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(54) Title: AN APPARATUS FOR VENTING AN ANNULAR SPACE BETWEEN A LINER AND A PIPELINE OF A SUBSEA RISER

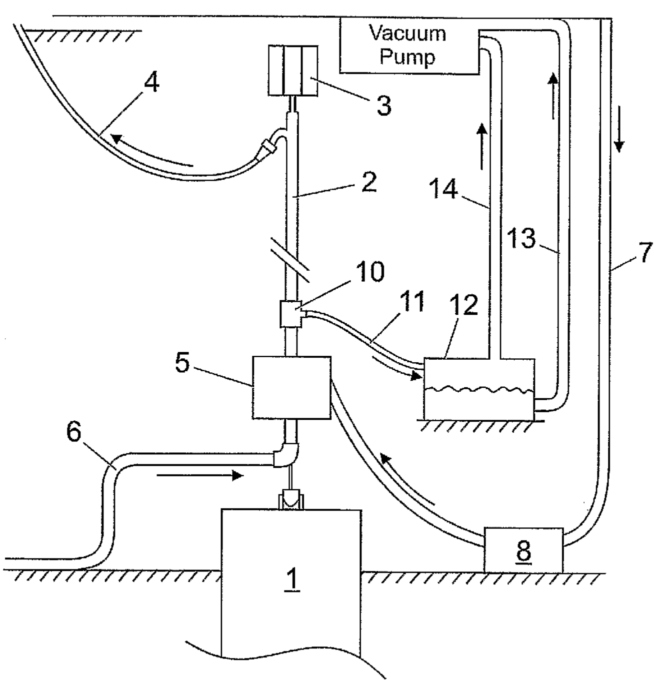

Fig. 1

(57) Abstract: An apparatus for venting an annular space between a liner and a pipeline of a subsea riser (2) for conveying hydrocarbons, said apparatus comprising permeate recovery means for recovering permeate passing through the liner into said annular space. Preferably said permeate recovery means comprises a first- vent port (10) provided in a wall of the pipeline at or adjacent a lower region of the pipeline and communicating with a permeate recovery line (11) defining a flow path between said annular space and a permeate collection vessel (12). Preferably a one-way valve is associated with said permeate recovery line for preventing flow from said permeate recovery line (11) into said annular space.

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An apparatus for venting an annular space between a liner and a pipeline of a subsea riser

The present invention relates to an apparatus for venting an annular space between a liner and the pipeline of a riser for conveying hydrocarbons.

Grooved liners are a technology used within steel pipelines as a cost efficient alternative to using Corrosion Resistant Alloys (CRA's) to construct pipelines transporting highly corrosive substances such as hydrocarbons. The system involves inserting a plastic liner, complete with a number of longitudinal external grooves, into the pipeline. The aim of the liner is to protect the carbon steel pipe from the highly corrosive nature of the production fluids. The grooves act as a method of transporting the gases / liquids that inevitably permeate through the liner to a venting location where they are released to atmosphere or stored in a collection vessel.

It is desirable to utilise the technology for vertical applications, such as production risers, Steel Catenery Risers (SCR) etc. Such applications involve lining vertical pipelines in exactly the same way as a standard horizontal pipeline. These vertical lines act as a method of transporting the production fluids from the main production transport line to the surface. In some applications, the production fluids are transported down to the seabed. Since some of these vertical lines can be exposed to depths in excess of 1000m, a method of aiding flow to the surface is usually required. One such method is Gas Lift, in which processed gas is pumped cyclically through the system to push the fluids from the seabed to the surface.

In the vertical orientation, the liquid permeate will condense on the inner walls of the pipeline and fall to the base of the riser under gravity, where a column of liquid would quickly develop between the liner and the pipeline. This phenomenon dictates that a reliable venting system is required for the removal of the condensed permeate which collects at the base of the riser. This is necessary to avoid the situation where the liner experiences external overpressure and possible collapse in the event that there is a loss of internal pressure in the bore.

According to the present invention there is provided an apparatus for venting an annular space between a liner and a pipeline of a subsea riser for conveying hydrocarbons, said apparatus comprising permeate recovery means for recovering permeate passing through the liner into said annular space.

Preferably said permeate recovery means comprises a first vent port provided in a wall of the pipeline at or adjacent a lower region of the pipeline and communicating with a permeate recovery line defining a flow path between said annular space and a permeate collection vessel. Preferably a one-way valve is associated with said permeate recovery line for preventing flow from said permeate recovery line into said annular space.

The permeate collection vessel may be mounted on or formed integrally with a suction pile upon which the riser is supported. Alternatively the permeate collection vessel may be formed from one or more pipe sections, the ends of which are closed by flanges or plugs.

In one embodiment, said permeate collection vessel includes a first outlet port provided in an upper region of the collection vessel, said first outlet port communicating with a gaseous permeate recovery line, and a second outlet port provided in a lower region of the collection vessel, said second outlet port communicating with a liquid permeate recovery line. One or both of said gaseous and liquid permeate recovery lines may be connected to pump means or other source of vacuum for pumping or drawing said gaseous and/or liquid permeate to the surface and for generating a vacuum in the collecting and/or disposing means.

The gaseous collection line and/or the liquid recovery line may be connected to a collection or storage vessel on the surface to permit measurement and/or analysis of the collected permeate.

In a second embodiment, a second vent port may be provided in a wall of the pipeline at or adjacent an upper region of the pipeline and communicating with a permeate recovery line for venting gaseous permeate from said annular space, said permeate collection vessel connected to said first vent port collecting primarily liquid permeate therefrom. A non-return valve may be associated with the second vent port and/or the permeate recovery line for preventing the return flow of permeate from said permeate recovery line to said annular space. The gaseous permeate recovery line may be connected to a vacuum source to draw gaseous permeate from said annular space. A storage vessel may be provided for storing said collected permeate.

