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(57) The liquid is cooled and intensive contact between the gas and liquid is effected by feeding each of the two media into the other in the same vessel (1). Continuous intermixing of the gas and gas-enriched liquid is carried out by circulating either gas or gas-enriched liquid from the vessel (1) to the feed means of the gas (10) or the liquid (6) respectively.



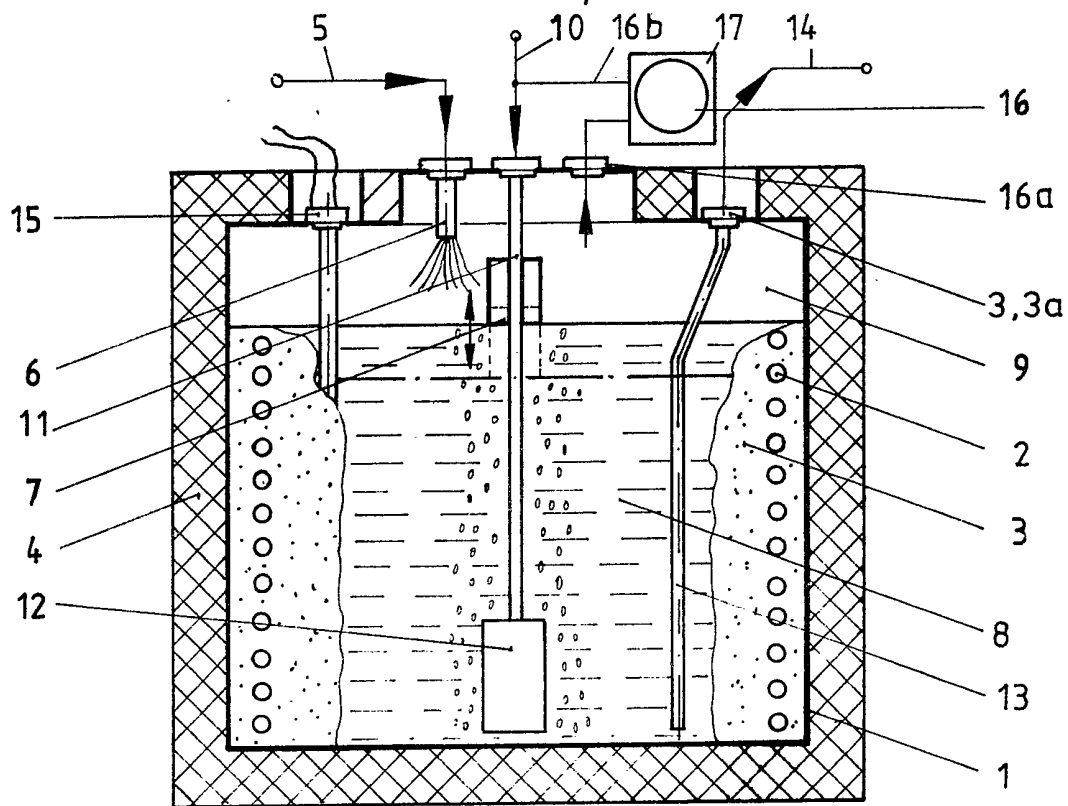


FIG. 1

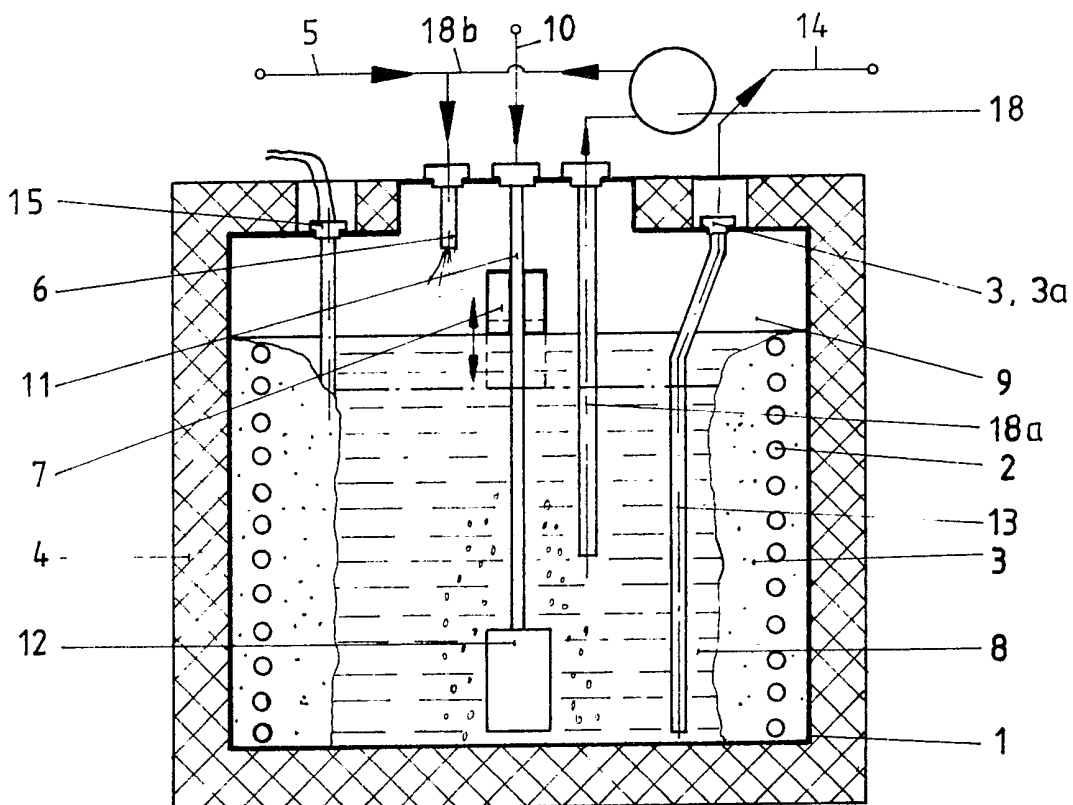


FIG. 2

SPECIFICATION

Process and apparatus for enriching liquids with gases

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The invention relates to a process and apparatus for enriching a liquid with a gas.

Processes and apparatus for this purpose are used particularly in the drinks industry for producing so-called refreshing drinks, such as lemonade, fruit drinks, mineral water or alcoholic liquids, which are enriched with CO₂ gas in order to give such liquids desirable properties, in particular in order to make them more digestible and refreshing by carbonation. Various processes have been proposed for enriching such liquids with gases.

In one of these proposed processes, liquid is pumped through a nozzle and gas is fed into the nozzle region, by which means intensive contact between the gas and liquid takes place. In another process, the liquid is sprayed under increased pressure through a nozzle onto a water surface in a so-called carbonating vessel, by which means CO₂ gas is absorbed into the liquid. Further processes operate by spraying the liquid by means of atomising nozzles or water-penetrable solid blocks in order to increase the surface area of the liquid in the carbonating vessel. Finally, there