

DESCRIPTION

TITLE OF THE INVENTION: GAS SUPPLY SYSTEM FOR HIGH- AND LOW-PRESSURE GAS CONSUMING APPLIANCES

5 [0001] The present invention relates to the field of liquid-state gas storage and/or transport ships and relates more particularly to a gas supply system for consuming appliances comprised within such ships.

[0002] During a journey made by a ship comprising a tank of gas in the liquid
10 state intended to be consumed and/or delivered to a destination point, said ship may be able to use at least a part of said gas in the liquid state in order to supply at least one of its engines, via a gas supply system. This is the case with ships provided with a ME-GI type propulsion engine. In order to supply
15 this type of engine, the gas must be compressed to very high-pressure by special compressors capable of compressing the gas up to 300 bar, but such compressors are expensive, giving rise to substantial maintenance costs and inducing vibrations within the ship.

[0003] An alternative to the installation of these high-pressure compressors is
20 to vaporize the gas in liquid form at 300 bar before the gas is sent to the propulsion engine. This operation can be carried out by a high-pressure evaporator. Such a solution does not make it possible to eliminate the gas in vapor form (or BOG, which stands for "Boil-Off Gas") naturally forming within a tank at least partially containing the cargo, low-pressure compressors can
25 be installed in order to supply an auxiliary engine, capable of consuming the gas in the form of a low-pressure vapor. On the other hand, in such a configuration, if the gas in vapor form is present in too great a quantity, or more generally in a quantity greater than a need for consumption of the auxiliary engine, the gas in vapor form not consumed by the auxiliary engine is then
30 accumulated in the form of pressure in the tank within a certain limit, then eliminated by combustion, or as a last resort by releasing it into the

atmosphere. Elimination of this kind causes a waste of fuel, as well as detrimental consequences for the environment.

5 [0004] With a view to constantly improving the performance of such a supply system, one objective is in particular to avoid wasting fuel while saving energy used for certain components of said supply system.

10 [0005] The present invention makes it possible to meet such an objective by providing a gas supply system for at least one high-pressure gas-consuming appliance and at least one low-pressure gas-consuming appliance of a floating structure comprising at least one tank configured to contain the gas, the supply system comprising:

- 15 - at least a first gas supply circuit of the high-pressure gas consuming appliance, comprising at least one pump configured to pump the gas collected in the liquid state in the tank,
 - at least one high-pressure evaporator configured to evaporate the gas circulating in the first gas supply circuit,
 - at least one second circuit supplying gas to the low-pressure gas-consuming appliance, comprising at least one compressor configured to compress gas
20 taken in the vapor state in the tank to a pressure compatible with the requirements of the low-pressure gas-consuming appliance,
 - at least one gas return line connected to the second supply circuit downstream of the compressor and extending to the tank,
 - at least one first heat exchanger and a second heat exchanger each
25 configured to exchange heat between the gas circulating in the return line and the gas circulating in the first supply circuit,
- characterized in that the first supply circuit comprises a main path and a bypass path that is arranged in parallel with at least one portion of the main path, the second heat exchanger being configured to exchange heat between
30 the gas circulating in the return line and the gas circulating in the bypass path.

[0006] The presence of the bypass path thus makes it possible to circulate the gas through the second heat exchanger only when necessary, for example in the event of excess gas in the vapor state present in the tank. The gas can also circulate within the main path in its entirety, including the portion of the main path arranged in parallel with the bypass path, and is directly treated by the high-pressure evaporator after having passed through the first heat exchanger. The gas collected within the tank and intended to supply the high-pressure gas-consuming appliance thus has several circulation modes, which prevents the circulation of superfluous gas and can also limit the amount of energy related to the use of the high-pressure evaporator and/or the second heat exchanger.

[0007] In addition, by virtue of such a supply system, the gas in the vapor state present in the tank and not used for the consumption of the low-pressure gas-consuming appliance can be recondensed and is thus returned to the tank in the liquid state, instead of being eliminated. The loss of the excess gas in the vapor state present in the tank is then at least reduced.

[0008] The first gas supply circuit therefore makes it possible to meet the fuel needs of the high-pressure gas-consuming appliance. Said appliance may for example be the means for propelling the floating structure, for example an ME-GI engine. The first supply circuit extends from the tank to the high-pressure gas-consuming appliance. The pump is installed at the bottom of the tank and ensures the pumping of the gas in the liquid state so that it can circulate in the first supply circuit.

[0009] As the gas must be in the vapor state to be able to supply the high-pressure gas-consuming appliance, the high-pressure evaporator guarantees the evaporation of the gas before it is supplied to the high-pressure gas-consuming appliance. The high-pressure evaporator is the site of the heat exchange between the gas circulating in the first supply circuit and a heat-transfer fluid, for example glycol water, seawater or water vapor. This heat

transfer fluid must be at a sufficiently high temperature to create a change of state of the gas so that it goes into the vapor or supercritical state and supplies the high-pressure gas-consuming appliance.

- 5 [0010] The gas circulating in the first supply circuit passes through the first heat exchanger and then, optionally, the second heat exchanger depending on the chosen configuration. The gas can subsequently be vaporized by means of the high-pressure evaporator. The temperature of said gas thus tends to increase somewhat before the passage thereof through the high-pressure evaporator if
10 the configuration of the first supply circuit allows it. Thus, the gas circulating in the first supply circuit can be in a two-phase, vapor, liquid or supercritical state at the outlet of the second heat exchanger if the bypass path is taken by the gas.
- 15 [0011] Generally, the gas contained in the tank can change naturally, or be forced by the floating structure, into the vapor state. The gas within the tank changing to the vapor state must be discharged in order to avoid creating overpressure within the tank.
- 20 [0012] Such a function is provided by the second gas supply circuit of the low-pressure gas-consuming appliance. The second supply circuit extends from the tank to the low-pressure gas-consuming appliance. Said appliance can for example be an auxiliary motor such as an electric generator. The compressor arranged on the second supply circuit is responsible for drawing the gas
25 present in the tank space in order to be able both to supply the low-pressure gas consuming appliance but also to regulate the pressure in the tank. The second supply circuit is structurally separate from the first supply circuit apart from the fact that both supply circuits are connected to the tank.
- 30 [0013] At the outlet of the compressor, the gas in the vapor state can supply the low-pressure gas consuming appliance or circulate through the return line if the low-pressure gas consuming appliance does not require fuel intake.

