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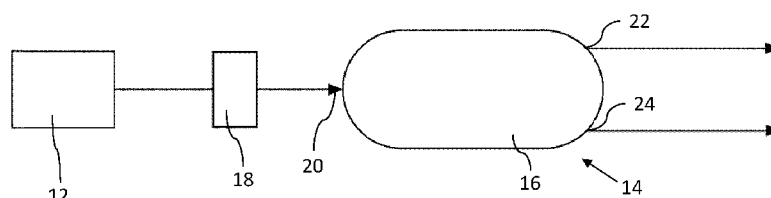


FIG. 1

(57) Abstract: There is provided a method of separating oil and water from a production stream, having the steps of producing a production fluid from a hydrocarbon producing well, the production fluid having a gas phase, a water phase, an oil phase, and sand phase, passing the production fluid directly from the hydrocarbon producing well through a series of separators, the series of separators having at least one water/oil separator that separates at least the water phase and the oil phase, and injecting microbubbles into the production upstream of or into the first water/oil separator relative to the hydrocarbon producing well.

SEPARATION OF WATER AND OIL FROM A PRODUCTION STREAM

TECHNICAL FIELD

[0001] This relates to a method of enhancing the separation of oil and water from fluids
5 produced from a hydrocarbon producing well by diffusing microbubbles into the production fluid.

BACKGROUND

[0002] Fluids that are produced from an underground formation containing hydrocarbons
10 generally include multiple phases, such as water, crude oil, gaseous product, and sand or other solids. Often, a well site will have separation equipment downstream of the wellhead to separate the majority of the phases in order to make the downstream processing more efficient. Separation equipment may include separators that separate the physical phases, such as separating the liquid phases from the solids and/or the gaseous phase. Other
15 separators may separate liquid phases, such as separating water and oil. Depending on the characteristics of the well, there may be any number of separators that may be required to achieve the desired level of separation.

SUMMARY

[0003] According to an aspect, there is provided a method of separating oil and water
20 from a production stream, comprising the steps of producing a production fluid from a hydrocarbon producing well, the production fluid comprising a gas phase, a water phase, an oil phase, and sand phase, passing the production fluid directly from the hydrocarbon producing well through a series of separators, the series of separators comprising at least one
25 water/oil separator that separates at least the water phase and the oil phase, and injecting microbubbles into the production fluid upstream of or into the first water/oil separator relative to the hydrocarbon producing well.

[0004] According to another aspect, the water/oil separator may further separate the gas
30 phase, the sand phase, or the gas phase and the sand phase.

[0005] According to another aspect, the microbubbles may be injected upstream of the first water/oil separator, directly into the water/oil separator, or upstream of the series of

separators.

[0006] According to another aspect, the microbubbles may be injected into a circulation loop of the water/oil separator.

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[0007] According to another aspect, the microbubbles may be injected by passing the entire stream of production fluid through a diffusion tower.

[0008] According to another aspect, the entire stream of production fluid may be passed
10 through the diffusion tower prior to passing through the first separator in the series of separators.

[0009] According to an aspect, there is provided a method of separating oil and water from a production stream, comprising the steps of receiving a production fluid directly from a
15 hydrocarbon producing well, the production fluid comprising at least an oil phase and a water phase, passing all of the oil phase and the water phase of the production fluids through a separator for separating the water phase from the oil phase, the separator having an oil outlet and a water outlet, and injecting microbubbles into the production fluid upstream of the oil outlet and the water outlet.

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[0010] According to another aspect, the production fluid may further comprise sand, a gas phase, or sand and a gas phase.

[0011] According to another aspect, the production fluid may be passed directly from the
25 hydrocarbon producing well to the separator.

[0012] According to another aspect, the production fluid may be passed directly from the hydrocarbon producing well to a series of phase separators, and the separator may be the first phase separator that separates the water phase from the oil phase.

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[0013] According to another aspect, the microbubbles may be injected upstream of the

separator or directly into the separator.

[0014] According to another aspect, the microbubbles may be injected into a circulation loop of the separator.

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[0015] According to another aspect, the microbubbles may be injected by passing the entire stream of production fluid through a diffusion tower.

[0016] According to another aspect, the entire stream of production fluid may be passed through the diffusion tower prior to passing through the first separator in the series of separators.

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[0017] In other aspects, the features described above may be combined together in any reasonable combination as will be recognized by those skilled in the art.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other features will become more apparent from the following description in which reference is made to the appended drawings, the drawings are for the purpose of illustration only and are not intended to be in any way limiting, wherein:

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FIG. 1 is a schematic view of a separator with a microbubble diffuser upstream.

