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Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*
 — *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

BOIL OFF GAS RECONDENSER AND LNG SUPPLY SYSTEM EQUIPPED WITH THE BOIL OFF GAS RECONDENSER

5 The present invention relates to a boil off gas recondenser (Boil off Gas Recondenser) and an LNG supply system equipped with the boil off gas recondenser.

 In general, a BOG recondenser needs a BOG compressor (compressor) to condense (liquefy) BOG by LNG having a saturation temperature under a tank pressure. However, the BOG compressor (compressor) like this is usually very
10 expensive because of a small-scale LNG terminal in particular.

 Patent Literature 1 discloses feeding BOG from an LNG tank to a BOG recondenser by a BOG compressor, and using the LNG which is fed from the LNG tank, as a cooling source for condensation.

 Patent Literature 2 discloses cooling LNG by using LN₂ as a coolant.

15 Patent Literature

 Patent Literature 1: U.S. Patent No. 7493778

 Patent Literature 2: U.S. Patent No. 3302416

20 Technical Problem

 However, the BOG compressor in Patent Literature 1 is very expensive. In addition, reliability of a rotation mechanism (for example, reciprocation, a piston ring and the like) of the compressor is low, and the members composing the rotation mechanism have abrasion, and require periodical maintenance.

25 Further, an object of Patent Literature 2 is to cool NG that is vaporized by heat input to stabilize LNG in a tank, but is neither to control a large amount of BOG that is generated at the time of transfer of LNG to the tank from an LNG carrier at an LNG

terminal, nor to recondense BOG under a lower pressure than an operating pressure of the LNG tank.

An object of the present invention is to provide a boil off gas recondenser that can recondense BOG (boil off gas) under a lower pressure than an operating pressure of an LNG tank, without using a BOG compressor, and an LNG supply system equipped with the boil off gas recondenser.

Solution to Problem

A first boil off gas recondenser of the present invention is

- a boil off gas recondenser that recondenses BOG of LNG, and has
- a BOG lead-out line that leads out BOG from an LNG terminal tank,
- an LNG lead-out line that leads out LNG from the LNG terminal tank,
- a sub-cooler that is provided in the LNG lead-out line, and cools LNG with a coolant,
- a condenser that recondenses (liquefies) BOG that is sent from the BOG lead-out line with LNG that is sent from the LNG lead-out line and is cooled by the sub-cooler, under a lower pressure than an operating pressure of the LNG terminal tank, and
- a return line that returns LNG that is produced by liquefaction of BOG in the condenser, to the LNG terminal tank.

According to the configuration, BOG can be recondensed under the lower pressure than the operating pressure of the LNG tank, without using a conventional BOG compressor. In the present invention, LNG is cooled first by using a coolant such as LN_2 , and BOG is liquefied with the cooled LNG. Thereby, recondensation of BOG can be performed effectively under the lower pressure than the operating pressure of the LNG tank.

In the present invention, the sub-cooler may be controlled so that LNG has a higher temperature than an LNG solidifying point by a pressure regulating valve or a flow rate regulating valve that is installed in a coolant line in which the coolant flows.

A second boil off gas recondenser of the present invention is a boil off gas recondenser that recondenses BOG of LNG, and has

- a BOG lead-out line that leads out BOG from an LNG terminal tank,
- a coolant line through which a coolant is sent,
- a condenser that recondenses (liquefies) BOG that is sent from the BOG lead-out line with the coolant that is sent from the coolant line, under a lower pressure than an operating pressure of the LNG terminal tank, and a return line that returns LNG that is produced by liquefaction of BOG in the condenser, to the LNG terminal tank.

According to the configuration, BOG can be recondensed under the lower pressure than the operating pressure of the LNG tank, without using the conventional BOG compressor. In the present invention, for example, LN₂ is directly used as the coolant and BOG is liquefied. Thereby, recondensation of BOG can be performed effectively under the lower pressure than the operating pressure of the LNG tank.

In the present invention, the coolant may be introduced into a heat exchanger provided in the condenser, and the BOG may be introduced into the heat exchanger.

Thereby, BOG can be effectively liquefied in a mode of the heat exchanger.

In the present invention, the coolant may be introduced into a heat exchanger provided in the condenser, and a volume of the heat exchanger may be smaller than an internal volume of the condenser, and the heat exchanger may be disposed in an internal space of the condenser.

Thereby, BOG can be effectively liquefied in the mode of the heat exchanger. The liquefied LNG accumulates on the bottom of the condenser. The accumulating LNG can be fed to the LNG tank from the return line with a liquid feed pump.

A pressure in the condenser or in the heat exchanger may be regulated as follows.

(1) Send LN₂ and pre-cool an interior of the condenser or an interior of the heat exchanger, before sending BOG. Start introduction of BOG, after a predetermined time period elapses or when the interior of the condenser or the interior of the heat exchanger has a predetermined temperature.

