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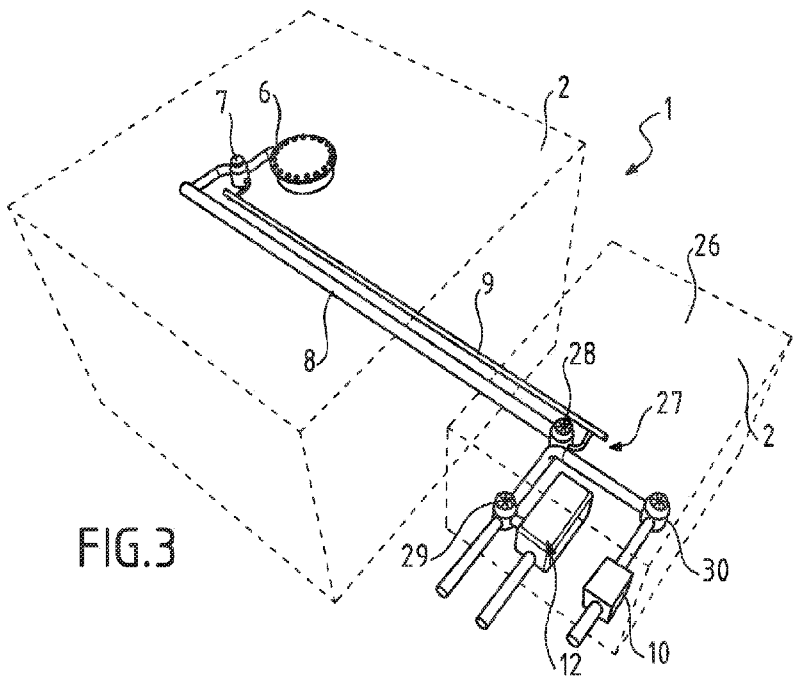

FIG.3

(57) Abstract: The invention relates to gas treatment process comprising: -providing a leaktight and thermally insulating tank (2); -providing a heat exchanger (12) for transferring cold from a vapour-phase gas stream collected in the tank (2) to a fluid to be cooled; and - extracting vapour-phase gas from the tank (2) via an admission pipe (6) which passes through an aperture made in a wall of the tank (2) and emerges in the internal space of the tank during a tank (2) loading operation and conveying it through the first pipe (8) to the manifold (1 1) which is connected to a gas storage terminal; and - extracting vapour-phase gas from the tank (2) via the admission pipe (6) during a tank utilizing operation and conveying it to the heat exchanger (12) through a second pipe (9) which is heat-insulated and has a gas passage cross section that is smaller than that of the first pipe (8).

WO 2017/196310 A1

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GAS STORAGE AND TREATMENT INSTALLATION

Technical field

The invention relates to the field of installations for storing and treating a gas, such as liquefied natural gas (LNG).

The invention relates more particularly to an installation comprising a tank for storing a gas in a liquid-vapour state of equilibrium and a heat exchanger for transferring cold from a vapour-phase gas stream extracted from the tank to another stream to be cooled.

Technological background

In the prior art, and especially in US 2015/0316208, an installation is known comprising a tank for storing liquefied natural gas and a heat exchanger for transferring cold from a vapour-phase gas stream to a stream to be cooled. More particularly, the installation comprises a collection circuit which collects vapour-phase gas in the gaseous headspace of the tank and then conveys it to the heat exchanger to be heated therein. On leaving the exchanger, the heated gas stream is compressed to high pressures that are compatible with the operating conditions of the gas-consuming members. Thereafter, a first portion of the compressed gas is conveyed to one or more gas-consuming members in order to be burnt therein, while a second portion of the compressed gas is conveyed to the heat exchanger in order to transfer heat to the stream of vapour-phase gas collected in the gaseous headspace of the tank. The second portion of gas thus cooled is then depressurized in an expansion device in which, by means of the Joule-Thomson effect, the temperature of the gas stream decreases further during its expansion so as at least partially to liquefy the gas. On leaving the expansion device, a phase separator allows the liquid phase and the vapour phase to be separated before conveying the liquid phase into the tank and sending the gas phase back into the vapour-phase gas collection circuit, upstream of the heat exchanger. Such an installation is particularly advantageous in that compression of the gas stream is used, both to make one portion of the gas stream compatible with the working pressures of the gas-consuming members and to allow subsequent reliquefaction of the other portion of the gas stream. Thus, the installation is thereby simplified and the cost of the additional reliquefaction function is limited.

The same vapour-phase gas collection circuit is moreover used for transferring vapour-phase gas during the loading and emptying of the tank. Specifically, during loading operations, when liquefied natural gas is transferred from a supply terminal to a tank, natural gas in the gas phase is simultaneously transferred from the tank to the terminal so as to keep the pressure prevailing in the gaseous headspace of the tank substantially constant. Conversely, during emptying operations during which liquefied natural gas is transferred from the tank to a terminal, natural gas in the gas phase is simultaneously transferred from the terminal to the tank in order to avoid a pressure decrease in the tank. The vapour-phase gas collection circuit is thus dimensioned as a function of the substantial throughputs that are liable to be involved during the loading and emptying of the tank.

Now, such dimensioning of the vapour-phase gas collection circuit entails that when the circulation throughput of the vapour-phase gas in the vapour-phase gas collection circuit is markedly lower than the throughput generated during the loading or emptying operations of the tank, for example when it is desired to convey vapour-phase gas from the tank to the heat exchanger during tank operations other than the loading or emptying operations, the flow rates in the vapour-phase gas collection circuit are low. Thus, given these low flow rates and despite the heat insulation of the vapour-phase gas collection circuit, the vapour-phase gas heats up considerably, for example by about 25 to 30°C, between the gaseous headspace of the tank and the inlet of the heat exchanger. The consequence of such heating is to reduce the cold available to be exchanged in the heat exchanger. Thus, the exchange of heat between the gas stream collected in the tank and the second portion of the compressed gas to be liquefied makes it possible to reliquefy only a limited proportion of the second portion of the compressed gas.

Summary

An idea forming the basis of the invention is to propose a gas storage and treatment installation, comprising a gas storage tank and a heat exchanger for transferring cold from a vapour-phase gas stream extracted from the tank to another stream to be cooled and in which the heat exchange in the heat exchanger is capable of being increased and a gas treatment process using such an installation

According to one embodiment, the invention provides a gas treatment process comprising:

-providing a leaktight and thermally insulating tank comprising an internal space filled with gas in a liquid-vapour two-phase state of equilibrium;

- providing a heat exchanger intended to transfer cold from a vapour-phase gas stream collected in the tank to a fluid to be cooled; the heat exchanger comprising a first channel and a second channel each having an inlet and an outlet and heat exchange walls for transferring heat from the second channel to the first channel; and

- extracting vapour-phase gas from the tank via an admission pipe which passes through an aperture made in a wall of the tank and emerges in the internal space of the tank during a tank loading operation and conveying it through the first pipe to a manifold which is connected to a gas storage terminal; and

- extracting vapour-phase gas from the tank via the admission pipe during a tank utilizing operation and conveying it to the heat exchanger through a second pipe which is heat-insulated and has a gas passage cross section that is smaller than that of the first pipe.

The tank utilizing operations may include any operation that utilizes the content of the tank while involving a comparatively lower flow rate of vapour-phase gas than the loading or emptying of the tank, e.g. tank operations for vessel propulsion or energy production.

Thus, by providing two distinct pipes, it is possible to dimension their cross section as a function of the gas throughputs that they are each liable to encounter in their specific case of use, so as to limit the heating of the gas.

Consequently, whereas the single pipe of a gas collection circuit was dimensioned in the prior art as a function of the largest throughputs that it is liable to encounter, the diameter of the second pipe is dimensioned on lower throughputs and thus has a smaller cross section than that of the single pipe of the prior art, such that, for an equal throughput, the flow rate of the gas in the second pipe is much higher than that of the gas in the pipe of the prior art. Consequently, for an equal throughput, the vapour-phase gas spends less time in the second pipe than in the pipe of the prior art, which makes it possible to limit the heating of the vapour-phase gas and is particularly advantageous when this gas is intended to absorb heat.

According to one embodiment, the gas treatment process further comprises :

- providing a compressor which is connected upstream to the outlet of the first channel of the heat exchanger so as to compress the gas stream that was heated in the heat exchanger and is connected downstream to a three-way connector that is capable of conveying a first portion of the gas stream to a gas-consuming member and of conveying a second portion of the gas stream to the inlet of the second channel of the heat exchanger in order to cool the second portion of the gas stream; and
- providing an expansion device that is connected upstream to the outlet of the second channel of the heat exchanger and is connected downstream to a return circuit leading to the tank; the expansion device being arranged to depressurize the second portion of the gas stream originating from the second channel of the heat exchanger so as to liquefy it;
- determining a set flow-rate of the gas-consuming member during the tank utilizing operation ;
- comparing the set flow rate with a determined threshold;
- extracting vapour-phase gas from the tank via the admission pipe and conveying it through the first pipe to the heat exchanger when the set flow rate is greater or equal to the determined threshold ; and
- extracting vapour-phase gas from the tank via the admission pipe and conveying it through the second pipe to the heat exchanger when the set flow rate is lower than the determined threshold.

According to one embodiment, the invention provides a gas storage and treatment installation, comprising:

- a leaktight and thermally insulating tank comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium;

- a heat exchanger intended to transfer cold from a vapour-phase gas stream collected in a tank to a fluid to be cooled; the heat exchanger comprising a first channel and a second channel each having an inlet and an outlet and heat exchange walls for transferring heat from the second channel to the first channel; and

- a vapour-phase gas collection circuit which comprises:
  - an admission pipe which is arranged to collect vapour-phase gas in the tank, said admission pipe passing through an aperture made in a wall of the tank and emerging in the internal space of the tank;
  - a first pipe which is arranged to convey vapour-phase gas from the admission pipe to a manifold intended to be connected to a gas storage terminal during the loading of the tank;
  - a second pipe which is arranged to convey vapour-phase gas from the admission pipe to the inlet of the first channel of the exchanger;

  the second pipe being heat-insulated and having a gas passage cross section that is smaller than that of the first pipe.