FIG. 2 is a schematic view of a separator with a microbubble diffuser attached to a separator.

FIG. 3 is a schematic view of a separator with a microbubble diffuser within the separator.

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FIG. 4 is a schematic view of a separator with additional preliminary separators prior to a microbubble diffuser upstream of the separator.

FIG. 5 is a schematic view of a separator with a microbubble diffuser upstream of additional preliminary separators and a separator.

30 DETAILED DESCRIPTION

[0019] A method of separating oil and water in a production stream of fluids from a

hydrocarbon producing well will now be described with reference to FIG. 1 through 5.

[0020] FIG. 1 depicts a general layout of a wellhead 12 and separation equipment, generally indicated by reference numeral 14, which receives the fluids produced from wellhead. The production fluids may be conventional production fluids, or may be produced in other circumstances, such as a water flood, polymer flood, etc. The production fluids generally have various components, including a gas phase, which consist primarily of lighter hydrocarbons such as methane and may also be referred to as a vapour phase; a liquid phase, which consists primarily of a water phase and an oil phase; and a solid phase, which is granular and generally referred to as sand, although it may include solids other than silicates, such as rock particles, clay, etc. that may be present in the underground formation. The sand is generally those solids that are carried by or suspended within the other liquid or gas phases as they are produced. After the production fluids exit wellhead 12, it is necessary to separate the various phases to isolate the oil phase for further processing. The other phases are also generally separated and used or disposed of as is known in the art. The downstream processing of the various components is well known in the art, and will not be described further.

[0021] At the wellsite, an initial separation of oil and water occurs. It will be understood that a complete separation may not be possible, and that there may be some emulsions or suspended solids that are difficult to remove using onsite equipment. Instead, the final separation occurs elsewhere, such as in a refinery. However, a better separation on site results in a more efficient process, as a higher concentration of oil is being collected and transported to the refinery.

25

[0022] Generally speaking, there are various separators that may be used at a wellsite. Examples may include a three phase separator, which is used to separate the gaseous phase, the liquid phase and the solid phase. Another type of separator is a sand knockout, which is used to remove sand from the production stream, with the liquid and gaseous phases continuing. Removing the sand is important, particularly in high pressure situations, as the sand acts as an abrasive and can erode equipment. Yet another separator is the water/oil

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separator, which separates the oil and water phases present in the liquid phase, such as a free water knockout tank. The separation scheme and separators that are used will generally depend on the composition of the produced fluid, such as the relative proportion of each phase, and the way in which the production fluids will be transported, such as the fluids being stored in a production tank for future transport by a tanker truck, or transported by pipeline. The presently described method was primarily designed for high pressure applications, however, it will be understood that it may be applied in a variety of other applications.

[0023] The presently described method relates to enhancing the initial separation of water and oil from the production stream by injecting microbubbles at the initial stage. As will be understood, the microbubbles may be injected in various ways and the actual position of the separator may vary depending on the configuration of the wellhead separator equipment. Some examples are given below. In each of the examples the microbubbles are injected upstream of, the first separator that is used to separate the water phase and the oil phase. It will be understood that this includes the scenario shown in FIG. 3, where the microbubble diffusion tower 18 is contained within the water/oil separator 16, as in this case the fluid flow is still passing through microbubble diffusion tower 18 prior to entering separator 16. For the situations described herein, this will still be considered upstream as the fluid has not yet entered the separation area of separator 16. The first water/oil separator may be downstream of a three phase separator, a sand knockout tank, or other type of separator, or may be integrated within the separator. The first separator where this occurs will be described herein as a water/oil separator. It should be kept in mind that, while the process may be discussed in terms of injecting the entire water and oil phases into the oil/water separator, there may be some ancillary, inherent removal of water or oil when separating the gas phase or the solid phase, as the gas phase may entrain water or oil droplets, and the sand may be wet with water or oil, as each phase is removed from a separator. As no separation can result in 100% separation, the residual amounts of phases that will be found in other phases after separation will not be considered to be part of the water or oil phase. Alternatively, it may be considered that the water/oil separator is the first separator that is designed to separate water from oil, and has separate outlets for outputting the water phase and the oil phase from the separation vessel.

[0024] It will also be noted that the fluid entering the water/oil separator will also likely include some sand, as it is difficult to fully remove the solid phase without more robust separation techniques. As such, even if water/oil separator is downstream of a sand separator (such as a three phase separator, sand knockout tank, etc.), there will likely still be some solids content in the fluid entering the water/oil separator.