5 (2) The introduced BOG is liquefied, and accumulates on the bottom of the condenser or the heat exchanger. The liquefied LNG accumulating on the bottom can be fed to the LNG terminal tank or to another supply destination by feeding by a pump or a pressurizing device, or the gravity without a power source.

10 (3) Close the valves of the respective lines, and end feed of LN₂, after the recondensing processing ends.

Another aspect of the present invention is an LNG supply system, and includes

- an LNG terminal tank, and
- the boil off gas recondenser described above.

15 In the above description, the BOG lead-out line may be provided with, for example, an automatic on-off valve, a pressure regulating valve, and a flow rate regulating valve.

In the above description, an LNG introduction line may be provided with, for example, a flow rate regulating valve.

20 In the above description, the return line may be provided with, for example, a liquid feed pump, and a pressurizer.

In the above description, the LNG terminal tank may be provided with a safety valve.

In the above description, the coolant line may be provided with, for example, a flow rate regulating valve, and a pressure regulating valve.

25

Brief Description of Drawings

Figure 1 is a diagram illustrating a configuration example of an LNG supply system of embodiment 1.

Figure 2 is a diagram illustrating a configuration example of an LNG supply system of embodiment 2.

Figure 3 is a diagram illustrating a configuration example of an LNG supply system of another embodiment.

5 Figure 4 is a diagram illustrating a configuration example of an LNG supply system of embodiment 3.

Description of Embodiments

Hereunder, several embodiments of the present invention will be described. The
10 embodiments described as follows explain only examples of the present invention. The present invention is not limited by the following embodiments in any way, and also includes various modified modes that are carried out within a range without changing the gist of the present invention. Note that all components described as follows are not always indispensable components of the present invention.

15 Embodiment 1

An LNG supply system of embodiment 1 will be described with use of Figure 1. A boil off gas recondenser 1 has a BOG lead-out line L1 that leads out BOG from an LNG terminal tank 20, an LNG lead-out line L2 that leads out LNG from the LNG terminal tank 20, a sub-cooler 15 that is provided in the LNG lead-out line L2 and cools
20 LNG with a coolant, a condenser 10 that recondenses (liquefies) BOG that is sent from the BOG lead-out line L1 with LNG that is sent from the LNG lead-out line L2 and is cooled by the sub-cooler 15, under a lower pressure than an operating pressure of the LNG terminal tank 20, and a return line L3 that returns the LNG that is produced by liquefaction of BOG in the condenser 10 to the LNG terminal tank 20. The respective
25 components will be described in detail hereunder.

The LNG terminal tank 20 is provided with an LNG introduction line L5 for introducing LNG, and when LNG is introduced, an automatic on-off valve is opened and closed. Further, the LNG terminal tank 20 is provided with an LNG supply line L6

for sending out LNG to a predetermined supply destination, and when LNG is sent out, an automatic on-off valve 36 is opened and closed. Further, in the LNG terminal tank 20, an in-tank pump (not illustrated) for sending out LNG is installed, and is connected to the LNG supply line L6.

5 The BOG lead-out line L1 is provided with a safety valve 21 for a time when pressure in the LNG terminal tank 20 becomes abnormally high. Further, the BOG lead-out line L1 is provided with an automatic on-off valve 32 for performing feeding control of BOG to the condenser 10. Further, the BOG lead-out line L1 is provided with a pressure regulating valve 31.

10 The operating pressure in the LNG terminal tank 20 is on average 1.2 barA (120 KPaA) at an absolute pressure, and is controlled within $\pm 15\%$ as upper and lower limit values. When a large amount of BOG is generated, a tank internal pressure becomes high. The tank internal pressure is measured by a pressure gauge, and based on a measurement result (conversion result) thereof, a valve control section (not illustrated)
15 controls opening and closing of the automatic on-off valve 32. For example, when the tank internal pressure becomes 1.3 times as high as 1.2 barA (120 KPaA), BOG is sent to the condenser 10. The pressure regulating valve 31 measures an in-piping pressure of the BOG lead-out line L1, and controls a valve opening degree based on a measurement result.

20 LNG is introduced into the sub-cooler 15 through the LNG lead-out line L2 from the LNG terminal tank 20. The valve control section (not illustrated) performs opening closing control of an automatic on-off valve 33 that is provided in the LNG lead-out line L2, and controls a liquid feed pump P1, whereby LNG is sent to the sub-cooler 15 from the LNG terminal tank 20, and is sent to the condenser 10 at a subsequent stage. A
25 coolant in the sub-cooler 15 can be a medium having a lower temperature than a boiling point of LNG, and LN₂ is used in the present embodiment. LN₂ is introduced into the sub-cooler 15 through a coolant line L4 from an LN₂ source (for example, an LN₂ tank), and is used as a cold source for cooling the LNG that passes inside the sub-

cooler 15. When LN₂ is discharged from the sub-cooler 15, LN₂ may be gasified, or may be discharged as a fluid in which a liquid and gas are mixed. The fluid (LN₂ and/or GN₂) that is discharged may be subjected to treatment to be discharged into the atmosphere, or may be subjected to treatment to be recycled.