Since the return line is connected downstream of the compressor, the gas in the vapor state drawn by the compressor can therefore circulate therein.

5 [0014] The gas in the vapor state circulating in the return line passes firstly through the second heat exchanger, then the first heat exchanger, before returning to the tank. Depending on the circulation of the gas in the first supply circuit, the exchange of heat can take place within both heat exchangers or only within the first heat exchanger.

10 [0015] By virtue of the exchange of heat occurring between the gas circulating in the first supply circuit and the gas circulating in the return line, the temperature of the gas in the vapor state decreases by passing through the two heat exchangers until said gas condenses and returns to the liquid state substantially when leaving the first heat exchanger. The recondensed gas then
15 circulates to the tank.

[0016] According to one feature of the invention, the main path comprises an additional pump placed between the first heat exchanger and the high-pressure evaporator. It is the additional pump that makes it possible to increase
20 the pressure of the gas circulating in the first supply circuit, so that it has a compatible pressure for supplying the high-pressure gas-consuming appliance.

[0017] The positioning of the additional pump is particularly advantageous.
25 Indeed, placing the additional pump upstream of the first heat exchanger causes an increase in the pressure and temperature of the gas in the liquid state as soon as it passes through the first heat exchanger, which is detrimental to the condensation of the gas in the vapor state circulating in the return line and passing through the first heat exchanger. The optimal
30 arrangement consists therefore in placing the additional pump downstream of the first heat exchanger.

[0018] According to one feature of the invention, the bypass path starts at a divergence point arranged on the main path between the additional pump and the high-pressure evaporator. It is from the divergence point that the first supply circuit is divided between the portion of the main path and the bypass path. Depending on the configuration of the first supply circuit, the gas circulating therein, after having passed through the first heat exchanger, can circulate in the portion of the main path in order subsequently to be directly treated by the high-pressure evaporator and/or within the bypass path in order to pass through the second heat exchanger.

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[0019] The divergence point is downstream of the additional pump so that the second heat exchanger is also downstream of the additional pump. Specifically, the gas circulating in the bypass path can be in a vapor, liquid, two-phase or supercritical state at the outlet of the second heat exchanger, and arranging the additional pump downstream of the second heat exchanger may adversely affect the correct operation thereof given that the additional pump only allows a fluid in the liquid state to be pumped.

[0020] According to one feature of the invention, the first supply circuit comprises a distribution device configured to control the distribution of the circulation of the gas to the portion of the main path and/or to the bypass path. The distribution device can be controlled remotely, so that the circulation of the gas within the first supply circuit is optimal for the consumption of the gas by the consuming appliance and for the condensation of the gas circulating in the return line.

[0021] According to one feature of the invention, the bypass path ends at a convergence point arranged on the main path between the divergence point and the high-pressure evaporator. Such a configuration corresponds to a first embodiment of the supply system according to the invention. In this first embodiment, the convergence point of the portion of the main path and the bypass path is arranged downstream of the divergence point and upstream of

the high-pressure evaporator. In other words, the gas circulating in the bypass path passes through the second heat exchanger, and then joins the main path before being treated by the high-pressure evaporator. All of the gas circulating in the first supply circuit is therefore treated by the high-pressure evaporator according to the first embodiment. The latter therefore allows the gas to pass through the second heat exchanger and/or to bypass it.

[0022] According to one feature of the invention, the distribution device comprises a first valve configured to manage the circulation of gas within the bypass path and a second valve arranged in the portion of the main path. The valves can be controlled remotely in order to switch to the open or closed position and thus determine the circulation of the gas circulating within the first supply circuit.

[0023] The first valve can be arranged on the bypass path upstream or downstream of the second heat exchanger. As for the second valve, it is arranged in the portion of the main path that is arranged in parallel with the bypass path.

[0024] The first valve makes it possible to control the circulation of the gas in the bypass path, while the second valve makes it possible to control the circulation of the gas in the portion of the main path that is arranged in parallel with the bypass path. If the first valve is closed and the second valve is open, then the gas circulates within the main path in its entirety. If the first valve is open and the second valve is closed, then the gas circulates entirely through the bypass path and then joins the main path upstream of the high-pressure evaporator. Both valves can also be opened so that the gas separates into two fractions, one going directly to the high-pressure evaporator via the portion of the main path, the other circulating within the bypass path via the second heat exchanger.

[0025] According to one feature of the invention, the bypass path and the first valve are configured so that the gas that circulates between the divergence point and the second heat exchanger is kept in the liquid state. In other words, the only function of the first valve is to allow or prevent the circulation of the gas within the bypass path without causing any change of state, for example by expanding the gas circulating in the bypass path. Thus, the gas circulating in the bypass path is kept in the liquid state until it passes through the second heat exchanger. At the outlet of the latter, and depending on a flow rate of gas circulating in the return line and its effect on the heat exchange, the gas circulating in the bypass path can exit from the second heat exchanger in a liquid, vapor, two-phase or supercritical state.

[0026] According to one feature of the invention, the bypass path ends at a convergence point arranged on the main path downstream of the high-pressure evaporator. Such a configuration corresponds to a second embodiment of the supply system according to the invention. In this embodiment, the bypass path makes it possible to bypass the high-pressure evaporator. The latter is therefore situated within the portion of the main path that is arranged in parallel with the bypass path.

[0027] According to the second embodiment, the gas circulating in the first supply circuit is therefore either treated by the high-pressure evaporator if the gas circulates within the portion of the main path, or treated by the second heat exchanger if the gas circulates within the bypass path. At the outlet of the high-pressure evaporator or the second heat exchanger, the gas has characteristics that are compatible for the consumption thereof by the high-pressure gas-consuming appliance, for example by being in a vapor or supercritical state. The second embodiment therefore makes it possible to distribute the state change load of the gas circulating within the first supply circuit while cooling the gas circulating in the return line by virtue of the heat exchange carried out within the second heat exchanger.

