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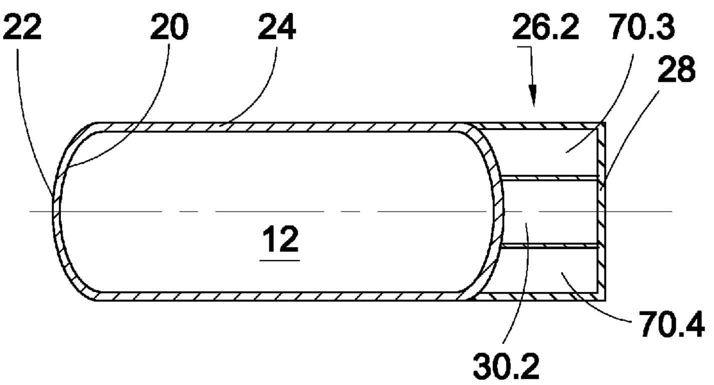

Fig. 2b

(57) Abstract: The present invention relates to a fuel tank arrangement for a gas fuelled marine vessel for storing LNG- fuel, the arrangement comprising an LNG- fuel tank (12), and a tank connection space (26.2) provided in communication with the LNG- fuel tank (12), wherein the tank connection space (26.2) is formed of at least three isolated compartments, i.e. one bunkering compartment (30.2) and at least two LNG- fuel feed compartments (70.3, 70.4).

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A fuel tank arrangement for a gas fuelled marine vessel

Technical field

[001] The present invention relates to a fuel tank arrangement for such a gas fuelled marine vessel that uses as its sole source of fuel liquefied natural gas (LNG). The present invention is mostly concerned of fulfilling the requirements the pure gas-fuelling sets to the construction of the LNG- fuel tank. More particularly, the present invention relates to such an LNG- fuel tank arrangement that the tank comprises at least one shell, a heat insulation and a tank connection space being formed of a plurality of compartments arranged at an end or at a side of the LNG- fuel tank.

Background art

[002] The use of LNG as fuel for marine applications is increasing since it is an efficient way of cutting emissions. Within the next few decades, natural gas (NG) is expected to become the world's fastest growing major energy source. The driving forces behind this development are the depleting known oil reserves, increasing environmental awareness and the continuous tightening of emission restrictions. All major emissions can be significantly reduced to truly form an environmentally sound solution. The reduction in CO_2, in particular, is difficult to achieve with conventional oil-based fuels. NG consists of methane (CH_4) with minor concentrations of heavier hydrocarbons such as ethane and propane. In normal ambient conditions NG is a gas, but it can be liquefied by cooling it down to -162°C. In liquid form the specific volume is reduced significantly, which allows a reasonable size of storage tanks relative to energy content. The burning process of NG is clean. Its high hydrogen-to-coal ratio (the highest among the fossil fuels) means lower CO_2 emissions compared with oil-based fuels. When NG is liquefied, all sulphur is removed, which means zero SO_X emissions. The clean burning properties of NG also significantly reduce NO_X and particle emissions compared with oil-based fuels. Particularly in cruise vessels, ferries and so called ro-pax vessels, where passengers are on board, the absence of soot emissions and visible smoke in the exhaust gases of ship's engines is a very important feature.

[003] LNG is not only an environmentally sound solution, but also economically interesting at today's oil prices. The most feasible way of storing NG in ships is in liquid form. In existing ship installations, LNG is stored in cylindrical, heat insulated single- or double-walled, tanks made of stainless or some other appropriate steel.

[004] Non-pressurized prior art LNG- tanks have normally only a single wall or shell covered with a heat insulation of, for instance, polyurethane. Pressurized prior art LNG- tanks have an inner wall or shell of stainless steel and an outer wall or shell spaced at a distance from the inner shell. The inner and outer shells define an insulation space there-between. The LNG- tank is provided, for emptying the tank, with at least one pipe of stainless steel connected at its first end to the LNG- tank and at its second end to a tank connection space arranged at a side or at an end of the tank, either as an extension of the tank or as a separate chamber at a short distance from the tank. The tank connection space is normally a gas tight enclosure containing all tank connections, fittings, flanges and tank valves. It is constructed of cryogenic temperature resistant materials, it has a bilge well with a high level indicator and a low temperature sensor. The tank connection space (TCS) is not normally accessible, it may not be entered by personnel unless checked for sufficient oxygen and absence of explosive atmosphere. For safety reasons the TCS is provided with permanent gas detection, fixed fire detection and mechanical forced ventilation, which changes air 30 times an hour.

[005] As is well known, environmental awareness motivates ship builders to move towards the use of fuels, which create the minimum amount of carbon dioxide emissions. One way to reach this goal is to build a marine vessel running solely on NG, i.e. NG being the only fuel available for the engine/s or other gas consumers. The international code of safety for ships using gases or other low-flashpoint fuels, so called IGF Code, gives a number of regulations for the single fuel installations. The aim behind the regulations is to ensure that a leakage or other problem related to the LNG- tank does not result in loss of power, i.e. reduced maneuverability of a marine vessel.

[006] There are two basic types of LNG- tanks in view of their usability in marine vessels using a single fuel. In a first type of tank some leaks of the tank structure are possible, and due to the leakage risk the IGF Code dictates that the fuel storage has to be divided between at least two tanks located in separate compartments, and further that each tank has to be provided with the instrumentation and equipment needed for delivering fuel from the tank to the engine. In other words, the first tank type requires full redundancy and segregation.

[007] In a second type of tank leakage is possible only from the valves, whereby the IGF Code only requires that a single fuel tank may be used for storing fuel for several engines provided that the tank has a tank connection space for each engine.

[008] Therefore, it is quite natural that the second type of LNG- tank is the choice for marine vessels, especially for those having at least two engines. It is much more cost-

efficient to build a single leakage-free large-sized LNG- tank than a number of smaller tanks with multiplied instrumentation and equipment for the delivery of fuel to each engine.

[009] In the following the second type of LNG- tank is discussed in more detail, and especially the tank connection space arranged in connection therewith. As was mentioned above the IGF Code dictates that a single LNG- tank may be accepted if an individual tank connection space for each engine is provided in connection with the single LNG- fuel tank. However, the IGF Code regulations leave it totally open, how the various pieces of instrumentation and equipment are divided between the individual tank connection spaces.

[0010] Thus, an object of the present invention is to design such an LNG- fuel tank arrangement for a gas fuelled marine vessel that the various pieces of instrumentation and equipment used for handling the LNG- fuel are divided in practical manner into more than one tank connection space.

[0011] Another object of the present invention is to design such an LNG- fuel tank arrangement for a gas fuelled marine vessel that a problem in feeding LNG- fuel to one engine is isolated from other engine/s such that the other engine/s may continue their problem-free operation.

[0012] A further object of the present invention is to design such an LNG- fuel tank arrangement that the tank connection space thereof is provided with inert atmosphere whenever the TCS is closed, i.e. not occupied by service and/or maintenance personnel.

Disclosure of the Invention

[0013] At least one object of the present invention is substantially met by a fuel tank arrangement in a gas fuelled marine vessel for storing LNG- fuel, the arrangement comprising an LNG- fuel tank, a tank connection space provided in communication with the LNG- fuel tank, the tank connection space being formed of at least three isolated compartments, i.e. one bunkering compartment and at least two LNG- fuel feed compartments.

[0014] Other characteristic features of the present invention become apparent in the appended dependent claims.

[0015] The fuel tank arrangement of the present invention offers at least some of the following advantages:

- only one LNG- tank needed for storing fuel for one or more engines,
- optimized division of instrumentation and equipment between the tank connection spaces,
- no continuous ventilation of the tank connection space, whereby
- continuous noise related to TCS ventilation is avoided,
- the amount of energy needed for TCS ventilation is reduced significantly, and
- risk of combustion or explosion of NG in the tank connection space is reduced, or, in fact, eliminated, and
- condensation and ice build-up on cold equipment in TCS due to humid ventilation air is avoided.

Brief Description of Drawings

[0016] In the following, the present invention will be described in more detail with reference to the accompanying exemplary, schematic drawings, in which

Figure 1 illustrates schematically a side view of a marine vessel having an LNG- fuel tank of the present invention on the deck thereof,

Figures 2a and 2b illustrate schematically two longitudinal and horizontal cross-sectional variations of an LNG- fuel tank in accordance with a preferred embodiment of the present invention,

Figure 3 illustrates schematically a partial cross sectional side view of a tank connection space of the LNG- fuel tank along line A-A of Figure 2a, i.e. the bunkering compartment thereof,

Figure 4 illustrates schematically a partial cross sectional side view of a tank connection space of the LNG- fuel tank along line B-B of Figure 2a, i.e. a first variation of the LNG- fuel feed compartment thereof,

Figure 5 illustrates schematically a partial cross sectional side view of a tank connection space of the LNG- fuel tank along line B-B of Figure 2a, i.e. a second variation of the LNG- fuel feed compartment thereof,

Figure 6 illustrates schematically a further development of the bunkering compartment of the LNG- fuel tank of Figure 3, and

Figure 7 illustrates schematically a further development of the LNG- fuel feed compartment of the LNG- fuel tank of Figure 4.

Detailed Description of Drawings

[0017] Figure 1 illustrates schematically and in a very simplified manner a marine vessel 10 with an LNG- fuel tank 12 provided on the deck thereof. Naturally, the LNG- fuel tank may also be positioned below the deck. The Figure shows also the internal combustion engine 14 receiving fuel from the LNG- fuel tank 12 and the drive means 16 coupled to both the engine 14 and the propeller 18. The drive means may here comprise either a mechanical gear or a generator – electric drive combination.

[0018] Figure 2a illustrates schematically the basic constructions of the LNG- fuel tank 12 in accordance with a first variation of the preferred embodiment of the present invention. The fuel tank 12 is, as an example, formed of an inner shell 20, an outer shell 22 and a heat insulation 24 therebetween. At an end of the fuel tank 12 a so called tank connection space, or TCS, 26.1 is arranged. Naturally, the tank connection space 26.1 may as well be located at a side of the LNG- fuel tank, and not necessarily as an extension of the shell of the tank but also at a distance from the shell of the tank, i.e. as a separate chamber at a side or at an end of the LNG- fuel tank. In such a case, however, a part of the connections between the tank and the tank connection space should be provided with double piping, which makes such connections less attractive. The tank connection space 26.1 is, preferably, but not necessarily, provided with heat insulation 28. The tank connection space 26.1 is formed of one bunkering compartment 30.1, and two LNG- fuel feed compartments 70.1 and 70.2.