5 In the sub-cooler 15, LNG may be controlled to have a higher temperature than an LNG solidifying point, by a pressure regulating valve (not illustrated), or a flow rate regulating valve (not illustrated), which is installed in the coolant line L4 in which the coolant (LN₂) flows.

10 An internal pressure of the condenser 10 is controlled to be at a lower pressure than the operating pressure (1.2 barA (120 KPaA) on average at the absolute pressure) of the LNG terminal tank 20, in BOG recondensing processing. The internal pressure of the condenser 10 is measured with a pressure gauge, and is regulated to be lower than the operating pressure of the LNG terminal tank 20.

15 In the present embodiment, LNG that is cooled by the sub-cooler 15 contacts BOG in the condenser 10, and thereby a volume of BOG decreases by liquefaction to reduce the pressure in the condenser 10. During an operation, cooled LNG is continuously supplied, and thereby keeps a low pressure state. The internal pressure of the condenser 10 is regulated by controlling a flow rate of the cooled LNG. By providing a flow rate regulating valve in the LNG lead-out line L2 between the sub-
20 cooler 15 and the condenser 10, the flow rate of LNG may be controlled with the flow rate regulating valve in accordance with a measurement result of the pressure gauge that measures the internal pressure of the above described condenser 10, the flow rate of LNG may be controlled by controlling an opening degree of the automatic on-off valve 33, or both of them may be controlled.

25 The BOG which is introduced into the condenser 10 is brought into contact with the cooled LNG, and thereby the BOG is liquefied to be LNG, and LNG accumulates on a bottom of the condenser 10. As a method for bringing both of the BOG and LNG into contact with each other, there are, for example, means for spraying LNG by a

shower, means for bringing both of them into contact with each other by using a filler and the like.

A lower portion of the condenser 10 and the return line L3 are connected. The valve control section (not illustrated) performs control of opening and closing an automatic on-off valve 34 provided in the return line L3, and controls a liquid feed pump P2, and thereby can send back LNG to the LNG terminal tank 20 from the condenser 10.

A processing procedure of recondensing processing of BOG will be described hereunder. The respective valves 31 to 34 are each in a closed state except during recondensing processing.

(1) Send LN₂ to the sub-cooler 15 when the tank internal pressure of the LNG terminal tank 20 exceeds a first threshold value.

(2) Feed LNG to the sub-cooler 15 from the LNG terminal tank 20 and cool the LNG, when the sub-cooler 15 reaches a predetermined temperature or less. For example, it is preferable to set a temperature of the LNG which is cooled at a temperature that is higher than the LNG solidifying point, and is lower than the temperature of the LNG in the LNG terminal tank 20. The temperature of the LNG which is cooled may be set, based on an amount of BOG and an amount of LNG which is cooled.

(3) Feed the cooled LNG to the condenser 10, and pre-cool the condenser 10. The automatic on-off valve 34 of the return line L3 is closed.

(4) Open the automatic on-off valve 32 and the pressure regulating valve 31, and introduce BOG into the condenser 10 from the LNG terminal tank 20, when the tank internal pressure of the LNG terminal tank 20 exceeds a second threshold value (the second threshold value > the first threshold value).

(5) The condenser 10 is pre-cooled, and the cooled LNG is introduced into the condenser 10 with BOG, whereby the BOG is cooled and changes state to LNG, and the LNG accumulates on the bottom of the condenser 10.

(6) Open the automatic on-off valve 34, control the liquid feed pump P2, and send back the LNG to the LNG terminal tank 20 from the condenser 10, when the LNG accumulating on the bottom of the condenser 10 accumulates in a predetermined amount (or at predetermined timing).

5 (7) Close the respective valves after the recondensing processing ends.

It is assumed that a condition of (4) (the tank internal pressure > the second threshold value) is established during processings of (1) to (3), so that BOG may be discharged from the LNG terminal tank 20 with the safety valve 21, or BOG may be discharged to external air by a vent not illustrated.

10 The above described "first threshold value" is a pressure that is 1.26 times as high as 1.2 barA (120 KPaA), for example.

The above described "second threshold value" is a pressure that is 1.3 times as high as 1.2 barA (120KPaA), for example.

Other Embodiments

15 In the above described embodiment, the respective automatic on-off valves, the pressure regulating valve, and the liquid feed pumps are provided at the respective lines, but the present invention is not limited to the above described disposition, and a part or all of them may be omitted in accordance with an object.

Further, in the above described present embodiment, in the BOG recondensing
20 processing, the condenser 10 is pre-cooled by feeding the cooled LNG before BOG is fed to the condenser 10, but the present invention is not limited to this, and the cooled LNG, and BOG may be sent together. In this case, a feeding amount of the cooled LNG (VL) and the feeding amount of BOG (VB) may be controlled to satisfy $VL > VB$. Flow rate regulating valves may be provided in the respective LNG introduction line
25 and the BOG introduction line, and flow rate control of respective feeding amounts may be performed.