[0028] According to one feature of the invention, the distribution device comprises a distribution valve. The distribution valve makes it possible to control the flow rate of gas circulating in the portion of the main path and/or in the bypass path. By way of example, the valve can have a degree of opening, the distribution of the gas circulating between the portion of the main path and/or the bypass path being dependent on the degree of opening of the distribution valve.

[0029] According to one feature of the invention, the distribution valve is arranged in the portion of the main path. In this configuration, the greater the degree of opening of the distribution valve, the greater the proportion of gas circulating within the portion of the main path. Conversely, the smaller the degree of opening of the distribution valve, the greater the proportion of gas circulating within the bypass path. If the distribution valve is completely open, the gas circulates exclusively in the portion of the main path. If the distribution valve is closed, the gas circulates exclusively in the bypass path. The distribution valve can be positioned either between the divergence point and the high-pressure evaporator, or between the high-pressure evaporator and the convergence point.

[0030] According to another feature of the invention, the distribution valve is arranged on the bypass path. In this configuration, the greater the degree of opening of the distribution valve, the greater the proportion of gas circulating within the bypass path. Conversely, the smaller the degree of opening of the distribution valve, the greater the proportion of gas circulating within the portion of the main path. If the distribution valve is completely open, the gas circulates exclusively in the bypass path. If the distribution valve is closed, the gas circulates exclusively in the portion of the main path. The distribution valve can be positioned either between the divergence point and the second heat exchanger, or between the second heat exchanger and the convergence point.

[0031] According to one feature of the invention, the return line comprises an expansion member arranged between the first heat exchanger and the tank and configured to regulate a flow rate of gas circulating in the return line, said expansion member and the distribution valve being configured so that the gas
5 that circulates within the bypass path transitions from the liquid state to the vapor or supercritical state.

[0032] As has been mentioned, the gas circulating in the first supply circuit is treated by the high-pressure evaporator or by the second heat exchanger. In
10 other words, unlike the first embodiment, the gas circulating in the bypass path must be, at the outlet of the second heat exchanger, in a state that is compatible for consumption by the high-pressure gas-consuming appliance, for example in a vapor or supercritical state. It is therefore important that the gas circulating in the bypass path be entirely in the vapor or supercritical state
15 at the outlet of the second heat exchanger.

[0033] The flow rate of gas circulating in the bypass path can be proportional to the flow rate of gas circulating in the return line so that, during heat exchange, the entirety of the gas circulating in the bypass path is in a vapor or
20 supercritical state at the outlet of the second heat exchanger. The expansion member arranged on the return line therefore makes it possible to control the flow rate of gas circulating in the return line, while the distribution valve makes it possible to control the flow rate of gas circulating in the bypass path. Thus, by virtue of the control by the expansion member and by means of the
25 distribution valve, the gas circulating in the bypass path exits from the second heat exchanger in a state that is compatible with the consumption thereof by the high-pressure gas-consuming appliance, without having been treated by the high-pressure evaporator.

30 [0034] According to one feature of the invention, the first heat exchanger is configured to condense the gas circulating within the return line. The first heat exchanger is the exchanger through which the gas in the liquid state of the first

supply circuit passes when said gas in the liquid state is at its lowest temperature. It is therefore the exchange of heat taking place in the first heat exchanger that will change the state of the gas circulating in the return line so that it transitions from the vapor state to the liquid state.

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[0035] According to one feature of the invention, the second heat exchanger is configured to pre-cool the gas circulating within the return line. At the outlet of the first heat exchanger, the gas circulating in the first supply circuit is less cold than at the inlet of the first heat exchanger, an exchange of heat having been
10 used to condense the gas circulating in the return line. The gas in the liquid state is subsequently compressed by the additional pump and then reaches the divergence point. Depending on the configuration of the first or second embodiment, the gas can subsequently pass through the second heat exchanger. If so, there is also an exchange of heat within the second heat
15 exchanger, allowing the pre-cooling of the gas in the vapor state within the return line.

[0036] According to one feature of the invention, the return line can comprise a divergence zone dividing the return line into a first section and a second
20 section both extending from the divergence zone to the tank, the first heat exchanger being configured to exchange heat between the gas circulating in the vapor state in the first section of the return line and the gas in the liquid state circulating in the first supply circuit, while the second section bypasses the first heat exchanger. The gas in the vapor state present in the tank and not
25 used for the consumption of the low-pressure gas-consuming appliance can be condensed by circulating via the first section of the return line and is thus returned to the tank in the liquid state, instead of being eliminated.

[0037] When the flow rate of gas in the liquid state circulating in the first supply
30 circuit is not sufficient to condense all the gas in the vapor state circulating in the return line, the excess fraction of the gas can be directed toward the second section of the return line in order to return directly in the tank. Such a

situation can occur when the floating structure equipped with the supply system according to the invention does not require a large quantity of gas in the liquid state for propulsion, for example when the floating structure moves at a reduced speed.

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[0038] It has been determined by the inventors that complete condensation of the gas in the vapor state circulating in the return line was possible only when the quantity of gas in the liquid state circulating in the first supply circuit is greater than or equal to six times the quantity of gas in the vapor state circulating in the return line. Such an example is applicable when the compressor compresses the gas in the vapor state to about 10 bar, but the ratio may change depending on the pressure delivered by the compressor. If this condition is satisfied, the gas in the vapor state then circulates in the first section of the return line in order to be condensed. If the quantity of gas in the liquid state circulating in the first supply circuit is less than six times the quantity of gas in the vapor state circulating in the return line, then it is advantageous to circulate the gas in the vapor state at least partially within the second section of the return line, a portion of the gas in the vapor state then circulating in the first section in an amount such that the condensation is complete.

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[0039] The gas in the vapor state circulating in the return line can circulate in the first section or in the second section from the divergence zone. If the gas in the vapor state circulates in the first section, it first passes through the second heat exchanger and then through the first heat exchanger, before returning to the tank, as described above. If the gas in the vapor state circulates in the second section, it passes through the second exchanger, then returns directly into the tank. According to this configuration, the temperature of the gas in the vapor state decreases due to the exchange of calories carried out in the second heat exchanger, however it is not condensed. The gas thus returns to the tank in the vapor state, but nevertheless being cooled.