[0019] Figure 2b illustrates schematically the basic constructions of the LNG- fuel tank 12 in accordance with a second variation of the preferred embodiment of the present invention. The fuel tank 12 is, as already earlier, formed of an inner shell 20, an outer shell 22 and a heat insulation 24 therebetween. At an end of the fuel tank 12 a so called tank connection space 26.2 is arranged. Naturally, the tank connection space may as well be located at a side of the LNG- fuel tank, and not necessarily as an extension of the shell of the tank but also at a distance from the shell of the tank, i.e. as a separate chamber at a side or at an end of the LNG- fuel tank. The tank connection space 26.2 is, preferably, but not necessarily, provided with heat insulation 28. The tank connection space 26.2 is formed of one bunkering compartment 30.2, and two LNG- fuel feed compartments 70.3 and 70.4.

[0020] The only difference between Figures 2a and 2b is the design of the tank connection spaces 26.1 and 26.2. The tank connection space 26.1 of Figure 2a has a small sized bunkering compartment 30.1 that is surrounded at one side by the LNG- tank and from three sides by the LNG- fuel feed compartments 70.1 and 70.2. Thereby the access to the bunkering compartment 30.1 is from above or from below. The tank connection space 26.2 of Figure 2b has a larger sized bunkering compartment 30.2 that is surrounded at one side by the LNG- tank 12 and from two sides by the LNG- fuel feed compartments 70.3 and 70.4 and the fourth side, i.e. the end of the bunkering compartment 30.2 opposite the LNG- tank 12 extends to the level of the ends of the LNG- fuel feed compartments, whereby the end wall of the bunkering compartment 30.2 ensures free access (however, through the wall thereof) to the bunkering compartment from the side thereof, too.

[0021] Figure 3 illustrates a cross section A-A of Figure 2a, and discusses the instrumentation and equipment needed for filling the LNG- fuel tank 12 with LNG. Such equipment is provided, in accordance with the present invention, in the bunkering compartment 30.1 of the tank connection space. The bunkering compartment 30.1 has a bunkering line 32 for receiving LNG from one of land based bunkering stations, tanker trucks, coastal tankers or bunker barges. The bunkering line 32 terminates to a bunkering valve 34, which is used to deliver LNG to a bottom filling line 36 leading from the bunkering compartment 30.1 to the bottom of the LNG- tank 12 or to a top filling line 38 leading to the LNG sprays 40 in the upper part of the LNG- tank 12. Preferably, the LNG filling lines 36 and 38 lead directly from the bunkering compartment 30.1 through the walls or shells of the tank inside the LNG- tank 12. However, corresponding lines may also be arranged to first leave the bunkering compartment 30.1 through the top wall thereof, and then enter the tank through the top wall thereof, whereby the lines need to be provided with double walls. The bunkering valve 34 may also be used to deliver LNG to both filling lines simultaneously. The bunkering compartment 30.1 has also a vapour return valve 42 with a vapour return line 44 for collecting vapour from the LNG- tank 12 when filling such. The vapour return line 44 takes the vapour for recovery outside the bunkering compartment 30.1,

[0022] The bunkering compartment 30.1 has further an emergency pressure relief valve 46, which opens a vent connection along a safety relief line 48 from the top or gas space of the LNG- fuel tank 12 to the vent mast 50 in case pressure in the tank 12 exceeds a predetermined value. Instruments 52 for measuring the LNG level L in the LNG- tank 12 are also provided in the bunkering compartment 30.1. In addition to the above discussed equipment for filling the LNG- fuel tank 12 with LNG the bunkering compartment 30.1 further includes ventilation equipment including an air or ventilation inlet line 54 with a first fire damper valve 56 and a ventilation outlet line 58 with a second fire damper valve 60 leading from the bunkering compartment 30.1 to the vent mast 50, and a blower 62, which is positioned in either the ventilation inlet line 54 or the ventilation outlet line 58 for ventilating the bunkering compartment 30.1. The first and the second fire damper valves 56 and 60 are in normal operating conditions always open and are automatically closed only if fire is detected in the bunkering compartment 30.1.

[0023] Further, the bunkering compartment 30.1 comprises also a pressure relief valve 64, which connects the interior of the bunkering compartment 30.1 via a pressure relief line 66 to the vent mast 48. The pressure relief valve 64 is set to open when the pressure in the bunkering compartment 30.1 exceeds, for instance due to a raised temperature, the maximal allowed bunkering compartment pressure p0. The maximal allowed pressure p0 in the bunkering compartment 30.1 is usually between 0.1 and 0.5 barg (gauge pressure) or 1.1 – 1.5 bar absolute pressure, preferably between 0.2 – 0.4 barg.

[0024] And finally, the bunkering compartment 30.1 has a drain 68 at the bottom of the bunkering compartment for collecting any liquid formed or leaked (Glycol/Water in heat exchange circuit/s) in the bunkering compartment 30.1.

[0025] Figure 4 illustrates a cross section B-B of Figure 2a, and discusses the instrumentation and equipment needed for providing an engine with NG and provided, in accordance with the present invention, in the LNG- fuel feed compartment 70.1 of the tank connection space. The LNG- fuel feed compartment has a number of same pieces of equipment than the bunkering compartment, now such are marked with the same reference numerals except for being preceded by ‘2’. The ventilation of the LNG- fuel feed compartment, thus, includes an air or ventilation inlet line 254 with a first fire damper valve 256 and a ventilation outlet line 258 with a second fire damper valve 260 leading from the LNG- fuel feed compartment 70.1 to the vent mast 250, and a blower 262, which is positioned in either the ventilation inlet line 254 or the ventilation outlet line 258 for ventilating the LNG- fuel feed compartment 70.1. The first and the second fire damper valves 256 and 260 are in normal operating conditions always open and are automatically closed only if fire is detected in the LNG- fuel feed compartment 70.1. Further, the LNG- fuel feed compartment comprises also a pressure relief valve 264, which connects the interior of the LNG- fuel feed compartment via a pressure relief line 266 to the vent mast 250. The pressure relief valve 264 is set to open when the pressure in the LNG- fuel feed compartment 70.1 exceeds, for instance due to a raised temperature, the maximal allowed LNG- fuel feed compartment pressure p0. The maximal allowed pressure p0 in the LNG- fuel feed compartment is usually between 0.1 and 0.5 barg (gauge pressure) or 1.1

– 1.5 bar absolute pressure, preferably between 0.2 – 0.4 barg. And finally, the LNG- fuel feed compartment the TCS has a drain 268 at the bottom of the space for collecting any liquid formed or leaked (Glycol/Water in heat exchange circuit/s) in the LNG- fuel feed compartment.

[0026] Equipment located specifically in the LNG- fuel feed compartment, i.e. equipment needed for providing an engine with NG fuel, comprise an LNG outlet line 72 taking liquid LNG from the bottom of the LNG- tank 12. In this variation of the invention LNG is taken via an LNG outlet valve 74 to a main LNG evaporator 76. The LNG- fuel is vaporized in the evaporator 76 and continues in a gaseous state to a gas heater 78 from where the heated gaseous NG is taken along fuel feed line 80 and via a main gas valve 82 to an engine. A line 84 leads from between the LNG outlet valve 74 and the main LNG evaporator 76 and via a valve 86 to the top or gas space of the LNG- tank 12 for taking liquid LNG to the tank 12. A line 88 introduces vaporized LNG from between the main LNG evaporator 76 and the gas heater 78 via a valve 90 to the gas cavity of the LNG- tank 12. Further, a line 92 takes heated NG from the fuel feed line 80 and via valve 94 to the line 84 taking heated NG to the gas cavity of the LNG- tank 12. Further, a boil-off gas (BOG) line 96 leads out of the gas space of the LNG- tank 12 via a boil-off gas valve 98 to a compressor room (not shown) outside the LNG- fuel feed compartment 70.1. A gas (BOG) heater 100 may be coupled if needed to the BOG line 96.

[0027] The LNG- fuel feed compartment comprises also a pressure build-up arrangement 102, which takes LNG from the LNG outlet line 72 at the bottom of the LNG- tank 12 via a pressure build-up valve 104 to a pressure build-up unit 106, i.e. a heat exchanger, that vaporizes the LNG. The vaporized LNG is taken via a pressure build-up line 108 to the gas cavity of the LNG- tank 12 for raising the pressure therein. The recirculation lines 84, 88 and 92 and the pressure build-up line 108 may be arranged to enter via a single line from the LNG- fuel feed compartment 70.1 to the LNG- tank 12.

[0028] Figure 5 illustrates schematically a second variation of the LNG- fuel feed compartment 70.1 of Figure 4. The only difference compared to the first variation discussed in Figure 4 is the way LNG is taken from the bottom of the tank 12. Here, in Figure 5 a cryogenic pump 110 is provided in the LNG outlet line 72 upstream of the LNG outlet valve 74. Now, the pump 110 replaces the pressure build-up arrangement of Figure 4.

[0029] Figure 6 illustrates schematically a further development of the bunkering compartment 30.1 of Figure 3. In accordance with Figure 6 the bunkering compartment 30.1 is here provided, in addition to the equipment needed for filling the LNG- fuel tank 12 with

LNG discussed in Figure 3, with means for arranging an inert atmosphere in the bunkering compartment 30.1. The ventilation inlet line 54 of the bunkering compartment 30.1 of the tank connection space is provided with a first closing valve 112 in addition to the first fire damper valve 56 and the ventilation outlet line 58 is provided with a second closing valve 114 in addition to the second fire damper valve 60 so that the bunkering compartment 30.1 may be closed from outside atmosphere for inerting thereof. The bunkering compartment 30.1 further comprises an inlet line 116 for introducing inert gas from a gas source 118 to the bunkering compartment 30.1 and a gas outlet line 120 for discharging gas from the bunkering compartment 30.1 to the vent mast 50. The inert gas inlet line 116 is provided with a first pressure regulating valve 122, preferably but not necessarily, outside the bunkering compartment 30.1 for controlling the inert atmosphere in the bunkering compartment 30.1. The gas outlet line 120 is connected via a second pressure regulating valve 124 therein to the vent mast 50. The gas outlet line 120 is provided with an oxygen analyser 126 for monitoring the oxygen concentration of the gas discharged from the bunkering compartment 30.1. The oxygen analyser 126 may also be located in connection with the bunkering compartment 30.1 upstream of the second pressure regulating valve 124 or the gas outlet line 120.