are processes in which CO₂ gas is fed into a carbonating vessel below the liquid surface through solid diffuser blocks, in order to produce a greater contact area between the gas and water. In order to increase the mixing efficiency, the liquid is cooled before carbonating.

All the above processes have the disadvantage that it is not possible for enrichment to proceed until the saturation level or the equilibrium pressure is attained. This means that the CO₂ gas which does not go into solution becomes located under increasing pressure in the so-called head space of the carbonating vessel above the liquid surface.

The increase in gas pressure in the head space of the carbonating vessel leads to a worsening of the carbonation efficiency during the carbonation process due to the steadily decreasing pressure difference between the liquid inlet pressure and the gas pressure. In some cases, the gas pressure can increase as far as the actual liquid inlet pressure, with the result that no more liquid can be fed to the carbonating vessel. In order to prevent any such undesirable pressure rise, gas has hitherto been bled to the atmosphere in a controlled manner. This leads to not inconsiderable losses.

In order to improve the carbonation efficiency, high operating pressures must be used in the hitherto proposed processes. Because of this increased pressure, difficulties arise in filling and emptying the carbonating vessel. In particular, because of the size of the pressure

difference across the valves of the carbonating vessel, the opening and closing of the valves produce considerable pressure surges which lead to large stresses in the valves and pumps, resulting in premature operation failures of the carbonating devices.

