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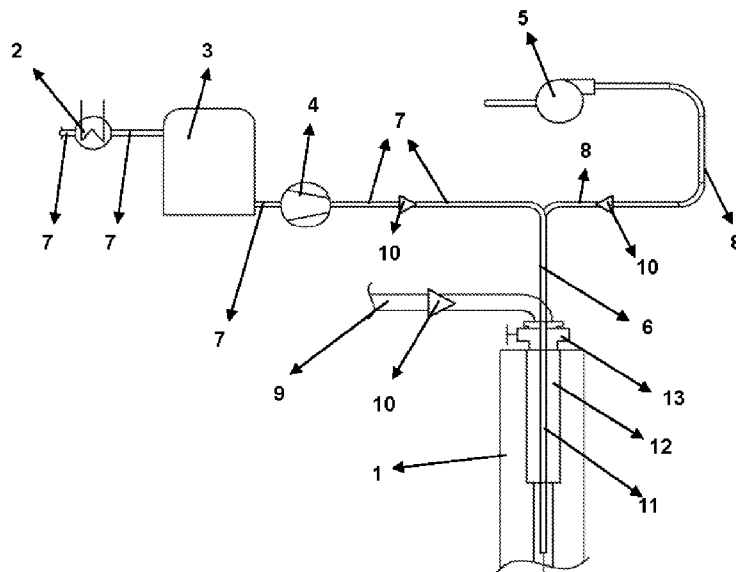


Figure 1

(57) Abstract: With the present invention, there is developed a gas injection system suitable for use in a geothermal plant comprising at least one reinjection well (1) which enables the geothermal fluid received from a geothermal energy source via at least one production well to be delivered again to the geothermal energy source after being treated. Said system comprises at least a first line (6) in which reinjection water, which is received from the pump (5) and the pressure of which is increased, and gases from said compressor (4), the pressure of which are increased, are gathered and delivered to the reservoir by said reinjection well (1); at least a first delivery line (7) which enables to deliver the gas, the pressure of which is increased, to the first line (6); at least a second delivery line (8) which enables to deliver the reinjection water, the pressure of which is increased, to the first line (6); at least a first outlet line (11) which is in communication with the first line (6), another side of which communicates with a lower part of the reinjection well (1), and which



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enables to deliver the mixture received from the first line (6) to the lower part of the reinjection well (1); at least one water delivery line (9) to allow receiving non-pressurized part of the reinjection water from the plant; at least a second outlet line (12) which enables to deliver the relatively low-pressure reinjection water that is received from the water delivery line (9) to the reinjection well (1).

A GAS INJECTION SYSTEM

5 **Technical Field**

The present invention relates to a non-condensable gas injection system developed for reducing non-condensable gases that are emitted by geothermal power plants.

10 **Background of the Invention**

Geothermal energy plays an important role among renewable energy sources. However, though geothermal energy is a clean energy source, one of the most important environmental factors associated with the geothermal plants is non-condensable gases released by the geothermal fluid. Geothermal fluids include non-condensable gases such as carbon dioxide, hydrogen sulphide, hydrogen, nitrogen, ammonia, mercury, boron vapour, radon and methane. While the amount of non-condensable gases present in the geothermal vapour varies depending on the geothermal fields, it generally ranges from 1% to 21% by weight of said vapour. Among such gases, the most environmentally important ones are the carbon dioxide that constitutes 96% to 99% by weight, and the hydrogen sulphide that constitutes less than 1% thereof. Carbon dioxide leads to global issues due to greenhouse effect that it created, and the hydrogen sulphide causes environmental problems as a result of its toxic effect.

25 The known state of art covers various applications developed for injecting non-condensable gases present in the geothermal fluid utilized at geothermal power plants. One of these applications is disclosed in document WO2014140756A2, in which there is disclosed a geothermal based heat utilization system for preventing scaling of geothermal fluid in a heat exchanger, and a method for treating water which is performed with said system. The system comprises a mixing unit to mix geothermal fluid, condensate and non-
30 condensable gases. Since the fluid from said mixing unit to the exchanger is acidified by dissolving the gases in the geothermal water, it is prevented from being scaled on the exchanger. However, said application cannot provide a solution for reducing non-condensable gases that are emitted by geothermal power plants.