[0030] In accordance with a first preferred operating scheme of the present invention the first pressure regulating valve 122 is a pilot operated valve that receives its control signal from the pressure of the bunkering compartment 30.1 such that the first pressure regulating valve 122 opens when pressure in the bunkering compartment 30.1 goes below upper limit pressure p1, i.e. the first pressure regulating valve 122 allows inert gas enter the bunkering compartment 30.1, when the pressure in the bunkering compartment 30.1 is below p1. In accordance with the same operating scheme the second pressure regulating valve 124 is also a pilot operated valve that receives its control signal from the pressure of the bunkering compartment 30.1. The second pressure regulating valve 124 opens, i.e. bleeds gas from the bunkering compartment 30.1 to the vent mast 50, when the pressure in the bunkering compartment 30.1 is above a predetermined lower limit pressure p2. Thus p1>p2.

[0031] In accordance with a second preferred operating scheme, the first pressure regulation valve 122 receives its control signal from the pressure of the bunkering compartment 30.1 such that it is adjusted or instructed to close when an upper pressure limit p1 is reached, in other words, it remains open below pressure of p1. The second pressure regulating valve 124 receives its control signal from the pressure of the bunkering compartment 30.1 such that it is adjusted or instructed to open at a pressure of px and remain open until pressure has reduced to p2, whereby px>p2. Pressures p1 and px may be equal or different, the only thing that matters is that p1 and px are greater than p2.

[0032] In accordance with a first alternate further feature of the second preferred operating scheme the opening of the second pressure regulating valve 124 at pressure of px is used to instruct the first pressure regulating valve 122 to close such that the first pressure regulating valve 122 remains closed until the second pressure regulating valve 124 closes at a pressure of p2. The closing of the second pressure regulating valve 124 returns the control of the first pressure regulating valve 122 to the bunkering compartment pressure, whereby the first pressure regulating valve 122 opens and pressure in the bunkering compartment 30.1 increases until the second pressure regulating valve 124 receives its control signal from the bunkering compartment pressure at px, opens and takes over the control of the first pressure regulating valve 122 closing it.

[0033] In accordance with a second alternate further feature of the second preferred operating scheme the closing of the first pressure regulating valve 122 at a pressure of p1 is used to instruct the second pressure regulating valve 124 to open, to take over the control and to keep the first pressure regulating valve 122 closed until the second pressure regulating valve 124 closes at a pressure p2. Thereafter, the control of the first pressure regulating valve 122' is given to the bunkering compartment pressure, so that the first pressure regulating valve 122 opens allowing the pressure in the bunkering compartment 30.1 to increase and keeps the second pressure regulating valve 124 closed until pressure of p1 is reached.

[0034] As the maximal bunkering compartment pressure p0 is somewhere between 0.1 and 0.5 barg, the pressures p2, p1 or px being used when setting the first and the second pressure regulating valves in operative condition are quite low, however it always applies that p2<p1 and p2<px.

[0035] Further, the oxygen concentration has an effect on the functioning of the first and the second pressure regulating valves 122 and 124 as will be discussed later on.

[0036] When either taking a new bunkering compartment 30.1 into use or making the bunkering compartment 30.1 inert after an inspection, i.e. switching the bunkering compartment 30.1 from air atmosphere to inert atmosphere, the ventilation inlet line 54 and the ventilation outlet line 58 are closed by means of the first and second fire damper valves 56 and 60 and the first and the second pressure regulating valves 122 and 124 are activated, i.e. the valves 122 and 124 receive their control signal from at least the pilot pressure of the bunkering compartment. The inerting of the bunkering compartment

30.1 may be performed by two basically different ways, i.e. by continuous purging or by using pressurization cycles.

[0037] The first way includes keeping both the first and the second pressure regulating valves 122 and 124 open, i.e. continuously purging the bunkering compartment 30.1 until the oxygen concentration of the gas in the bunkering compartment 30.1, i.e. upstream of the gas outlet line 120, or of the gas discharged from the bunkering compartment 30.1 downstream of the second pressure regulation valve 124 in the discharge line 120 is, determined by the oxygen analyser 126, reduced below maximum allowable oxygen concentration. Here, the first preferred operation scheme is used such that the activation of the pressure regulating valves 122 and 124 means that as long as the oxygen concentration in the bunkering compartment 30.1, i.e. in the analyser 126, is high both valves 122 and 124 remain open, and only after the maximum allowable oxygen concentration is reached either the first pressure regulation valve 122 or the second pressure regulating valve 124 closes, i.e. after having received control signal from the oxygen analyser 126. In the former instance, the second pressure regulating valve 124 closes, too, as soon as the pressure in the bunkering compartment 30.1 is reduced below p2, and in the latter instance, the first pressure regulating valve 122 closes when the pressure in the bunkering compartment 30.1 reaches p1. Thus, in the former instance the bunkering compartment pressure after inerting is p2 and in the latter instance p1. Naturally, the oxygen concentration may, optionally, be followed such that the first or the second pressure regulating valve 122 or 124 is manually (instead of automatic control) closed. Thereby both valves 122 and 124 are inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the bunkering compartment. Thus, the pressure control of the bunkering compartment 30.1 is left for the pressure relief valve 64.

[0038] The second way includes utilizing pressurisation cycles which requires that the operation of the valves are set in a manner different from the first operating scheme. Thus, in accordance with the second preferred operating scheme and the first alternate further feature thereof, when taking the bunkering compartment 30.1 into use or inerting the bunkering compartment 30.1 after service or maintenance, the first pressure regulating valve 122 used for introducing inert gas into the bunkering compartment 30.1 opens as the pressure in the bunkering compartment 30.1 is atmospheric pressure p1 and the second pressure regulating valve 124 remains closed until the pressure in the bunkering compartment 30.1 exceeds the predetermined pressure p1 causing opening of the second pressure regulating valve 124 and, as a function thereof, closing of the first pressure regulating valve122, whereby the pressure is allowed to decrease below the second predetermined value p2, which causes the closing of the second pressure regulating valve 124 and, as a function thereof, opening of the first pressure regulating valve 122. The operation is continued until the oxygen concentration of the gas in the bunkering compartment 30.1, i.e. upstream of the gas outlet line 120, or of the gas discharged from the bunkering compartment 30.1 downstream of the second pressure regulation valve 124 in the gas outlet line 120 is, determined by the oxygen analyser 126, reduced below maximum allowable oxygen concentration, i.e. such an oxygen concentration is reached that combustion of NG is not any more possible irrespective of the concentration of the fuel. When the desired oxygen concentration is reached at least either the first or the second pressure regulating valve 122 or 124 is closed. Thereafter the pressure in the bunkering compartment 30.1 is either p2 or p1, respectively, and both valves 122 and 124 may be inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the bunkering compartment 30.1. Thus, the pressure control of the bunkering compartment 30.1 is left for the pressure relief valve 64.

[0039] Further, in accordance with the second preferred operating scheme and the second alternate further feature thereof, when taking the bunkering compartment 30.1 into use or inerting the bunkering compartment 30.1 after service or maintenance, the first pressure regulating valve 122 used for introducing inert gas into the bunkering compartment 30.1 opens as the pressure in the bunkering compartment 30.1 is atmospheric pressure and thus below p1 and the second pressure regulating valve 124 remains closed until the pressure in the bunkering compartment 30.1 exceeds the predetermined pressure p1 causing closing of the first pressure regulating valve 122 and, as a function thereof, opening of the second pressure regulating valve 124. The first pressure regulating valve 122 remains closed, whereby the bunkering compartment pressure is allowed to decrease below the second predetermined value p2, which causes the closing of the second pressure regulating valve 124 and, as a function thereof, opening of the first pressure regulating valve 122. The operation is continued until the oxygen concentration of the gas in the bunkering compartment 30.1, i.e. upstream of the gas outlet line 120, or of the gas discharged from bunkering compartment 30.1 downstream of the second pressure regulation valve 124 in the gas outlet line 120 is, determined by the oxygen analyser 126, reduced below maximum allowable oxygen concentration, i.e. such an oxygen concentration is reached that combustion of NG is not any more possible irrespective of the concentration of the fuel. When the desired oxygen concentration is reached at least either the first or the second pressure regulating valve 122 or 124 is closed. Thereafter the pressure in the bunkering compartment is either p2 or p1, respectively, and both valves 122 and 124 may be inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the bunkering compartment 30.1. Thus, the pressure control of the bunkering compartment 30.1 is left for the pressure relief valve 64.

[0040] In normal operating conditions, i.e. when the ventilation inlet and outlet are closed and the inert atmosphere in the bunkering compartment is controlled by the first and the second pressure regulating valves 122 and 124, the operation of the first fire damper valve 56 and the first closing valve 112 in the ventilation inlet line 54 and the second fire damper valve 60 and the second closing valve 114 in the ventilation outlet line 58 should be checked regularly. In order to minimize the wasting of the inert gas both the ventilation inlet line 54 and the ventilation outlet line 58 are thus provided with the first and second closing valves 112 and 114. The checking of the functionality of the fire damper and the closing valves is performed such that first the fire damper valve 56 or 60 is closed and the closing valve 112 or 114 is opened, and the inlet line 54 or the outlet line 58 leading away from the closing valve 112 or 114, i.e. in a direction opposite to the bunkering compartment 30.1, is monitored to see if any leak from the bunkering compartment 30.1 may be noticed. If not, the fire damper valve 56 or 60 appears to be in good condition, whereafter the closing valve 112 or 114 is closed and the fire damper valve 56 or 60 opened. Next, again the inlet line 54 or the outlet line 58 leading away from the closing valve 112 or 114, i.e. in a direction opposite to the bunkering compartment 30.1, is monitored to see if any leak from the bunkering compartment 30.1 may be noticed. If not, the closing valve 112 or 114 is also in good condition, and may be closed. Naturally, if any leakage is detected through any one of the fire damper and closing valves 56, 60, 112 or 114, or any other problems in their operation is found out, the malfunctioning valve needs to be replaced or maintained.