The permeate collection vessel associated with said first vent port may be located on the seabed or an adjacent structure. The permeate collection vessel may be provided with a vacuum pump for aid extraction of liquid permeate from the annular space adjacent said first vent port. The permeate collection vessel may be provided with valve means to permit disconnection and recovery of the permeate collection vessel to enable the vessel to be drained and/or replaced.

In a third embodiment, the permeate collection vessel may be associated with a gas lift system for urging production fluids up the riser, whereby liquid permeate may be entrained out of the permeate collection vessel by means of a flow of high speed and/or high pressure gas and subsequently passed into the riser with the production fluids, thereby returning the liquid permeate into the liner and recovering the liquid permeate to the surface with the production fluid.

Said high speed gas may be injected into the permeate collection vessel over the surface of collected liquid permeate within the collection vessel, preferably in the direction of a permeate and high speed gas outlet, to entrain said liquid permeate into said high speed gas flow. Alternatively said high speed gas may be injected into a lower region of the condensate recovery vessel below the liquid level to entrain the liquid permeate into said high speed gas flow.

A second vent port may be provided in a wall of the pipeline at or adjacent an upper region of the pipeline and communicating with a permeate recovery line connected, preferably to a vacuum pump, for venting gaseous permeate from said annular space, said permeate collection vessel collecting primarily liquid permeate from said first vent port.

Alternatively said first vent may be utilised to collect both gaseous and liquid condensate, said gaseous and liquid condensate being entrained into said high speed gas flow of the gas lift system. The flow of high speed gas into the condensate collection vessel may be utilised to create a vacuum in the collection vessel, possible by means of a venturi effect, actively drawing condensate from said annular space. Alternatively a vacuum pump may be used for generating a vacuum in the permeate collection vessel. Such arrangement advantageously avoids the need for any permeate recovery lines extending to the surface.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic view of a permeate recovery apparatus according to a first embodiment of the present invention;

Fig. 2 is a schematic view of a permeate recovery apparatus according to a second embodiment of the present invention;

Fig. 3 is a schematic view of a permeate recovery apparatus according to a modification of the second embodiment of the present invention;

Fig. 4 is a schematic view of a permeate recovery apparatus according to a third embodiment of the present invention;

Fig. 5 is a sectional view of a permeate recovery vessel of the apparatus of Fig. 4;

Fig. 6 is a sectional view of a modified permeate recovery vessel of the apparatus of Fig. 4;

Fig. 7 is a schematic view of a permeate recovery apparatus according to a fourth embodiment of the present invention; and

Fig. 8 is a schematic view of a storage tank for use with either of the first and second embodiments of the invention.

As shown in the drawings, the riser assembly comprises a suction pile 1 located on the seabed for supporting a lower end of the riser 2. The riser 2 comprises a rigid steel outer pipeline having an inner liner for protecting the steel pipeline from the corrosive effects of the production fluid (typically crude oil and/or natural gas) conveyed by the riser 2.

A buoyancy module 3 supports an upper end of the riser and the production flow is conveyed from an upper end of the riser 2 to a vessel or surface installation by means of a production jumper 4.

A gas lift system 5 is provided at a lower end of the riser for urging the production fluid up the riser 2, the production fluid being fed to the lower end of the riser 2 and the gas lift system 5 via one or more production feed lines 6. High speed gas is supplied from the surface via a feed line 7 connected to a gas lift manifold 8 on the seabed before being injected into a lower end of the riser 2.

In a first embodiment of the present invention, as illustrated in Fig. 1, a first vent port 10 is located as low as possible on the vertical riser 2 for providing communication between an annular space between the liner and the inner walls of the riser 2 and a permeate jumper line 11. The permeate jumper line 11 is connected to a permeate collection tank 12 to collect permeate extracted from said annular space. A non-return valve is provided in the first vent port 10 for preventing return flow of permeate from the permeate jumper line 11 to the annular space.

The permeate collection tank 12 may be located on top of the suction pile 1 and may be integrated into the suction pile 1. Alternatively the permeate collection tank 12 may be located on the seabed separate from the suction pile 1 or may be mounted on other structures of the pipeline assembly.

It is envisaged that the permeate collection tank 12 may be formed from a section of pipeline, plugged at each end with blind flanges. The collection tank 12 may be formed from a number of interconnected pipe sections, stacked on top of one another in parallel relationship.

A liquid permeate recovery line 13 extends from a lower region of the permeate collection tank 12 to a vacuum pump on the surface to draw liquid permeate from the collection tank 12. A gaseous permeate recovery line 14 extends from an upper region of the permeate collection tank 12 to a vacuum pump on the surface to draw gaseous permeate from the collection tank and to generate a vacuum within the collection tank 12 to actively draw permeate from said annular space of the riser 2.

On the topside, the liquid permeate can be drained and / or samples taken for monitoring. The gases can be safely disposed of.

The first embodiment of the invention allows measurement and analysis of permeated gas / liquid from subsea location as opposed to directly venting to atmosphere and can ensure that the necessary venting process does not damage the environment.

A second embodiment of the present invention is illustrated in Fig. 2.

In the second embodiment, a second vent port 20 is located in an upper region of the riser 2 for extraction of gaseous permeate from the annular space between the liner and the pipeline of the riser 2. The second vent port 20 is connected to a gaseous permeate jumper 21 leading to a storage tank 22 on the surface.

The second vent port 20 for the gas extraction is located at the top of the riser 2 to ensure the gaseous permeate jumper 21 is as short as possible, limiting the possibility of damage during service. The extraction of the gas will be controlled by limited topside equipment such as a vacuum pump. This equipment could also be of lower specification and hence cheaper than the same equipment required for the first embodiment. On the topside the gases can be safely disposed of.

As with the first embodiment, a first vent port 7 is located at the base of the riser 2. This vent port 7 is as low as possible on the riser 2 to maximise efficiency. The first vent port 7 is attached to liquid permeate jumper 11, complete with anti-return valve, to a liquid permeate collection tank 12, such tank being of sufficient volume to be capable of containing the volume of permeated fluid for the entire life of the pipeline. The collection tank 12 is fitted with a vacuum pump to aid the extraction of fluids.