Brief Description of the Invention

5 With the present invention, there is developed a gas injection system suitable for use in a geothermal plant comprising at least one reinjection well which enables the geothermal fluid received from a geothermal energy source via at least one production well to be delivered again to the geothermal energy source after being treated. Said system comprises at least one exchanger to which non-condensable gases from the plant are delivered and which allows decreasing temperature of said gases; at least one storage to
10 which said gases, temperatures of which are decreased by said exchanger, are delivered and stored therein; at least one compressor which is provided at an outlet of said storage and allows increasing pressure of the gases received from the storage; at least one pump which allows increasing pressure of at least one part of the reinjection water received from said plant; at least a first line in which reinjection water, which is received from said pump
15 and the pressure of which is increased, and gases from said compressor, the pressure of which are increased, are gathered and delivered to the reservoir by said reinjection well; at least a first delivery line which enables to deliver the gas, the pressure of which is increased, to said first line; at least a second delivery line which enables to deliver the reinjection water, the pressure of which is increased, to said first line; at least a first outlet
20 line which is in communication with said first line on at least one side, at least another side of which communicates with a lower part of the reinjection well, and which enables to deliver the reinjection water, received from the first line and the pressure of which is increased, and the gases, the pressure of which are increased, to said lower part of the reinjection well; at least one water delivery line to allow receiving non-pressurized part of
25 the reinjection water from said plant; and at least a second outlet line which enables to deliver the relatively low-pressure reinjection water that is received from the water delivery line to the reinjection well.

30 Said gas injection system provides to minimize greenhouse effects that are gradually made themselves more apparent in the global and local scale, and to extend productivity spans of the geothermal plants such that their activeness are maintained for a long period of time.

Object of the Invention

An object of the present invention is to provide a non-condensable gas injection system for reducing emission of non-condensable gases produced by the geothermal fluid in the geothermal power plants.

Another object of the present invention is to provide a non-condensable gas injection system for reducing emission of non-condensable gases emitted by the geothermal power plants, in which non-condensable gases are pumped back into the reservoir where they are produced.

Yet another object of the present invention is to provide a gas injection system which allows pumping the carbon dioxide and the hydrogen sulphide back into the reservoir where they are produced, wherein the carbon dioxide generates greenhouse effect within the non-condensable gases produced by the geothermal fluid and the hydrogen sulphide is known for its unpleasant smell and generates toxic effect.

Description of the Drawings

Exemplary embodiments of the gas injection system according to the present invention are illustrated in the accompanying drawings, in which:

Figure 1 is a schematic view of an exemplary embodiment of the gas injection system according to the present invention.

Figure 2 is a schematic view of another exemplary embodiment of the gas injection system according to the present invention.

Figure 3 is an exemplary detailed view of the gas injection system according to the present invention.

All the parts illustrated in the drawings are individually assigned a reference numeral and the corresponding terms of these numbers are listed as follows:

Reinjection well (1)

Exchanger (2)

	Storage	(3)
	Compressor	(4)
	Pump	(5)
	First line	(6)
5	First delivery line	(7)
	Second delivery line	(8)
	Water delivery line	(9)
	Check valve	(10)
	First outlet line	(11)
10	Outlet hole	(11a)
	Second outlet line	(12)
	Well inlet valve	(13)

Description of the Invention

15

Geothermal energy plays an important role among renewable energy sources. However, though geothermal energy is a clean energy source, one of the most important environmental factors associated with the geothermal plants is non-condensable gases released by the geothermal fluid. Geothermal fluids include non-condensable gases such as carbon dioxide, hydrogen sulphide, hydrogen, nitrogen, ammonia, mercury, boron vapour, radon and methane. While the amount of non-condensable gases present in the geothermal steam varies depending on the geothermal fields, it generally ranges from 10% to 21% by weight of said steam. Among such gases, the most environmentally important ones are the carbon dioxide that constitutes 96% to 99% by weight, and the hydrogen sulphide that constitutes less than 1% thereof. Carbon dioxide leads to global issues due to greenhouse effect that it created, and the hydrogen sulphide causes environmental problems as a result of its toxic effect. For that reason, with the present invention, there is developed a gas injection system for reducing emissions of the non-condensable gases emitted by the geothermal power plants, in which non-condensable gases are pumped back into the reservoir where they are produced.