[0025] Referring now to FIG. 1, there is shown an example of a separation scheme in which there is a separator 16 downstream of a microbubble diffusion tower 18. Diffusion tower 18 injects microbubbles of a gas into the stream of production fluids. Preferably, the gas is a gas that is non-reactive with the oil in the fluid stream, such as methane, nitrogen, or the like. An example of a suitable diffusion tower for injecting the microbubbles includes the diffusion systems produced by Seair Inc. of Alberta, Canada. Some of these systems apply shear forces to the fluids when injecting microbubbles, which may help destabilize any oil/water emulsions, i.e. emulsions that may exist in a “rag layer” at the oil/water interface, and may also help separate any entrained or emulsified sand.

[0026] Preferably, the system is used in situations where the oil content is between 30 – 70%, and preferably 40 – 60%, but may also used with production flows having an oil content of down to 2% or less, or up to 80% or more. Generally speaking, for higher concentrations of oil, more gas will be required, and the impact of the diffused gas is more noticeable.

[0027] Separator 16 is a water/oil separator that has a production fluid inlet 20, an oil outlet 22 and a water outlet 24. Separator 16 may vary and may be selected from among commercially available separators, or custom manufactured based on known design principles, that are known able to separate oil from water. A further example is shown in FIG. 2, where diffusion tower is connected in a circulation loop 26 of separator 16, which draws fluid out of separator 16, aerates the liquid using diffusion tower 18, and reintroduces the fluid into separator 16. Referring to FIG. 3, another example is shown, where diffusion tower 18 is positioned within separator 16. In this example, with diffusion tower 18 surrounded by separator 16, the flow through inlet 20 is still directed through diffusion tower 18 in which a gas/water mixture may be sheared before entering the full volume of separator

16. This eliminates a vessel that would normally be required for diffusion tower 18. It will be understood that separator 16 may require some modifications to be able to handle the gas that will be injected into the production fluid. For example, separator 16 may be provided with an additional gas outlet or vent (not shown), or may be designed to allow the gas to exit through one of the existing liquid outlets.

[0028] The method is accomplished by passing all of the oil phase and the water phase of the production fluids from wellhead 12 through separator 16 for separating the water phase from the oil phase, while injecting microbubbles into the production fluid upstream of oil outlet and water outlets 22 and 24. In one configuration, referring to FIG. 1-3, the production fluid is passed directly from wellhead 12 to separator 16. In another configuration, referring to FIG. 4, the production fluid is passed directly from wellhead 12 to a series of phase separators, with the microbubbles being injected upstream of the first phase separator that separates the water phase from the oil phase. This is represented by additional separator 28, which may represent multiple separators in series or parallel, connected between wellhead 12 and water/oil separator 16. Referring to FIG. 5, diffusion tower 18 may also be used prior to additional separator 28. For example, the fluid flow may pass through diffusion tower 18 prior to entering a three phase separator at 28, which separates the gas, liquid, and sand phases, after which the fluid enters separator 16.

[0029] While microbubbles have been commonly injected to treat or separate fluids in separation tanks, this is generally seen as a polishing step. Contrary to current industry practice, it has been found that the efficiency of the separation of oil and water in this initial separator can be enhanced by injecting microbubbles at the initial stage, where the gross separation occurs, and where other solids may also be present. When performing bulk separation of oil and water using other separation techniques, it is common for there to be high oil concentration carry-overs, known as excursions, in the water phase. For example, a free water knock out separator may have about 2% oil in the separated water stream, but an excursion may be 30 – 50% oil. By passing the fluid through diffusion tower 18, the shearing force and the microbubbles serve to break up these excursions and aid in separation of the oil and water. It has also been found that by passing fluid flows with high concentrations of oil

through diffusion tower 18 prior to separation, the oil tends to collect, and the small remaining amounts of oil in the water is reduced relative to fluid flows with low concentrations of oil. As such, applying diffusion tower 18 to the fluid flow early in the separation process is more effective in separating the oil and water phases than if diffusion tower 18 is used later in the process.