There are a number of options for the storage facility:-

1. A purpose built storage tank built into the top of the riser suction pile 1. This would allow the liquid permeate to drain down vertically using gravitational force, aided by the vacuum pump. This is shown in Fig. 2.

2. A separate purpose built storage tank secured on the seabed.

3. A section of pipe or multiple sections linked together, both ends fitted with blind flanges. A schematic can be seen in Fig. 3.

Advantages of the second embodiment:-

- Fluids do not need to be pumped to the surface if the storage tank has adequate volume. This removes the need for umbilical lines from the seabed to the surface. This will reduce the risk of damage in service;

- Vacuum pump equipment on topside could be of lower specification than if required to vent from seabed;

- Feasible for valves to be closed temporarily for change-out of storage tanks for options 2 & 3. This would not affect production.

A third embodiment of the present invention is illustrated in Fig. 4.

Typical vertical lines, such as risers, utilise a Gas Lift system to assist the extraction of production fluids to the surface. The system injects gas at the base of the riser at high pressure with the gas travelling at high velocities. The pressure of the gas lifts the fluids up the riser to the surface.

The manifold 8 utilised by the gas lift system 5 on the seabed could be modified to include a small storage tank 30 for the vented liquid permeate. The high pressure, high velocity gas can be routed through the storage tank 30. The small amount of liquid permeate stored in the tank 30 can then be slowly removed along with the high velocity gas, passing over the liquid permeate collected in the tank 30, whereby the liquid permeate passes into the riser 2 with the production fluids (see Fig. 5).

The second vent port 20 for the gas extraction is located at the top of the riser 2 to ensure the extraction jumper 21 is as short as possible, limiting the possibility of damage during service. The extraction of the gas can be controlled by limited topside equipment such as a vacuum pump. This equipment may be of lower specification and hence cheaper than the same equipment required for the first embodiment. On the topside the gases can be safely disposed of.

A variation on this solution may be to inject the high speed gas through the reservoir of permeated liquid within the tank 30, rather than passing over the top. This would in effect cause a spray which can be introduced into the production flow as described before. A sketch of this variation on the process is shown in Fig. 6.

Advantages of the third embodiment:-

- No umbilicals are required from the seabed to the surface for transport of permeates. This reduces the risk of damage to the venting system in operation;

- No external equipment necessary to draw a vacuum in the annulus – the fluid would drip into the container under gravity and hydrostatic load from head of permeated liquid;

- Can be incorporated to current standard gas lift / riser designs;

- Vacuum pump equipment on topside could be of lower specification than if required to vent from seabed.

A fourth embodiment of the present invention is illustrated in Fig. 7.

In the fourth embodiment, the gas lift system is used to transport the liquid permeate to the surface via the riser 2. Due to the small amount of liquid permeated, a vacuum may be created in the storage tank 30 that could be used to suck both the liquid and the gaseous permeates from the annular space between the liner and the pipeline of the riser 2. This system would allow both the gas and the liquid to be reintroduced into the production flow and transported to the surface. This would negate the need for the second vent port 20 at the top of the riser as the gas would be vented from the single base vent port 10.

Advantages of the fourth embodiment:

- No umbilicals are required from the seabed to the surface for transport of permeates. This reduces the risk of damage to the venting system in operation;

- No external equipment necessary to draw a vacuum in the annulus – the vacuum would be naturally created by the gas lift flow through the tank;

- Can be incorporated to current standard gas lift / riser designs;

- No need for topside venting equipment or umbilicals.

Fig. 8 illustrates a storage tank 12 for use with either of the first and second embodiments described above. The storage tank is defined by a section of small diameter pipe 100, identical or similar to the pipe used for the permeate jumper line 11, the storage pipe 100 being fomed into a convoluted or serpentine shape and mounted within a frame 102 mounted on the seabed 104, whereby the storage pipe 100 can be used to collect permeate from the annular space between the inner walls of the riser 2 and the liner. A first valve 106 is provided at in inlet end of the pipe 100 for controlling communication between the storage pipe 100 and the jumper line 11.

To enable the storage pipe 100 to be drained, a further pipe 110, of similar diameter and construction to the storage pipe 100, is arranged in parallel to the storage pipe 100 and connected to an upper end of the storage pipe 100 via a second valve 108. An inlet end of the further pipe 110 is connected to a source of gas (e.g. air) from an umbilical termination unit and the lower end of the storage pipe 100 is connected to vent or drain pipe of the umbilical termination unit, each via a respective valves 112,114.

In normal operation, the second 108 and further 112,114 valves are closed and the first valve is open so that permeate from the permeate jumper line is collected in the storage pipe 100. When it is desired to drain the storage pipe 100, the first valve 106 is closed, to close communication between the storage pipe 100 and the jumper line 11, and the second 108 and further 112,114 valves are opened whereby air is supplied into the further pipe 110 from the umbilical termination unit via valve 112 and passes into an upper end of the storage pipe 100 via valve 108, thereby flushing out permeate from the storage pipe 100 into the vent or drain of the umbilical termination unit via valve 114. Thus a closed circuit is created between the further pipe 110 and the storage pipe 110 for flushing the storage pipe 100.

Various modifications and variations to the described embodiments of the invention will be apparent to those skilled in the art without departing from the scope of the invention as defined in the appended claims. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments.

Claims

1. An apparatus for venting an annular space between a liner and a pipeline of a subsea riser for conveying hydrocarbons, said apparatus comprising permeate recovery means for recovering permeate passing through the liner into said annular space.

2. An apparatus as claimed in claim 1, wherein said permeate recovery means comprises a first vent port provided in a wall of the pipeline at or adjacent a lower region of the pipeline and communicating with a permeate recovery line defining a flow path between said annular space and a permeate collection vessel.

3. An apparatus as claimed in claim 2, wherein a one-way valve is associated with said permeate recovery line for preventing flow from said permeate recovery line into said annular space.