Further, in the above described embodiment, the return line L3 is provided with the liquid feed pump P2, but the return line L3 may be configured to be provided with

no liquid feed pump. The LNG that changes state from BOG in the condenser 10 is fed to the LNG terminal tank 20 by the gravity.

Embodiment 2

An LNG supply system of embodiment 2 will be described with use of Figure 2.

- 5 Components with the same reference signs as those in the LNG supply system of embodiment 1 have the same functions, and therefore, explanation of the components will be omitted, or will be explained briefly.

A boil off gas recondenser 2 has the BOG lead-out line L1 that leads out BOG from the LNG terminal tank 20, a coolant line L41 through which a coolant is sent, a
10 condenser 210 that recondenses (liquefies) BOG that is sent from the BOG lead-out line L1 with the coolant that is sent from the coolant line L41, under a lower pressure than the operating pressure of the LNG terminal tank 20, and the return line L3 that returns the LNG that is produced by liquefaction of BOG in the condenser 210 to the LNG terminal tank 20.

- 15 In the present embodiment, LN₂ is used as the coolant. LN₂ is directly introduced into a heat exchanger 211 provided in the condenser 210 from an LN₂ source (for example, an LN₂ tank). When LN₂ is discharged from the heat exchanger 211, LN₂ may be gasified, or may be discharged as a fluid in which a liquid and gas are mixed. The fluid (LN₂ and/or GN₂) that is discharged may be subjected to treatment to be
20 discharged into the atmosphere, or may be subjected to treatment to be recycled.

In the coolant line L41, a pressure regulating valve (not illustrated) or a flow rate regulating valve (not illustrated) may be installed, and a feeding amount (VN) of LN₂ and a feeding amount (VB) of BOG may be controlled to satisfy $VN > VB$.

- An internal pressure of the heat exchanger 211 of the condenser 210 is
25 controlled to be at a lower pressure than the operating pressure (1.2 barA (120 KPaA) on average at the absolute pressure) of the LNG terminal tank 20, in BOG recondensing processing. The internal pressure of the heat exchanger 211 is

measured with a pressure gauge, and is regulated to be lower than the operating pressure of the LNG terminal tank 20.

In the present embodiment, BOG exchanges heat with LN₂ in the heat exchanger 211, and thereby a volume of BOG decreases by liquefaction to reduce the pressure in the heat exchanger 211. During an operation, cooled LN₂ is continuously supplied, and thereby keeps a low pressure state. The internal pressure of the heat exchanger 211 is regulated by controlling a flow rate of LN₂. A flow rate regulating valve may be provided in the coolant line L41, the flow rate of LN₂ may be controlled with the flow rate regulating valve, in accordance with a measurement result of the pressure gauge that measures the internal pressure of the above described heat exchanger 211, the flow rate of LN₂ may be controlled by controlling an opening degree of the automatic on-off valve provided in the coolant line L41, or both of them may be controlled.

An upper portion of the heat exchanger 211 and the BOG introduction line L1 are directly connected. Further, a lower portion of the heat exchanger 211 and the return line L3 are directly connected.

A processing procedure of the recondensing processing of BOG will be described hereunder. The respective valves 31 to 34 are each in a closed state except during recondensing processing.

(1) Send LN₂ to the heat exchanger 211, and pre-cool the heat exchanger 211, when the tank internal pressure of the LNG terminal tank 20 exceeds the first threshold value. It is preferable to set a temperature of LN₂ at a temperature higher than the LNG solidifying point, and lower than the temperature of the LNG in the LNG terminal tank 20, for example. The temperature of LNG that is cooled may be set based on the amount of BOG and the amount of LNG that is cooled.

(2) Regulate a supply amount of LN₂ by the flow rate regulating valve (not illustrated) provided in the coolant line L41, so that when the heat exchanger 211 has a predetermined temperature or less, the heat exchanger 211 keeps the temperature.

(3) Open the automatic on-off valve 32 and the pressure regulating valve 31 to introduce BOG directly into the heat exchanger 211 of the condenser 210 from the LNG terminal tank 20, when the tank internal pressure of the LNG terminal tank 20 exceeds the second threshold value (the second threshold value > the first threshold value). Perform regulation of the supply amount of LN₂ to the heat exchanger 211 when BOG is introduced, and keep an interior of the heat exchanger 211 under a negative pressure (or under a lower pressure than the operating pressure of the LNG terminal tank 20).

(4) The heat exchanger 211 is pre-cooled, the BOG is cooled quickly and changes state to LNG, and the LNG drops onto a bottom of the heat exchanger 211.

(5) LNG is sent back to the LNG terminal tank 20 through the return line L3.

(6) Close the respective valves after the recondensing processing ends.

It is assumed that a condition of (3) (the tank internal pressure > the second threshold value) is established during processing of (1) and/or processing of (2), so that BOG may be discharged from the LNG terminal tank 20 with the safety valve 21, or BOG may be discharged to external air by a vent not illustrated.

The above described "first threshold value" is a pressure that is 1.26 times as high as 1.2 barA (120 KPaA), for example.