According to embodiments, such an installation may comprise one or more of the following characteristics.

According to one embodiment, the admission pipe is connected to the first pipe, on the one hand, and to the second pipe, on the other hand, via a three-way connector that is capable of selectively conveying vapour-phase gas collected via the admission pipe either to the first pipe or to the second pipe.

According to one embodiment, the three-way connector is a three-way valve. According to another embodiment, the three-way connector is a Y-shaped coupling comprising three arms; the two arms leading, respectively, to the first and second pipes each being equipped with a valve.

According to one embodiment, the three-way connector is placed at a distance from the aperture made in the tank wall that is less than 20 metres, advantageously less than 10 metres and preferably less than 5 metres.

Advantageously, the first pipe is heat-insulated.

According to one embodiment, the installation also comprises a compressor connected to the first pipe and arranged to suck vapour-phase gas through the first pipe and deliver it to the manifold.

According to one embodiment, the installation comprises a cargo room. Advantageously, the heat exchanger is housed in the cargo room. Advantageously, the compressor is housed in the cargo room.

According to one embodiment, the first pipe and the second pipe run parallel to each other between the admission pipe and the cargo room.

According to one embodiment, the first pipe and the second pipe are each connected to the compressor and to the heat exchanger via a four-way connector capable of selectively conveying vapour-phase gas circulating in the first pipe or in the second pipe to the compressor or to the heat exchanger.

According to one embodiment, the installation comprises a plurality of leaktight and thermally insulating tanks each comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium; the vapour-phase gas collection circuit comprising, for each of said tanks, an admission pipe passing through an aperture made in a wall of said tank and emerging in the internal space of said tank.

According to a first embodiment variant, each admission pipe is connected to the first pipe, on the one hand, and to the second pipe, on the other hand, via a three-way connector that is capable of selectively conveying vapour-phase gas collected via the admission pipe either to the first pipe or to the second pipe.

According to one embodiment, the second pipe has a gas passage cross section of variable diameter; the diameter of the gas passage cross section of said second pipe increasing in the direction of the first channel of the heat exchanger and increasing in stages at each connection of the second pipe to one of the admission pipes.

According to one embodiment, the first pipe has a gas passage cross section of variable diameter; the diameter of the gas passage cross section of said first pipe increasing in the direction of the manifold and increasing in stages at each connection of the first pipe to one of the admission pipes.

According to a second embodiment, the installation also comprises a plurality of second pipes that are each capable of conveying vapour-phase gas from one of the admission pipes to the inlet of the first channel of the heat exchanger; the second pipes each having a gas passage cross section that is smaller than that of the first pipe; each admission pipe being connected to the first pipe, on the one hand, and to one of the second pipes, on the other hand, by a three-way connector that is capable of selectively conveying vapour-phase gas collected via said admission pipe either to the first pipe or to one of the second pipes.

According to one embodiment, the first pipe has a gas passage cross section whose diameter is between 300 and 600 mm.

According to one embodiment, the second pipe has a gas passage cross section whose diameter is between 50 and 200 mm.

According to one embodiment, the first and/or second pipe is formed by a jacketed tube comprising an inner wall and an outer wall that are concentric and separated from each other by an intermediate insulating space.

According to one embodiment, the inner and outer walls of the jacketed tube are made of stainless steel.

According to one embodiment, the intermediate insulating space of the second pipe is under vacuum. Such an insulation makes it possible to achieve excellent insulation performance and is thus particularly pertinent for the second pipe whose heat insulation is particularly critical as regards the amount of heat exchanged in the heat exchanger located downstream.

According to one embodiment, the intermediate insulating space of the first pipe is lined with an insulating material. The insulating material lining the intermediate space of the second pipe is, for example, a polymer foam or glass wool.

According to one embodiment, the installation also comprises:

- a compressor which is connected upstream to the outlet of the first channel of the heat exchanger so as to compress the heated gas stream in the heat exchanger and is connected downstream to a three-way connector that is capable of conveying a first portion of the gas stream to a gas-consuming member and of conveying a second portion of the gas stream to the inlet of the second channel of the heat exchanger in order to cool the second portion of the gas stream; and

- an expansion device that is connected upstream to the outlet of the second channel of the heat exchanger and is connected downstream to a return circuit leading to the tank; the expansion device being arranged to depressurize the second portion of the gas stream originating from the second channel of the heat exchanger so as to liquefy it.

According to one embodiment, the installation comprises a phase separator connected upstream to the expansion device and downstream, on the one hand, to a return circuit leading to the tank and, on the other hand, to a return pipe connected to the inlet of the first channel of the heat exchanger; the phase separator being arranged to convey the liquid phase of the combustible gas stream to the return circuit and to convey the gas phase of the combustible gas stream to the return pipe.

According to an advantageous variant, the compressor is a multi-stage compressor. Advantageously, the compressor comprises a plurality of compression stages and a plurality of intermediate heat exchangers, each of the intermediate heat exchangers being placed at the outlet of one of the compression stages.

According to one embodiment, the expansion device is an expansion valve, also known as a Joule-Thomson valve.

According to one embodiment, the gas is a combustible gas.

According to one embodiment, the gas is a gaseous mixture of the LNG or LPG type.

According to one embodiment, the invention provides a vessel comprising an abovementioned installation.

According to one embodiment, the invention also provides a process for loading or unloading such a vessel, wherein gas is conveyed through insulated pipelines from or to a floating or land-based gas storage terminal to or from the tank of the vessel's gas storage and treatment installation.

According to one embodiment, the invention also provides a system for transferring a gas, the system comprising a vessel of the abovementioned type, insulated pipelines arranged so as to connect the tank of the installation installed in the hull of the vessel to a floating or land-based gas storage terminal and a pump for entraining a liquid-phase gas stream through the cryogenic transfer pipes from or to the floating or land-based gas storage terminal, to or from the vessel's tank; the transfer system also comprising a vapour-phase gas transfer pipe arranged so as to connect the manifold to the gas storage terminal so as to allow transfer of vapour-phase gas between the gas storage and treatment installation and the gas storage terminal.

Brief description of the figures

The invention will be better understood and further aims, details, characteristics and advantages thereof will appear more clearly from the following description of several particular embodiments of the invention, given merely for illustration and without limitation, with reference to the attached drawings.

- **Figure 1** is a schematic illustration of a gas storage and treatment installation according to one embodiment.

- **Figure 2** is a partial view in perspective of an installation illustrating the first and second pipes that run in parallel between a vapour-phase gas collector of a tank and a cargo room.

- **Figure 3** is another partial view in perspective of an installation illustrating the first and second pipes that run in parallel between the vapour-phase gas collector of a tank and the cargo room.

- **Figure 4** comprises a partial view in perspective of an installation in which the first and second pipes each connect the admission pipe of each tank to the cargo room and detailed views of the structure of the first and second pipes according to one embodiment.

- **Figure 5** is a partial view in perspective of an installation in which the first and second pipes each connect several admission pipes to the cargo room and each have a cross section whose diameter increases once said pipe is connected to an additional admission pipe.

- **Figure 6** is a partial view in perspective of an installation in which the first pipe connects several admission pipes to the cargo room and in which each of the admission pipes is also connected via a respective second pipe to the cargo room.

- **Figure 7** is a schematic representation of a vessel and of a transfer system for loading/unloading combustible gas.

- **Figure 8** is a graph representing the energy increase estimate (in kJ/Kg) as a function of the flow rate (in Kg/h) when the vapour-phase gas extracted from the tank is conveyed through the first pipe (curve a) and through the second pipe (curve b).

Detailed description of embodiments

In the description and the claims, the term "gas" has a generic nature and refers without preference to a gas constituted of a single pure substance or a gaseous mixture constituted of a plurality of components.

A gas storage and treatment installation 1 is represented in figure 1. Such an installation 1 may be installed on land or on a floating structure. In the case of a floating structure, the installation may be intended for a liquefaction or regasification barge or for a liquefied natural gas cargo vessel, such as a methane tanker.

The installation 1 comprises one or more leaktight and heat-insulating tanks 2. Each tank 2 comprises an internal space intended to be filled with gas. The gas is a combustible gas and may especially be a liquefied natural gas (LNG), i.e. a gaseous mixture predominantly comprising methane and also one or more other hydrocarbons, such as ethane, propane, n-butane, i-butane, n-pentane, i-pentane, neopentane, and nitrogen in small proportion. The combustible gas may also be ethane or a liquefied petroleum gas (LPG), i.e. a mixture of hydrocarbons derived from oil refinery essentially comprising propane and butane and nitrogen in small proportion.

The gas is stored in the internal space of each tank 2 in a liquid-vapour two-phase state of equilibrium. The gas is thus present in the vapour phase in the upper part 3 of the tank 2, and in the liquid phase in the lower part 4 of the tank 2. By way of example, the equilibrium temperature of the liquefied natural gas corresponding to its liquid-vapour two-phase state of equilibrium is about -162°C when it is stored at atmospheric pressure.

The installation 1 comprises a vapour-phase gas collection circuit 5. This circuit comprises, for each tank 2, an admission pipe 6 which passes through an aperture made in the upper wall of the tank 2 and thus emerges in the gaseous headspace of the tank 2, i.e. above the maximum height for filling the tank 2 with liquefied gas. The admission pipe 6 thus makes it possible to extract the gas phase of the gas stored in the tank 2. By way of example, such an admission pipe 6 is described in FR 2 984 454.

Each admission pipe 6 is connected via a three-way connector 7 to a first and a second pipe 8, 9. The three-way connector 7 is a connector that can selectively connect the admission pipe 6 either to the first pipe 8 or to the second pipe 9. In the embodiment shown, the three-way connector 7 is a three-way valve. In another embodiment, not shown, the three-way connector 7 comprises a Y-shaped coupling, the two arms of which leading, respectively, to the first and second pipes 8, 9 each being equipped with an adjustable valve.