According to the present invention, there is provided a process for enriching a liquid with a gas, wherein the liquid is cooled and intensive contact between the gas and liquid is effected as one of the two media is fed into the other, and continuous intermixing of the gas and the gas-enriched liquid is carried out by means of a closed recirculation of gas or the gas-enriched liquid which is superimposed on the feed of the two media.

Either gas can be continuously withdrawn from a gas cushion which forms above the liquid in the vessel and fed into the gas-enriched or carbonated liquid below the liquid surface, or a portion of the carbonated liquid can be continuously withdrawn and fed back into the gas cushion.

Further according to the present invention there is provided apparatus for carrying out the process as defined above, the apparatus comprising a pressure vessel arranged to hold a gas-enriched liquid and provided with a refrigeration system and insulation, a liquid feed pipe terminating above the liquid surface in the pressure vessel, a gas pipe opening below the said liquid surface, a dip pipe arranged to withdraw gas-enriched liquid and extending to the vicinity of the base of the pressure vessel, and a gas circulation pump a suction nozzle which is connected to a head space formed above the liquid surface in the pressure vessel and filled with gas, the pump delivery nozzle being connected to a gas feed line leading to the gas pipe.

In this apparatus, gas is continuously withdrawn from the gas cushion which forms above the liquid and is fed below the liquid surface into the carbonated liquid. The gas circulation pump can either be disposed inside the head space of the pressure vessel or in a housing which is connected to the pressure vessel head space. An inexpensive and operationally reliable gas circulation pump can be used, as the performance of the pump merely has to be that required for circulating the gas stream independently of the pressure level in the apparatus.

Yet further according to the present invention there is provided apparatus for carrying out a process as defined above, the apparatus comprising a pressure vessel arranged to hold a gas-enriched liquid and provided with a refrigeration system and insulation, a liquid feed pipe terminating above the liquid surface in the pressure vessel, a gas pipe opening below the said liquid surface, a dip pipe arranged to withdraw gas-enriched liquid and extending to the vicinity of the base of the pressure vessel, and a liquid circulation pump

a suction nozzle of which projects into a liquid space below the liquid surface in the pressure vessel, the pump delivery nozzle being connected to a feed pipe provided with a spray nozzle and opening into a head space above the said liquid surface.

In this case, part of the gas-enriched or carbonated liquid is continuously withdrawn and is returned into the gas cushion which forms above the liquid surface, in order to increase the degree of enrichment thereof until the gas absorption equilibrium pressure is attained.

Still further according to the present invention there is provided a process for enriching a gas with a liquid the process comprising cooling the liquid, contacting the gas with the liquid by feeding the gas through a gas feed into a liquid space in a pressure vessel and feeding liquid through a liquid feed into a gas head space within the pressure vessel, and circulating either gas or gas-enriched liquid to the gas feed or the liquid feed respectively.

Yet further according to the present invention there is provided apparatus for enriching a liquid with a gas, the apparatus comprising a pressure vessel, cooling means arranged to cool the contents of the pressure vessel, liquid feed means extending into an upper portion of the pressure vessel, gas feed means extending into a lower portion of the pressure vessel, means for withdrawing liquid from the lower portion of the pressure vessel, and pumping means arranged to pump either gas or liquid contained in the vessel to the gas feed means or liquid feed means respectively.

Preferably the end of the gas feed means or pipe is provided with a solid diffuser block by means of which distribution of the gas fed into the liquid is improved, and the surface area produced for the enrichment process is increased.

Processes according to the invention and apparatus embodying the invention will now be particularly described by way of example with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a section through a first embodiment of the apparatus; and

Figure 2 is a section through a second embodiment.

Both embodiments of the apparatus (Figs. 1 and 2) comprise a pressure vessel 1, which is preferably constructed of high quality steel and is provided with a safety valve (not shown). In the pressure vessel 1 there is located an evaporator coil 2 of a refrigeration system, in which liquid refrigerant is evaporated, so that the pressure vessel 1 is intensively cooled. This cooling produces a so-called ice bank 3 in the region of the evaporator coil 2. In order to limit the leakage of heat into the pressure vessel 1 from the outside, the pressure vessel 1 is provided with insulation 4 on its outer surface.

