Claims

1. A method for producing or dispensing liquid products in which a membrane contactor employing a plurality of gas-permeable hollow fibres, the contactor having a gas port communicating with the interior of the fibres and input and output ports for liquid communicating with space within the contactor surrounding the fibres, is employed to dissolve a gas comprising carbon dioxide or nitrous oxide in a liquid, the method comprising the steps of:

supplying the said gas at a controlled pressure to the gas port;

supplying a liquid at a higher pressure than the gas to the input port for liquid from a supply of such liquid via a first valve having a first valve inlet port communicating with the supply of liquid and a first valve outlet port communicating with the inlet port for liquid; and

dispensing liquid with said gas dissolved therein from the output port for liquid via a dispense tap to ambient, the dispensing liquid step including a start dispense step in which dispensing commences and a stop dispense step in which dispensing is stopped, the first valve being opened with said dispensing tap in said start dispense step, and being closed in said stop dispense step; and

relieving pressure build-up in liquid in communication with the said space after closure of the first valve and while maintaining the first valve closed.

2. A method according to Claim 1, wherein the step of relieving pressure build-up comprises withdrawing at least a predetermined volume of liquid from an otherwise closed volume of liquid in communication with the said space.

3. A method according to Claim 2, wherein said predetermined volume comprises a characteristic volume corresponding to the expansion of liquid that would otherwise occur in said space absent said withdrawing step due to continuing dissolving of the gas in liquid in said space after stopping dispense.

4. A method according to Claim 3, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad \text{.....(1)}$$

where

K = a constant specific to the particular gas, 7.2 x 10^{-4} when the gas is carbon dioxide

Δv = characteristic volume, in millilitres

V_c = liquid volume of contactor, in millilitres

C = saturation level of the gas in the liquid, in grams per litre

η = efficiency of contactor at continuous flow condition.

A method according to Claim 1, wherein the step of relieving pressure build-up comprises allowing a closed volume of liquid in communication with the said space to expand by at least a characteristic volume in an expansion step.

5. A method according to Claim 1, wherein the step of relieving pressure build-up comprises allowing a closed volume of liquid in communication with the said space to expand by at least a characteristic volume in an expansion step.

6. A method according to Claim 5, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad .....(1)$$

where

K = a constant specific to the particular gas, 7.2 x 10^{-4} when the gas is carbon dioxide

Δv = characteristic volume, in millilitres

V_c = liquid volume of contactor, in millilitres

C = saturation level of the gas in the liquid, in grams per litre

η = efficiency of contactor at continuous flow condition.

7. A method according Claim 1, wherein the withdrawing step is performed by closing the dispense tap at least a pre-determined interval corresponding to said predetermined volume after closure of the first valve.

8. A method according to Claim 1, wherein a second valve having a second valve input port and a second valve output port, and coupled to receive liquid from said space at said second valve input port, is opened in the interval from and including one of opening of the first valve and closure of the first valve and closed a pre-determined interval corresponding to said predetermined volume after closure of the first valve to pass liquid

from said second valve output port to a position permanently at a pressure below that of said space.

9. A method according to Claim 8, wherein the start dispense step comprises opening the first and second valves and the dispense tap at the same time.

10. A method according to Claim 8, wherein the second valve is opened when the first valve closes.

11. A method according to Claim 8, wherein the second valve outlet port communicates with the outlet of the dispense tap.

12. A method according to Claim 8, wherein the step of supplying a liquid at a higher pressure than the gas comprises delivering liquid from a supply thereof at a pressure lower than said higher pressure by a pump having a suction side and a delivery side, the suction side being coupled to said supply and the delivery side being coupled to the inlet port for liquid; and wherein the second valve outlet port communicates with one of said suction side and said supply.

13. A method according to Claim 5, wherein said expansion step comprises coupling a diaphragm chamber having respective compartments on either side of a flexible diaphragm between liquid in communication with the said space and gas at the gas port.

14. A method according to Claim 1, wherein the liquid comprises a beverage supplied substantially at ambient pressure in a bag-in-box container, the step of supplying a liquid at a higher pressure than the gas comprising delivering liquid from the said container by a pump having a suction side and a delivery side, the suction side being coupled to said container and the delivery side being coupled to the inlet port for liquid.