4. An apparatus as claimed in claim 2 or claim 3, wherein the permeate collection vessel is mounted on or formed integrally with a suction pile upon which the riser is supported.

5. An apparatus as claimed in claim 2 or claim 3, wherein the permeate collection vessel may be formed from one or more pipe sections, the ends of which are closed by flanges or plugs.

6. An apparatus as claimed in any of claims 2 to 5, wherein said permeate collection vessel includes a first outlet port provided in an upper region of the collection vessel, said first outlet port communicating with a gaseous permeate recovery line, and a second outlet port provided in a

lower region of the collection vessel, said second outlet port communicating with a liquid permeate recovery line.

7. An apparatus as claimed in claim 6, wherein one or both of said gaseous and liquid permeate recovery lines are connected to pump means or other source of vacuum for pumping or drawing said gaseous and/or liquid permeate to the surface and for generating a vacuum in the collecting and/or disposing means.

8. An apparatus as claimed in claim 7, wherein the gaseous collection line and/or the liquid recovery line is connected to a collection or storage vessel on the surface to permit measurement and/or analysis of the collected permeate.

9. An apparatus as claimed in any of claims 2 to 5, wherein a second vent port is provided in a wall of the pipeline at or adjacent an upper region of the pipeline and communicating with a permeate recovery line for venting gaseous permeate from said annular space, said permeate collection vessel connected to said first vent port collecting primarily liquid permeate therefrom.

10. An apparatus as claimed in claim 9, wherein a non-return valve is associated with the second vent port and/or the permeate recovery line for preventing the return flow of permeate from said permeate recovery line to said annular space.

11. An apparatus as claimed in claim 9 or claim 10, wherein the gaseous permeate recovery line is connected to a vacuum source to draw gaseous permeate from said annular space.

12. An apparatus as claimed in any of claims 9 to 11, wherein a storage vessel is provided for storing said collected permeate.

13. An apparatus as claimed in any of claims 9 to 12, wherein the permeate collection vessel associated with said first vent port is located on the seabed or an adjacent structure.

14. An apparatus as claimed in claim 13, wherein the permeate collection vessel may be provided with a vacuum pump for aid extraction of liquid permeate from the annular space adjacent said first vent port.

15. An apparatus as claimed in claim 13 or claim 14, wherein the permeate collection vessel is provided with valve means to permit disconnection and recovery of the permeate collection vessel to enable the vessel to be drained and/or replaced.

16. An apparatus as claimed in any of claims 2 to 5, wherein the permeate collection vessel is associated with a gas lift system for urging production fluids up the riser, whereby liquid permeate may be entrained out of the permeate collection vessel by means of a flow of high speed and/or high pressure gas and subsequently passed into the riser with the production fluids, thereby returning the liquid permeate into the liner and recovering the liquid permeate to the surface with the production fluid.

17. An apparatus as claimed in claim 16, wherein said high speed gas is injected into the permeate collection vessel over the surface of collected liquid permeate within the collection vessel, preferably in the direction of a permeate and high speed gas outlet, to entrain said liquid permeate into said high speed gas flow.

18. An apparatus as claimed in claim 16, wherein said high speed gas is injected into a lower region of the condensate recovery vessel below the liquid level to entrain the liquid permeate into said high speed gas flow.

19. An apparatus as claimed in any of claims 16 to 18, wherein a second vent port is provided in a wall of the pipeline at or adjacent an upper region of the pipeline and communicating with a permeate recovery line connected, preferably to a vacuum pump, for venting gaseous permeate from said annular space, said permeate collection vessel collecting primarily liquid permeate from said first vent port.

20. An apparatus as claimed in any of claims 16 to 18, wherein said first vent is utilised to collect both gaseous and liquid condensate, said gaseous and liquid condensate being entrained into said high speed gas flow of the gas lift system.

21. An apparatus as claimed in claim 20, wherein the flow of high speed gas into the condensate collection vessel is utilised to create a vacuum in the collection vessel, actively drawing condensate from said annular space.

22. An apparatus as claimed in claim 21 wherein said vacuum is generated by a venture.

23. An apparatus as claimed in claim 20, wherein a vacuum pump is provided for generating a vacuum in the permeate collection vessel.

24. An apparatus as claimed in claim 2 or 3, wherein the permeate collection vessel is provided with an outlet port at or adjacent a lower region thereof for communication with a permeate recovery line, such as a

pipe connection of an umbilical termination unit, the outlet port being associated with a valve means for selectively enabling fluid communication between the collection vessel and said permeate recovery line.

25. An apparatus as claimed in claim 24, wherein the permeate collection vessel is provided with a flushing port provided at or adjacent an upper region of the collection vessel and being associated with a valve means, the flushing port being connectable to a supply of fluid, such as pressurised gas, for selectively flushing permeate stored in the collection vessel out through the outlet port, a further valve means being provided for selectively closing communication between the permeate recovery line and the collection vessel when the flushing port valve means and the drain outlet valve means are opened during a collection vessel flushing operation.

26. An apparatus as claimed in any of claim 25, wherein the permeate collection vessel comprises a first elongate pipeline having an upper end connected to the permeate recovery line and a lower end connected to or defining said outlet port.

27. An apparatus as claimed in claim 26, wherein the first pipeline is folded or otherwise shaped into a serpentine or coiled form and is mounted on or within a mounting structure.

28. An apparatus as claimed in claim 26 or 27, wherein the collection vessel comprises a further elongate pipeline, preferably arranged parallel to said first elongate pipeline, said further elongate pipeline extending between the supply of flushing fluid and the flushing inlet of the first pipeline.