The second pipe 9 is connected to a heat exchanger 12. The heat exchanger 12 comprises a first and a second channel 13, 14 each having an inlet 13a, 14a and an outlet 13b, 14b and heat-exchange walls for transferring heat from the second channel 14 to the first channel 13. So as to optimize the heat exchanges, the heat exchanger 12 is a counter-current exchanger. The inlet 13a of the first channel 13 is connected to the second pipe 9 so as to heat the gas stream derived from the natural evaporation collected in the tank 2. The outlet 13b of the first channel 13 is connected to a compressor 15 for compressing the gas stream to pressures that are compatible with the operating of the gas-consuming members 23, 24, 25.

In the embodiment shown, the compressor 15 is a multi-stage compressor. In other words, the compressor 15 comprises a plurality of compression stages 15a, 15b, 15c, 15d, 15e and intermediate heat exchangers 16a, 16b, 16c, 16d, 16e which are placed at the outlet of each of the compression stages 15a, 15b, 15c, 15d, 15e. The intermediate heat exchangers 16a, 16b, 16c, 16d, 16e are directed toward cooling the compressed gas between two compression stages 15a, 15b, 15c, 15d, 15e. By way of example, the intermediate heat exchangers 16a, 16b, 16c, 16d, 16e may especially provide an exchange with seawater, thus making it possible to bring the compressed gas stream to a temperature substantially equal to that of seawater.

Downstream of the compressor 15, the installation 1 comprises a three-way connector 17 for conveying a first portion of the gas stream to a gas-consuming member 25 and a second portion of the gas stream to the inlet 14a of the second channel 14 of the heat exchanger 12. This three-way connector 17 is driven by a control unit which is arranged to vary the proportions of gas circulating, respectively, to the gas-consuming member 25 and to the inlet 14a of the second channel 14 of the heat exchanger 12 as a function of the gas needs of the gas-consuming member 25.

Moreover, in the event that the gas-consuming members 23, 24, 25 have different feed pressures as in the embodiment shown, the installation 1 comprises an intermediate three-way connector 18 which is placed between two compression stages 15b, 15c and thus makes it possible to divert part of the gas stream to the gas-consuming members 23, 24 before the outlet of the compressor 15. Such an arrangement makes it possible to divert gas to a gas-consuming member 23, 24 once it has passed through a sufficient number of compression stages 15a, 15b, 15c, 15d, 15e to reach the feed pressure corresponding to said gas-consuming member 23, 24.

In the embodiment shown, the installation 1 comprises three different types of gas-consuming members, namely a burner 23, an electrical generator 24 and a motor 25, for example of the ME-GI type, for propelling a vessel.

The compressor 15 is dimensioned as a function of the gas-consuming members 23, 24, 25 intended to be fed and especially as a function of their maximum flow rate and of the pressure level at which the combustible gas must be distributed thereto. Thus, when one of the gas-consuming members 25 is a motor of ME-GI type, the compressor 15 is dimensioned such that the gas stream leaving the compressor 17 typically has a pressure of between 250 and 300 bar absolute.

In addition, according to a preferred embodiment, the operating rate of the compressor 27 is constant and corresponds substantially to the maximum flow rate of the gas-consuming members. Thus, the control unit acts on the three-way connectors 17, 18 so as to adapt the flow rates of the gas streams conveyed to the gas-consuming members as a function of their needs.

The second part of the gas stream is cooled in the second channel 14 of the heat exchanger 12 during the transfer of its heat to the vapour-phase gas originating from the vapour-phase gas collection circuit 5.

The outlet 14b of the second channel 14 of the heat exchanger 12 is connected to a phase separator 19 via an expansion device 20 through which the gas stream will be depressurized to a pressure substantially equal to the pressure prevailing in the tank 2, for example a pressure close to atmospheric pressure. Consequently, the gas stream undergoes an expansion which gives rise, via the Joule-Thomson effect, to a decrease of its temperature and its liquefaction, at least partially. The expansion device 20 is, for example, an expansion valve.

The phase separator 19, occasionally referred to as a mist separator, allows the liquid phase to be separated from the gas phase. Downstream, the phase separator 19 is connected, on the one hand, to a return circuit 21 leading to the tank 2 and, on the other hand, to a return pipe 22 which is connected to the inlet 13a of the first channel 13 of the heat exchanger 12. The phase separator 19 thus conveys the liquid phase of the gas to the tank 2, whereas the vapour phase is returned to the inlet 13a of the first channel 13 of the heat exchanger 12.

Moreover, the first pipe 8 is intended to convey vapour-phase gas to a maritime or harbour terminal during the transfer of gas cargo from or to the tank 2. In point of fact, it is necessary that, during transfer of liquefied gas from or to the tank 2, the gas phase be transferred in the opposite direction to or from the tank 2 so as to keep the pressure in the tank 2 substantially constant. In order to allow such a transfer, the first pipe 8 is arranged to convey vapour-phase gas to a manifold 11 intended to be connected via an insulated pipeline to the terminal.

According to one embodiment, the installation 1 also comprises a compressor 10 for sucking a gas stream through the first pipe 8 and for returning it to the manifold 11. According to another embodiment, the installation 1 may be without such a compressor, the gas transfer between the tank 2 and the terminal then being performed by means of a compressor of the terminal. According to yet another embodiment, a part of the compression stages 15a, 15b, 15c, 15d, 15e of the multi-stage compressor 15 may be used to suck a gas stream through the first pipe 8 and to convey it to the manifold 11. This means that the first pipe 8 is connected upstream of a compressor stage 15 and that a three-way connector is arranged downstream of the compression stage(s) concerned so as to divert the compressed gas stream to the manifold 11 intended to be connected via an insulated pipeline to the loading/emptying terminal.

In relation with figures 3 and 4, the structure of the vapour-phase gas collection circuit 5 according to one embodiment is more particularly observed. The first and second pipes 8, 9 run parallel to each other between the three-way connector 7 and the cargo room 26. Specifically, advantageously, a large proportion of the gas-treating equipment, such as the compressors 10, 15, the heat exchanger 13, the expansion device 20 and the phase separator 19, are regrouped in the cargo room 26.

The first and second pipes 8, 9 have different gas passage cross sections, the gas passage cross section of the second pipe 9 being smaller than that of the first pipe 8. The dimensions of the gas passage cross sections of the first pipe 8 and of the second pipe 9 are, respectively, determined as a function of the gas flow rates that are liable to pass through them for their respective case of use and so as to limit the heating of the gas.

The heating of a gas circulating in a pipe depends on two conflicting phenomena. On the one hand, the heating of the gas circulating in a pipe depends on the heat transfers taking place between the exterior and the interior of the pipe. The intensity of these heat transfers obviously depends on the insulation characteristics of the pipe, but also depends on the residence time of the gas in the pipe, and consequently on the flow rate and the cross section of the tube. Specifically, for an equal flow rate, the gas spends longer in a pipe of larger cross section and consequently becomes heated up more. On the other hand, the heating of the gas circulating in a pipe also depends on the phenomenon of viscous dissipation which leads to increasing the heating of the fluid when, for the same flow rate, the cross section of the pipe decreases. Thus, an optimum dimension of gas passage cross section exists, which, for a given flow rate, allows the heating of the gas to be limited.

The cross section of the first pipe 8 is dimensioned as a function of the rates of vapour phase gas transfer, between the tank 2 and a loading/emptying terminal, which are liable to be used during loading or emptying of the tank. By way of example, for the loading or emptying of a methane tanker's tank, the vapour-phase gas transfer rates that are liable to be generated through the first pipe 8 are of the order of 12 000 to 14 000 m^3/h. Thus, for such flow rates, the cross section of the first pipe 8 typically has a diameter of between 300 and 600 mm.

The cross section of the second pipe 9 is, for its part, dimensioned as a function of the average flow rates that are liable to be used for supplying the gas-consuming member(s) 23, 24, 25 of the installation 1. By way of example, for the gas feed of a motor of the ME-GI type liable to propel a vessel, the average vapour-phase gas transfer rate that is liable to be generated through the second pipe 9 is of the order of 4700 m^3/h. Thus, for such flow rates, the cross section of the second pipe 9 typically has a diameter of between 50 and 200 mm.

Curves a and b of figure 8 respectively represents the heating of the gas circulating in the first pipe 8 and in the second pipe 9 as a function of the flow rate.

Figure 8 shows that heating of the gas is lower in the second pipe 9 than in the first pipe 8 for a flow rate lower than 8000 Kg/h while heating of the gas is lower in the first pipe 8 than in the second pipe 9 for a flow rate greater than 8000 Kg/h. Thus, as an example, with a flow rate of roughly 4000 kg/h, the heating of the gas circulating in the second pipe 9 is slightly lower than 3°C while the heating of the gas circulating in the second pipe 9 is approximately of 15°C. With a lower flow rate of 2000 kg/h, which corresponds for example to circumstances in which a high flow rate of gas circulates through the return pipe 22, the heating of the gas circulating in the second pipe 9 is slightly lower than 6°C while the heating of the gas circulating in the second pipe 9 is approximately of 30°C.

Advantageously, the three-way connector 7 is placed close to the aperture of the tank 2 through which passes the admission pipe 7. In other words, the three-way connector 7 is placed at a distance from the aperture made in the tank wall of less than 20 metres, advantageously less than 10 metres and preferably less than 5 metres. Thus, virtually as soon as vapour-phase gas is extracted from the tank 2, the pipe 8, 9 through which the gas passes has an optimized cross section as a function of its flow rate. This also contributes towards minimizing the heating of the gas.

Moreover, in the embodiment shown in figure 3, it is observed that the first pipe 8 and the second pipe 9 are each connected to the compressor 10 and to the heat exchanger 12 via a four-way connector 27. The four-way connector 27 is capable of selectively conveying vapour-phase gas circulating in the first pipe 8 or in the second pipe 9; either to the compressor 10 in order to be returned to the manifold intended to be connected to a gas storage terminal; or to the heat exchanger 11 in order partly to be conveyed to a gas-consuming member and partly returned to the second channel of the heat exchanger 11. In the embodiment shown, the four-way connector 27 is constituted by a three-way valve 28 which is connected to a Y-shaped coupling, the two arms of which leading, respectively, to the heat exchanger 12 and to the compressor 10 are equipped with a valve 29, 30.