15. Apparatus for adding a gas comprising carbon dioxide or nitrous oxide to a liquid during dispense thereof from a supply of said liquid; the apparatus comprising:

a membrane contactor having a contactor housing with a plurality of gas-permeable hollow fibres mounted therein, the contactor housing having a gas port communicating with the interior of the fibres and adapted to receive said gas at a

controlled pressure thereat, and input and output ports for liquid communicating with space within the contactor housing surrounding the fibres;

a first valve having a first valve inlet port arranged for communication with the supply of liquid and a first valve outlet port communicating with the inlet port for liquid and arranged for supply of said liquid to the inlet port for liquid at a higher pressure than said controlled gas pressure;

a dispense tap coupled to the output port for liquid and adapted to dispense liquid to ambient:

and a control system coupled to monitor opening and closing of the first valve and the dispense tap, whereby to the control a start dispense step in which dispensing commences and a stop dispense step in which dispensing is stopped, the control system being arranged to open the first valve with said dispensing tap in said start dispense step, and being arranged to close said first valve in said stop dispense step, and to relieve pressure build-up in liquid in communication with the said space after closure of the first valve and while maintaining the first valve closed.

16. Apparatus according to Claim 15, wherein the control system is arranged to relieve pressure build-up in liquid in communication with the said space by causing at least a predetermined volume of liquid to be withdrawn from an otherwise closed volume of liquid in communication with the said space.

17. Apparatus according to Claim 16, wherein said predetermined volume comprises a characteristic volume corresponding to the expansion of liquid that would otherwise occur in said space absent said withdrawal of said predetermined volume due to continuing dissolving of the gas in liquid in said space after stopping dispense.

18. Apparatus according to Claim 17, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad .....(1)$$

where

K = a constant specific to the particular gas, 7.2×10^{-4} when the gas is carbon dioxide

Δv = characteristic volume, in millilitres

V_c = liquid volume of contactor, in millilitres

C = saturation level of the gas in the liquid, in grams per litre

η = efficiency of contactor at continuous flow condition.

19. Apparatus according to Claim 15, wherein the control system is arranged to relieve pressure build-up in liquid in communication with the said space by allowing a closed volume of liquid in communication with the said space to expand by at least a characteristic volume.

20. Apparatus according to Claim 19, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad \ldots\ldots\ldots\ldots (1)$$

where

K = a constant specific to the particular gas, 7.2×10^{-4} when the gas is carbon dioxide

Δv = characteristic volume, in millilitres

V_c = liquid volume of contactor, in millilitres

C = saturation level of the gas in the liquid, in grams per litre

η = efficiency of contactor at continuous flow condition.

21. Apparatus according to Claim 15, wherein the control system is adapted to close the dispense tap at least a pre-determined interval corresponding to said predetermined volume after closure of the first valve.

22. Apparatus according to Claim 15, wherein the control system includes a second valve having a second valve input port and a second valve output port, and coupled to receive liquid from said space at said second valve input port, the second valve being controlled to open in the interval from and including one of opening of the first valve and closure of the first valve and being controlled to close a pre-determined interval corresponding to said predetermined volume after closure of the first valve, the second valve output port being coupled to a position arranged in use to be permanently at a pressure below that of said space.

23. Apparatus according to Claim 22, wherein the control system is adapted to open the first and second valves and the dispense tap at the same time.

24. Apparatus according to Claim 22, wherein the control system is adapted to open the second valve when the first valve closes.

25. Apparatus according to Claim 22, wherein the second valve outlet port communicates with the outlet of the dispense tap.

26. Apparatus according to Claim 22, further comprising a pump having a suction side and a delivery side, the delivery side being coupled to the first valve inlet port for delivering liquid at said higher pressure, and the suction side being arranged for communication with a supply of the liquid at a pressure lower than said higher pressure; and wherein the second valve outlet port communicates with one of said suction side and said supply.