30

The gas injection system according to the present invention, as illustrated in Figure 1, suitable for use in a geothermal plant comprising at least one reinjection well (1) which enables the geothermal fluid received from a geothermal energy source (reservoir) via at

least one production well (not shown in the figures) to be delivered again to the geothermal energy source after being treated, the gas injection system comprises: at least one exchanger (2) to which non-condensable gases from the plant are delivered and which allows decreasing temperature of said gases (preferably allows decreasing it from 5 65°C to 40°C); at least one storage (3) to which said gases, temperatures of which are decreased by said exchanger (2), are delivered and stored therein; at least one compressor (4) which is provided at an outlet of said storage (3) and allows increasing pressure of the gases received from the storage (3) (preferably allows increasing it to 55 bar); at least one pump (5) which allows increasing pressure of at least one part of the 10 reinjection water (brine) received from said plant (preferably allows increasing it to a pressure of 70 bar); at least a first line (6) in which reinjection water, which is received from said pump (5) and the pressure of which is increased, and gases from said compressor (4), the pressure of which are increased, are gathered and delivered to the reservoir by said reinjection well (1); at least a first delivery line (7) which enables to 15 deliver the gas, the pressure of which is increased, to said first line (6); at least a second delivery line (8) which enables to deliver the reinjection water, the pressure of which is increased, to said first line (6); at least a first outlet line (11) which is in communication with said first line (6) on at least one side, at least another side of which communicates with a lower part of the reinjection well (1) (preferably with a point 800 meters below the 20 surface), and which enables to deliver the reinjection water, received from the first line (6) and the pressure of which is increased, and the gases, the pressure of which are increased, to said lower part of the reinjection well (1); at least one water delivery line (9) to allow receiving non-pressurized part of the reinjection water from said plant; and at least a second outlet line (12) which enables to deliver the relatively low-pressure 25 (preferably at a pressure of 55 bar) reinjection water that is received from the water delivery line (9) to the reinjection well (1).

In an exemplary embodiment of the invention, for example, non-condensable gases comprised within the geothermal fluid which is drawn from the reservoir by the geothermal 30 plant for electrical energy production are delivered to the exchanger (2) through said first delivery line (7). According to the Henry's Law, dissolubility of a gas in a liquid decreases as the temperature rises. On condition that the temperature remains constant, dissolubility of a component in the liquid phase is directly proportional to the partial pressure in the gaseous or vapour phase thereof. Based on this principle, first of all, temperature of the

gases from the plant is decreased by said exchanger (2) from 65°C to 40°C and then delivered to said storage (3) through said first delivery line (7), after that, the gas stored is delivered to said compressor (4) through the first delivery line (7), again, so as to pressurize it up to 55 bar. In the meantime, pressure of at least one part of the reinjection water received from the plant is increased by said pump (5) to a pressure of 70 bar, and the gas, the pressure of which is increased by the compressor (4), and the reinjection water from the plant, the pressure of which is increased to a pressure of 70 bar, are gathered together in the said first line (6) so as to pumped them into said reinjection well (1) through the first outlet line (11) (e.g. as in the “aerated drilling” system utilized for drilling industry). Furthermore, non-pressurized part of the reinjection water received from the plant is pumped into the reinjection well (1) via the water delivery line and the second outlet line (12). Here, said non-condensable gases are mixed with the pressurized reinjection water at the inlet of the reinjection well (1), and this mixture is mixed with the reinjection water, the pressure of which is not increased, at a lower part of the reinjection well (1) (preferably at 800 meters below the surface). By this way, the gas injection system according to the present invention is enabled to be a dual-phase and dual-line system.

In a preferred embodiment of the invention, returns are prevented by the check valves (10) which are provided on the first delivery line (7), the second delivery line (8) and the water delivery line (9), and said operations are able to be controlled and monitored by control valves, flow meters, thermometers and pH meters provided on said lines. Yet in another preferred embodiment, said system comprises at least one control unit to which said pressure control valve, flow meter, thermometer and pH meter are connected.

In another preferred embodiment of the invention, said first outlet line (11) is in the form of a tube (for example, with a diameter of 2 inches) which is preferably 800 meters in length. In this embodiment, there is provided at least one (preferably multiple) outlet hole (11a) at a side of the outlet line (11) which is away from the first line (6). By this way, it is ensured that the mixture of gas/reinjection water passing through the first outlet line (11) is safely pumped into a desired depth of the reinjection well (1).