The above described "second threshold value" is a pressure that is 1.3 times as high as 1.2 barA (120 KPaA), for example.

Other Embodiments

In the above described embodiment, the return line L3 is provided with the liquid feed pump P2, but Figure 3 illustrates a configuration in which the return line L31 is not provided with a liquid feed pump. The LNG that changes state from BOG in the heat exchanger 211 is fed to the LNG terminal tank 20 by the gravity.

Embodiment 3

An LNG supply system of embodiment 3 will be described with use of Figure 4. Components with the same reference signs as those in the LNG supply systems of

embodiments 1 and 2 have the same functions, and therefore, explanation of the components will be omitted, or will be explained briefly.

A boil off gas recondenser 3 has the BOG lead-out line L1 that leads out BOG from the LNG terminal tank 20, the coolant line L41 through which a coolant is sent, a condenser 410 that recondenses (liquefies) BOG that is sent from the BOG lead-out line L1 with the coolant that is sent from the coolant line L41, under a lower pressure than the operating pressure of the LNG terminal tank 20, and the return line L3 that returns LNG that is produced by liquefaction of BOG in the condenser 410 to the LNG terminal tank 20.

In the present embodiment, LN₂ is used as the coolant. LN₂ is directly introduced into a heat exchanger 411 provided in the condenser 410 from an LN₂ source (for example, an LN₂ tank). When LN₂ is discharged from the heat exchanger 411, LN₂ may be gasified, or may be discharged as a fluid in which a liquid and gas are mixed. The fluid (LN₂ and/or GN₂) that is discharged may be subjected to treatment to be discharged into the atmosphere, or may be subjected to treatment to be recycled.

In the coolant line L41, a pressure regulating valve (not illustrated) or a flow rate regulating valve (not illustrated) may be installed, and a feeding amount (VN) of LN₂ and a feeding amount (VB) of BOG may be controlled to satisfy $VN > VB$.

The condenser 410 is provided with the heat exchanger 411. In the present embodiment, a volume of the heat exchanger 411 is smaller than an internal volume of the condenser 410, and the heat exchanger 411 is disposed to have a predetermined space from an inner surface of the condenser 410.

An upper portion of an internal space of the condenser 410 (preferably, an upper side of the heat exchanger 411) and the BOG introduction line L1 are directly connected. Further, a lower portion of the internal space of the condenser 410 and the return line L3 are directly connected.

An internal pressure of the condenser 410 is controlled to be at a lower pressure than the operating pressure (1.2 barA (120 KPaA) on average at the absolute pressure)

of the LNG terminal tank 20, in the BOG recondensing processing. The internal pressure of the condenser 410 is measured with a pressure gauge, and is regulated to be lower than the operating pressure of the LNG terminal tank 20.

In the present embodiment, LN₂ is sent to the heat exchanger 411, and an interior of the condenser 410 is cooled by the LN₂. When BOG is introduced into the condenser 410 which is cooled, a volume of BOG decreases by liquefaction, and a pressure in the condenser 410 is reduced. During an operation, LN₂ is continuously supplied to the heat exchanger 411 to thereby continue to cool the condenser 410, and liquefies BOG to keep the interior of the condenser 410 in a low pressure state. The internal pressure of the condenser 410 is regulated by controlling a flow rate of LN₂. A flow rate regulating valve may be provided in the coolant line L41, and the flow rate of LN₂ may be controlled with the flow rate regulating valve in accordance with a measurement result of the pressure gauge that measures the internal pressure of the above described condenser 410, the flow rate of LN₂ may be controlled by controlling an opening degree of the automatic on-off valve provided in the coolant line L41, or both of them may be controlled.

A processing procedure of recondensing processing of BOG will be described hereunder. The respective valves 31 to 34 are each in a closed state except during recondensing processing.

(1) Send LN₂ to the heat exchanger 411 when the tank internal pressure of the LNG terminal tank 20 exceeds the first threshold value, and pre-cool the condenser 410. It is preferable to set a temperature of LN₂ at a temperature that is higher than the LNG solidifying point, and is lower than the temperature of the LNG in the LNG terminal tank 20, for example. The temperature of LNG that is cooled may be set based on the amount of BOG and the amount of LNG that is cooled.

(2) Regulate a supply amount of LN₂ by the flow rate regulating valve (not illustrated) provided in the coolant line L41, so that when the condenser 410 has a predetermined temperature or less, the condenser 410 keeps the temperature.

(3) Open the automatic on-off valve 32 and the pressure regulating valve 31 to introduce BOG into the condenser 410 from the LNG terminal tank 20, when the tank internal pressure of the LNG terminal tank 20 exceeds the second threshold value (the second threshold value > the first threshold value). Perform regulation of the supply amount of LN₂ to the heat exchanger 411 when BOG is introduced, and keep the interior of the condenser 410 under a negative pressure (or under a lower pressure than the operating pressure of the LNG terminal tank 20).