27. Apparatus according to Claim 15, wherein the liquid comprises a beverage supplied substantially at ambient pressure in a bag-in-box container, and wherein a pump having a suction side and a delivery side is coupled between the container and the first valve, the delivery side being coupled to the first valve inlet port for delivering liquid at said higher pressure, and the suction side being coupled to said container.

28. Apparatus according to Claim 18, further comprising a diaphragm chamber having respective compartments on either side of a flexible diaphragm, one said compartment being permanently in communication with liquid in the said space, and the other said compartment being arranged to communicate with gas at the gas port to allow said closed volume of liquid to expand.

29. Apparatus according to Claim 28, wherein the other said compartment is coupled to the common port of a three port valve; said three port valve having two further ports, one coupled to receive said gas from a source thereof, and the other coupled to said gas port, and having a first state in which said common port communicates only with said one port, and a second state in which said common port communicates only with said other port.

CLAIMS

1. A method for producing or dispensing liquid products in which a membrane contactor employing a plurality of gas-permeable hollow fibres, the contactor having a gas port communicating with the interior of the fibres and input and output ports for liquid communicating with space within the contactor surrounding the fibres, is employed to dissolve a gas comprising carbon dioxide or nitrous oxide in a liquid, the method comprising the steps of:

supplying the said gas at a controlled pressure to the gas port;

supplying a liquid at a higher pressure than the gas to the input port for liquid from a supply of such liquid via a first valve having a first valve inlet port communicating with the supply of liquid and a first valve outlet port communicating with the inlet port for liquid; and

dispensing liquid with said gas dissolved therein from the output port for liquid via a dispense tap to ambient, the dispensing liquid step including a start dispense step in which dispensing commences and a stop dispense step in which dispensing is stopped, the first valve being opened with said dispensing tap in said start dispense step, and being closed in said stop dispense step; and

relieving pressure build-up in liquid in communication with the said space after closure of the first valve and while maintaining the first valve closed.

2. A method according to Claim 1, wherein the step of relieving pressure build-up comprises withdrawing at least a predetermined volume of liquid from an otherwise closed volume of liquid in communication with the said space.

3. A method according to Claim 2, wherein said predetermined volume comprises a characteristic volume corresponding to the expansion of liquid that would otherwise occur in said space absent said withdrawing step due to continuing dissolving of the gas in liquid in said space after stopping dispense.

4. A method according to Claim 3, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad \text{.....(1)}$$

where

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η = efficiency of contactor at continuous flow condition.

5. A method according to Claim 1, wherein the step of relieving pressure build-up comprises allowing a closed volume of liquid in communication with the said space to expand by at least a characteristic volume in an expansion step.

6. A method according to Claim 5, wherein the characteristic volume is determined by the formula (1) below:

$$\Delta v = K.V_c.C.(1-0.5\eta) \quad \text{.....(1)}$$

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7. A method according Claim 1, wherein the withdrawing step is performed by closing the dispense tap at least a pre-determined interval corresponding to said predetermined volume after closure of the first valve.

8. A method according to Claim 1, wherein a second valve having a second valve input port and a second valve output port, and coupled to receive liquid from said space at said second valve input port, is opened in the interval from and including one of opening of the first valve and closure of the first valve and closed a pre-determined interval corresponding to said predetermined volume after closure of the first valve to pass liquid from said second valve output port to a position permanently at a pressure below that of said space.

9. A method according to Claim 8, wherein the start dispense step comprises opening the first and second valves and the dispense tap at the same time.

10. A method according to Claim 8, wherein the second valve is opened when the first valve closes.

11. A method according to Claim 8, wherein the second valve outlet port communicates with the outlet of the dispense tap.

12. A method according to Claim 8, wherein the step of supplying a liquid at a higher pressure than the gas comprises delivering liquid from a supply thereof at a pressure lower than said higher pressure by a pump having a suction side and a delivery side, the suction side being coupled to said supply and the delivery side being coupled to the inlet port for liquid; and wherein the second valve outlet port communicates with one of said suction side and said supply.

13. A method according to Claim 5, wherein said expansion step comprises coupling a diaphragm chamber having respective compartments on either side of a flexible diaphragm between liquid in communication with the said space and gas at the gas port.