The liquid to be enriched with gas, preferably CO₂ gas, is fed from a liquid line 5 through a feed pipe 6 and into the pressure vessel 1, the feed pipe 6 being preferably provided with a spray nozzle for distributing the liquid. The spray nozzle aids the gas enrichment by increasing the liquid surface area. The maximum liquid level is controlled by a float switch 7, which holds the liquid level between given limits. The maximum liquid level is shown in the two figures by means of a full line, and the minimum liquid level is shown by means of a dashed and dotted line. Thus in operation, the pressure vessel 1 contains a liquid space 8 and a head space 9 which is filled with gas.

From a gas feed line 10, which for example is connected to a gas cylinder by way of a pressure reducer, the gas is fed through a gas pipe 11 and into the liquid space 8 of the pressure vessel 1 by way of a solid diffuser block 12. The solid diffuser block 12 divides the gas into very fine gas bubbles, so that the distribution of the gas in the liquid is improved and the surface area for the absorption of the gas into the liquid is increased.

Liquid enriched with gas is removed through a dip pipe 13 which extends almost to the base of the pressure vessel 1, and through which the liquid enriched with gas is fed to an outlet line 14. The outlet line 14 is connected to valves or taps (not shown) through which the liquid enriched with gas can be drawn off.

The ice bank 3 acts as a cold store. The thickness of the ice bank 3 is controlled by an ice bank sensor 15, which switches the refrigeration system on or off according to the thickness of the ice bank 3.

In the embodiment of Fig. 1, a suction nozzle 16a of a gas circulation pump 16 is connected to the head space 9 in the pressure vessel 1 which forms above the liquid surface and is filled with gas, the delivery nozzle 16b of this pump 16 being connected to the gas line 10 leading to the gas pipe 11. The gas circulation pump 16 can preferably be a diaphragm pump, driven by an oscillating magnet. Such a pump contains no rotating parts, requires no maintenance and is particularly inexpensive. The gas circulation pump 16 is disposed in a housing 17 which is connected to the head space 9 of the pressure vessel 1, so that the pressure difference between the suction nozzle 16a and delivery nozzle 16b corresponds only to that necessary for the operation of the pump, and is independent of the operating pressure of the apparatus. The use of pressure-increasing pumps, which are not only expensive but are also subject to faults, can be avoided.

Gas is continuously removed from the gas cushion in the head space 9 of the pressure vessel 1 by means of the gas circulation pump 16 and fed back into the liquid space

8. Thus a continuous intermixing of the gas and carbonated liquid takes place within a closed gas circulation system which is superimposed on the intermittent feed of the two

5 media. By this means, the degree of gas enrichment can be increased until the equilibrium pressure is attained, at small expense. For example, water taken from the domestic main water supply can dissolve a maximum
10 quantity of CO₂ gas, for the carbonating pressure and the temperature employed. In practice, the carbonating pressure is typically 1.8 bars. At a temperature of zero degrees centigrade, a CO₂ content of 4.65 volumes or 9.3
15 g/litre can be reached.

In the second embodiment shown in Fig. 2, a suction nozzle 18a of a liquid circulation pump 18 projects into the liquid space 8 of the pressure vessel 1, the pump delivery
20 nozzle 18b being connected to the liquid feed pipe 6, which is provided with a spray nozzle and opens into the head space 9. By means of the liquid circulation pump 18, a portion of the carbonated liquid is continuously removed
25 from the pressure vessel 1 and is fed back into the gas cushion formed above the liquid. Thus the liquid is subjected to continuous intermixing with gas. This embodiment also comprises the closed recirculation of one of
30 the media, namely the carbonated liquid, this being superimposed on the intermittent gas and liquid feed, and leading to a decided increase in the degree of enrichment of the liquid by the absorbed gas.