Thanks to said system, a closed cycle is formed between the production and reinjection wells, thereby the non-condensable gases produced by the geothermal fluid are allowed to be pumped back into the reservoir, not to the atmosphere, through the reinjection wells.

- 5 In an alternative embodiment of the invention which is illustrated in figure 2, the gas to be pumped into the reinjection well (1) is able to be received from at least another reinjection well (1), too. By this way, it is ensured that gases of the plurality of reinjection wells (1) are safely sent to the reinjection well (1).
- 10 In another preferred embodiment of the invention, said gas injection system comprises at least one well inlet valve (13) which is located at the inlet of the reinjection well (1). Said well inlet valve (13) provides to open and close the inlet of the reinjection well (1). By this way, different materials (e.g. protective chemicals) are able to be sent through the inlet into the reinjection well (1) in necessary cases.
- 15 Said gas injection system provides to minimize greenhouse effects that are gradually made themselves more apparent in the global and local scale, and to extend productivity spans of the geothermal plants such that their activeness are maintained for a long period of time.

20

CLAIMS

1. A gas injection system suitable for use in a geothermal plant comprising at least one reinjection well (1) which enables the geothermal fluid received from a geothermal energy source via at least one production well to be delivered again to the geothermal energy source after being treated, characterized by comprising:
- at least one exchanger (2) to which non-condensable gases from the plant are delivered and which allows decreasing temperature of said gases;
 - at least one storage (3) to which said gases, temperatures of which are decreased by said exchanger (2), are delivered and stored therein;
 - at least one compressor (4) which is provided at an outlet of said storage (3) and allows increasing pressure of the gases received from the storage (3);
 - at least one pump (5) which allows increasing pressure of at least one part of the reinjection water received from said plant;
 - at least a first line (6) in which reinjection water, which is received from said pump (5) and the pressure of which is increased, and gases from said compressor (4), the pressure of which are increased, are gathered and delivered to the reservoir by said reinjection well (1);
 - at least a first delivery line (7) which enables to deliver the gas, the pressure of which is increased, to said first line (6);
 - at least a second delivery line (8) which enables to deliver the reinjection water, the pressure of which is increased, to said first line (6);
 - at least a first outlet line (11) which is in communication with said first line (6) on at least one side, at least another side of which communicates with a lower part of the reinjection well (1), and which enables to deliver the reinjection water, received from the first line (6) and the pressure of which is increased, and the gases, the pressure of which are increased, to said lower part of the reinjection well (1);
 - at least one water delivery line (9) to allow receiving non-pressurized part of the reinjection water from said plant; and
 - at least a second outlet line (12) which enables to deliver the relatively low-pressure reinjection water that is received from the water delivery line (9) to the reinjection well (1).

2. A gas injection system according to Claim 1, characterized in that said first outlet line (11) is in the form of a tube.

5 3. A gas injection system according to Claim 2, characterized in that said first outlet line (11) is 800 meters in length.

10 4. A gas injection system according to Claim 2, characterized in that at least one outlet hole (11a) is provided at a side of said first outlet line (11) which is away from the first line (6).

5. A gas injection system according to Claim 1, characterized in that the system comprises at least one well inlet valve (13) which is located at the inlet of the reinjection well (1).