Thus, in certain specific cases of use, it is also possible to convey vapour-phase gas from the first pipe 8 to the heat exchanger 12.

Such a gas circulation may especially be useful in the following specific cases of use:

- in the 24 to 48 hours following the loading of the tank 2. Specifically, in this case, the degree of natural evaporation in the tank 2 may reach the values of the order of 180% of the degree of natural evaporation in a state of equilibrium. In this case, the vapour-phase gas collected in the tank 2 may be conveyed to at a relatively high flow rate through the first pipe 8 to the heat exchanger 12 so as to reliquefy large amounts of gas.

- under all the other conditions in which the degree of natural evaporation in the tank 2 is markedly above the degree of natural evaporation in a state of equilibrium, i.e. storm conditions, taking to rough sea after a long period of stoppage, calm sea with partial filling of the tank.

- under certain conditions of damage, and especially of fire, such as to convey the vapour-phase gas at a high flow rate to the gas-consuming members 23, 24, 25 in order to empty the tank 2 as quickly as possible.

Moreover, according to an embodiment, the vapour-phase gas extracted from the tank 2 is conveyed to the heat exchanger 12 either through the first pipe 8 or to the second pipe in function of the need of the gas consuming members 23, 24, 25. To that end, the set flow rate of the gas consuming members 23, 24, 25 is compared to a determined threshold and the vapour-phase gas is conveyed through the first pipe when the set flow-rate is greater or equal than the determined threshold while the vapour-phase gas is conveyed through the second pipe when the set flow-rate is lower than to the determined threshold.

The set flow-rate approximately corresponds to the flow rate for which the energy increase is equal for a gas circulation in the first pipe 8 and in the second pipe 9. Thus, as an example, for a first and a second pipe 8, 9 having dimensional and insulating features corresponding to the curves a and b of Figure 8, the determined threshold is between 6600 and 10000 kg/h, for example about 8000 kg/h.

As shown in figure 4, the installation 1 may comprise a plurality of tanks 2, three in figure 4. Thus, each tank 2 comprises an admission pipe 6 which passes through an aperture made in the upper wall of the tank 2 and emerges in the gaseous headspace of the tank 2. Each of the admission pipes 6 is connected via a three-way connector 7, on the one hand, to the first pipe 8 and, on the other hand, to the second pipe 9. Thus, the gaseous headspaces of the tanks 6 are connected in series to the first pipe 8, on the one hand, and to the second pipe 9, on the other hand.

In relation with figure 5, the detailed structures of the first pipe 8 and of the second pipe 9 according to one embodiment are also observed. Each of the first and second pipes 8, 9 is formed by a jacketed tube comprising two cylindrical and concentric walls 8a, 8b; 9a, 9b, which are separated from each other by an intermediate insulating space 8c, 9c. The two walls 8a, 8b; 9a, 9b are made, for example, of stainless steel.

The intermediate insulating space 8c of the first pipe 8 is lined with an insulating material, for instance polymer foam or glass wool. The intermediate insulating space 9c of the second pipe 9 is placed under vacuum, which contributes towards obtaining excellent heat-insulating characteristics.

The first and second pipes 8, 9 advantageously have compensation devices giving them flexibility along the longitudinal direction so as to allow their contraction and expansion depending on whether or not a stream of vapour-phase gas is passing therethrough. To do this, the first pipe 8 has compensation loops 31, i.e. a U-shaped form using 90° bends. Although such a compensation device is bulky and contributes towards lengthening the travel time and consequently increases the heating of the gas, it is relatively expensive. The second pipe 9 is, on the other hand, straight over virtually its entire length. Thus, in order to allow its expansion and contraction, the inner wall 9b of the second pipe 9 regularly has gusset zones 32.

In relation with figure 5, it is observed that, according to an advantageous embodiment, the diameter of the gas passage cross section of each of the first and second pipes 8, 9 is variable, this diameter increasing on approaching the cargo room 26 and increasing in stages at each connection of the pipe to one of the admission pipes 6.

In other words, the cross sections of the first and second pipes 8, 9 each have a first diameter $d8_1$, $d9_1$ in a first portion running between the tank 2 that is furthest from the cargo room 26 and a second adjacent tank, a second diameter $d8_2$, $d9_2$ in a second portion between the second tank and a third adjacent tank and a third diameter $d8_3$, $d9_3$ in a third portion between the third tank and the cargo room 26; the abovementioned diameters corresponding to the following inequality:

$$d9_1 < d9_2 < d9_3 \ll d8_1 < d8_2 < d8_3$$

Such an arrangement makes it possible to take into account the increase in gas flow in the first and second pipes 8, 9 as and when they are connected to other admission pipes 6 so as to dimension the cross section of the pipes 8, 9 as closely as possible. This also contributes towards limiting the heating of the gas in the first and second pipes 8, 9.

Figure 6 shows an installation 1 according to an alternative embodiment. This embodiment differs from the embodiments of figures 4 and 5 in that the installation 1 comprises a second pipe 9, 9', 9'' for each of the tanks 2. The second pipes 9, 9', 9'' are each capable of conveying vapour-phase gas from one of the admission pipes 6 to the inlet 13a of the first channel 13 of the heat exchanger 12. In other words, each of the admission pipes 6 is connected via a three-way connector 7 to the first pipe 8 and to each of the second pipes 9, 9', 9''. Such an arrangement is advantageous in that, to convey gas between the tanks 2 and the heat exchanger 12, the gas circulates in pipes 9, 9', 9'' whose dimensions are optimized as a function of the gas flow rate liable to pass therethrough, whether the vapour-phase gas stream to be conveyed to the heat exchanger 12 originates from only one of the tanks 2 or from all of the tanks 2.

Figure 7 shows a transfer system 40 for loading/unloading combustible gas such as liquefied natural gas and forming the interface between a vessel 41 and a floating or land-based installation, not shown. The vessel 41 is equipped with an installation for feeding gas-consuming members with combustible gas and for liquefying said combustible gas as described above. As an example, the fluid-tight and insulated tank, not shown, is of generally prismatic form and is mounted in the double hull of the vessel.

The product transfer is ensured by immersed cryogenic lines denoted 42. The transfer system 40 forming the interface between the vessel 41 and the floating or land-based installation comprises at least one platform 43 bearing a storage/handling gantry 44 and a main platform 45 to take all the equipment that allows connecting the immersed cryogenic lines 42 to flexible transfer pipes 46. Each flexible transfer pipe 46 is intended to be connected to a vessel’s manifold 47 through a connection module 48. The vessel’s manifolds 47 are connected to the tank by means of loading/unloading pipelines arranged on the upper deck of the vessel 41 in order to transfer a cargo of liquefied gas from or to the tank.

The chief function of gantry 44 is to enable handling and storage of transfer parts, namely each connection module 48 and the mobile ends of the flexible transfer pipe 46, by means of a crane and winches.

According to an embodiment, the transfer system comprises three parallel flexible transfer pipes 46, two of which make it possible to transfer the liquefied natural gas between the floating or land-based installation and the vessel, whereas the third transfer pipe makes it possible to transfer gas in order to balance the pressures in the gaseous headspaces of the tank of the vessel.

To create the pressure necessary for the transfer of liquefied gas, on-board pumps in the vessel 41 are used, and/or pumps installed in the land-based installation, and/or pumps fitted to transfer system 40.

Although the invention has been described in connection with several particular embodiments, it is evident that it is in no way limited thereto and comprises all technical equivalents of the means described and their combinations if these fall within the scope of the invention.

The use of the verb "comprise" or "contain" or "include" and its conjugated forms does not exclude the presence of elements or steps other than those stated in a claim.

As such, the methods and installations implemented in accordance with some non-limiting embodiments of the present technology can be represented as follows, presented in numbered clauses.

[Clause 1] Gas treatment process comprising :

-providing a leaktight and thermally insulating tank (2) comprising an internal space filled with gas in a liquid-vapour two-phase state of equilibrium;

- providing a heat exchanger (12) intended to transfer cold from a vapour-phase gas stream collected in the tank (2) to a fluid to be cooled; the heat exchanger (12) comprising a first channel and a second channel (13, 14) each having an inlet (13a, 14a) and an outlet (13b, 14b) and heat exchange walls for transferring heat from the second channel (14) to the first channel (13); and

- extracting vapour-phase gas from the tank (2) via an admission pipe (6) which passes through an aperture made in a wall of the tank (2) and emerges in the internal space of the tank during a tank (2) loading operation and conveying it through the first pipe (8) to a manifold (11, 47) which is connected to a gas storage terminal; and

- extracting vapour-phase gas from the tank (2) via the admission pipe (6) during a tank utilizing operation and conveying it to the heat exchanger (12) through a second pipe (9) which is heat-insulated and has a gas passage cross section that is smaller than that of the first pipe (8).

[Clause 2] Gas treatment process according to clause 1, further comprising:
- providing a compressor (15) which is connected upstream to the outlet (13b) of the first channel (13) of the heat exchanger (12) so as to compress the heated gas stream in the heat exchanger (12) and is connected downstream to a three-way connector (17, 18) that is capable of conveying a first portion of the gas stream to a gas-consuming member (23, 24, 25) and of conveying a second portion of the gas stream to the inlet (14a) of the second channel (14) of the heat exchanger (12) in order to cool the second portion of the gas stream; and
- providing an expansion device (20) that is connected upstream to the outlet (14b) of the second channel (14) of the heat exchanger (12) and is connected downstream to a return circuit (21) leading to the tank (2); the expansion device (20) being arranged to depressurize the second portion of the gas stream originating from the second channel (14) of the heat exchanger (12) so as to liquefy it;
- determining a set flow-rate of the gas-consuming member (23, 24, 25) during the tank utilizing operation;
- comparing the set flow rate with a determined threshold;
- extracting vapour-phase gas from the tank (2) via the admission pipe (6) and conveying it through the first pipe (8) to the heat exchanger (12) when the set flow rate is greater or equal to the determined threshold ; and
- extracting vapour-phase gas from the tank (2) via the admission pipe (6) and conveying it through the second pipe (9) to the heat exchanger (12) when the set flow rate is lower than the determined threshold.