[0041] When the bunkering compartment itself or any piece of equipment therein needs service or maintenance the inert atmosphere in the bunkering compartment has to be switched to air atmosphere, whereby both pressure regulating valves 122 and 124 are inactivated, the fire damper and closing valves 56, 60, 112 or 114 are opened and blower 62 started, i.e. standard ventilation is switched on for flushing the nitrogen out and filling the bunkering compartment 30.1 with air.

[0042] Figure 7 illustrates schematically a further development of the LNG- fuel feed compartment 70.1 of Figure 4. The illustrated further development is the same as discussed above in connection with the bunkering compartment. Now the same inerting equipment are brought to or in connection with the LNG- fuel feed compartment 70.1. Thus, in accordance with Figure 7 the LNG- fuel feed compartment 30.1 is here provided, in addition to the equipment needed for filling the LNG- fuel tank 12 with LNG discussed in Figure 3, with means for arranging an inert atmosphere in the LNG- fuel feed compartment 70.1. The ventilation inlet line 254 of the LNG- fuel feed compartment 70.1 of the tank connection space is provided with a first closing valve 212 in addition to the first fire damper valve 256 and the ventilation outlet line 258 is provided with a second closing valve 214 in addition to the second fire damper valve 260 in so that the LNG- fuel feed compartment 70.1 may be closed from outside atmosphere for inerting thereof. The LNG- fuel feed compartment 70.1 further comprises an inlet line 216 for introducing inert gas from a gas source 218 to the LNG- fuel feed compartment 70.1 and a gas outlet line 220 for discharging gas from the LNG- fuel feed compartment 70.1 to the vent mast 250. The inert gas inlet line 216 is provided with a first pressure regulating valve 222, preferably but not necessarily, outside the LNG- fuel feed compartment 70.1 for controlling the inert atmosphere in the LNG- fuel feed compartment. The gas outlet line 220 is connected via a second pressure regulating valve 224 therein to the vent mast 250. The gas outlet line 220 is provided with an oxygen analyser 226 for monitoring the oxygen concentration of the gas discharged from the LNG- fuel feed compartment 70.1. The oxygen analyser 226 may also be located in connection with the LNG- fuel feed compartment 70.1 upstream of the second pressure regulating valve 224 or the gas outlet line 220.

[0043] In accordance with a first preferred operating scheme of the present invention the first pressure regulating valve 222 is a pilot operated valve that receives its control signal from the pressure of the LNG- fuel feed compartment 70.1 such that the first pressure regulating valve 222 opens when pressure in the LNG- fuel feed compartment 70.1 goes below upper limit pressure p1, i.e. the first pressure regulating valve 222 allows inert gas enter the LNG- fuel feed compartment 70.1, when the pressure in the LNG- fuel feed compartment 70.1 is below p1. In accordance with the same operating scheme the second pressure regulating valve 224 is also a pilot operated valve that receives its control signal from the pressure of the LNG- fuel feed compartment 70.1. The second pressure regulating valve 224 opens, i.e. bleeds gas from the LNG- fuel feed compartment 70.1 to the vent mast 250, when the pressure in the LNG- fuel feed compartment 70.1 is above a predetermined lower limit pressure p2. Thus p1>p2.

[0044] In accordance with a second preferred operating scheme, the first pressure regulation valve 222 receives its control signal from the pressure of the LNG- fuel feed compartment 70.1 such that it is adjusted or instructed to close when an upper pressure limit p1 is reached, in other words, it remains open below pressure of p1. The second pressure regulating valve 224 receives its control signal from the pressure of the LNG- fuel feed compartment 70.1 such that it is adjusted or instructed to open at a pressure of px and remain open until pressure has reduced to p2, whereby px>p2. Pressures p1 and px may be equal or different, the only thing that matters is that p1 and px are greater than p2.

[0045] In accordance with a first alternate further feature of the second preferred operating scheme the opening of the second pressure regulating valve 224 at pressure of px is used to instruct the first pressure regulating valve 222 to close such that the first pressure regulating valve 222 remains closed until the second pressure regulating valve 224 closes at a pressure of p2. The closing of the second pressure regulating valve 224 returns the control of the first pressure regulating valve 222 to the LNG- fuel feed compartment pressure, whereby the first pressure regulating valve 222 opens and pressure in the LNG- fuel feed compartment 70.1 increases until the second pressure regulating valve 224 receives its control signal from the LNG- fuel feed compartment pressure at px, opens and takes over the control of the first pressure regulating valve 222 closing it.

[0046] In accordance with a second alternate further feature of the second preferred operating scheme the closing of the first pressure regulating valve 222 at a pressure of p1 is used to instruct the second pressure regulating valve 224 to open, to take over the control and to keep the first pressure regulating valve 222 closed until the second pressure regulating valve 224 closes at a pressure p2. Thereafter, the control of the first pressure regulating valve 222' is given to the LNG- fuel feed compartment pressure, so that the first pressure regulating valve 222 opens allowing the pressure in the LNG- fuel feed compartment 70.1 to increase and keeps the second pressure regulating valve 224 closed until pressure of p1 is reached.

[0047] As the maximal LNG- fuel feed compartment pressure p0 is somewhere between 0.1 and 0.5 barg, the pressures p2, p1 or px being used when setting the first and the second pressure regulating valves in operative condition are quite low, however it always applies that p2<p1 and p2<px.

[0048] Further, the oxygen concentration has an effect on the functioning of the first and the second pressure regulating valves 222 and 224 as will be discussed later on.

[0049] When either taking a new LNG- fuel feed compartment 70.1 into use or making the LNG- fuel feed compartment inert after an inspection, i.e. switching the LNG- fuel feed compartment from air atmosphere to inert atmosphere, the ventilation inlet line 254 and the ventilation outlet line 258 are closed by means of the first and second closing valves 256 and 260 and the first and the second pressure regulating valves 222 and 224 are activated, i.e. the valves 222 and 224 receive their control signal from at least the pilot pressure of the LNG- fuel feed compartment. The inerting of the LNG- fuel feed compartment 70.1 may be performed by two basically different ways, i.e. by continuous purging or by using pressurization cycles.

[0050] The first way includes keeping both the first and the second pressure regulating valves 222 and 224 open, i.e. continuously purging the LNG- fuel feed compartment 70.1 until the oxygen concentration of the gas in the LNG- fuel feed compartment 70.1, i.e. upstream of the gas outlet line 220, or of the gas discharged from the LNG- fuel feed compartment 70.1 downstream of the second pressure regulation valve 224 in the discharge line 220 is, determined by the oxygen analyser 226, reduced below maximum allowable oxygen concentration. Here, the first preferred operation scheme is used such that the activation of the pressure regulating valves 222 and 224 means that as long as the oxygen concentration in the LNG- fuel feed compartment 70.1, i.e. in the analyser 226, is high both valves 222 and 224 remain open, and only after the maximum allowable oxygen concentration is reached either the first pressure regulation valve 222 or the second pressure regulating valve 224 closes, i.e. after having received control signal from the oxygen analyser 226. In the former instance, the second pressure regulating valve 224 closes, too, as soon as the pressure in the LNG- fuel feed compartment 70.1 is reduced below p2, and in the latter instance, the first pressure regulating valve 222 closes when the pressure in the LNG- fuel feed compartment 70.1 reaches p1. Thus, in the former instance the LNG- fuel feed compartment pressure after inerting is p2 and in the latter instance p1. Naturally, the oxygen concentration may, optionally, be followed such that the first or the second pressure regulating valve 222 or 224 is manually (in place of automatic control) closed. Thereby both valves 222 and 224 are inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the LNG- fuel feed compartment. Thus, the pressure control of the LNG- fuel feed compartment 70.1 is left for the pressure relief valve 264.

[0051] The second way includes utilizing pressurisation cycles which requires that the operation of the valves are set in a manner different from the first operating scheme. Thus, in accordance with the second preferred operating scheme and the first alternate further feature thereof, when taking the LNG- fuel feed compartment 70.1 into use or inerting the LNG- fuel feed compartment 70.1 after service or maintenance, the first pressure regulating valve 222 used for introducing inert gas into the LNG- fuel feed compartment 70.1 opens as the pressure in the LNG- fuel feed compartment 70.1 is atmospheric pressure p1 and the second pressure regulating valve 224 remains closed until the pressure in the LNG- fuel feed compartment 70.1 exceeds the predetermined pressure p1 causing opening of the second pressure regulating valve 224 and, as a function thereof, closing of the first pressure regulating valve 222, whereby the pressure is allowed to decrease below the second predetermined value p2, which causes the closing of the second pressure regulating valve 224 and, as a function thereof, opening of the first pressure regulating valve 222. The operation is continued until the oxygen concentration of the gas in the LNG- fuel feed compartment 70.1, i.e. upstream of the gas outlet line 220, or of the gas discharged from the LNG- fuel feed compartment 70.1 downstream of the second pressure regulation valve 224 in the gas outlet line 220 is, determined by the oxygen analyser 226, reduced below maximum allowable oxygen concentration, i.e. such an oxygen concentration is reached that combustion of NG is not any more possible irrespective of the concentration of the fuel. When the desired oxygen concentration is reached at least either the first or the second pressure regulating valve 222 or 224 is closed. Thereafter the pressure in the LNG- fuel feed compartment 70.1 is either p2 or p1, respectively, and both valves 222 and 224 may be inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the LNG- fuel feed compartment 70.1. Thus, the pressure control of the LNG- fuel feed compartment 70.1 is left for the pressure relief valve 264.