[0030] In addition to the effects described above, it has been found that, by passing the entire stream of production fluid through the diffusion tower, interaction between the oil and the microbubbles of gas is enhanced. In a typical injection situation, where microbubbles are injected into a separator tank such as by using compressed gas, the microbubbles rise through the tank and may not contact the oil particles. In this type of system, the oil is attached to the gas through incidental contact only. By passing the production fluid through a diffusion tower, the microbubbles are generated within the production fluid flow and interaction between the gas and the fluid is enhanced. Instead of passive or incidental interaction, this results in active contact and interaction being created between the oil and gas and enhances the separation of the oil and water. This technique may be beneficial as it can be applied to "dirty" fluid streams that have either had no separation of the sand and other solid components, or have had minimal separation.

[0031] In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the elements is present, unless the context clearly requires that there be one and only one of the elements.

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[0032] The scope of the following claims should not be limited by the preferred embodiments set forth in the examples above and in the drawings, but should be given the broadest interpretation consistent with the description as a whole.

30

What is Claimed is:

1. A method of separating oil and water from a production stream, comprising the steps of:
 - 5 producing a production fluid from a hydrocarbon producing well, the production fluid comprising a gas phase, a water phase, an oil phase, and sand phase;
passing the production fluid directly from the hydrocarbon producing well through a series of separators, the series of separators comprising at least one water/oil separator that separates at least the water phase and the oil phase; and
 - 10 injecting microbubbles into the production fluid by passing an upstream production flow through a microbubble diffuser, the microbubbles being injected upstream of the first water/oil separator relative to the hydrocarbon producing well, the upstream production flow comprising production fluid flowing between the hydrocarbon producing well and the water/oil separator.
- 15 2. The method of claim 1, wherein the water/oil separator further separates the gas phase, the sand phase, or the gas phase and the sand phase.
3. The method of claims 1 or 2, wherein the microbubbles are injected upstream of the
20 series of separators.
4. The method of any of claims 1 through 3, wherein the microbubbles are injected by passing the entire upstream production flow through the microbubble diffuser.
- 25 5. The method of claim 4, wherein the entire upstream production flow is passed through the microbubble diffuser prior to passing through the first separator in the series of separators.
6. The method of any of claims 1 through 5, wherein the water/oil separator is positioned downstream from one or more separators that separate sand, gas, or sand and gas from the
30 production fluid.

7. A method of separating oil and water from a production stream, comprising the steps of:

receiving a production fluid directly from a hydrocarbon producing well, the production fluid comprising at least an oil phase and a water phase;

5 passing the oil phase and the water phase of the production fluids through a separator for separating the water phase from the oil phase, the separator having an oil outlet and a water outlet; and

injecting microbubbles into the production fluid by passing an upstream production flow through a microbubble diffuser, the microbubbles being injected upstream of the separator relative to the hydrocarbon producing well, the upstream production flow comprising production fluid flowing between the hydrocarbon producing well and the separator.

8. The method of claim 7, wherein the production fluid further comprises sand, a gas phase, or sand and a gas phase.

9. The method of claims 7 or 8, wherein the production fluid is passed directly from the hydrocarbon producing well to the separator.

20 10. The method of claims 7 or 8, wherein the production fluid is passed directly from the hydrocarbon producing well to a series of phase separators, and the separator is the first phase separator that separates the water phase from the oil phase.

25 11. The method of any of claims 7 through 10, wherein the microbubbles are injected by passing the entire stream of production fluid through the microbubble diffuser.

12. The method of claim 10, wherein the entire upstream production flow is passed through the microbubble diffuser prior to passing through the first separator in the series of phase separators.

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13. The method of any of claims 7 through 11, wherein the separator is positioned

downstream from one or more phase separators that separate sand, gas, or sand and gas from the production fluid.