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[0040] The second section of the return line thus comprises an end that is submersed in the liquid contained in the tank. The second section may comprise an ejection member arranged at the submerged end. The ejection member makes it possible in particular to expand the gas in the vapor state
5 circulating in the second section of the return line before the gas is dispersed into the tank. The expansion of the gas in the vapor state, associated with the fact that the submerged end is preferentially arranged at the bottom of the tank, makes it possible to liquefy at least part of the gas in the vapor state when it returns to the tank, also leading to an increase in temperature of the gas in
10 liquid form present in the tank. The ejection member may for example be an ejector or a bubbling device.

[0041] According to one feature of the invention, the supply system comprises an auxiliary supply line connected to the first supply circuit, upstream of the
15 first heat exchanger, and extending to the second supply circuit, downstream of the compressor, the supply system comprising a low-pressure evaporator configured to evaporate the gas circulating in the auxiliary supply line. Such an auxiliary supply line is used when the low-pressure gas consuming appliance requires being supplied with gas in the vapor state, but there is an
20 insufficient quantity in the tank space. The auxiliary supply line thus makes it possible to derive a part of the gas in the liquid state circulating in the first supply circuit. This part is then evaporated by the low-pressure evaporator, according to an operation similar to that of the high-pressure evaporator, that is to say, by heat exchange with a heat-transfer fluid such as glycol water,
25 seawater or water vapor, for example. The low-pressure evaporator thus induces an exchange of heat between the gas in the liquid state circulating in the auxiliary supply line and this heat-transfer fluid.

[0042] Once changed to the vapor state, the gas circulates within the auxiliary
30 supply line, then joins the second supply circuit in order to supply the low-pressure gas consuming appliance.

[0043] If gas in the vapor state is present in sufficient quantity in the tank space, then the auxiliary supply line is not used and can for example be closed by a valve.

- 5 [0044] The invention also covers a floating structure for storing and/or transporting gas in the liquid state, comprising at least one tank containing gas in the liquid state, at least one-high-pressure gas-consuming appliance, at least one low-pressure gas-consuming appliance and at least one system for supplying gas to these appliances.

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[0045] The invention also covers a system for loading or unloading a liquid gas which combines at least one land and/or port facility and at least one floating structure for storing and/or transporting liquid gas.

- 15 [0046] Finally, the invention covers a method for loading or unloading a liquid gas from a floating structure for storing and/or transporting gas in which pipes for loading and/or unloading liquid-state gas arranged on an upper deck of the floating structure can be connected, by means of appropriate connectors, to a maritime or port terminal in order to transfer the gas in the liquid state from or
20 to the tank.

- [0047] Other features and advantages of the invention will appear both from the description which follows and from several exemplary embodiments, which are given for illustrative purposes and without limitation with reference to the
25 appended schematic drawings, in which:

[0048] [Fig 1] shows a first embodiment of a supply system according to the invention,

- 30 [0049] [Fig 2] shows the first embodiment of the supply system comprising a return line divided into two sections,

[0050] [Fig 3] shows a second embodiment of the supply system,

[0051] [Fig 4] is a cutaway schematic representation of a tank of a floating structure and of a terminal for loading and/or unloading this tank.

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[0052] Figures 1 to 3 show a gas supply system 1 arranged on a floating structure. The supply system 1 makes it possible to circulate gas that can be in the liquid state, in the vapor state, in the two-phase state or in the supercritical state, from a storage and/or transport tank 8, to a high-pressure gas-consuming appliance 4 and/or to a low-pressure gas-consuming appliance 5, in order to supply said appliances with fuel.

[0053] Said floating structure may for example be a ship that can store and/or transport gas in the liquid state. In this case, the supply system 1 is capable of using the gas in the liquid state that the floating structure stores and/or transports to supply the high-pressure gas-consuming appliance 4, which may for example be a propulsion engine, and the low-pressure gas-consuming appliance 5, which may for example be an electric generator supplying the floating structure with electricity.

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[0054] In order to ensure the circulation of the gas contained in the tank 8 to the high-pressure gas-consuming appliance 4, the supply system 1 is provided with a first gas supply circuit 2. The first supply circuit 2 comprises a pump 9 arranged within the tank 8. The pump 9 makes it possible to pump the gas in the liquid state and to circulate it in particular in the first supply circuit 2. By drawing and compressing the gas in the liquid state, the pump 9 raises the pressure thereof to a value of between 6 and 17 bar.

[0055] The first supply circuit 2 comprises a main path 40 and a bypass path 41. The main path 40 extends from the pump 9 to the high-pressure gas-consuming appliance 4. As for the bypass path 41, it is arranged in parallel with a portion 50 of the main path 40. The gas circulating in the first supply

circuit 2 can therefore circulate via the portion 50 of the main path 40 or via the bypass path 41.

[0056] The gas circulating in the first supply circuit 2, in a direction of circulation
5 going from the tank 8 to the high-pressure gas-consuming appliance 4, circulates within the main path 40, passes through a first heat exchanger 6, is pumped by an additional pump 10 and reaches a divergence point 42 in order to circulate within the portion 50 of the main path 40 or within the bypass path 41. The control of the circulation of the gas within the portion 50 of the main
10 path 40 and/or within the bypass path 41 is managed by a distribution device 60 that ensures that the gas is distributed according to factors and/or requirements which will be described in detail hereinafter. If the gas circulates within the bypass path 41, the gas passes through a second heat exchanger 7. The details concerning the two heat exchangers 6, 7 will be described below.
15 The bypass path 41 comprises a first part 41a extending between the divergence point 42 and the second heat exchanger 7, and a second part 41b extending between the second heat exchanger 7 and the convergence point 43.