[Clause 3] Gas storage and treatment Installation (1) comprising:

- a leaktight and thermally insulating tank (2) comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium;

- a heat exchanger (12) intended to transfer cold from a vapour-phase gas stream collected in the tank (2) to a fluid to be cooled; the heat exchanger (12) comprising a first channel and a second channel (13, 14) each having an inlet (13a, 14a) and an outlet (13b, 14b) and heat exchange walls for transferring heat from the second channel (14) to the first channel (13); and

- a vapour-phase gas collection circuit (5) which comprises:

an admission pipe (6) which is arranged to collect vapour-phase gas in the tank (2), said admission pipe (6) passing through an aperture made in a wall of the tank (2) and emerging in the internal space of the tank;

a first pipe (8) which is arranged to convey vapour-phase gas from the admission pipe (6) to a manifold (11) intended to be connected to a gas storage terminal during the loading of the tank (2);

a second pipe (9) which is arranged to convey vapour-phase gas from the admission pipe (6) to the inlet (13a) of the first channel (13) of the exchanger (12); the second pipe (9) being heat-insulated and having a gas passage cross section that is smaller than that of the first pipe (8);

[Clause 4] Installation (1) according to Clause 3, in which the admission pipe (6) is connected to the first pipe (8), on the one hand, and to the second pipe (9), on the other hand, via a three-way connector (7) that is capable of selectively conveying vapour-phase gas collected via the admission pipe (6) either to the first pipe (8) or to the second pipe (9).

[Clause 5] Installation (1) according to Clause 4, in which the three-way connector (7) is placed at a distance from the aperture made in the tank wall that is less than 20 metres, advantageously less than 10 metres and preferably less than 5 metres.

[Clause 6] Installation (1) according to any one of Clauses 3 to 5, also comprising a compressor (10) connected to the first pipe (8) and arranged to suck vapour-phase gas through the first pipe (8) and deliver it to the manifold (11).

[Clause 7] Installation (1) according to Clause 6, comprising a cargo room (26) and in which the heat exchanger (12) and the compressor (11) are housed in the cargo room (26), the first pipe (8) and the second pipe (9) running parallel to each other between the admission pipe (6) and the cargo room (26).

[Clause 8] Installation (1) according to Clause 7, in which the first pipe (8) and the second pipe (9) are each connected to the compressor (11) and to the heat exchanger (12) via a four-way connector (27) capable of selectively conveying vapour-phase gas circulating in the first pipe (8) or in the second pipe (9) to the compressor (11) or to the heat exchanger (12).

[Clause 9] Installation (1) according to any one of Clauses 3 to 8, comprising a plurality of leaktight and thermally insulating tanks (2) each comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium; the vapour-phase gas collection circuit (5) comprising, for each of said tanks (2), an admission pipe (6) passing through an aperture made in a wall of said tank (2) and emerging in the internal space of said tank (2).

[Clause 10] Installation (1) according to Clause 9, in which each admission pipe (6) is connected to the first pipe (8), on the one hand, and to the second pipe (9), on the other hand, via a three-way connector (7) that is capable of selectively conveying vapour-phase gas collected via the admission pipe (6) either to the first pipe (8) or to the second pipe (9).

[Clause 11] Installation (1) according to Clause 10, in which the second pipe (9) has a gas passage cross section of variable diameter; the diameter of the gas passage cross section of said second pipe (9) increasing in the direction of the first channel (13) of the heat exchanger (12) and increasing in stages at each connection of the second pipe (9) to one of the admission pipes (6).

[Clause 12] Installation (1) according to Clause 10, also comprising a plurality of second pipes (9, 9', 9'') that are each capable of conveying vapour-phase gas from one of the admission pipes (6) to the inlet (13a) of the first channel (13) of the heat exchanger (12); the second pipes (9, 9', 9'') each having a gas passage cross section that is smaller than that of the first pipe (8); each admission pipe (6) being connected to the first pipe (8), on the one hand, and to one of the second pipes (9, 9', 9''), on the other hand, by a three-way connector (7) that is capable of selectively conveying vapour-phase gas collected via said admission pipe (6) either to the first pipe (8) or to one of the second pipes (9).

[Clause 13] Installation (1) according to any one of Clauses 3 to 12, in which the first pipe (8) has a gas passage cross section whose diameter is between 300 and 600 mm and in which the second pipe (9) has a gas passage cross section whose diameter is between 50 and 200 mm.

[Clause 14] Installation (1) according to any one of Clauses 3 to 13, in which the first and/or second pipe (8, 9) is formed by a jacketed tube comprising an inner wall (8b, 9b) and an outer wall (8a, 9a) which are concentric and separated from each other by an intermediate insulating space (8c, 9c).

[Clause 15] Installation (1) according to Clause 14, in which the intermediate insulating space (9c) of the second pipe (9) is under vacuum.

[Clause 16] Installation (1) according to Clause 14 or 15, in which the intermediate insulating space (8c) the first pipe (8) is lined with an insulating material.

[Clause 17] Installation (1) according to any one of Clauses 3 to 16, also comprising:

- a compressor (15) which is connected upstream to the outlet (13b) of the first channel (13) of the heat exchanger (12) so as to compress the heated gas stream in the heat exchanger (12) and is connected downstream to a three-way connector (17, 18) that is capable of conveying a first portion of the gas stream to a gas-consuming member (23, 24, 25) and of conveying a second portion of the gas stream to the inlet (14a) of the second channel (14) of the heat exchanger (12) in order to cool the second portion of the gas stream; and

- an expansion device (20) that is connected upstream to the outlet (14b) of the second channel (14) of the heat exchanger (12) and is connected downstream to a return circuit (21) leading to the tank (2); the expansion device (20) being arranged to depressurize the second portion of the gas stream originating from the second channel (14) of the heat exchanger (12) so as to liquefy it.

[Clause 18] Vessel (40) for transporting a gas, the vessel comprising an installation (1) according to any one of Clauses 3 to 17.

[Clause 19] Gas transfer system, the system comprising a vessel (40) according to Clause 16, cryogenic transfer pipes (42, 46) arranged so as to connect the tank of the installation installed in the hull of the vessel to a floating or land-based gas storage terminal and a pump for entraining a liquid-phase gas stream through the cryogenic transfer pipes from or to the floating or land-based gas storage terminal, to or from the vessel's tank (2); the transfer system also comprising a vapour-phase gas transfer pipe arranged so as to connect the manifold (11, 47) to the gas storage terminal so as to allow transfer of vapour-phase gas between the gas storage and treatment installation (1) and the gas storage terminal.

[Clause 20] Process for loading or emptying a vessel (40) according to Clause 16, in which a gas is conducted through cryogenic transfer pipes (42, 46) from or to a floating or land-based gas storage terminal to or from the tank of the vessel's gas storage and treatment installation.

CLAIMS

What is claimed is:

1. Gas treatment process comprising :

-providing a leaktight and thermally insulating tank comprising an internal space filled with gas in a liquid-vapour two-phase state of equilibrium;

- providing a heat exchanger intended to transfer cold from a vapour-phase gas stream collected in the tank to a fluid to be cooled; the heat exchanger comprising a first channel and a second channel each having an inlet and an outlet and heat exchange walls for transferring heat from the second channel to the first channel; and

- extracting vapour-phase gas from the tank via an admission pipe which passes through an aperture made in a wall of the tank and emerges in the internal space of the tank during a tank loading operation and conveying it through the first pipe to a manifold which is connected to a gas storage terminal; and

- extracting vapour-phase gas from the tank via the admission pipe during a tank utilizing operation and conveying it to the heat exchanger through a second pipe which is heat-insulated and has a gas passage cross section that is smaller than that of the first pipe.

2. Gas treatment process according to claim 1, further comprising :
- providing a compressor which is connected upstream to the outlet of the first channel of the heat exchanger so as to compress the heated gas stream in the heat exchanger and is connected downstream to a three-way connector that is capable of conveying a first portion of the gas stream to a gas-consuming member and of conveying a second portion of the gas stream to the inlet of the second channel of the heat exchanger in order to cool the second portion of the gas stream; and
- providing an expansion device that is connected upstream to the outlet of the second channel of the heat exchanger and is connected downstream to a return circuit leading to the tank; the expansion device being arranged to depressurize the second portion of the gas stream originating from the second channel of the heat exchanger so as to liquefy it;
- determining a set flow-rate of the gas-consuming member during the tank utilizing

operation ;

- comparing the set flow rate with a determined threshold;

- extracting vapour-phase gas from the tank via the admission pipe and conveying it through the first pipe to the heat exchanger when the set flow rate is greater or equal to the determined threshold ; and

- extracting vapour-phase gas from the tank via the admission pipe and conveying it through the second pipe to the heat exchanger when the set flow rate is lower than the determined threshold.

3. Gas storage and treatment Installation comprising:

- a leaktight and thermally insulating tank comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium;

- a heat exchanger intended to transfer cold from a vapour-phase gas stream collected in the tank to a fluid to be cooled; the heat exchanger comprising a first channel and a second channel each having an inlet and an outlet and heat exchange walls for transferring heat from the second channel to the first channel ; and

- a vapour-phase gas collection circuit which comprises:

- an admission pipe which is arranged to collect vapour-phase gas in the tank, said admission pipe passing through an aperture made in a wall of the tank and emerging in the internal space of the tank;
- a first pipe which is arranged to convey vapour-phase gas from the admission pipe to a manifold intended to be connected to a gas storage terminal during the loading of the tank;
- a second pipe which is arranged to convey vapour-phase gas from the admission pipe to the inlet of the first channel of the exchanger; the second pipe being heat-insulated and having a gas passage cross section that is smaller than that of the first pipe;

4. Installation according to Claim 3, in which the admission pipe is connected to the first pipe, on the one hand, and to the second pipe, on the other hand, via a three-way connector that is capable of selectively conveying vapour-phase gas collected via the admission pipe either to the first pipe or to the second pipe .

5. Installation according to Claim 4, in which the three-way connector is placed at a distance from the aperture made in the tank wall that is less than 20 metres, advantageously less than 10 metres and preferably less than 5 metres.