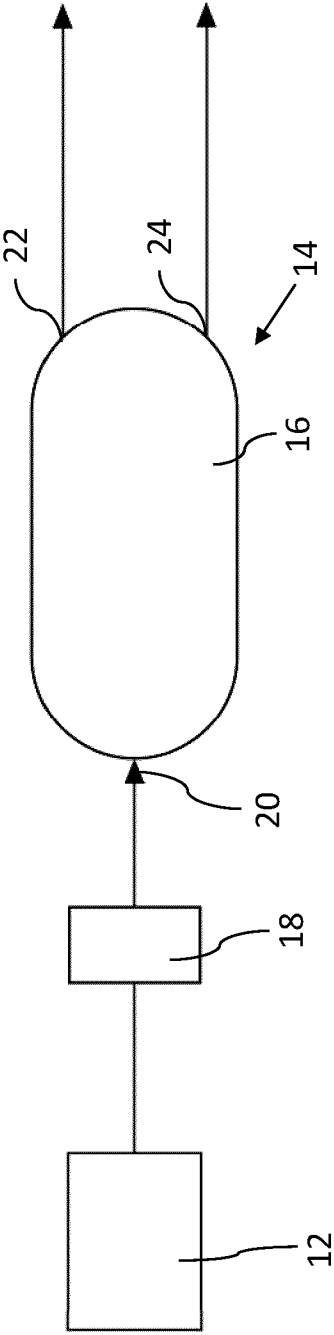


FIG. 1

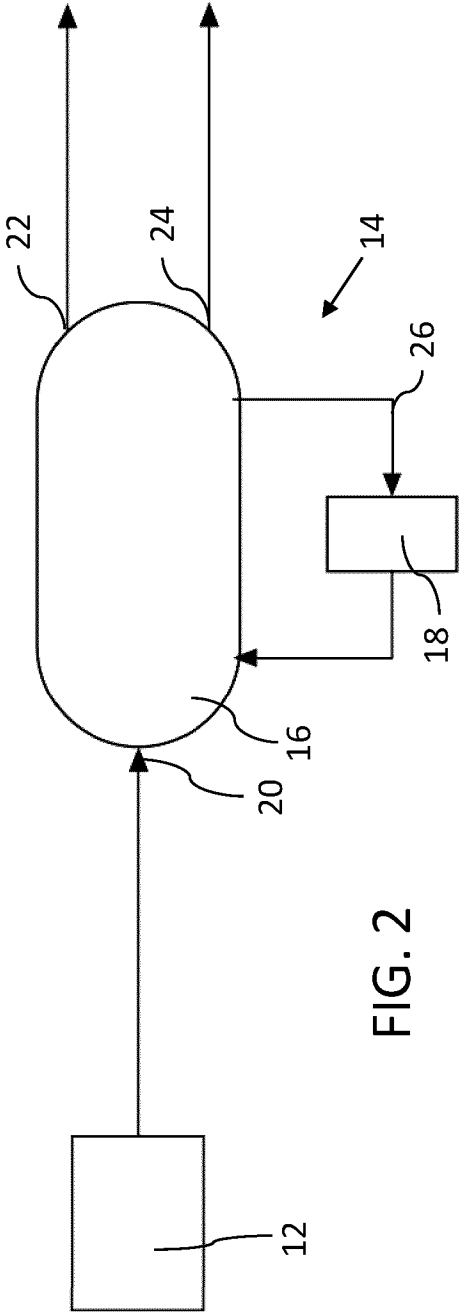
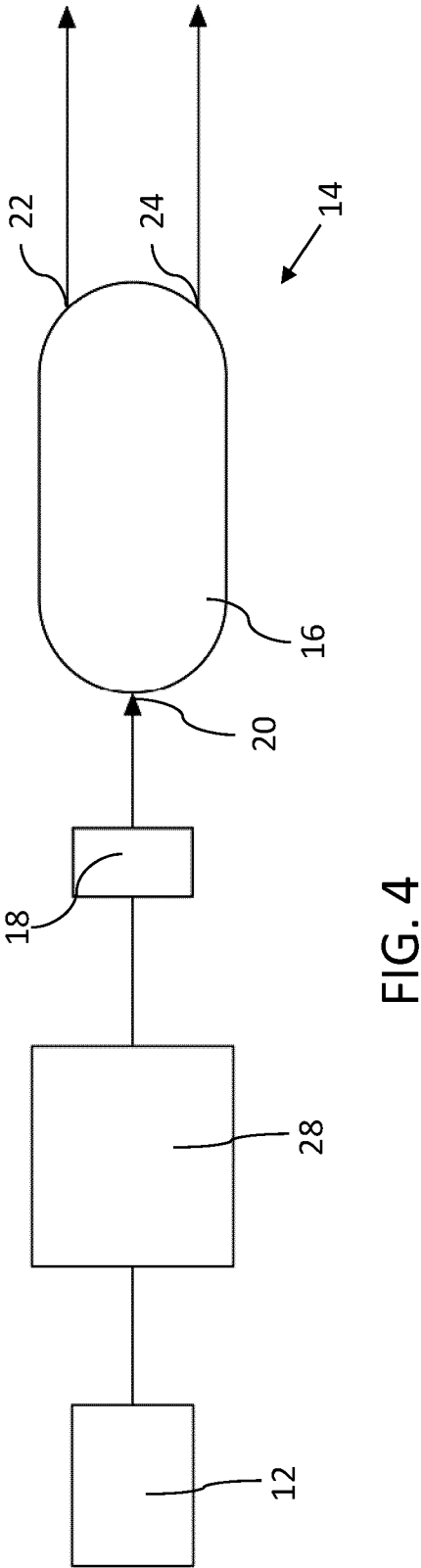
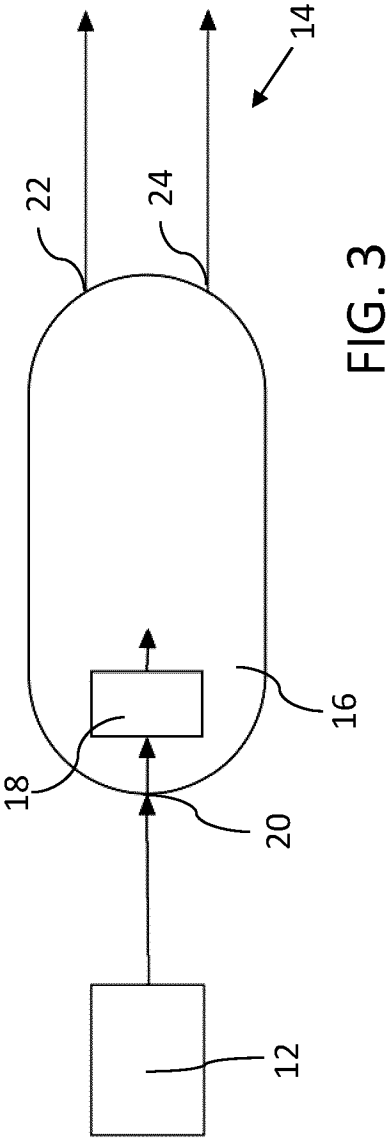