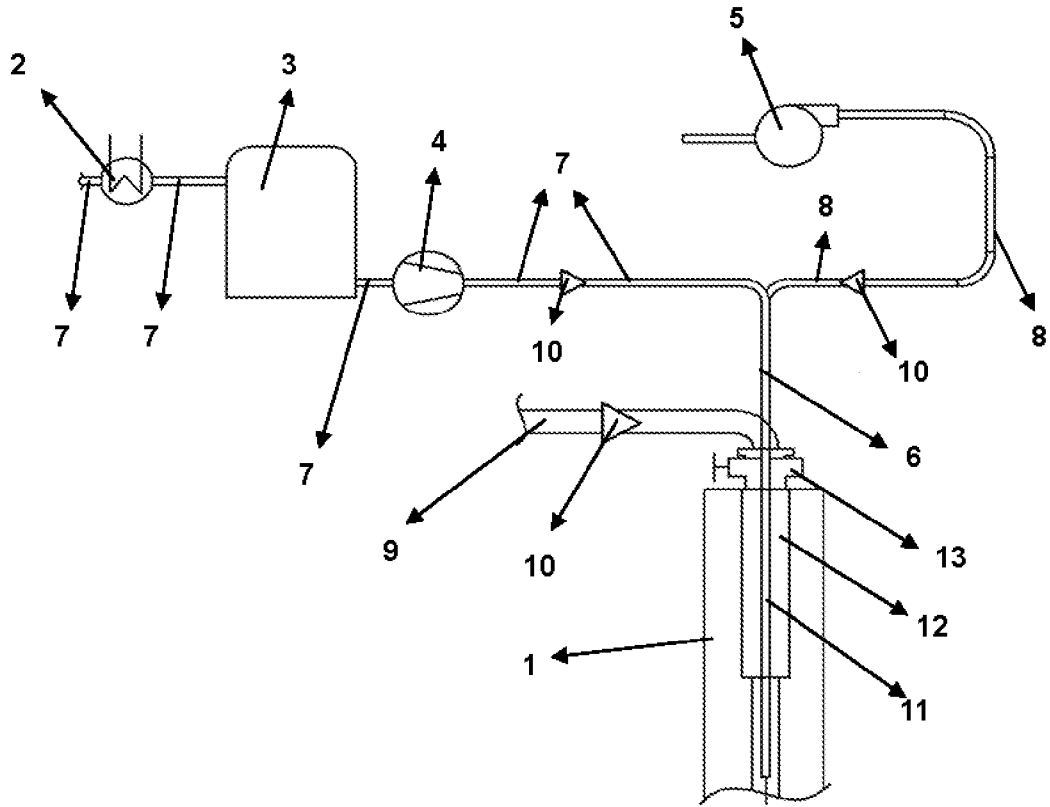


Figure 1

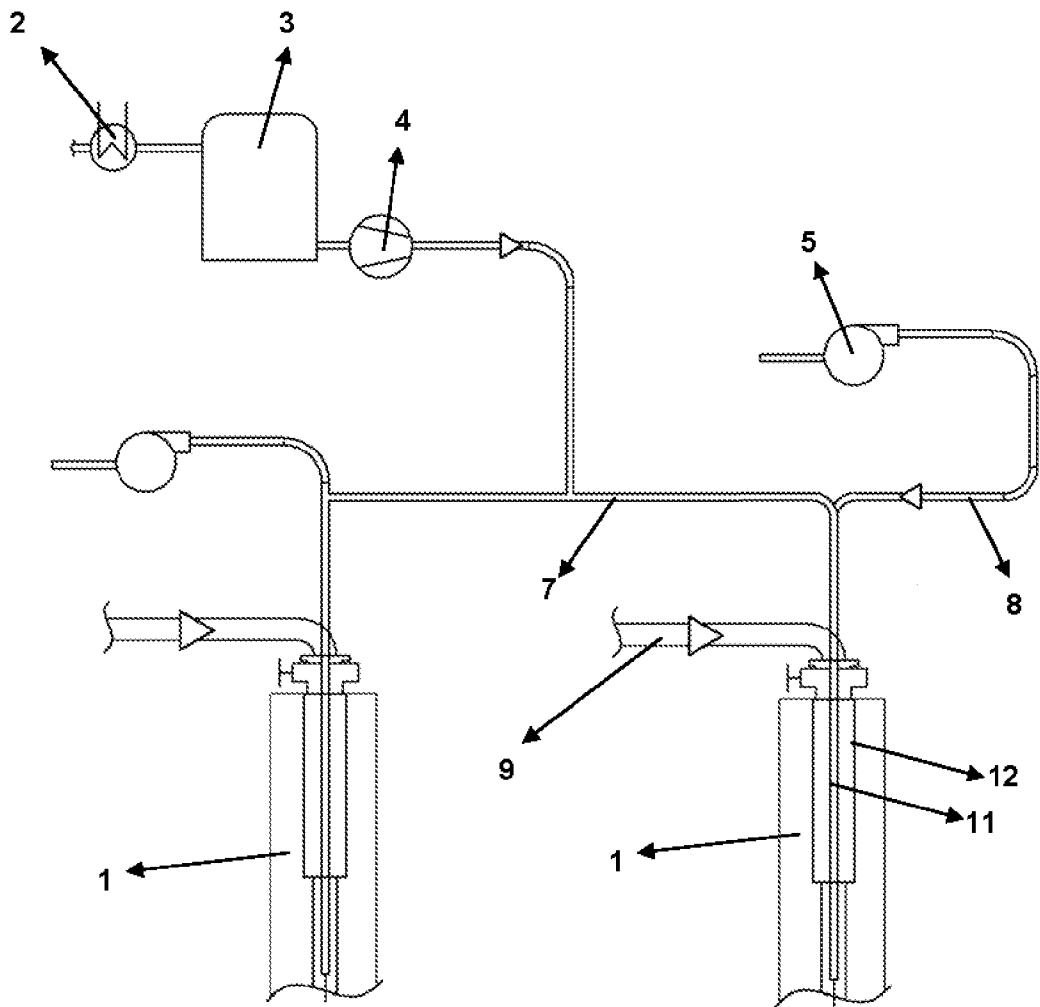