6. Installation according to any one of Claims 3 to 5, also comprising a compressor connected to the first pipe and arranged to suck vapour-phase gas through the first pipe and deliver it to the manifold.

7. Installation according to Claim 6, comprising a cargo room and in which the heat exchanger and the compressor are housed in the cargo room , the first pipe and the second pipe running parallel to each other between the admission pipe and the cargo room.

8. Installation according to Claim 7, in which the first pipe and the second pipe are each connected to the compressor and to the heat exchanger via a four-way connector capable of selectively conveying vapour-phase gas circulating in the first pipe or in the second pipe to the compressor or to the heat exchanger.

9. Installation according to any one of Claims 3 to 5, comprising a plurality of leaktight and thermally insulating tanks each comprising an internal space intended to be filled with gas in a liquid-vapour two-phase state of equilibrium; the vapour-phase gas collection circuit comprising, for each of said tanks, an admission pipe passing through an aperture made in a wall of said tank and emerging in the internal space of said tank.

10. Installation according to Claim 9, in which each admission pipe is connected to the first pipe, on the one hand, and to the second pipe, on the other hand, via a three-way connector that is capable of selectively conveying vapour-phase gas collected via the admission pipe either to the first pipe or to the second pipe.

11. Installation according to Claim 10, in which the second pipe has a gas passage cross section of variable diameter; the diameter of the gas passage cross section of said second pipe increasing in the direction of the first channel of the heat exchanger and increasing in stages at each connection of the second pipe to one of the admission pipes.

12. Installation according to Claim 10, also comprising a plurality of second pipes that are each capable of conveying vapour-phase gas from one of the

admission pipes to the inlet of the first channel of the heat exchanger; the second pipes each having a gas passage cross section that is smaller than that of the first pipe; each admission pipe being connected to the first pipe , on the one hand, and to one of the second pipes, on the other hand, by a three-way connector that is capable of selectively conveying vapour-phase gas collected via said admission pipe either to the first pipe or to one of the second pipes .

13. Installation according to any one of Claims 3 to 5, in which the first pipe has a gas passage cross section whose diameter is between 300 and 600 mm and in which the second pipe has a gas passage cross section whose diameter is between 50 and 200 mm.

14. Installation according to any one of Claims 3 to 5, in which the first and/or second pipe is formed by a jacketed tube comprising an inner wall and an outer wall which are concentric and separated from each other by an intermediate insulating space.

15. Installation according to Claim 14, in which the intermediate insulating space of the second pipe is under vacuum.

16. Installation according to Claim 14 or 15, in which the intermediate insulating space the first pipe is lined with an insulating material.

17. Installation according to any one of Claims 3 to 5, also comprising:

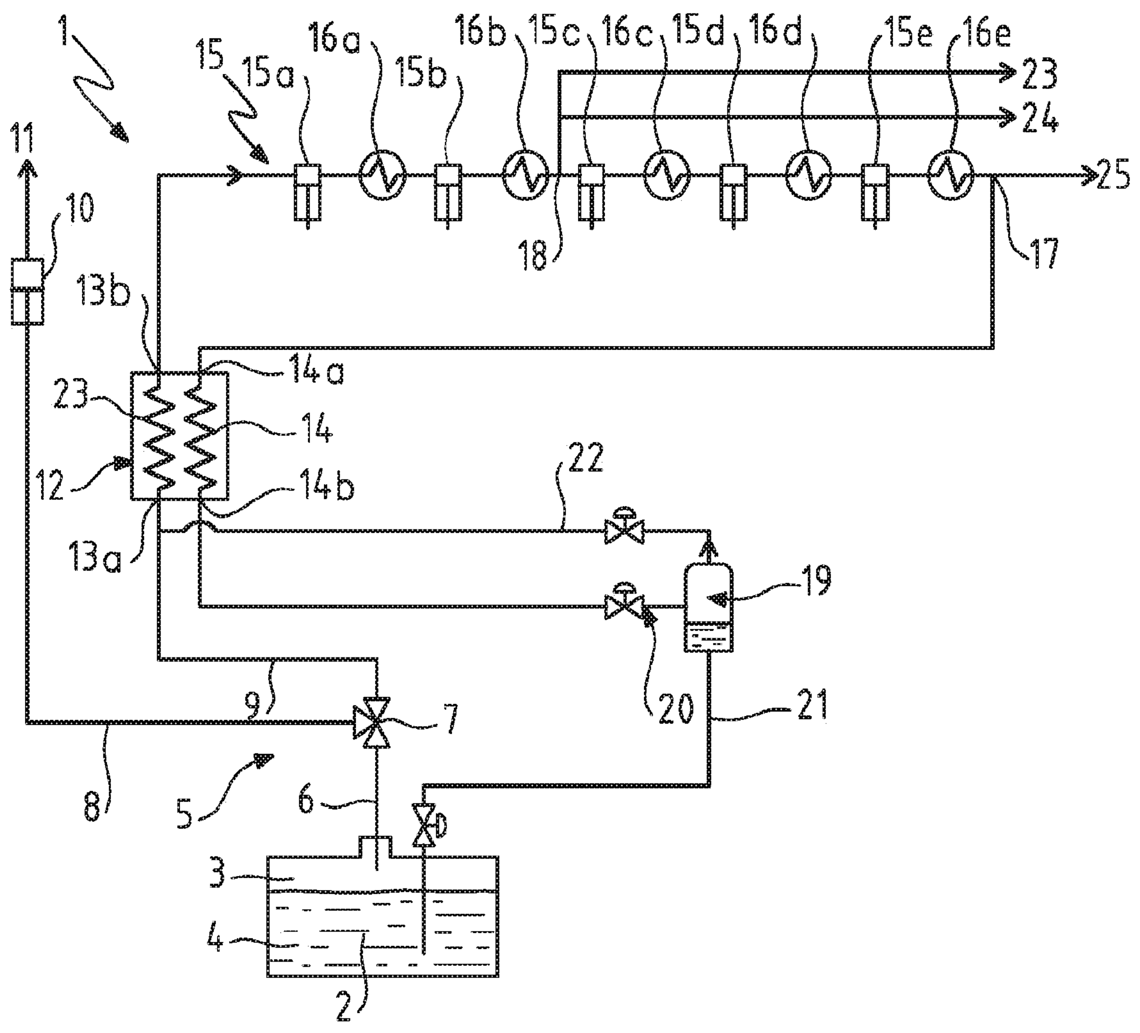
- a compressor which is connected upstream to the outlet of the first channel of the heat exchanger so as to compress the heated gas stream in the heat exchanger and is connected downstream to a three-way connector that is capable of conveying a first portion of the gas stream to a gas-consuming member and of conveying a second portion of the gas stream to the inlet of the second channel of the heat exchanger in order to cool the second portion of the gas stream; and

- an expansion device that is connected upstream to the outlet of the second channel of the heat exchanger and is connected downstream to a return circuit leading to the tank; the expansion device being arranged to depressurize the second portion of the gas stream originating from the second channel of the heat exchanger so as to liquefy it.

18. Vessel for transporting a gas, the vessel comprising an installation according to Claim 3.

19. Gas transfer system, the system comprising a vessel according to Claim 16, cryogenic transfer pipes arranged so as to connect the tank of the installation installed in the hull of the vessel to a floating or land-based gas storage terminal and a pump for entraining a liquid-phase gas stream through the cryogenic transfer pipes from or to the floating or land-based gas storage terminal, to or from the vessel's tank; the transfer system also comprising a vapour-phase gas transfer pipe arranged so as to connect the manifold to the gas storage terminal so as to allow transfer of vapour-phase gas between the gas storage and treatment installation and the gas storage terminal.

20. Process for loading or emptying a vessel according to Claim 16, in which a gas is conducted through cryogenic transfer pipes from or to a floating or land-based gas storage terminal to or from the tank of the vessel's gas storage and treatment installation.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16a
15b
16b
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15d
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13b
14a
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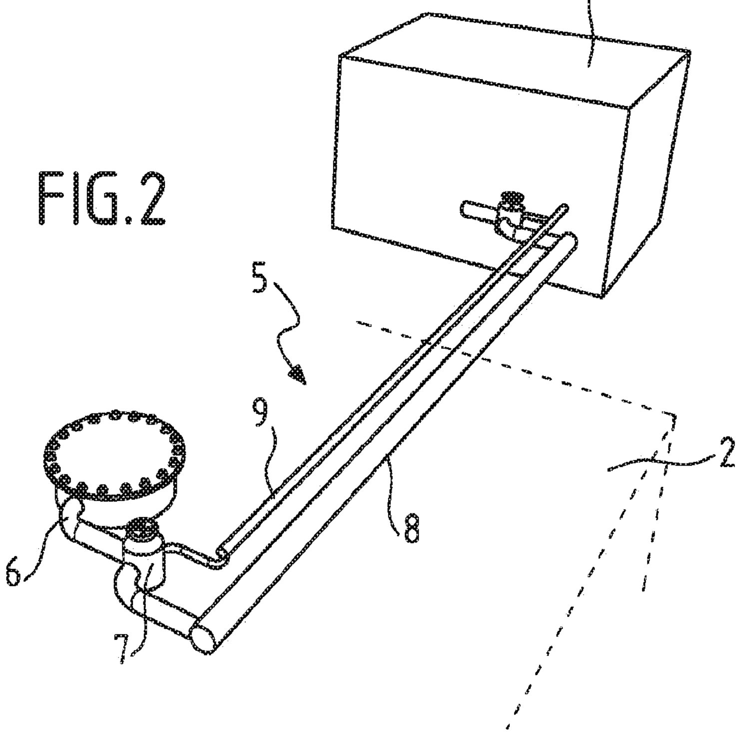
FIG.1