(4) The condenser 410 is pre-cooled, the BOG is cooled quickly and changes state to LNG, and the LNG accumulates on a bottom of the condenser 410.

(5) The LNG accumulating on the bottom of the condenser 410 is sent back to the LNG terminal tank 20 through the return line L3.

(6) Close the respective valves after the recondensing processing ends.

It is assumed that a condition of (3) (the tank internal pressure > the second threshold value) is established during processing of (1) and/or processing of (2), so that BOG may be discharged from the LNG terminal tank 20 with the safety valve 21, or BOG may be discharged to external air by a vent not illustrated.

The above described "first threshold value" is a pressure that is 1.26 times as high as 1.2 barA (120 KPaA), for example.

The above described "second threshold value" is a pressure that is 1.3 times as high as 1.2 barA (120 KPaA), for example.

Other Embodiments

In the above described embodiment, the return line L3 is provided with the liquid feed pump P2, but a configuration in which the return line L3 is not provided with a liquid feed pump may be adopted. The LNG that changes state from BOG in the condenser 410 is fed into the LNG terminal tank 20 by the gravity.

Reference Signs List

1	Boil off gas recondenser
10	Condenser
15	sub-cooler
20	LNG terminal tank
L1	BOG lead-out line
L2	LNG lead-out line
L3	Return line
P1	liquid feed pump

5

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Claims

5 Claim 1

A boil off gas recondenser that recondenses BOG of LNG, comprising:

a BOG lead-out line that leads out BOG from an LNG terminal tank;

an LNG lead-out line that leads out LNG from the LNG terminal tank;

- a sub-cooler that is provided in the LNG lead-out line, and cools LNG with a
10 coolant;
- a condenser that recondenses BOG that is sent from the BOG lead-out line
with LNG that is sent from the LNG lead-out line and is cooled by the sub-cooler, under
a lower pressure than an operating pressure of the LNG terminal tank; and
- a return line that returns LNG that is produced by liquefaction of BOG in the
15 condenser, to the LNG terminal tank.

Claim 2

The boil off gas recondenser according to claim 1, wherein LNG is controlled to
have a higher temperature than an LNG solidifying point by a pressure regulating valve
20 or a flow rate regulating valve that is installed in a coolant line in which the coolant
flows.

Claim 3

A boil off gas recondenser that recondenses BOG of LNG, comprising:

- 25 • a BOG lead-out line that leads out BOG from an LNG terminal tank;
- a coolant line in which a coolant is sent;

- a condenser that recondenses BOG that is sent from the BOG lead-out line with the coolant that is sent from the coolant line, under a lower pressure than an operating pressure of the LNG terminal tank; and

- a return line that returns LNG that is produced by liquefaction of BOG in the condenser, to the LNG terminal tank.

Claim 4

The boil off gas recondenser according to claim 3, wherein the coolant is introduced into a heat exchanger provided in the condenser, and the BOG is introduced into the heat exchanger.

Claim 5

The boil off gas recondenser according to claim 3,

- wherein the coolant is introduced into a heat exchanger provided in the condenser, and

- a volume of the heat exchanger is smaller than an internal volume of the condenser, and the heat exchanger is disposed in an internal space of the condenser.

Claim 6

An LNG supply system, comprising:

- an LNG terminal tank; and
- the boil off gas recondenser according to any one of claims 1 to 5.