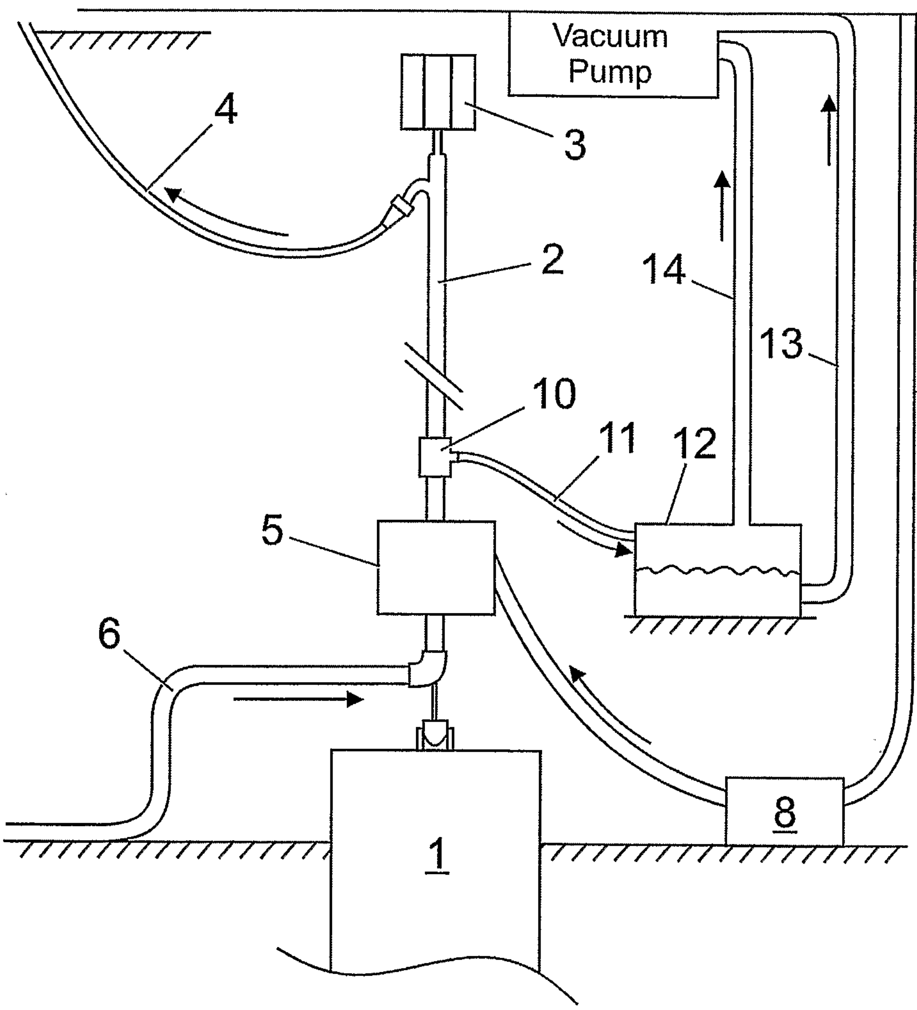

Fig. 1

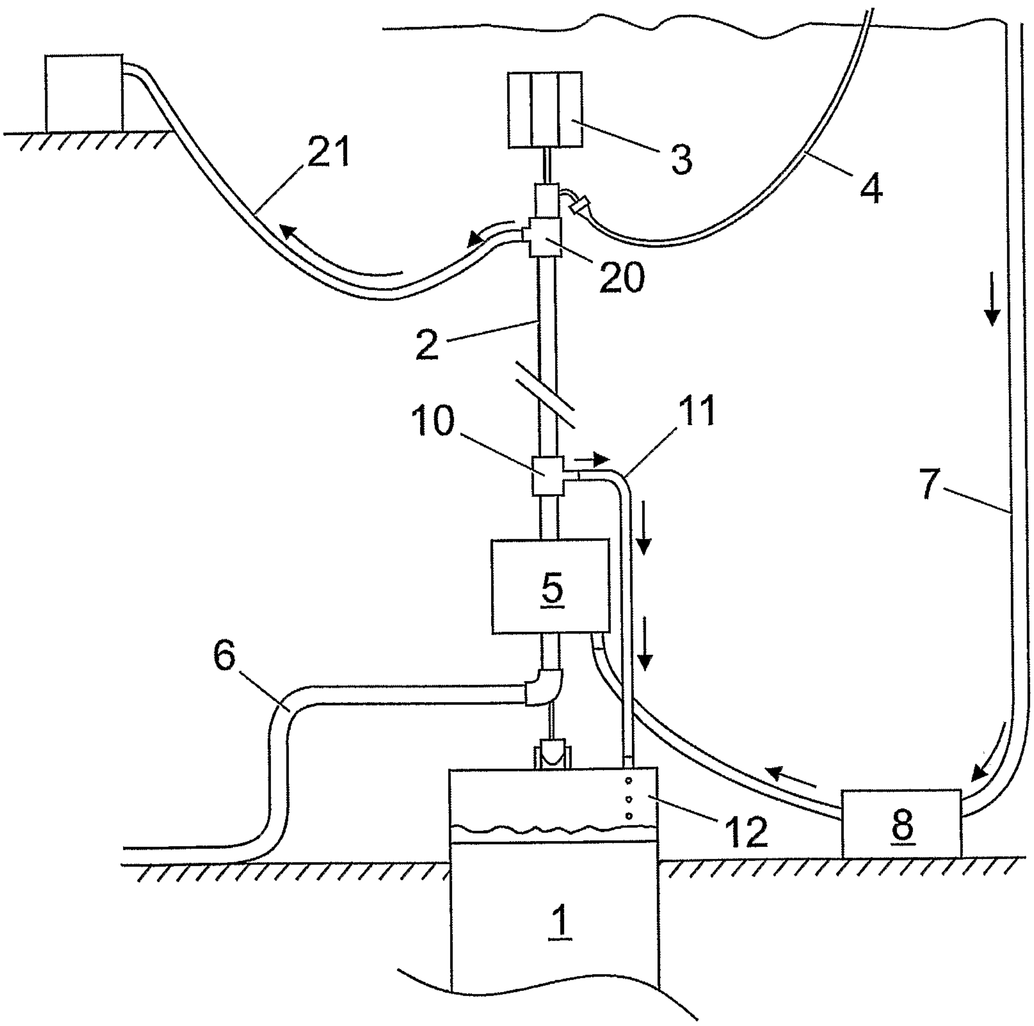

Fig. 2

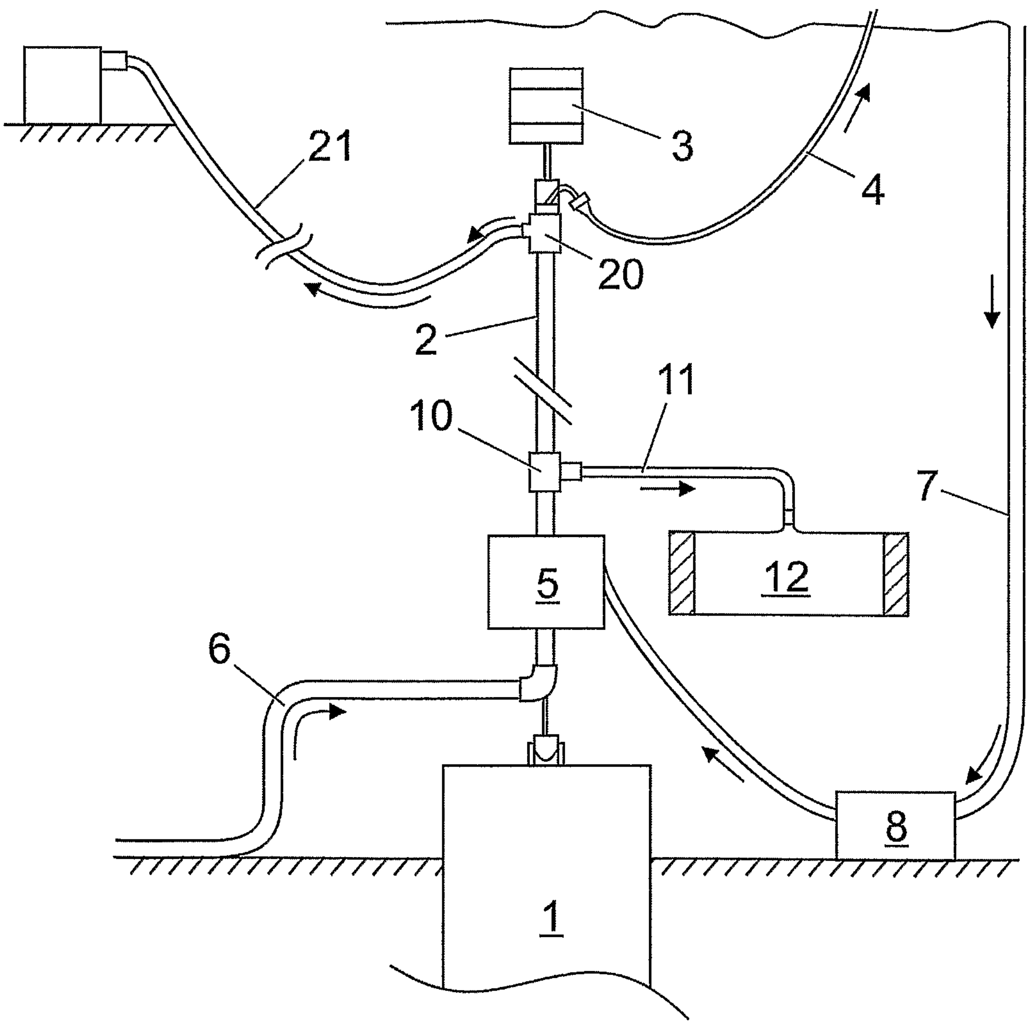

Fig. 3

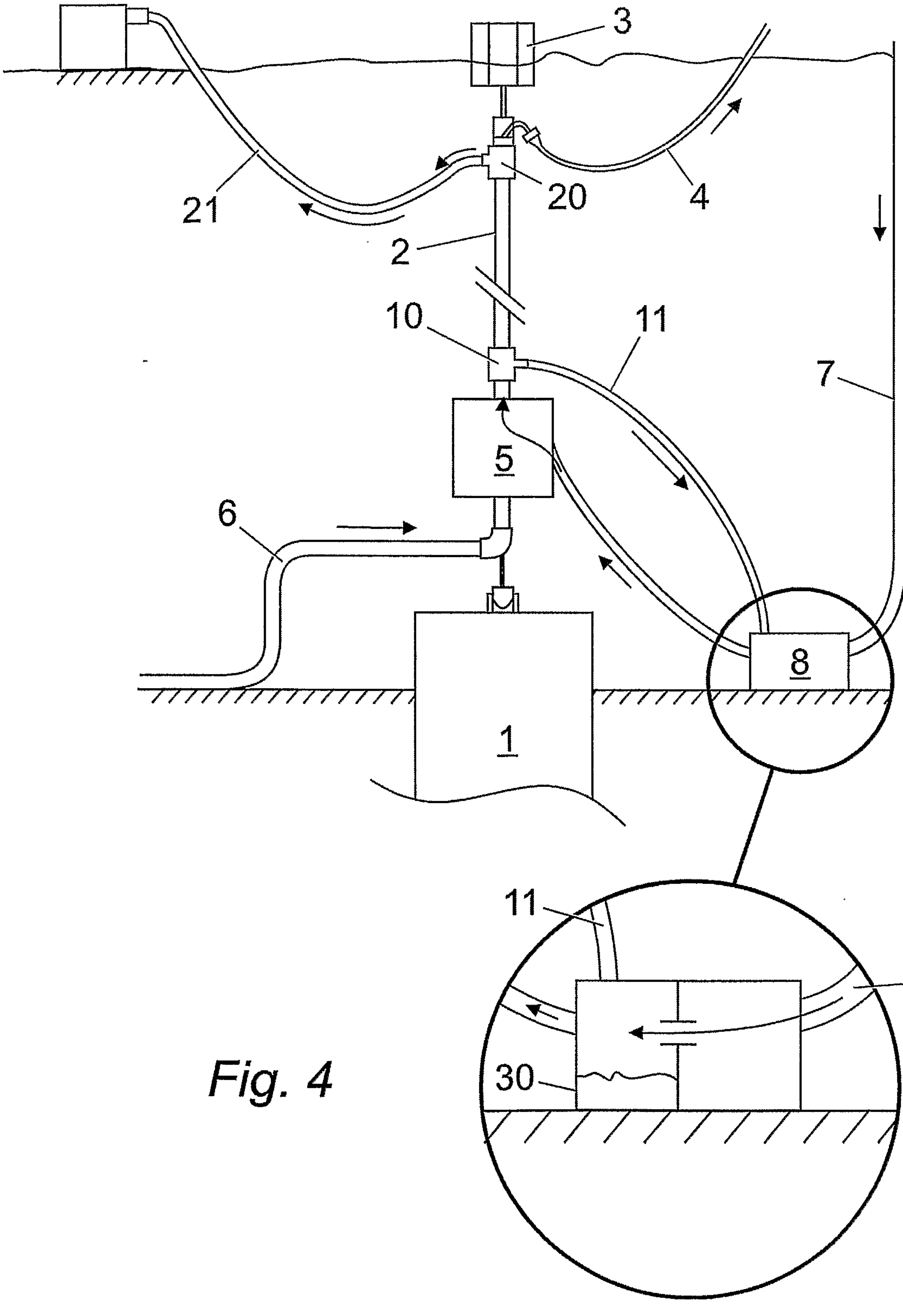

Fig. 4

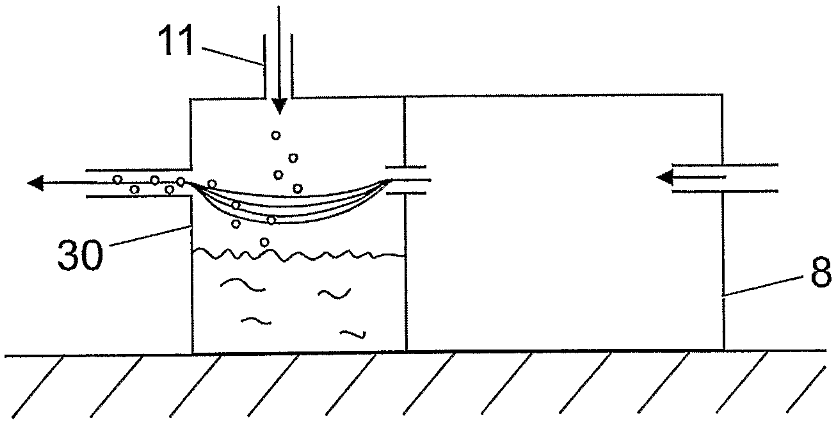

Fig. 5

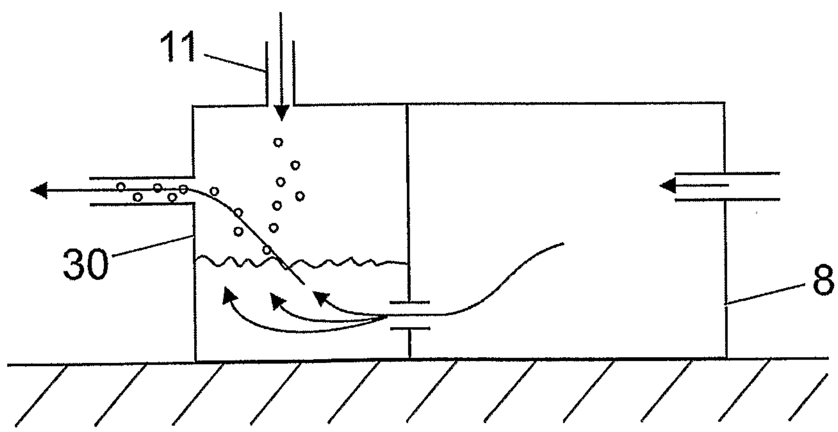

Fig. 6

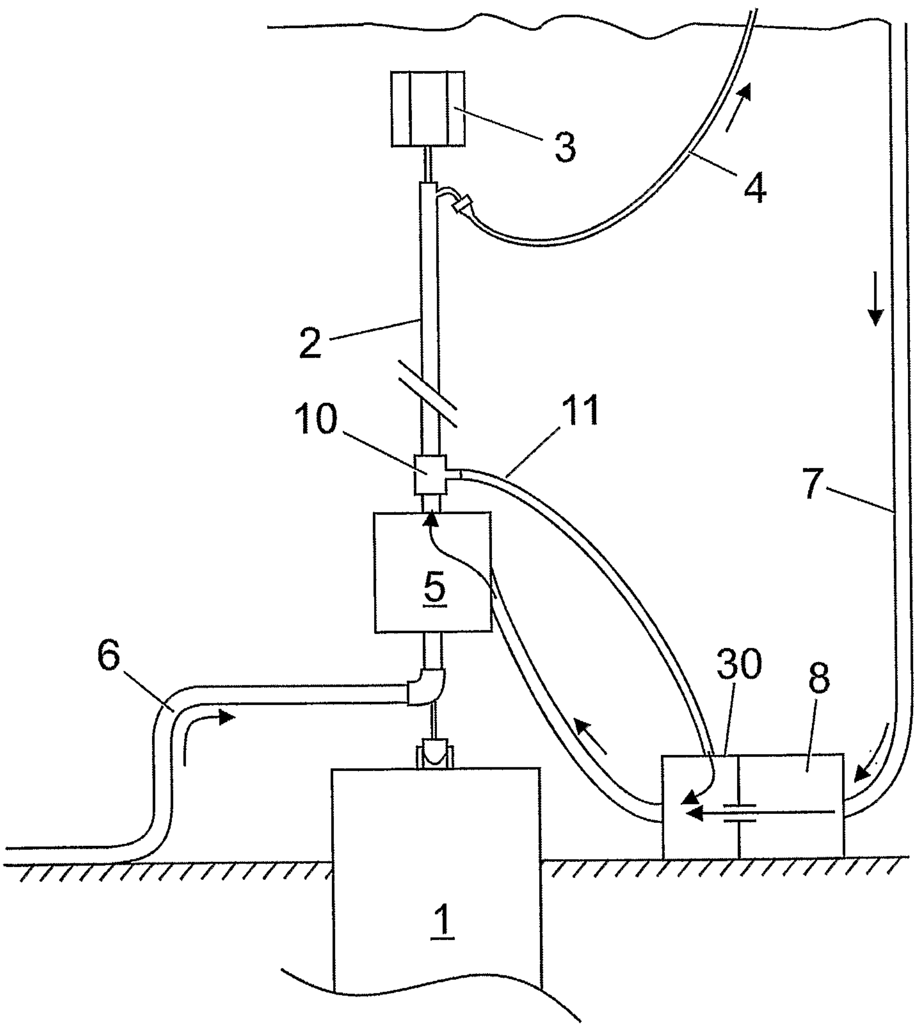