[0057] The portion 50 of the main path 40 and the bypass path 41 both extend
20 from the divergence point 42 to a convergence point 43. From there, the gas circulates within the main path 40 again to a high-pressure evaporator 11. The high-pressure evaporator 11 makes it possible to modify the state of the gas circulating in the first supply circuit 2 in order to change it to the vapor state.
25 Such a state allows the gas to be compatible for supplying the high-pressure gas-consuming appliance 4, for example by being in a vapor or supercritical state. The evaporation of the gas in the liquid state can for example be carried out by heat exchange with a heat transfer fluid at a temperature high enough to evaporate the gas in the liquid state, in this case glycol water, seawater or
30 water vapor.

[0058] The increase in gas pressure is ensured by the additional pump 10 when it pumps the gas in the liquid state. The additional pump 10 makes it possible to raise the pressure of the gas in the liquid state to a value of between 30 and 400 bar, in particular for use with ammonia or hydrogen, between 30 and 70 bar for use with liquefied petroleum gas, and preferably between 150 and 400 bar for use with ethane, ethylene or else liquefied natural gas consisting mainly of methane.

[0059] By virtue of the combination of the additional pump 10 and the high-pressure evaporator 11, the gas is at a pressure and in a compatible state for the supply of the high-pressure consuming appliance 4. Such a configuration makes it possible to avoid the installation of high-pressure compressors on the first supply circuit 2 which have cost constraints and generate strong vibrations.

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[0060] In order to determine a configuration of the circulation of the gas within the first supply circuit 2, the distribution device 60 comprises a first valve 44 arranged on the bypass path 41 and a second valve 45 arranged in the portion 50 of the main path 40. Thus, depending on whether these two valves 44, 45 are open or closed, the gas circulates from the divergence point 42 to the convergence point 43 via the portion 50 or via the bypass path 41 depending on what is needed. These valves can be controlled remotely according to a desired circulation mode.

[0061] In Figure 1, the first valve 44 is arranged at the first part 41a of the bypass path 41. Alternatively, the first valve 44 can also be arranged on the second part 41b of the bypass path 41.

[0062] Within the tank 8, a part of the gas cargo can naturally change to the vapor state and diffuse into a space of the tank 12. In order to avoid overpressure within the tank 8, the gas in the vapor state contained in the tank space 12 must be discharged. However, the first supply circuit 2 is configured

to use the gas in the liquid state to supply the high-pressure gas consuming appliance 4.

[0063] The supply system 1 therefore comprises a second gas supply circuit 3, which uses the gas in the vapor state to supply the low-pressure gas-consuming appliance 5. The second supply circuit 3 extends between the tank space 12 and the low-pressure gas consuming appliance 5. With the exception of being connected to the tank 8, the first supply circuit 2 and the second supply circuit 3 are structurally separate from one another. In order to suck in the gas in the vapor state contained in the tank space 12, the second supply circuit 3 comprises a compressor 13. In addition to sucking in the gas in the vapor state, the compressor 13 also makes it possible to compress the gas in the vapor state circulating in the second supply circuit 3 to a pressure of between 6 and 20 bar absolute, so that the gas in the vapor state is at a compatible pressure for the supply of the low-pressure gas-consuming appliance 5. The second supply circuit 3 thus makes it possible to supply the low-pressure gas-consuming appliance 5, while regulating the pressure within the tank 8 by sucking in the gas in the vapor state present in the tank space 12.

[0064] The presence of the gas in the vapor state in excess quantity within the tank space 12 causes an overpressure within the tank 8. It is therefore necessary to evacuate the gas in the vapor state in order to lower the pressure within the tank 8. The excess vapor state gas can then for example be eliminated by a burner 18. However, the supply system 1 according to the invention comprises a return line 14 which extends from the second supply circuit 3 to the tank 8.

[0065] The return line 14 is connected to the second supply circuit 3 downstream of the compressor 13 relative to a direction of circulation of the gas in the vapor state circulating in the second supply circuit 3. According to the direction of circulation of the gas in the vapor state circulating in the return line 14, said gas passes through the second heat exchanger 7 in a first step,

then passes through the first heat exchanger 6. The exchange of heat carried out within the first heat exchanger 6 and the second heat exchanger 7 is therefore between the gas circulating in the first supply circuit 2 and the gas circulating in the return line 14. More particularly, the exchange of heat carried out within the second heat exchanger 7 is between the gas circulating in the bypass path 41 and the gas circulating in the return line 14. The objective of this exchange of heat via the second heat exchanger 7 and then the first heat exchanger 6 is to condense the gas in the vapor state in the return line 14, so that it transitions to the liquid state and returns to the tank 8 in this state, instead of being eliminated by the burner 18.

[0066] The inlet of the first heat exchanger 6 is where the gas in the liquid state of the first supply circuit 2 has the lowest temperature. Consequently, it is therefore after having passed through the first heat exchanger 6 that the gas circulating in the return line 14 is condensed. The gas in the return line 14 is therefore in the vapor state at the inlet of the first heat exchanger 6 and exits in the liquid state following the exchange of heat that takes place within the first heat exchanger 6.

[0067] In order to match the pressure of the gas circulating in the return line 14 with the pressure that prevails in the tank 8, the return line 14 may comprise an expansion member 15 which lowers the pressure of the gas to a pressure of between 1 and 3 bar absolute. The expansion member 15 is also able to regulate a flow rate of gas circulating within the return line 14. Once the gas is condensed, it circulates to the tank 8. The first heat exchanger 6 therefore acts as a condenser.

[0068] The second heat exchanger 7 is located downstream of the first heat exchanger 6 in the direction of circulation of the gas in the first supply circuit 2, and upstream of the first heat exchanger 6 in the direction of circulation of the gas in the return line 14. Provided that the gas circulating within the first supply circuit 2 goes via the bypass path 41, the second heat exchanger 7 therefore

ensures pre-cooling of the gas in the vapor state circulating in the return line 14 before the gas is condensed in the first heat exchanger 6. At the bypass path 41, the gas at the inlet of the second heat exchanger 7 has previously passed through the first heat exchanger 6 and has been pumped by the
5 additional pump 10, which therefore increased its temperature and pressure. It is thus possible that, following the exchange of heat occurring in the second heat exchanger 7, the gas circulating within the first supply circuit 2 leaves the second heat exchanger 7 in a liquid, vapor, two-phase or supercritical state. The temperature of the gas circulating in the return line 14 is therefore lowered
10 after passing through the second heat exchanger 7, implementing the pre-cooling indicated above.