[0052] Further, in accordance with the second preferred operating scheme and the second alternate further feature thereof, when taking the LNG- fuel feed compartment 70.1 into use or inerting the LNG- fuel feed compartment 70.1 after service or maintenance, the first pressure regulating valve 222 used for introducing inert gas into the LNG- fuel feed compartment 70.1 opens as the pressure in the LNG- fuel feed compartment 70.1 is atmospheric pressure and thus below p1 and the second pressure regulating valve 224 remains closed until the pressure in the LNG- fuel feed compartment 70.1 exceeds the predetermined pressure p1 causing closing of the first pressure regulating valve 222 and, as a function thereof, opening of the second pressure regulating valve 2124. The first pressure regulating valve 222 remains closed, whereby the LNG- fuel feed compartment pressure is allowed to decrease below the second predetermined value p2, which causes the closing of the second pressure regulating valve 224 and, as a function thereof, opening of the first pressure regulating valve 222. The operation is continued until the oxygen concentration of the gas in the LNG- fuel feed compartment 70.1, i.e. upstream of the gas outlet line 220, or of the gas discharged from LNG- fuel feed compartment 70.1 downstream of the second pressure regulation valve 224 in the gas outlet line 220 is, determined by the oxygen analyser 226, reduced below maximum allowable oxygen concentration, i.e. such an oxygen concentration is reached that combustion of NG is not any more possible irrespective of the concentration of the fuel. When the desired oxygen concentration is reached at least either the first or the second pressure regulating valve 222 or 224 is closed. Thereafter the pressure in the LNG- fuel feed compartment is either p2 or p1, respectively, and both valves 222 and 224 may be inactivated, i.e. set to a stand-by mode from which they would be re-activated by increase in the oxygen concentration or reduction of pressure in the LNG- fuel feed compartment 70.1. Thus, the pressure control of the LNG- fuel feed compartment 70.1 is left for the pressure relief valve 64.

[0053] In normal operating conditions, i.e. when the ventilation inlet and outlet are closed and the inert atmosphere in the LNG- fuel feed compartment is controlled by the first and the second pressure regulating valves 222 and 224, the operation of the first fire damper valve 256 and the first closing valve 212 in the ventilation inlet line 254 and the second fire damper valve 260 and the second closing valve 214 in the ventilation outlet line 258 should be checked regularly. In order to minimize the wasting of the inert gas both the ventilation inlet line 254 and the ventilation outlet line 258 are thus provided with the first and second closing valves 212 and 214. The checking of the functionality of the fire damper and the closing valves is performed such that first the fire damper valve 256 or 260 is closed and the closing valve 212 or 214 is opened, and the inlet line 254 or the outlet line 258 leading away from the closing valve 212 or 214, i.e. in a direction opposite to the LNG- fuel feed compartment 70.1, is monitored to see if any leak from the LNG- fuel feed compartment 70.1 may be noticed. If not, the fire damper valve 256 or 260 appears to be in good condition, whereafter the closing valve 212 or 214 is closed and the fire damper valve 256 or 260 opened. Next, again the inlet line 254 or the outlet line 258 leading away from the closing valve 212 or 214, i.e. in a direction opposite to the LNG- fuel feed compartment 70.1, is monitored to see if any leak from the LNG- fuel feed compartment 70.1 may be noticed. If not, the closing valve 212 or 214 is also in good condition, and may be closed. Naturally, if any leakage is detected through any one of the fire damper and closing valves 256, 260, 212 or 214, or any other problems in their operation is found out, the malfunctioning valve needs to be replaced or maintained.

[0054] When the LNG- fuel feed compartment itself or any piece of equipment therein needs service or maintenance the inert atmosphere in the LNG- fuel feed compartment has to be switched to air atmosphere, whereby both pressure regulating valves 222 and 224 are inactivated, the fire damper and closing valves 256, 260, 212 or 214are opened and blower 262 started, i.e. standard ventilation is switched on for flushing the nitrogen out and filling the LNG- fuel feed compartment 70.1 with air.

[0055] In view of the above description is should be noted that the inert gas used for inerting the bunkering or LNG- fuel feed compartments is preferably nitrogen, though also argon may be used. The inert gas source 118/218 is either a generator separating the inert gas from air, or a pressurized container carrying the inert gas. In case the generator is used, it is preferable to store the inert gas in a buffer tank for later use. With regard to the above discussed preferred embodiments, running schemes and their variations it has to be understood that they are just exemplary ones and other embodiments, running schemes and variations may also be used without departing from the spirit of the present invention. In a similar manner pressures p1, p2, px or p0 do not necessarily refer to the same pressure values in each and every example, but they may change. Thus, as mentioned already earlier, the only thing that matters is that $p2<p1<p0$ and $p2<px<p0$ in each exemplary embodiment, running scheme or variation. Further, it should be noted that the first and the second pressure regulation valves 122/222 and 124/224 may be positioned either inside or outside the bunkering or the LNG- fuel feed compartment. And finally it should also be understood that though the Figures 3 - 7 discusses a tank, and bunkering and LNG- fuel feed compartments with an inner and an outer shell the present invention is as well applicable to LNG- tanks, and bunkering and LNG- fuel feed compartments having only an inner shell with a heat insulation thereon.

[0056] It should be understood that the equipment for filling the LNG- fuel tank with LNG in the bunkering compartment as well as the equipment needed for providing an engine with NG in the LNG- fuel feed compartment comprises such pipelines, valves and other instrumentation that has not been shown in Figures 3 – 7. One piece of such equipment is thermal valves and pipelines related thereto for connecting any such parts of the various lines to the vent mast that warming of the LNG or gaseous NG may increase pressure in. Also, all connections and pipelines relating to heating or evaporating of the LNG and heating of NG, i.e. various water or water/glycol lines have been left out.

[0057] It should also be understood that in the above exemplary embodiment/s an internal combustion engine, or generally, an engine is used as a mere example of various gas consumers. Such gas consumers include, in addition to engines, also turbine gas burners, for example.

[0058] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments of the present invention, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. It should be understood that the tank arrangement comprises several features which are not shown in figures for the sake of clarity. The details mentioned in connection with any embodiment above may be used in connection with any other embodiment when such combination is technically feasible.

Claims

1. A fuel tank arrangement for a gas fuelled marine vessel for storing LNG- fuel, the arrangement comprising an LNG- fuel tank (12), and a tank connection space (26.1; 26.2) provided in communication with the LNG- fuel tank (12), **characterized** in the tank connection space (26.1; 26.2) being formed of at least three isolated compartments, i.e. one bunkering compartment (30.1; 30.2) and at least two LNG- fuel feed compartments (70.1, 70.2; 70.3, 70.4).

2. The fuel tank arrangement as recited in claim 1, **characterized** in that the bunkering compartment (30.1; 30.2) houses equipment needed for filling the LNG- fuel tank (12) with LNG.

3. The fuel tank arrangement as recited in claim 1, **characterized** in that the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) houses equipment needed for providing a gas consumer with NG.

4. The fuel tank arrangement as recited in claim 2, **characterized** in that the equipment in connection with the bunkering compartment (30.1; 30.2) needed for filling the LNG- fuel tank (12) with LNG comprises a bunkering line (32) with a bunkering valve (34), a vapour return line (44) and instruments (52) for measuring the LNG level (L) in the LNG- fuel tank (12).

5. The fuel tank arrangement as recited in claim 2, **characterized** in that the equipment in connection with the bunkering compartment (30.1; 30.2) further comprises a vent mast (50), a safety relief line (48) from the top or gas space of the LNG- fuel tank (12) to the vent mast (50), the safety relief line (48) having an emergency pressure relief valve (46).

6. The fuel tank arrangement as recited in claim 2, **characterized** in that the equipment in connection with the bunkering compartment (30.1; 30.2) further comprises ventilation inlet and outlet lines (54; 58) with a first and a second fire damper valves (56; 60) therein.

7. The fuel tank arrangement as recited in claim 2, **characterized** in that the equipment in connection with the bunkering compartment (30.1; 30.2) further comprises a pressure relief line (66) with a pressure relief valve (64) therein.

8. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment

(70.1, 70.2; 70.3, 70.4) comprises an LNG- outlet line (72) for taking LNG from the bottom of the LNG- fuel tank (12), an LNG- outlet valve (74), a main LNG- evaporator (76) and a fuel feed line (80) with a main gas valve (82) for forwarding NG towards a gas consumer.

9. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) comprises a boil-off gas line (96) with a boil-off gas valve (98) for taking boil-off gas from the top of the tank (12) and a heater (100) for heating the boil-off gas.

10. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) comprises a pressure build-up line (108) branching from the LNG- outlet line (72), having a pressure build-up unit (106) therein and leading to the top of the LNG- fuel tank (12).

11. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) comprises a cryogenic pump (110) provided in the LNG- outlet line (72) upstream of the LNG- outlet valve (74).

12. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) comprises ventilation inlet and outlet lines (254; 258) with a first and a second fire damper valve (256; 260) therein and a blower (262) in connection with one of the ventilation inlet line (254) and the ventilation outlet line (258).

13. The fuel tank arrangement as recited in claim 3, **characterized** in that the equipment needed for providing a gas consumer with NG in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) comprises a pressure relief line (266) with a pressure relief valve (264) therein

14. The fuel tank arrangement as recited in claim 1, **characterized** in that the bunkering compartment (30.1; 30.2) is provided with an inert gas inlet line (116) for introducing inert gas from an inert gas source (118) into the bunkering compartment (30.1; 30.2)

15. The fuel tank arrangement as recited in claim 14, **characterized** in a first pressure regulating valve (122) arranged in flow communication with the inert gas inlet line (116).

16. The fuel tank arrangement as recited in claim 14 or 15, **characterized** in that the bunkering compartment (30.1; 30.2) is provided with a gas outlet line (120) arranged in flow communication with the vent mast (50)

17. The fuel tank arrangement as recited in claim 16, **characterized** in that a second pressure regulating valve (124) is arranged in flow communication with the gas outlet line (120) for maintaining a desired pressure in the bunkering compartment (30.1; 30.2).