14. A method according to Claim 1, wherein the liquid comprises a beverage supplied substantially at ambient pressure in a bag-in-box container, the step of supplying a liquid at a higher pressure than the gas comprising delivering liquid from the said container by a pump having a suction side and a delivery side, the suction side being coupled to said container and the delivery side being coupled to the inlet port for liquid.

15. Apparatus for adding a gas comprising carbon dioxide or nitrous oxide to a liquid during dispense thereof from a supply of said liquid; the apparatus comprising:

a membrane contactor having a contactor housing with a plurality of gas-permeable hollow fibres mounted therein, the contactor housing having a gas port communicating with the interior of the fibres and adapted to receive said gas at a controlled pressure thereat, and input and output ports for liquid communicating with space within the contactor housing surrounding the fibres;

a first valve having a first valve inlet port arranged for communication with the supply of liquid and a first valve outlet port communicating with the inlet port for liquid and

arranged for supply of said liquid to the inlet port for liquid at a higher pressure than said controlled gas pressure;

a dispense tap coupled to the output port for liquid and adapted to dispense liquid to ambient:

and a control system coupled to monitor opening and closing of the first valve and the dispense tap, whereby to the control a start dispense step in which dispensing commences and a stop dispense step in which dispensing is stopped, the control system being arranged to open the first valve with said dispensing tap in said start dispense step, and being arranged to close said first valve in said stop dispense step, and to relieve pressure build-up in liquid in communication with the said space after closure of the first valve and while maintaining the first valve closed.

16. Apparatus according to Claim 15, wherein the control system is arranged to relieve pressure build-up in liquid in communication with the said space by causing at least a predetermined volume of liquid to be withdrawn from an otherwise closed volume of liquid in communication with the said space.

17. Apparatus according to Claim 16, wherein said predetermined volume comprises a characteristic volume corresponding to the expansion of liquid that would otherwise occur in said space absent said withdrawal of said predetermined volume due to continuing dissolving of the gas in liquid in said space after stopping dispense.

18. Apparatus according to Claim 17, wherein the characteristic volume is determined by the formula (1) below:

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21. Apparatus according to Claim 15, wherein the control system is adapted to close the dispense tap at least a pre-determined interval corresponding to said predetermined volume after closure of the first valve.

22. Apparatus according to Claim 15, wherein the control system includes a second valve having a second valve input port and a second valve output port, and coupled to receive liquid from said space at said second valve input port, the second valve being controlled to open in the interval from and including one of opening of the first valve and closure of the first valve and being controlled to close a pre-determined interval corresponding to said predetermined volume after closure of the first valve, the second valve output port being coupled to a position arranged in use to be permanently at a pressure below that of said space.

23. Apparatus according to Claim 22, wherein the control system is adapted to open the first and second valves and the dispense tap at the same time.

24. Apparatus according to Claim 22, wherein the control system is adapted to open the second valve when the first valve closes.

25. Apparatus according to Claim 22, wherein the second valve outlet port communicates with the outlet of the dispense tap.

26. Apparatus according to Claim 22, further comprising a pump having a suction side and a delivery side, the delivery side being coupled to the first valve inlet port for delivering liquid at said higher pressure, and the suction side being arranged for communication with a supply of the liquid at a pressure lower than said higher pressure; and wherein the second valve outlet port communicates with one of said suction side and said supply.

27. Apparatus according to Claim 15, wherein the liquid comprises a beverage supplied substantially at ambient pressure in a bag-in-box container, and wherein a pump having a suction side and a delivery side is coupled between the container and the first valve, the delivery side being coupled to the first valve inlet port for delivering liquid at said higher pressure, and the suction side being coupled to said container.

28. Apparatus according to Claim 18, further comprising a diaphragm chamber having respective compartments on either side of a flexible diaphragm, one said compartment being permanently in communication with liquid in the said space, and the other said compartment being arranged to communicate with gas at the gas port to allow said closed volume of liquid to expand.

29. Apparatus according to Claim 28, wherein the other said compartment is coupled to the common port of a three port valve; said three port valve having two further ports, one coupled to receive said gas from a source thereof, and the other coupled to said gas port, and having a first state in which said common port communicates only with said one port, and a second state in which said common port communicates only with said other port.