Fig. 7

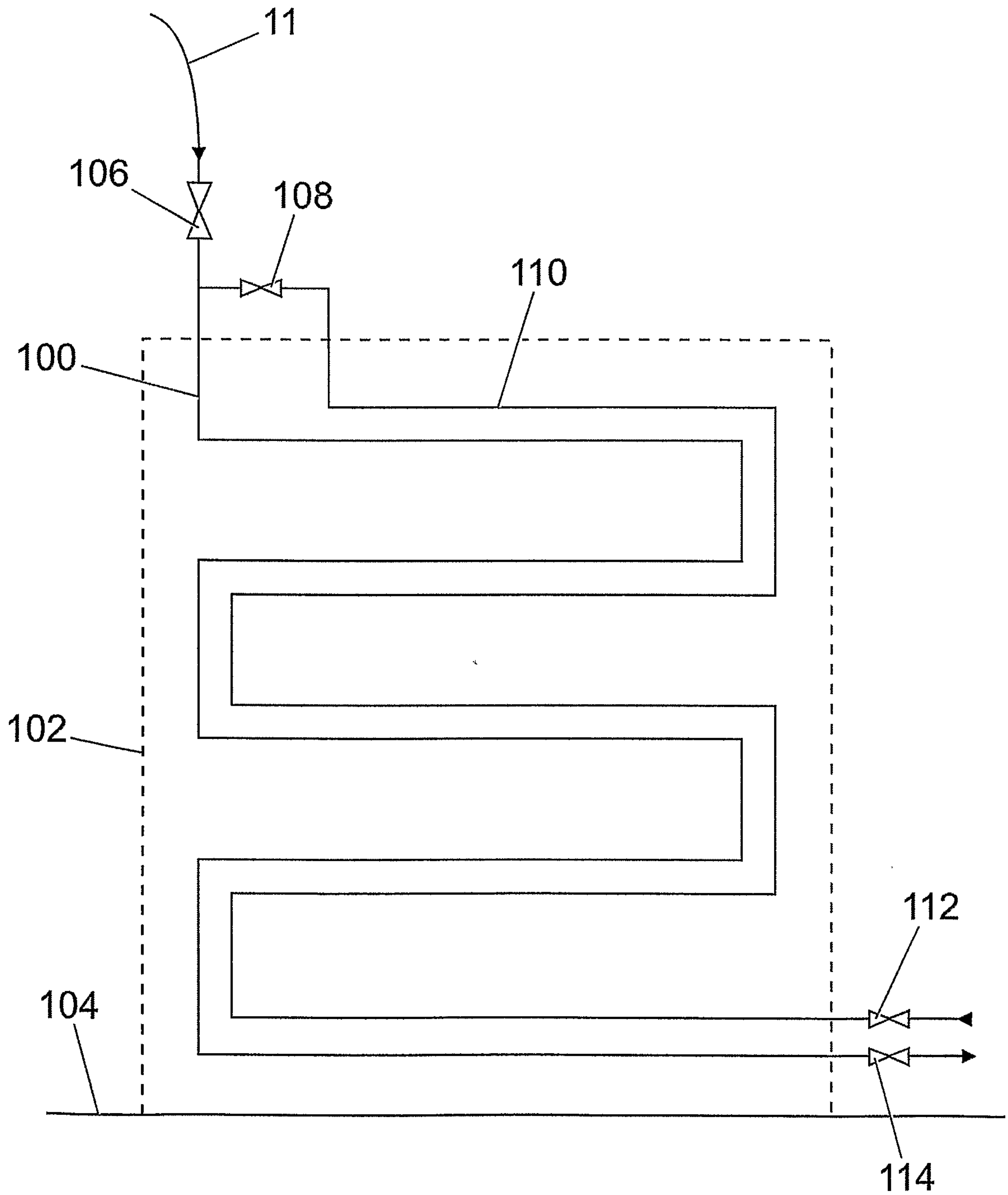

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/000440

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B17/01 E21B43/01

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)
E21B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/238177 A1 (FOSSLI BORRE [NO]) 2 December 2004 (2004-12-02) paragraph [0089]	1-5
X	US 4 216 834 A (WARDLAW HAROLD W R [US]) 12 August 1980 (1980-08-12) column 9, lines 21-52	1-5
A	US 4 634 314 A (PIERCE ROBERT H [US]) 6 January 1987 (1987-01-06) column 6, line 48 - column 7, line 9	1-28
A	US 3 643 751 A (CRICKMER CHARLES D) 22 February 1972 (1972-02-22) column 3, lines 36-48	1-28
A	US 2004/182567 A1 (MATTHEWS MARTIM VINCENT [CA]) 23 September 2004 (2004-09-23) abstract	1-28

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2008	01/07/2008

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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