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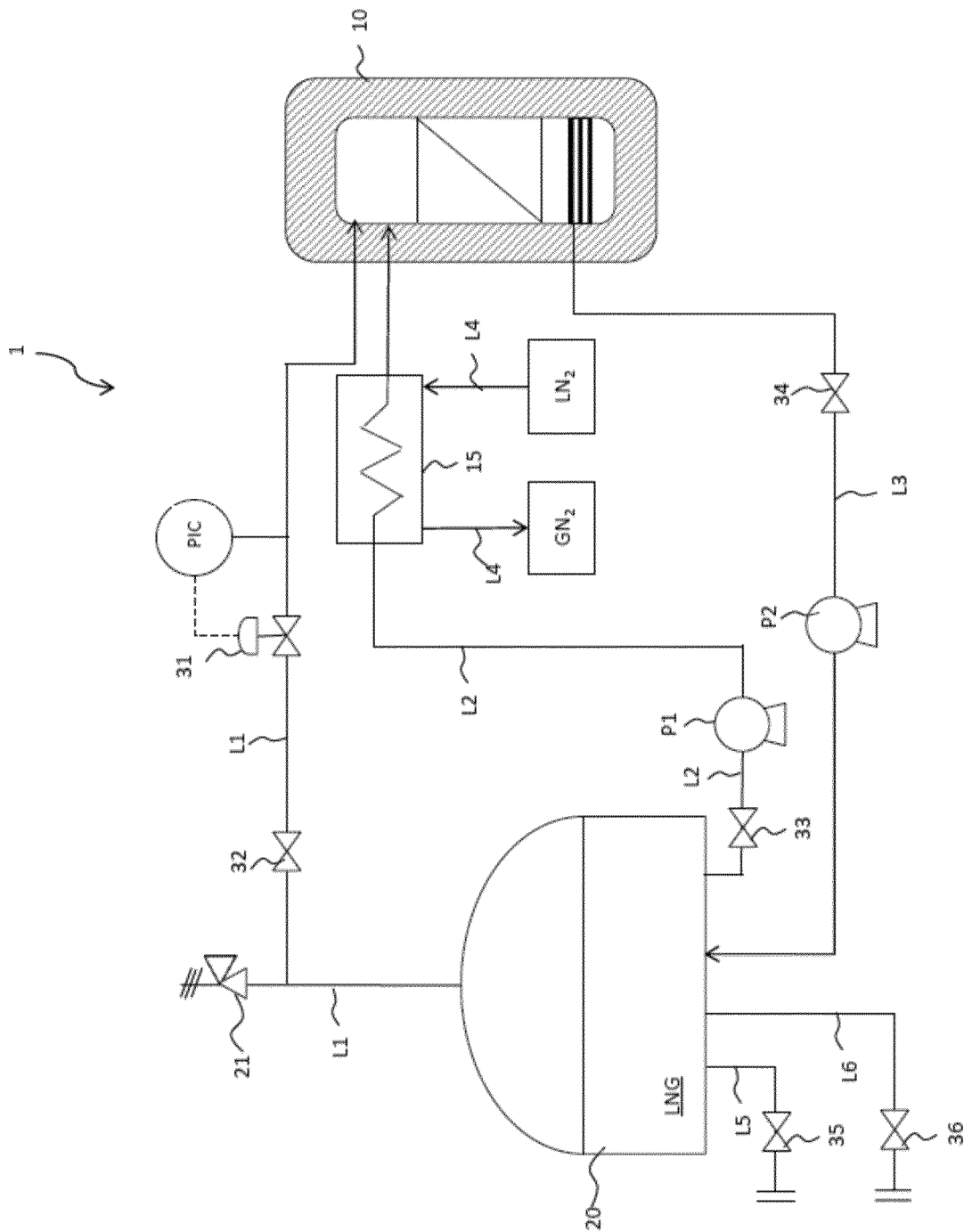