FIG.2



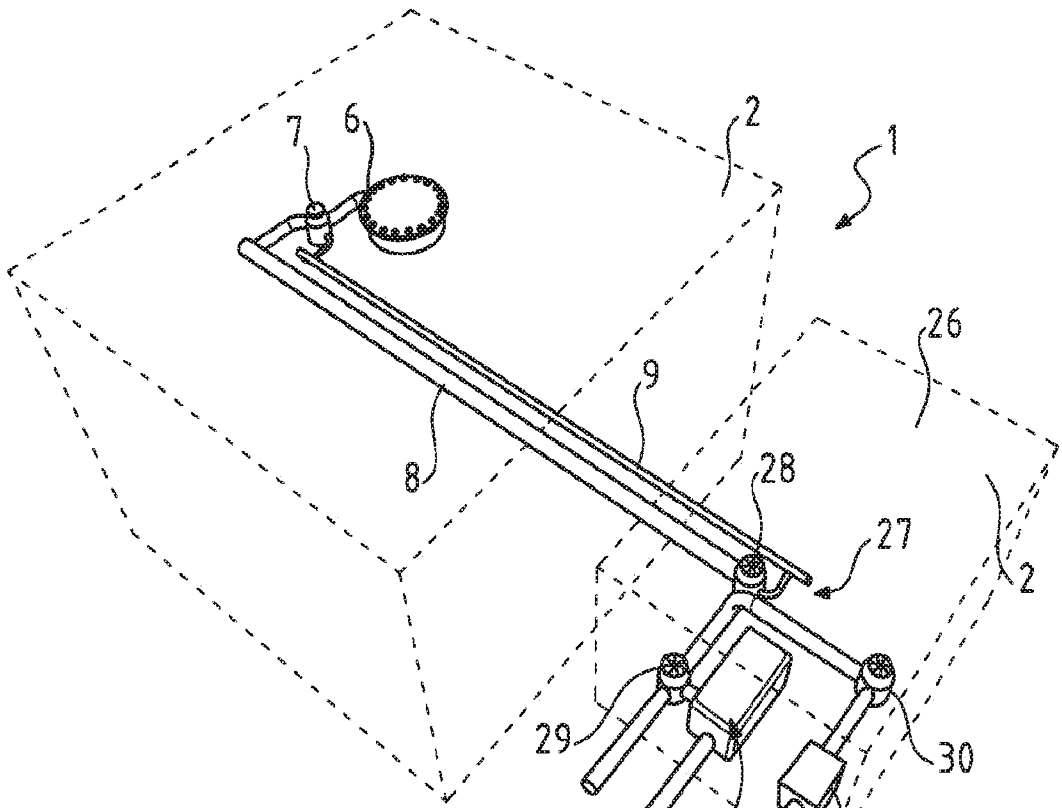


FIG.3

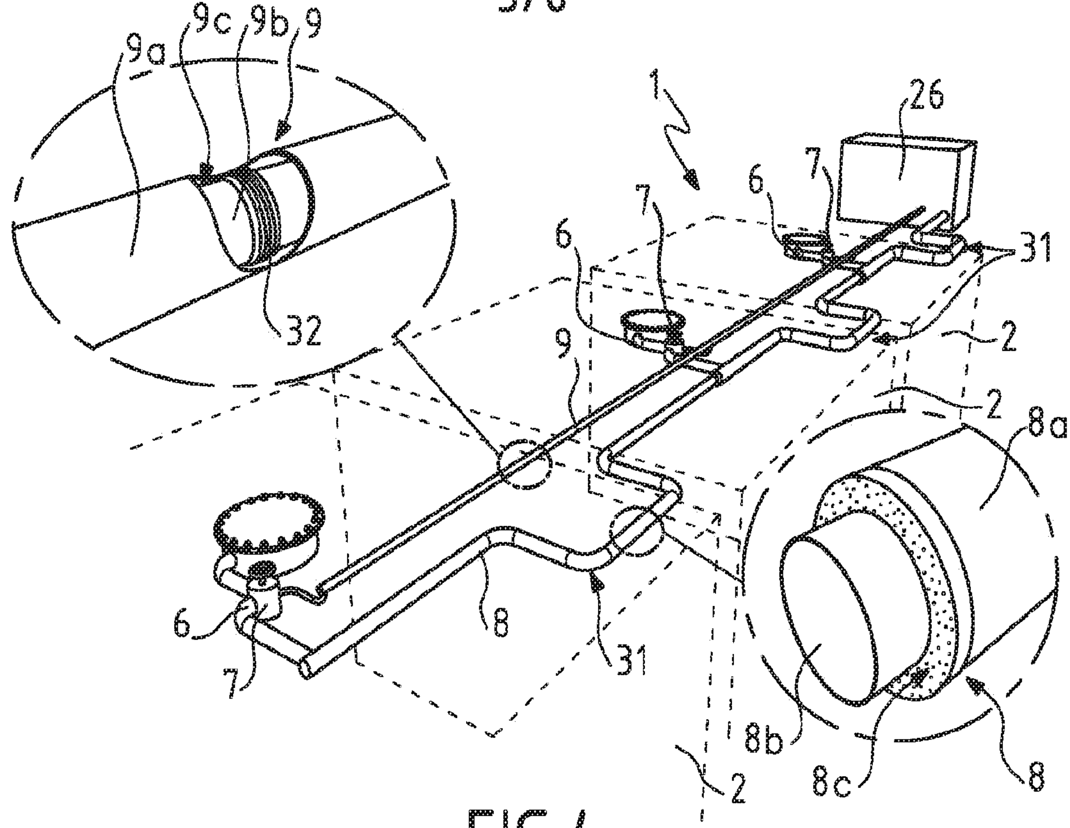


FIG.4

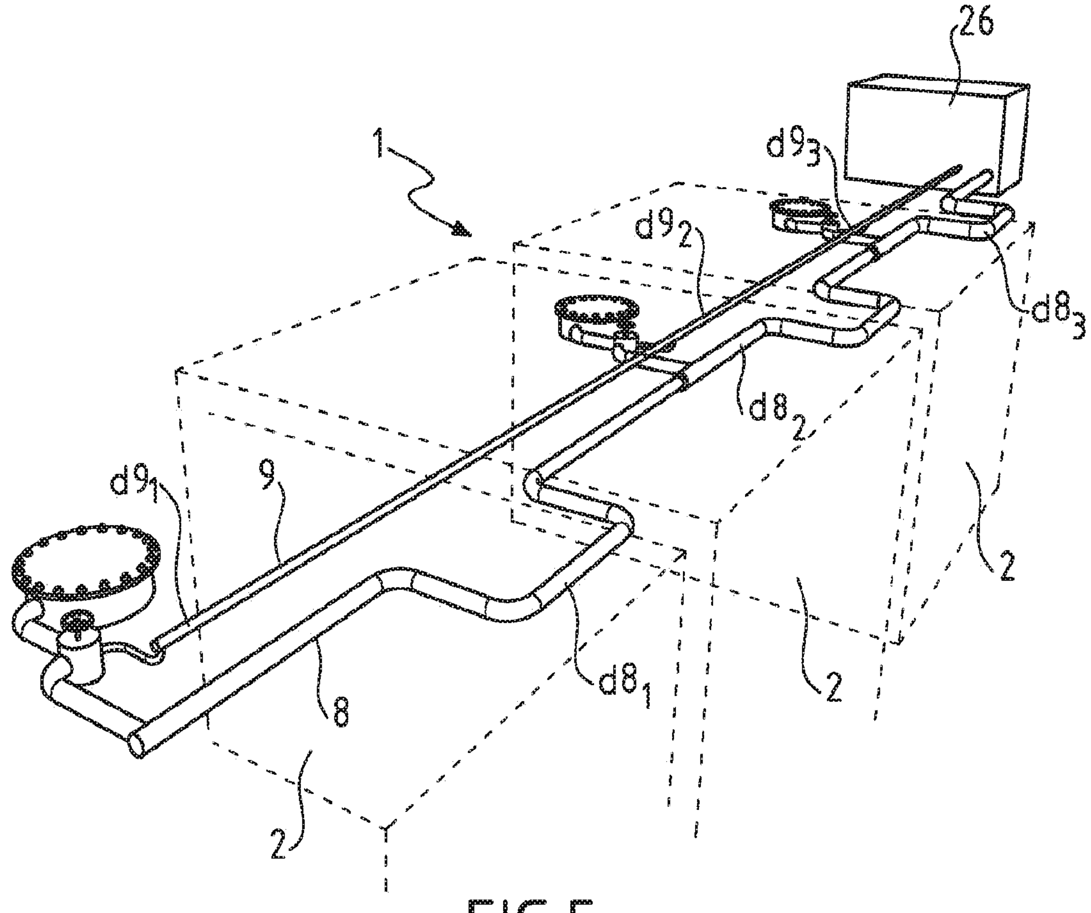


FIG.5

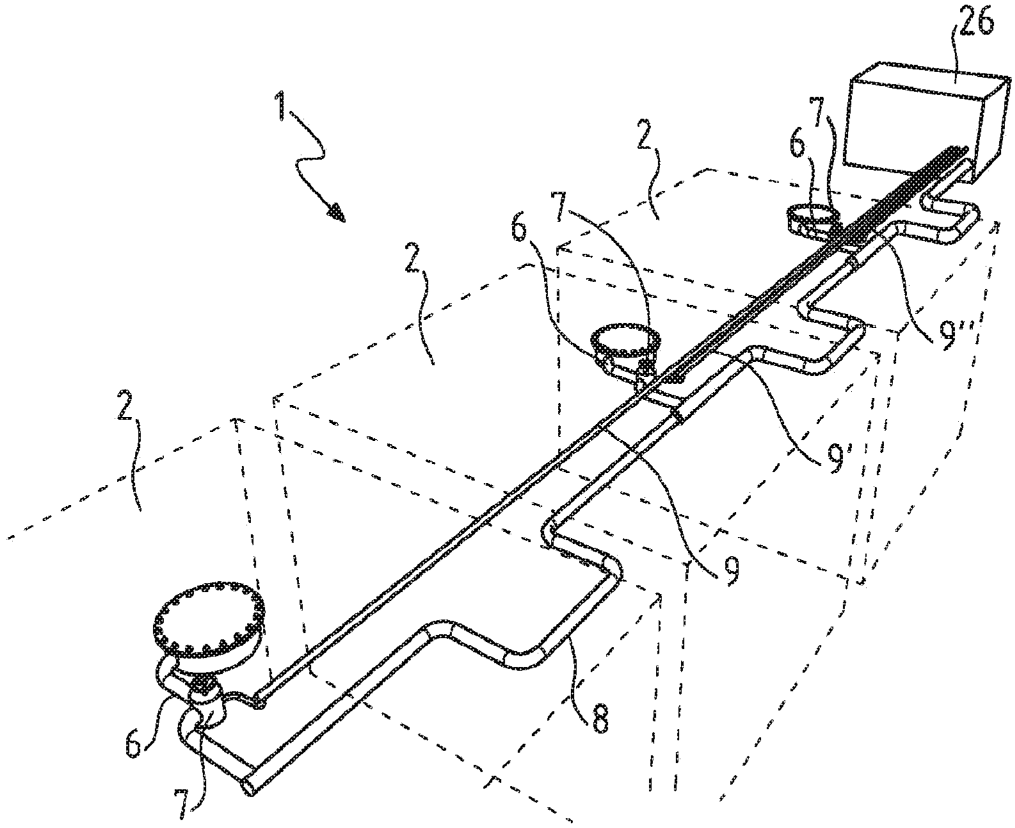


FIG.6

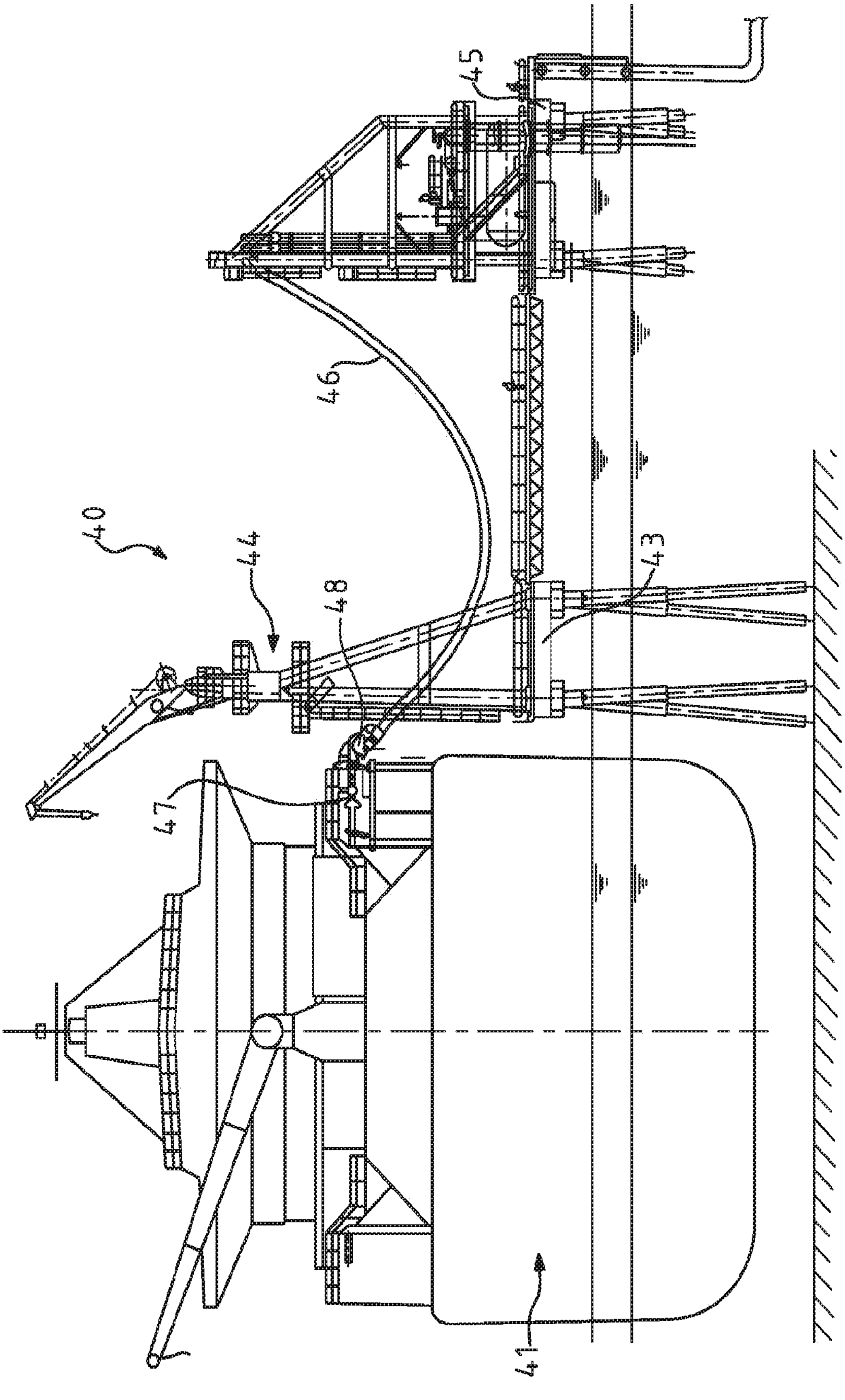


FIG.7

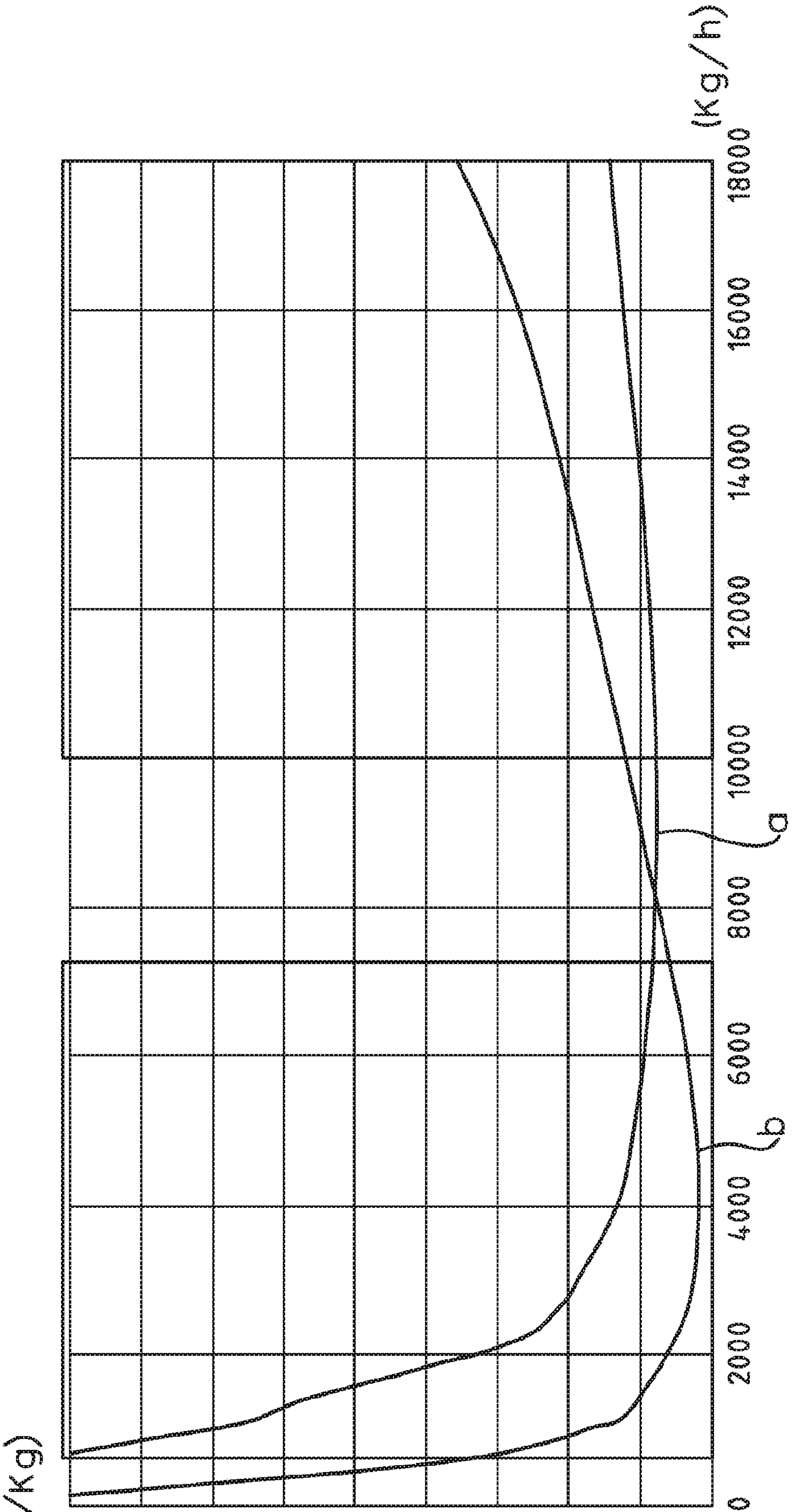

(KJ/Kg)
180
160
140
120
100
80
60
40
20
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
(Kg/h)
a
b

FIG.8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/031763

A. CLASSIFICATION OF SUBJECT MATTER

F17C 9/00(2006.01)i, F17C 9/04(2006.01)i, F17C 13/00(2006.01)i

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)
F17C 9/00; B63H 21/38; F17C 9/04; F02M 21/02; F16L 9/18; B63B 25/16; B63B 22/02; F17C 13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: reliquefy, regasify, LNG, storage tank, admission pipe, heat exchanger, compressor, vapor phase, and expansion device

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	KR 10-2014-0130092 A (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 07 November 2014 See paragraphs [0004], [0110]-[0122] and figures 1-2.	1,3-20 2
Y	KR 10-2015-0135157 A (HYUNDAI HEAVY INDUSTRIES CO., LTD) 02 December 2015 See paragraph [0068] and figures 1-2.	1,3-20
Y	US 2005-0121903 A1 (OFFREDI, MICHAEL) 09 June 2005 See claim 1.	14-16
Y	US 7056177 B2 (POLDERVAART, LEENDERT) 06 June 2006 See column 2, lines 42-52 and figure 1.	19-20
A	US 2014-0196474 A1 (YOO et al.) 17 July 2014 See paragraph [0049] and figure 1.	1-20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January 2017 (13.01.2017)	**16 January 2017 (16.01.2017)**

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