[0069] If at least the first valve 44 is closed, the gas does not circulate in the bypass path 41, and the gas circulating in the return line 14 passes through
15 the second heat exchanger 7 without being pre-cooled therein. The circulation of the gas via the portion 50 of the main path 40 may also be preferred when there is no gas to be recondensed circulating in the return line 14. However, the exchange of heat carried out within the second heat exchanger 7 makes it possible to increase the temperature of the gas circulating in the bypass path
20 41 and thus makes it possible to limit the energy that has to be supplied to the heat transfer fluid circulating in the high-pressure evaporator 11 in order to evaporate the gas that has previously passed through the second heat exchanger 7.

[0070] The additional pump 10 is advantageously arranged downstream of the first heat exchanger 6 and upstream of the second heat exchanger 7 if the gas flows via the bypass path 41. By virtue of the expansion member 15, the regulation of the flow rate of gas circulating within the return line 14 ensures that the gas circulating in the first supply circuit 2 and passing through the first
30 heat exchanger 6 is kept in the liquid state at the outlet of the latter. The additional pump 10 then draws in the gas kept in the liquid state without risk of

being damaged by the presence of at least one fraction of gas in the vapor state.

5 [0071] Furthermore, the presence of the additional pump 10 downstream of the first heat exchanger 6 ensures the increase in pressure of the gas in the liquid state, without disrupting the exchange of heat occurring within the first heat exchanger 6. The condensation of the gas in the vapor state circulating in the return line 14 is thus carried out optimally.

10 [0072] The supply system 1 further comprises an auxiliary supply line 16, extending from the first supply circuit 2, via a tap between the pump 9 and the first heat exchanger 6, to the second supply circuit 3, connecting thereto between the compressor 13 and the low-pressure gas consuming appliance 5. The auxiliary supply line 16 makes it possible to power the low-pressure gas-
15 consuming appliance 5 in the event of insufficient flow of gas in the vapor state formed within the tank space 12.

[0073] When the gas in the vapor state is not present in sufficient quantity in the tank space 12, the liquid gas pumped by the pump 9 can then circulate in
20 this auxiliary supply line 16 in order to supply the low-pressure gas consuming appliance 5. To do this, the auxiliary supply line 16 passes through a low-pressure evaporator 17 so that the gas in the liquid state circulating in the auxiliary supply line 16 passes to the vapor state. The operation of the low pressure evaporator 17 can for example be identical to that of the high-
25 pressure evaporator 11, that is, the gas is evaporated by heat exchange with a heat transfer fluid at a temperature high enough to evaporate the gas in the liquid state. At the outlet of the low pressure evaporator 17, the gas in the vapor state circulates within the auxiliary supply line 16, then joins the second supply circuit 3 in order to supply the low-pressure gas-consuming appliance 5.

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[0074] It is understood from the foregoing that the auxiliary supply line 16 is used only when there is not enough gas in the vapor state in the tank space

12. Thus, the auxiliary supply line 16 comprises a valve 19 controlling the circulation of gas in the auxiliary supply line 16 when the use thereof is not necessary.

5 [0075] Figure 2 shows the first embodiment of the supply system 1 with a return line 14 divided into two separate sections. The return line 14 thus comprises a main section 56 which begins at the connection with the second supply circuit 3 and which extends to a divergence zone 53. At the divergence zone 53, the return line 14 is divided into a first section 51 and a second section 52 which
10 both extend from the divergence zone 53 to the tank 8.

[0076] The divergence zone 53 is arranged downstream of the second heat exchanger 7. It is therefore the main section 56 of the return line 14 that passes through the second heat exchanger 7.

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[0077] At the outlet of the second heat exchanger 7, the gas in the vapor state circulates to the divergence zone 53 and can subsequently circulate within the first section 51 or the second section 52. The first section 51 passes through the first heat exchanger 6 while the second section 52 extends to the tank 8
20 by bypassing the first heat exchanger 6. In other words, the gas in the vapor state can circulate within the first section 51 and be condensed by virtue of the exchange of calories occurring at the first heat exchanger 6, or it can circulate within the second section 52 and return to the tank 8 in the gaseous state.

25 [0078] The choice of the section within which the gas in the vapor state circulates is in particular dependent on a flow rate of gas in the liquid state circulating in the first supply circuit 2, said flow rate having to be sufficient to fully condense the gas in the vapor state circulating in the return line 14. Thus, when the quantity of gas in the liquid state circulating in the first supply circuit
30 is greater than or equal to six times the quantity of gas in the vapor state circulating in the return line, the gas in the vapor state can be directed to the first section 51 so that condensation thereof can be implemented.

[0079] If the quantity of gas in the liquid state circulating in the first supply circuit is less than six times the quantity of gas in the vapor state circulating in the return line, then a first fraction of the gas in the vapor state circulates within the first section 51 in a quantity such that the first fraction is fully condensed within the first exchanger 6, while a second fraction of the gas in the vapor state, corresponding to the quantity of gas in the vapor state not circulating in the first section 51, circulates within the second section 52 in order to return directly to the tank 8. In the case where there is little or no circulation of gas in the liquid state circulating in the first supply circuit 2, the entirety of the gas in the vapor state then circulates in the second section 52 to return directly to the tank 8, in order to avoid a pressure drop resulting from passing through the first heat exchanger 6. In this condition, the return of the gas into the tank 8 is done in the vapor state. Such a situation occurs when the gas in the liquid state is little used to supply the high-pressure gas consuming appliance 4.

[0080] In order to regulate circulation within the return line 14, the expansion member 15 is arranged at the first section 51, downstream of the first heat exchanger 6, while the second section 52 comprises a flow rate regulating member 54. The expansion member 15 and the flow rate regulating member 54 can also provide a function of expanding the gas circulating in either of the sections.