FIG. 2



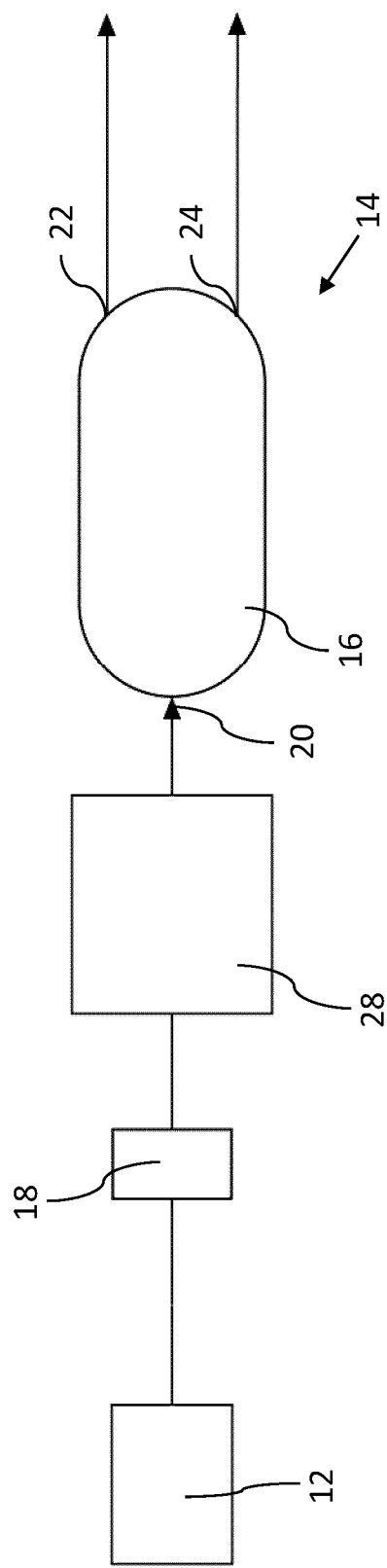


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2016/051509A. CLASSIFICATION OF SUBJECT MATTER
IPC: **B03B 9/02** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: B03B 9/02 (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel-Orbit:
((+bubbles)/TI/AB/IW/OBJ/ADB/ICLM AND (separator+ OR classif+)/TI/AB/IW/OBJ/ADB/ICLM) AND (b03b+)/IPC/CPC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US2012285892 (TUCKETT et al.) 15 November 2012 (15-11-2012)	1-13

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search
05 April 2017 (05-04-2017)Date of mailing of the international search report
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Gatineau, Quebec K1A 0C9
Facsimile No.: 819-953-2476

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US2012285892A1	15 November 2012 (15-11-2012)	US2012285892A1 AU2012202657A1	15 November 2012 (15-11-2012) 29 November 2012 (29-11-2012)