35 By means or the above described process, a uniform and intensive enrichment of the liquid with gas is attained up to total gas absorption on reaching the respective equilibrium pressure, without the operating pressure having to
40 be increased. The low operating pressure makes it possible not only to use more simple and less expensive pressure vessels, connection lines and pump units, but also ensures operational reliability in spite of a considerable
45 increase in the degree of enrichment.

With the above described apparatus it is possible to quickly and strongly carbonate liquid up to the equilibrium pressure while using a low internal vessel pressure.

CLAIMS

1. A process for enriching a liquid with a gas, wherein the liquid is cooled and intensive contact between the gas and liquid is effected
55 as one of the two media is fed into the other, and continuous intermixing of the gas and the gas-enriched liquid is carried out by means of a closed recirculation of gas or the gas-enriched liquid, which is superimposed on the
60 feed of the two media.

2. A process according to claim 1, wherein gas is continuously withdrawn from a gas cushion which forms above the liquid, and is fed into the gas-enriched liquid below
65 the liquid surface.

3. A process according to claim 1, wherein part of the gas-enriched liquid is continuously removed and fed back into the gas cushion which forms above the liquid.

70 4. Apparatus for carrying out the process according to claim 1 or claim 2, the apparatus comprising a pressure vessel arranged to hold a gas-enriched liquid and provided with a refrigeration system and insulation, a liquid
75 feed pipe terminating above the liquid surface in the pressure vessel, a gas pipe opening below the said liquid surface, a dip pipe arranged to withdraw gas-enriched liquid and extending to the vicinity of the base of the
80 pressure vessel, and a gas circulation pump a suction nozzle which is connected to a head space formed above the liquid surface in the pressure vessel and filled with gas, the pump delivery nozzle being connected to a gas feed
85 line leading to the gas pipe.

5. Apparatus according to claim 4, wherein the gas circulation pump is disposed inside the head space of the pressure vessel.

6. Apparatus according to claim 4,
90 wherein the gas circulation pump is disposed in a housing which is connected to the head space of the pressure vessel.

7. Apparatus for carrying out a process according to claim 1 to claim 3, the apparatus
95 comprising a pressure vessel arranged to hold a gas-enriched liquid and provided with a refrigeration system and insulation, a liquid feed pipe terminating above the liquid surface in the pressure vessel, a gas pipe opening
100 below the said liquid surface, a dip pipe arranged to withdraw gas-enriched liquid and extending to the vicinity of the base of the pressure vessel, and a liquid circulation pump a suction nozzle of which projects into a liquid
105 space below the liquid surface in the pressure vessel, the pump delivery nozzle being connected to a feed pipe provided with a spray nozzle and opening into a head space above the said liquid surface.

8. Apparatus according to any one of claims 4 to 7, wherein the end of the gas pipe is provided with a solid diffuser block.

9. Apparatus according to any one of claims 4 to 8 wherein the said liquid feed
115 pipe is provided with a spray nozzle.

10. A process for enriching a gas with a liquid, the process comprising cooling the liquid, contacting the gas with the liquid by feeding the gas through a gas feed into a
120 liquid space in a pressure vessel and feeding liquid through a liquid feed into a gas head space within the pressure vessel, and circulating either gas or gas-enriched liquid to the gas feed or the liquid feed respectively.

11. Apparatus for enriching a liquid with a gas, the apparatus comprising a pressure vessel, cooling means arranged to cool the contents of the pressure vessel, liquid feed means extending into an upper portion of the pressure vessel, gas feed means extending into a
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lower portion of the pressure vessel, means for withdrawing liquid from the lower portion of the pressure vessel, and pumping means arranged to pump either gas or liquid contained in the vessel to the gas feed means or liquid feed means respectively.

12. Apparatus according to claim 9 further comprising means for maintaining a level of liquid in the pressure vessel intermediate the said liquid feed means and the said gas feed means.

13. Apparatus for enriching a liquid with a gas substantially as hereinbefore described with reference to Fig. 1 or Fig. 2 of the accompanying drawing.

14. A process according to claim 1 or claim 10 substantially as hereinbefore described.

15. Gas-enriched liquid whenever produced by a process according to any one of claims 1 to 3 or claim 10.

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