[0081] Advantageously, whether for the first section 51 or the second section 52, the gas that circulates therein returns to the bottom of the tank 8 or at least in an area where the gas is in liquid form. More particularly, the gas circulating in the vapor state in the second section 52 returns to the bottom of the tank in the vapor state. The temperature and density of the gas in the liquid state present in the tank 8 thus makes it possible to condense the gas in the vapor state leaving the second section 52. In order to facilitate this condensation of the gas in the vapor state, the second section 52 can comprise an ejection member 55 arranged at one end of the second section 52 submerged in the

liquid content of the tank 8. The ejection member 55 makes it possible to expand the gas in the vapor state circulating in the second section 52 in order to facilitate the condensation thereof in the tank 8. The ejection member 55 may for example be an ejector or a bubbling device. The return of the gas to
5 the vapor state in the tank 8 via the second section 52 causes an increase in the temperature of the gas in the liquid state present in the tank 8.

[0082] Since the undescribed features of the supply system 1 that is illustrated in Figure 2 are identical to those of the supply system 1 that is illustrated in
10 Figure 1, reference will therefore be made to the description of Figure 1 for the description of the elements common to both embodiments.

[0083] Figure 3 shows a second embodiment of the supply system 1 according to the invention. The second embodiment differs from the first embodiment by
15 the configuration of the main path 40 and of the bypass path 41. Reference will therefore be made to the description of Figures 1 and 2 for those concepts which are common to both embodiments.

[0084] According to the second embodiment of the supply system 1, the
20 convergence point 43 is in this case arranged downstream of the high-pressure evaporator 11. In other words, the bypass path, still comprising the second heat exchanger 7, is configured to bypass the high-pressure evaporator 11. The latter is consequently arranged within the portion 50 of the main path 40. Thus, if the gas circulates within the bypass path 41, it then
25 arrives at the convergence point 43 and then circulates to the high-pressure gas-consuming appliance 4 without being treated by the high-pressure evaporator 11. If the first supply circuit 2 is configured so that the gas circulates entirely within the main path 40, this gas, after having passed through the first heat exchanger 6 and the additional pump 10, is directly treated by the high-
30 pressure evaporator 11 by circulating within the portion 50.

[0085] According to the second embodiment, the distribution device 60 comprises a distribution valve 47 arranged in the first part 41a of the bypass path 41. Alternatively, the distribution valve 47 can be arranged in the second part 41b of the bypass path 41, or on the portion 50 of the main path 40, between the divergence point 42 and the high-pressure evaporator 11 or between the high-pressure evaporator 11 and the convergence point 43.

[0086] The distribution of the gas circulating in the portion 50 of the main path 40 and/or in the bypass path 41 takes place according to a degree of opening of the distribution valve 47.

[0087] In Figure 3, the distribution valve 47 is arranged on the bypass path 41. Thus, the greater the degree of opening of the distribution valve 47, the greater the proportion of gas circulating in the bypass path 41. By controlling the degree of opening of the distribution valve 47, it is therefore possible to manage the distribution of the gas in the portion 50 of the main path 40 and/or in the bypass path 41.

[0088] Because the gas circulating in the bypass path 41 is not treated by the high-pressure evaporator 11, it is essential that the characteristics of the gas, after having passed through the second heat exchanger 7, comply with its use as fuel for the high-pressure gas-consuming appliance 4, for example by corresponding to a vapor or supercritical state. The distribution valve 47 is thus controlled in order to allow an amount of gas to circulate in the bypass path 41 such that the exchange of heat that occurs in the second heat exchanger 7 is sufficient for the entirety of said amount of gas to transition to the vapor or supercritical state in order to be compatible with the high-pressure gas-consuming appliance 4. The expansion member 15 of the return line 14 can also have an effect on such a condition by controlling the flow rate of gas circulating in the return line 14.

[0089] Like for the first embodiment, the gas circulating in the return line 14 is pre-cooled within the second heat exchanger 7, provided that at least a fraction of gas circulating within the first supply circuit 2 goes via the bypass path 41.

5 [0090] Advantageously, the second embodiment allows the evaporation of the gas circulating in the first supply circuit 2 to be distributed between the portion 50 via the high-pressure evaporator 11 and the bypass path 41 via the second heat exchanger 7. Such evaporation carried out in parallel makes it possible to limit the activity of the high-pressure evaporator 11 and therefore to partly
10 save the energy required for the operation thereof when all of the gas circulating in the first supply circuit 2 is treated by the high-pressure evaporator 11.

[0091] When there is no gas to be recondensed circulating in the return line
15 14, and heat exchange does not take place within the second heat exchanger 7, the distribution valve 47 is closed in order to make the gas circulate entirely within the portion 50 so that it is treated by the high-pressure evaporator 11.

[0092] Like for the first embodiment, more particularly as illustrated in Figure
20 2, the return line 14 can comprise the main section 56, and then divide into the first section 51 and into the second section 52 from the divergence zone 53. This zone is always positioned downstream of the second heat exchanger 7. The operation of the return line 14 as illustrated in Figure 3 and identical to what has been described in Figure 2.

25 [0093] Figure 4 is a cutaway view of a floating structure 20 showing the tank 8 that contains the gas in the liquid state and in the vapor state, this tank 8 having a generally prismatic shape mounted in a double hull 22 of the floating structure 20. The wall of the tank 8 includes a primary sealing membrane intended to be in contact with the gas in the liquid state contained in the tank
30 8, a secondary sealing membrane arranged between the primary sealing membrane and the double hull 22 of the floating structure 20, and two thermally

insulating barriers respectively arranged between the primary sealing membrane and the secondary sealing membrane and between the secondary sealing membrane and the double hull 22.

5 [0094] Loading and/or unloading pipes 23 for gas in the liquid state, arranged on the upper deck of the floating structure 20, can be connected, by means of suitable connectors, to a marine or port terminal to transfer the cargo of gas in the liquid state from or to the tank 8.

10 [0095] Figure 4 also shows an example of a maritime or port terminal including loading and/or unloading equipment 25, an underwater pipeline 26 and an onshore and/or port facility 27. The onshore and/or port facility 27 can for example be arranged on the dock of a port, or according to another example be arranged on a concrete gravity platform. The onshore and/or port facility 27
15 includes storage tanks for gas in the liquid state 30, and connecting pipes 31 that are connected by the underwater pipe 26 to the loading and unloading equipment 25.