18. The fuel tank arrangement as recited in claim 16 or 17, **characterized** in an oxygen analyser (126) provided either in connection with the bunkering compartment (30.1; 30.2) or downstream of the second pressure regulating valve (124), between the second pressure regulating valve (124) and the vent mast (50) in the gas outlet line (120).

19. The fuel tank arrangement as recited in any one of the preceding claims 14 – 18, **characterized** in a first fire damper valve (56) and a first closing valve (112) in a ventilation inlet line (54) and a second fire damper valve (60) and a second closing valve (114) in a ventilation outlet line (58).

20. The fuel tank arrangement as recited in any one of the preceding claims, **characterized** in a pressure relief valve (64) providing a flow communication from the bunkering compartment (30.1; 30.2) to a vent mast (50), the pressure relief valve (64) being set to open when pressure in the bunkering compartment (30.1; 30.2) exceeds maximal allowed pressure p0.

21. The fuel tank arrangement as recited in claim 14, **characterized** in that the inert gas source (118) is one of an inert gas generator or a pressurized container.

22. The fuel tank arrangement as recited in any one of the preceding claims 14 – 21, **characterized** in that the inert gas is one of nitrogen and argon.

23. The fuel tank arrangement as recited in any one of the preceding claims 15 – 22, **characterized** in that the first pressure regulation valve (122) is set to open when pressure in the bunkering compartment (30.1; 30.2) is reduced below a predetermined pressure p1 and set to close when pressure in the bunkering compartment (30.1; 30.2) exceeds a predetermined pressure p1.

24. The fuel tank arrangement as recited in any one of the preceding claims 17 – 23, **characterized** in that the second pressure regulation valve (124) is set to open when pressure in the bunkering compartment (30.1; 30.2) exceeds a predetermined pressure p2 and set to close when pressure in the bunkering compartment (30.1; 30.2) is reduced below a predetermined pressure p2.

25. The fuel tank arrangement as recited in claims 15 and 18 or 17 and 18, **characterized** in that either the first pressure regulation valve (122) or the second pressure regulating valve (124) is set to close when the oxygen analyser (126) indicates oxygen concentration below a predetermined value.

26. The fuel tank arrangement as recited in claim 1, **characterized** in that the LNG-fuel feed compartment (70.1, 70.2; 70.3, 70.4) is provided with an inert gas inlet line (216) for introducing inert gas from an inert gas source (218) into the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4).

27. The fuel tank arrangement as recited in claim 26, **characterized** in a first pressure regulating valve (222) arranged in flow communication with the inert gas inlet line (216).

28. The fuel tank arrangement as recited in claim 26 or 27, **characterized** in that the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) is provided with a gas outlet line (220) arranged in flow communication witha vent mast (250).

29. The fuel tank arrangement as recited in claim 28, **characterized** in that a second pressure regulating valve (224) is arranged in flow communication with the gas outlet line (220) for maintaining a desired pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4).

30. The fuel tank arrangement as recited in claim 29, **characterized** in an oxygen analyser (226) provided either in connection with the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) or downstream of the second pressure regulating valve (224), between the second pressure regulating valve (224) and the vent mast (250) in the gas outlet line (220).

31. The fuel tank arrangement as recited in any one of the preceding claims 26 - 30, **characterized** in a first fire damper valve (256) and a first closing valve (212) in a ventilation inlet line (254) and a second fire damper valve (260) and a second closing valve (214) in a ventilation outlet line (258).

32. The fuel tank arrangement as recited in any one of the preceding claims, characterized in a pressure relief valve (264) providing a flow communication from the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) to a vent mast (250), the pressure relief valve (264) being set to open when pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) exceeds maximal allowed pressure p0.

33. The fuel tank arrangement as recited in claim 26, **characterized** in that the inert gas source (218) is one of an inert gas generator or a pressurized container.

34. The fuel tank arrangement as recited in any one of the preceding claims 26 - 33, **characterized** in that the inert gas is one of nitrogen and argon.

35. The fuel tank arrangement as recited in any one of the preceding claims 27 - 34, **characterized** in that the first pressure regulation valve (222) is set to open when pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) is reduced below a predetermined pressure p1 and set to close when pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) exceeds a predetermined pressure p1.

36. The fuel tank arrangement as recited in any one of the preceding claims 29 - 35, **characterized** in that the second pressure regulation valve (224) is set to open when pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) exceeds a predetermined pressure p2 and set to close when pressure in the LNG- fuel feed compartment (70.1, 70.2; 70.3, 70.4) is reduced below a predetermined pressure p2.

37. The fuel tank arrangement as recited in claims 27 and 30 or 29 and 30, **characterized** in that either the first pressure regulation valve (222) or the second pressure regulating valve (224) is set to close when the oxygen analyser (226) indicates oxygen concentration below a predetermined value.