Figure 2

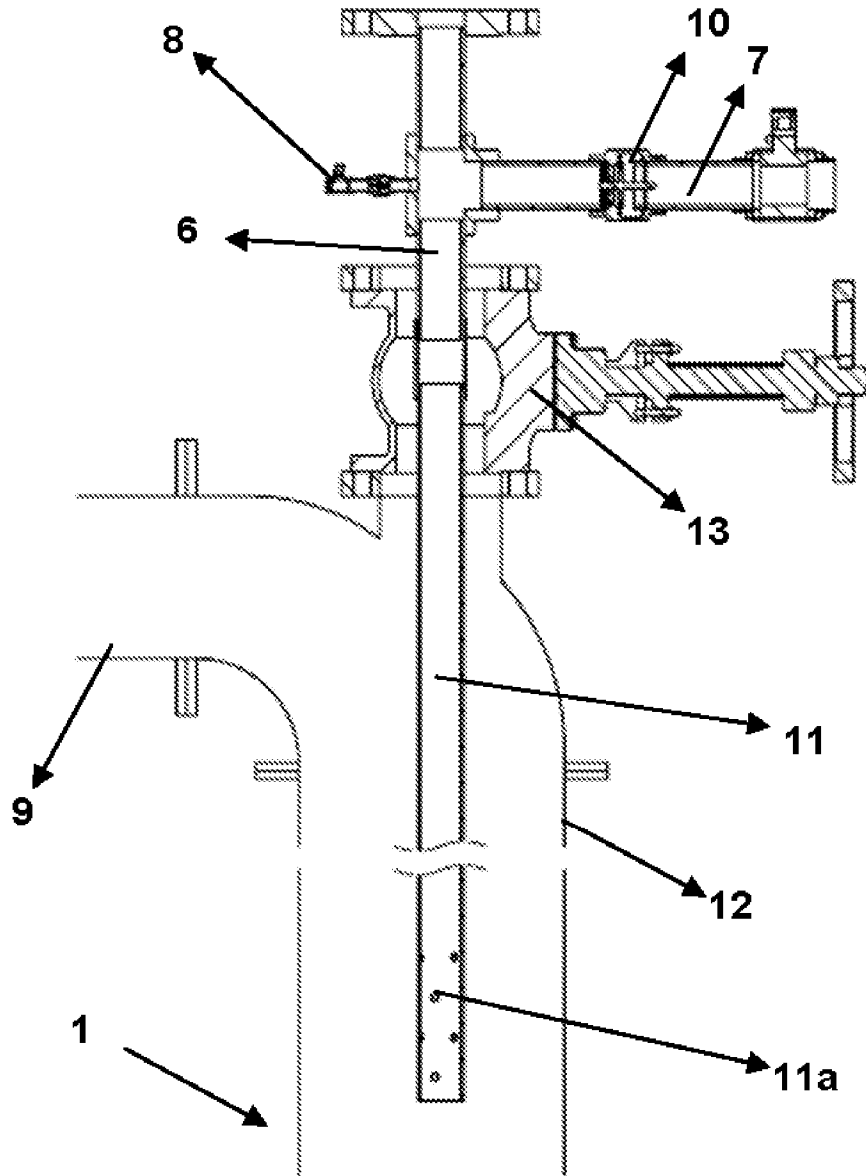


Figure 3