as the liquid flows outwardly between the members 54 and 55 by centrifugal force responsive to the rotation of the shaft 17.

As will be apparent, gas discharging outwardly from the constricted substantially annular space between the members 123' and 50 is reduced in velocity as it discharges into the annular expansion space 53, prior to mixing with the liquid. Liquid moving outwardly by centrifugal action past said expansion space through the radial passages defined by the radial partition members 60 and 63 produces an aspirating action, causing a reduction in velocity of the gas discharging from said expansion space, whereby the high-velocity, low-pressure gas is mixed with the outwardly moving liquid in said radial passages.

Referring now to Figures 6, 7 and 8, an arrangement generally similar to that disclosed in Figures 3 to 5 is illustrated except that the leg portions of the wall members, shown respectively at 62' and 59', are substantially longer than in the form of the invention of Figures 3 to 5, the lower leg portions 62' extending inwardly to positions wherein they substantially contact each other, as shown in Figure 8. However, the operation of the rotor of Figures 6, 7 and 8 is substantially similar to that of the rotor of Figures 3, 4 and 5 in that liquid flows into the rotor through the inlet openings 64 and 65 and flows through the relatively constricted passages defined between the opposing surfaces of members 54 and 123' and members 55 and 50, and thence emerges into the passage portions of greatly increased cross-sectional area outwardly adjacent the flaring space 53 between the peripheral portions of the members 123' and 50. The outward movement of the liquid by centrifugal force through said relatively constricted passage portions provides the reduction in pressure adjacent the gas outlet space 53 which produces aspirating action of the gas into the liquid as the liquid moves into the outer portion of the rotor.

While certain specific embodiments of apparatus for mixing gas with liquid have been disclosed in the foregoing description, it will be understood that various additional modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. In an apparatus for mixing gas and liquid, a rotor comprising a hollow shaft, a first dome-like member axially secured to the end of said shaft and communicating with the bore thereof, a second dome-like member secured to the first dome-like member in opposing relation thereto, spacer means interposed between the peripheral margins of the dome-like members and defining a substantially annular constricted passage therebetween, the rim portions of the dome-like members being formed to define an outwardly flaring annular expansion space therebetween communicating directly with said annular constricted passage, an annular plate member secured in spaced relation to the dome-like members coaxially therewith, and a plurality of radial wall elements secured between the dome-like members and the annular plate member and having inner edges located adjacent and radially outward of said flaring expansion space, said radial wall elements being constructed and arranged to define radial passages adjacent to and extending past the peripheral marginal portions of the dome-like members, said radial passages increasing outwardly in area and extending outwardly past said annular expansion space, whereby gas discharging outwardly from between the dome-like members through said constricted passage is reduced in velocity as it discharges into said annular expansion space, and whereby liquid moving outwardly past the expansion space through said radial passages by centrifugal action

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produces an aspirating action, causing a reduction in pressure and increase in velocity of the gas discharging from said expansion space, and whereby the high-velocity, low-pressure gas is mixed with the outwardly moving liquid in said radial passages.

2. In an apparatus for mixing gas and liquid, a rotor comprising a hollow shaft, a first dome-like member axially secured to the end of said shaft and communicating with the bore thereof, a second dome-like member secured to the first dome-like member in opposing relation thereto, spacer means interposed between the peripheral margins of the dome-like members and defining a substantially annular constricted passage therebetween, the rim portions of the dome-like members being tapered outwardly in thickness so as to define an outwardly flaring annular expansion space therebetween communicating directly with said annular constricted passage, a pair of annular plate members secured on opposite sides of and in spaced relation to the dome-like members coaxially therewith, and a plurality of radial wall elements secured between the annular plate members and having inner edges located adjacent and radially outward of said outwardly flaring expansion space, said wall elements being constructed and arranged to define radial passages adjacent to and extending on opposite sides of the peripheral marginal portions of the dome-like members, said radial passages increasing outwardly in area and extending past said outwardly flaring expansion space, whereby gas discharging outwardly from between the dome-like members through said constricted passage is reduced in velocity as it discharges into said annular expansion space, and whereby liquid moving outwardly past the expansion space through said radial passages by centrifugal action produces an aspirating action, causing a reduction in pressure and increase in velocity of the gas discharging from said expansion space, and whereby the high-velocity, low-pressure gas is mixed with the outwardly moving liquid in said radial passages.

3. The structure of claim 2, and inwardly directed leg portions on said radial wall elements disposed between said annular plate members and said dome-like members.

4. The structure of claim 2, and wherein said radial wall elements comprise generally L-shaped members having inwardly directed leg portions disposed between said annular plate members and said dome-like members.

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5. The structure of claim 2, and wherein said radial wall elements comprise generally L-shaped members having inwardly directed leg portions disposed alternately in the space between the first dome-like member and the annular plate member adjacent thereto and in the space between the second dome-like member and the annular plate member adjacent thereto.

6. The structure of claim 2, and wherein said radial wall elements comprise generally L-shaped members having inwardly directed leg portions, some of said leg portions being disposed in the space between the first dome-like member and the annular plate member adjacent thereto and other of the leg portions being disposed in the space between the second dome-like member and the annular plate member adjacent thereto.

7. The structure of claim 6, and wherein said other of the inwardly directed leg portions are of sufficient length to substantially meet adjacent the axis of the shaft.

8. The structure of claim 2, and wherein said spacer means comprises a plurality of spaced washers secured between the rim portions of the dome-like members.

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