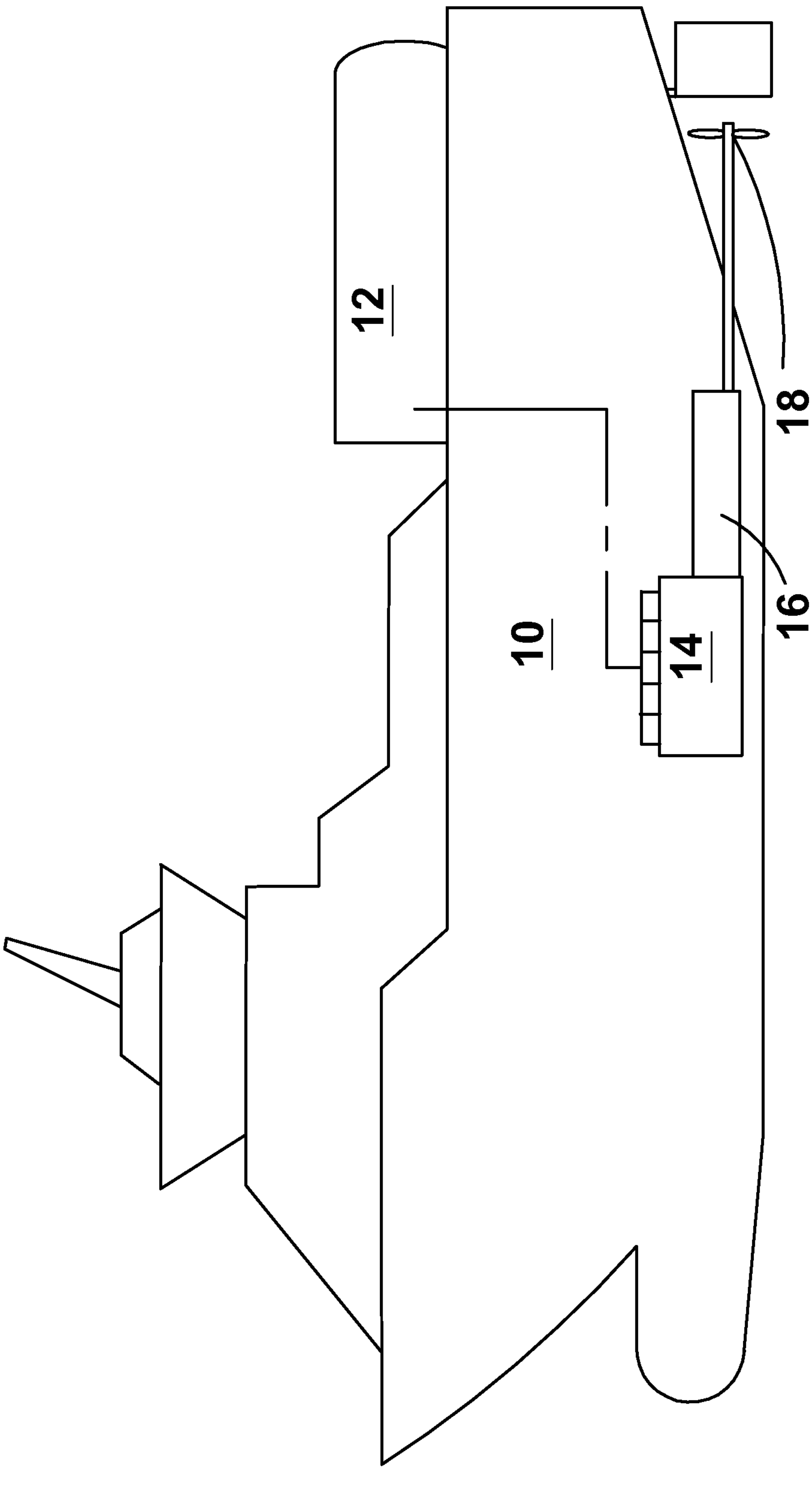


Fig. 1

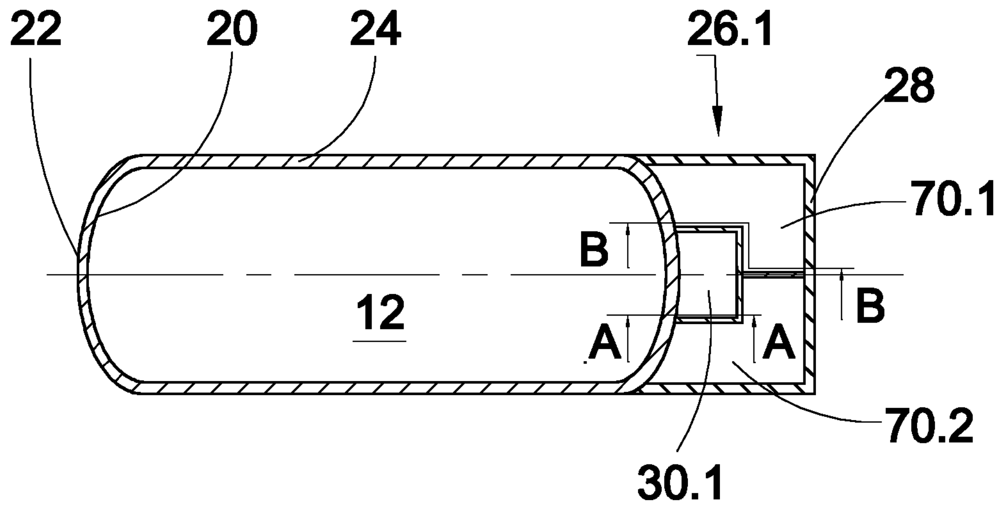


Fig. 2a

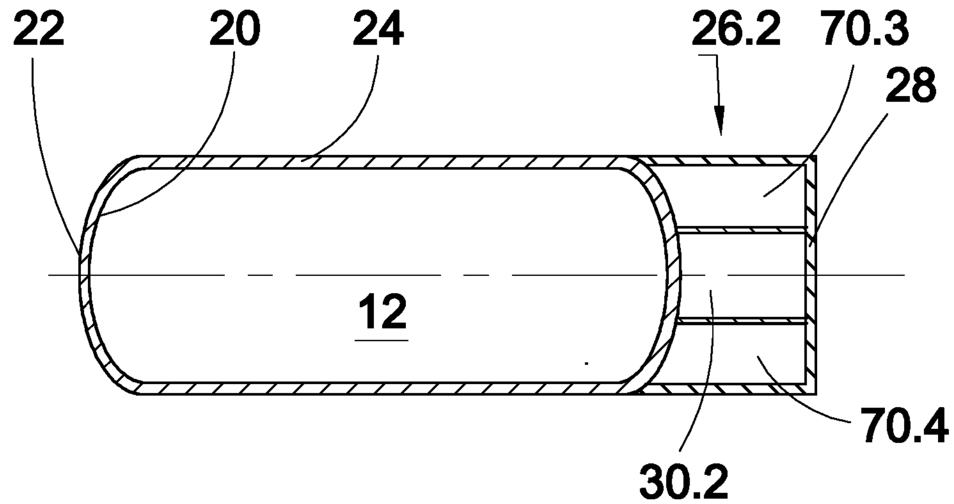
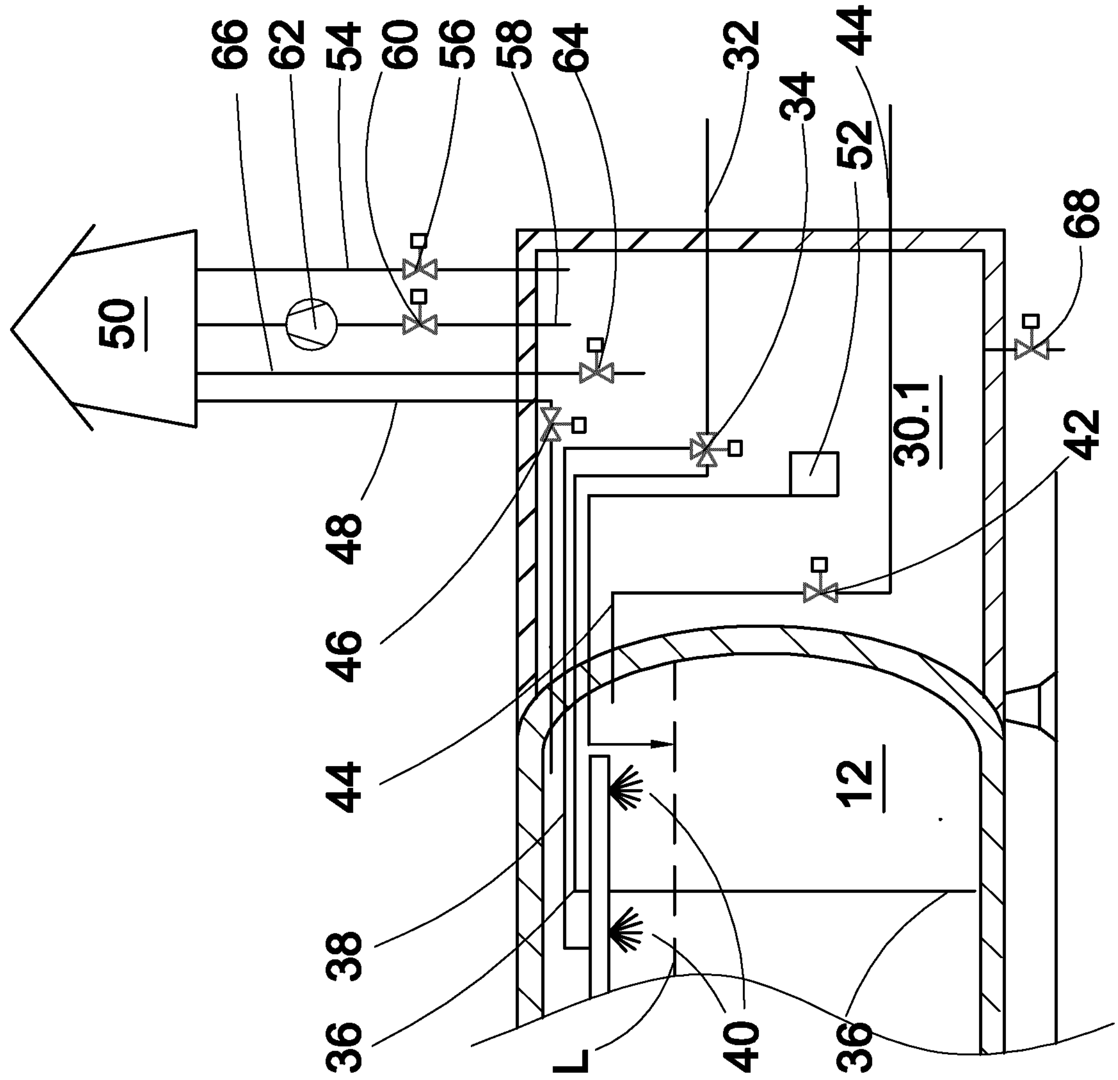
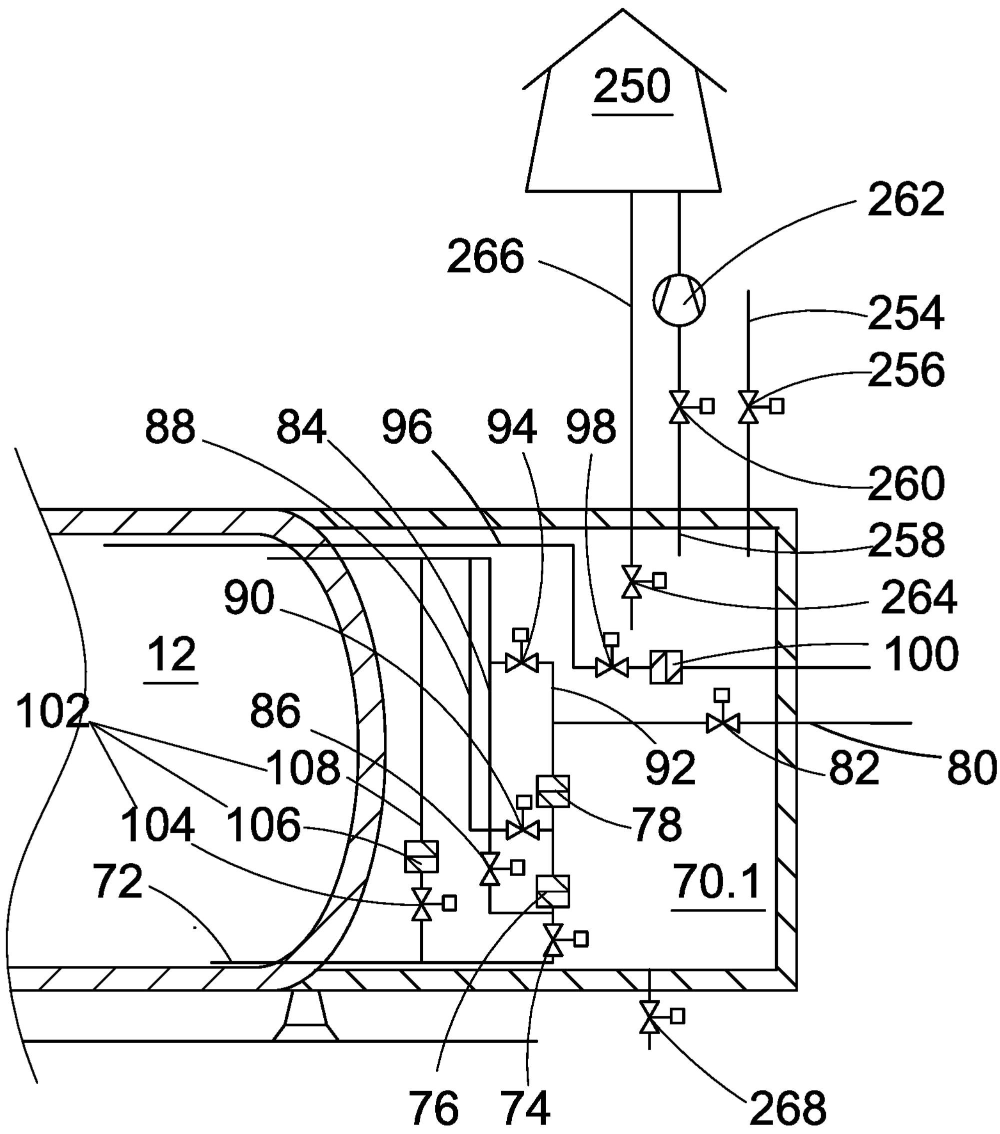


Fig. 2b

Fig. 3 (A - A)

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268

Fig. 4 (B-B)