[0096] To generate the pressure necessary for the transfer of the gas in the
20 liquid state, pumps equipping the onshore and/or port facility 27 and/or pumps equipping the floating structure 20 are implemented.

[0097] Of course, the invention is not limited to the examples that have just been described, and numerous modifications can be made to these examples
25 without departing from the scope of the invention.

[0098] The invention, as has just been described, clearly achieves the goal that it set for itself, and makes it possible to provide a gas supply system for appliances that consume gas at high or low pressure, the pressurization of
30 which is achieved using pumps and an evaporator, comprising a means for condensing a gas in the vapor state before it is returned to the tank and a high-pressure gas supply allowing the energy used to pressurize said gas to be

optimized. Variants not described here could be implemented without departing from the context of the invention, since, in accordance with the invention, they comprise a supply system according to the invention.

Claims

1. A system (1) for supplying gas to at least one high-pressure gas-consuming appliance (4) and at least one low-pressure gas-consuming
5 appliance (5) of a floating structure (20) comprising at least one tank (8) configured to contain the gas, the supply system (1) comprising:
- at least a first gas supply circuit (2) of the high-pressure gas consuming appliance (4), comprising at least one pump (9) configured to pump the gas collected in the liquid state in the tank (8),
10 - at least one high-pressure evaporator (11) configured to evaporate the gas circulating in the first gas supply circuit (2),
 - at least one second circuit (3) supplying gas to the low-pressure gas-consuming appliance (5), comprising at least one compressor (13) configured to compress gas taken in the vapor state in the tank (8) to a pressure
15 compatible with the requirements of the low-pressure gas-consuming appliance (5),
 - at least one gas return line (14) connected to the second supply circuit (3) downstream of the compressor (13) and extending to the tank (8),
 - at least a first heat exchanger (6) and a second heat exchanger (7)
20 each configured to exchange heat between the gas circulating in the return line (14) and the gas circulating in the first supply circuit (2), characterized in that the first supply circuit (2) comprises a main path (40) and a bypass path (41) that is arranged in parallel with at least a portion (50) of the main path (40), the second heat exchanger (7) being configured to exchange heat
25 between the gas circulating in the return line (14) and the gas circulating in the bypass path (41).
2. The supply system (1) according to claim 1, wherein the main path (40) comprises an additional pump (10) placed between the first heat exchanger
30 (6) and the high-pressure evaporator (11).

3. The supply system (1) according to the preceding claim, wherein the bypass path (41) starts at a divergence point (42) arranged on the main path (40) between the additional pump (10) and the high-pressure evaporator (11).
- 5 4. The supply system (1) according to any one of the preceding claims, wherein the first supply circuit (2) comprises a distribution device (60) configured to control a distribution of the circulation of the gas to the portion (50) of the main path (40) and/or to the bypass path (41).
- 10 5. The supply system (1) according to claim 3, wherein the bypass path (41) ends at a convergence point (43) arranged on the main path between the divergence point (42) and the high-pressure evaporator (11).
6. The supply system (1) according to the preceding claim in combination
15 with claim 4, wherein the distribution device (60) comprises a first valve (44) configured to manage the circulation of gas within the bypass path (41) and a second valve (45) arranged on the portion (50) of the main path (40).
7. The supply system (1) according to claim 3, wherein the bypass path
20 (41) ends at a convergence point (43) arranged on the main path (40) downstream of the high-pressure evaporator (11).
8. The supply system (1) according to the preceding claim in combination
with claim 4, wherein the distribution device (60) comprises a distribution valve
25 (47).
9. The supply system (1) according to the preceding claim, wherein the distribution valve (47) is arranged on the portion (50) of the main path (40).
- 30 10. The supply system (1) according to claim 8, wherein the distribution valve (47) is arranged on the bypass path (41).

11. The supply system (1) according to any one of claims 8 to 10, wherein the return line (14) comprises an expansion member (15) arranged between the first heat exchanger (6) and the tank (8) and configured to regulate a flow rate of gas circulating in the return line (14), said expansion member (15) and the distribution valve (47) being configured so that the gas that circulates within the bypass path (41) transitions from the liquid state to the vapor or supercritical state.
12. The supply system (1) according to any one of the preceding claims, wherein the first heat exchanger (6) is configured to condense the gas circulating within the return line (14).
13. The supply system (1) according to any one of the preceding claims, wherein the second heat exchanger (7) is configured to pre-cool the gas circulating within the return line (14).
14. The supply system (1) according to any one of the preceding claims, wherein the return line (14) comprises a divergence zone (53) dividing the return line (14) into a first section (51) and a second section (52) both extending from the divergence zone (53) to the tank (8), the first heat exchanger (6) being configured to exchange heat between the gas circulating in the vapor state in the first section (51) of the return line (14) and the gas in the liquid state circulating in the first supply circuit (2), the second section (52) bypassing the first heat exchanger (6).
15. The supply system (1) according to any one of the preceding claims, comprising an auxiliary supply line (16) connected to the first supply circuit (2), upstream of the first heat exchanger (6), and extending to the second supply circuit (3), downstream of the compressor (13), the supply system (1) comprising a low-pressure evaporator (17) configured to evaporate the gas circulating in the auxiliary supply line (16).

16. A floating structure (20) for storing and/or transporting gas in the liquid state, comprising at least one tank (8) containing gas in the liquid state, at least one high-pressure gas-consuming appliance (4), at least one low-pressure gas-consuming appliance (5) and at least one system (1) for supplying gas to these appliances according to any one of the preceding claims.

17. A system for loading or unloading a liquid gas which combines at least one on-shore and/or port facility (27) and at least one floating structure (20) for storing and/or transporting liquid gas according to the preceding claim.

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18. A method for loading or unloading a liquid gas from a floating structure (20) for storing and/or transporting gas according to claim 16, wherein pipes (23) for loading and/or unloading gas in the liquid state arranged on an upper deck of the floating structure (20) can be connected, by means of appropriate connectors, to a maritime or port terminal in order to transfer the gas in the liquid state from or to the tank (8).

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