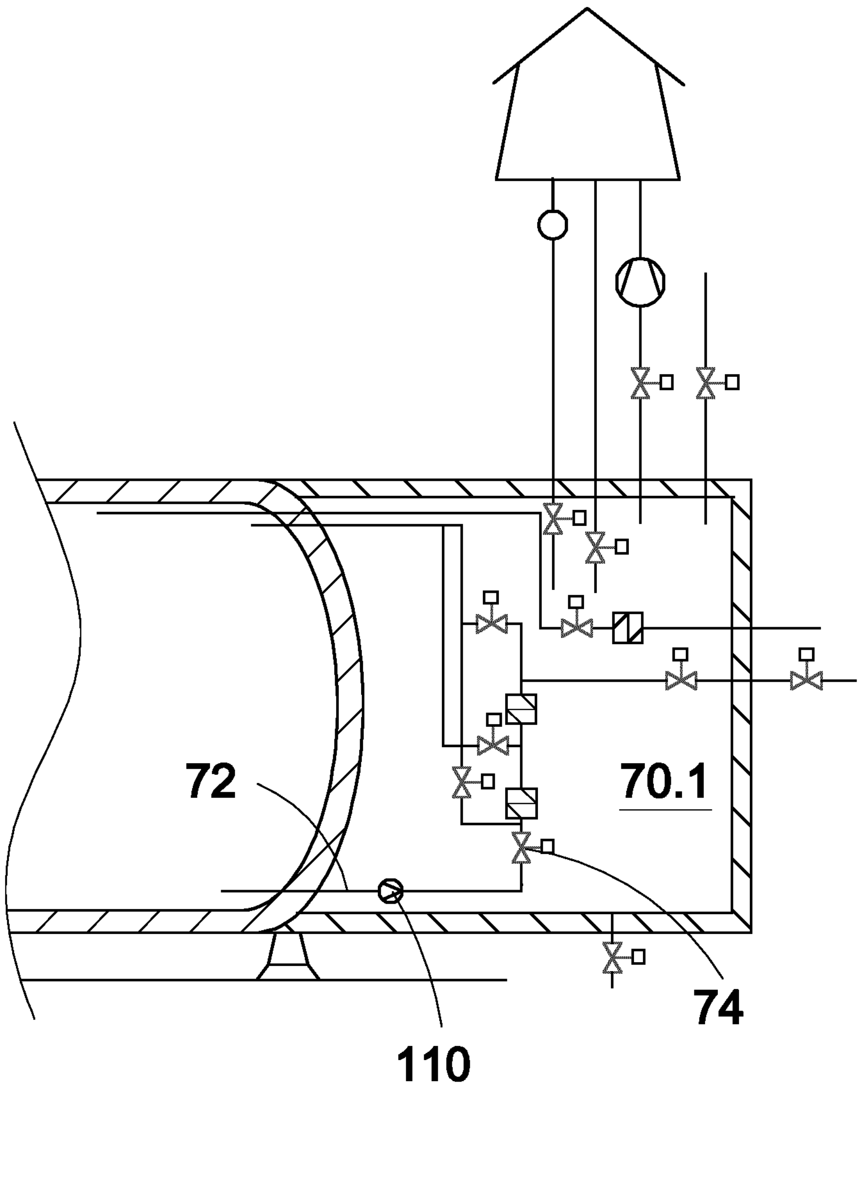


Fig. 5

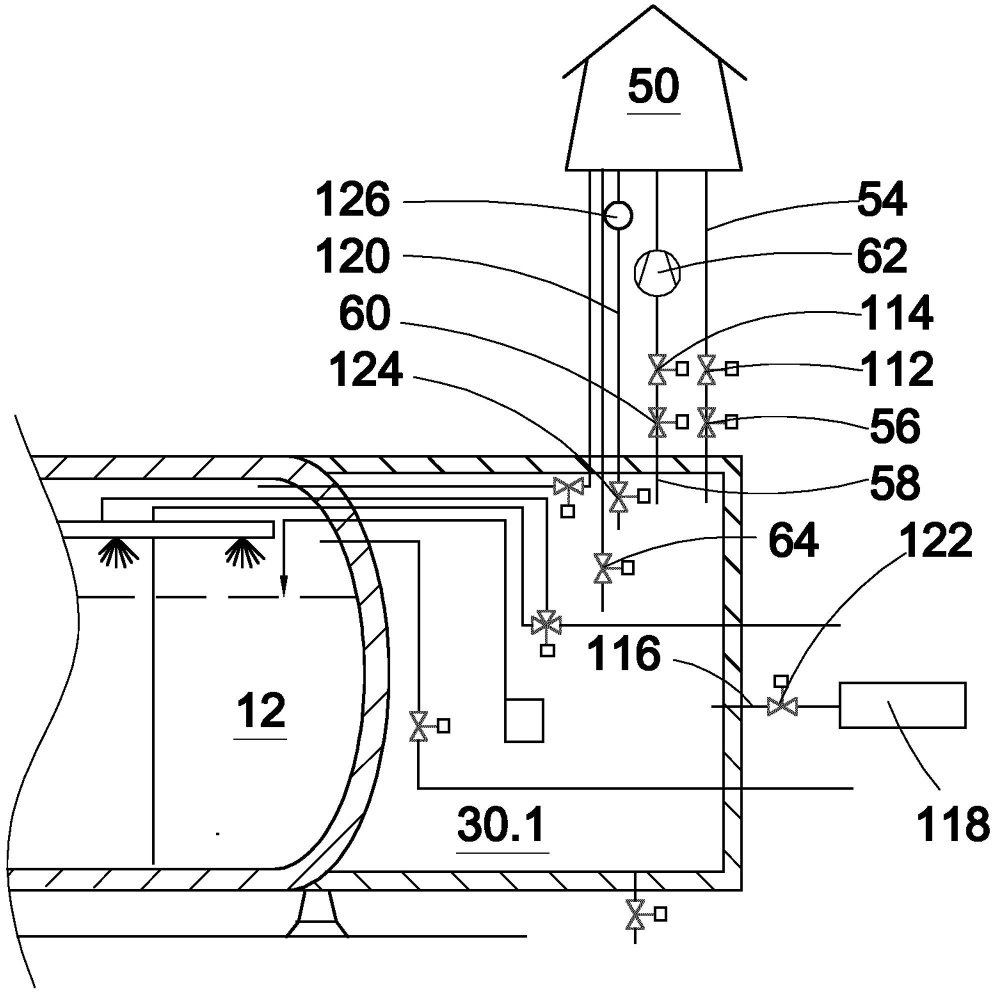
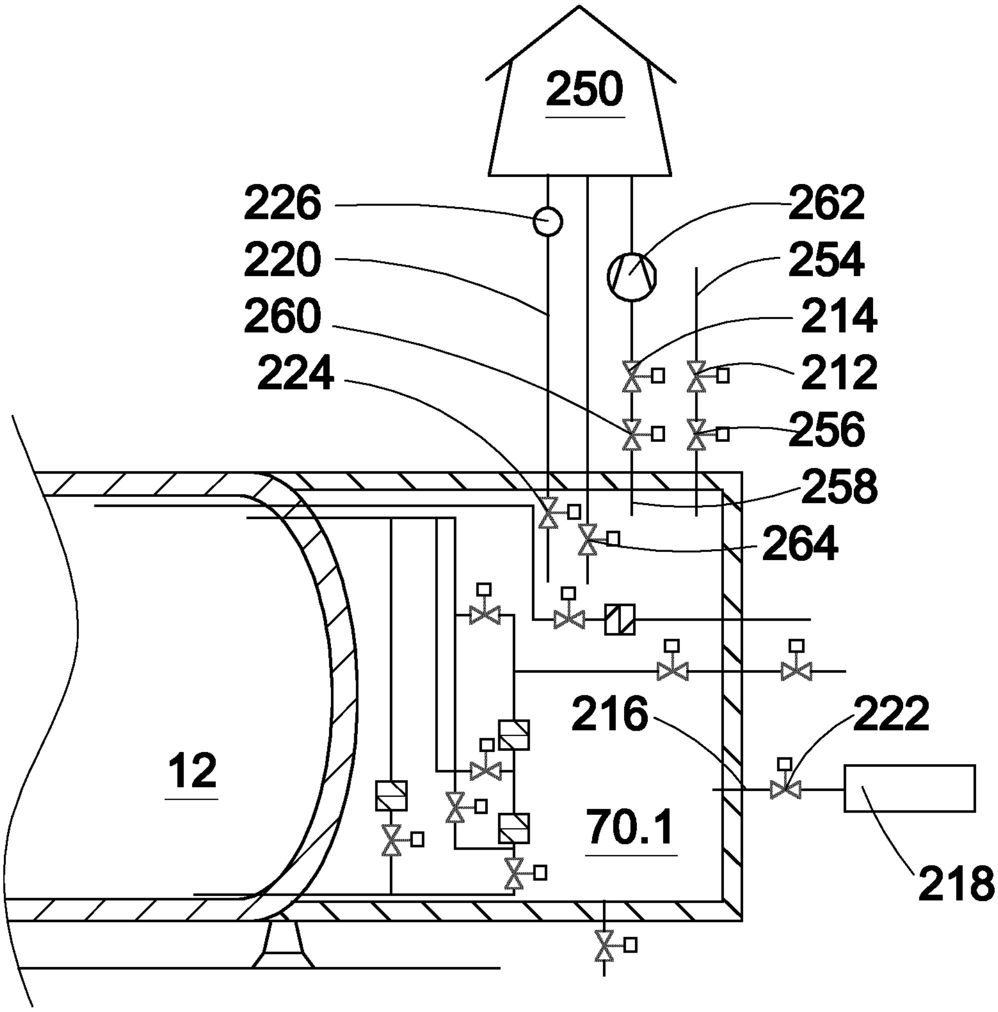


Fig. 6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218
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70.1

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/074375

A. CLASSIFICATION OF SUBJECT MATTER
INV. F17C13/00
ADD.

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

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/111525 A1 (BOC GROUP PLC [GB]; ROACH JOHN [GB]) 23 December 2004 (2004-12-23)	1-4,6, 8-13, 26-34, 36,37
A	pages 4-9; figures 1-3	5,7, 14-25,35
A	WO 2016/097460 A1 (WÄRTSILÄ FINLAND OY [FI]) 23 June 2016 (2016-06-23) figures 1-4	1
A	WO 2014/177761 A1 (WÄRTSILÄ FINLAND OY [FI]) 6 November 2014 (2014-11-06) figures 1-3	1-37
A	WO 2015/040268 A1 (WÄRTSILÄ FINLAND OY [FI]) 26 March 2015 (2015-03-26) figures 1-6	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 May 2019	14/05/2019

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nicol, Boris

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2017/194817 A1 (WÄRTSILÄ FINLAND OY [FI]) 16 November 2017 (2017-11-16) figures 1-3 -----	1

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Information on patent family members

International application No
PCT/EP2018/074375

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