Figure 1

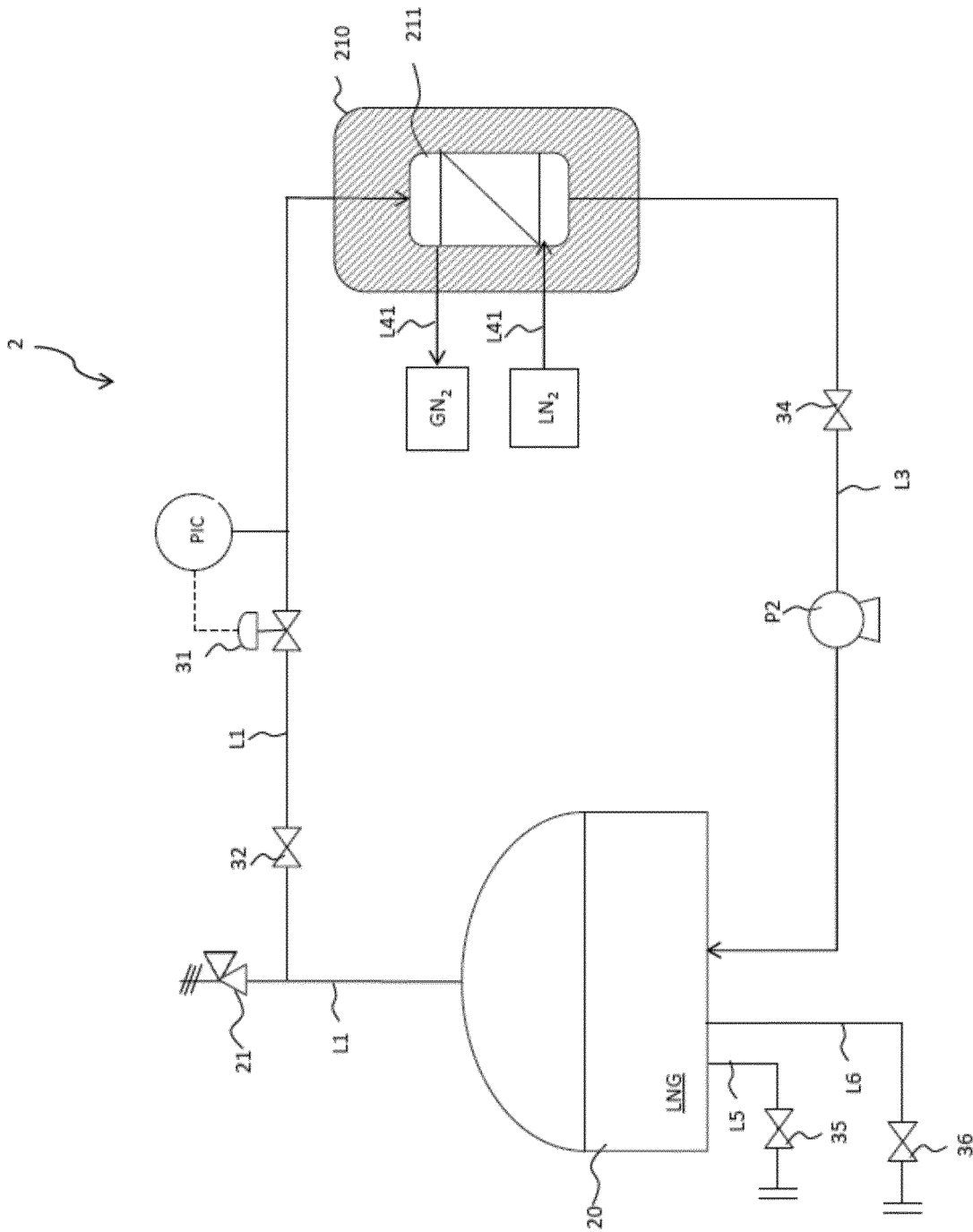


Figure 2

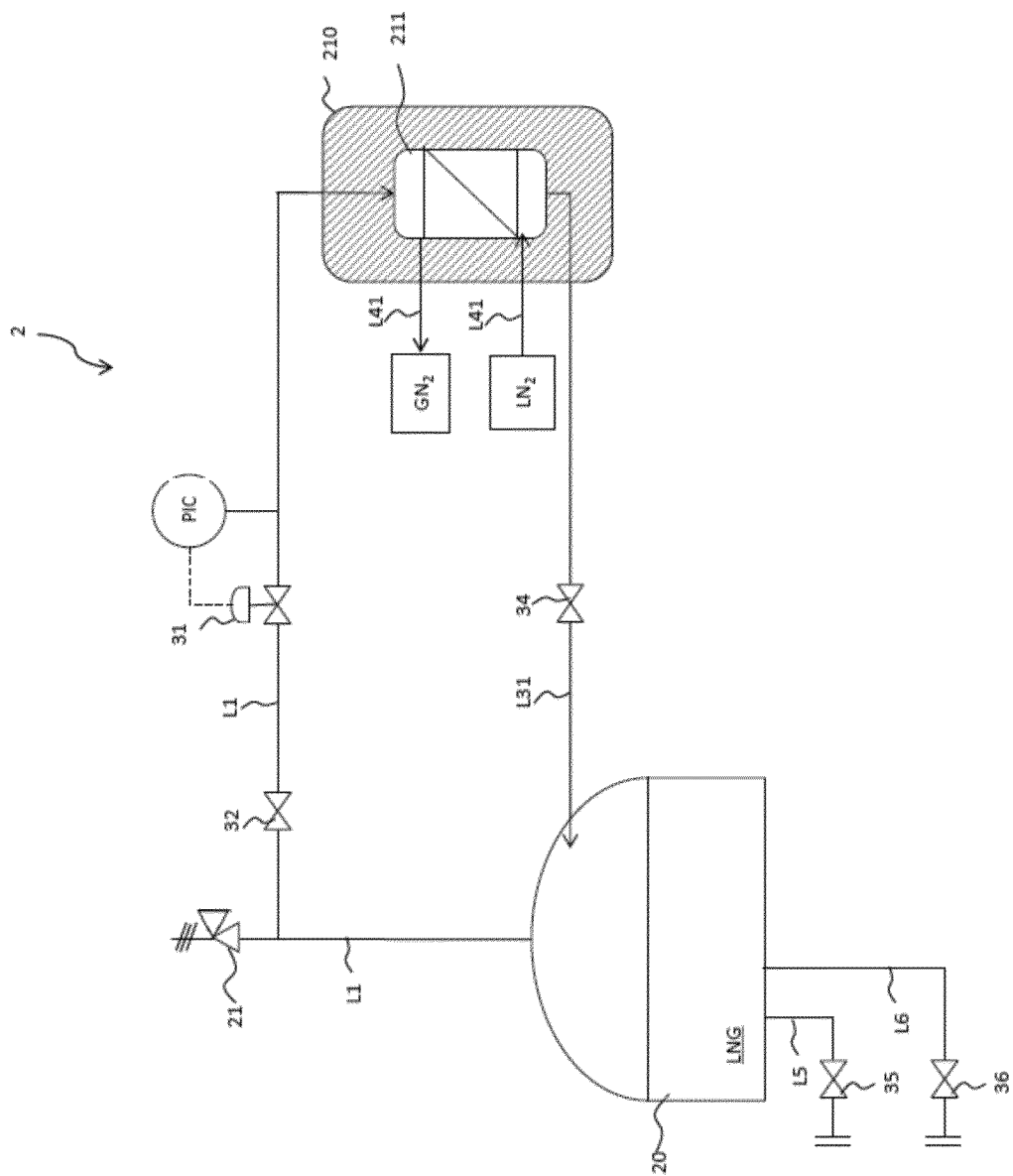


Figure 3

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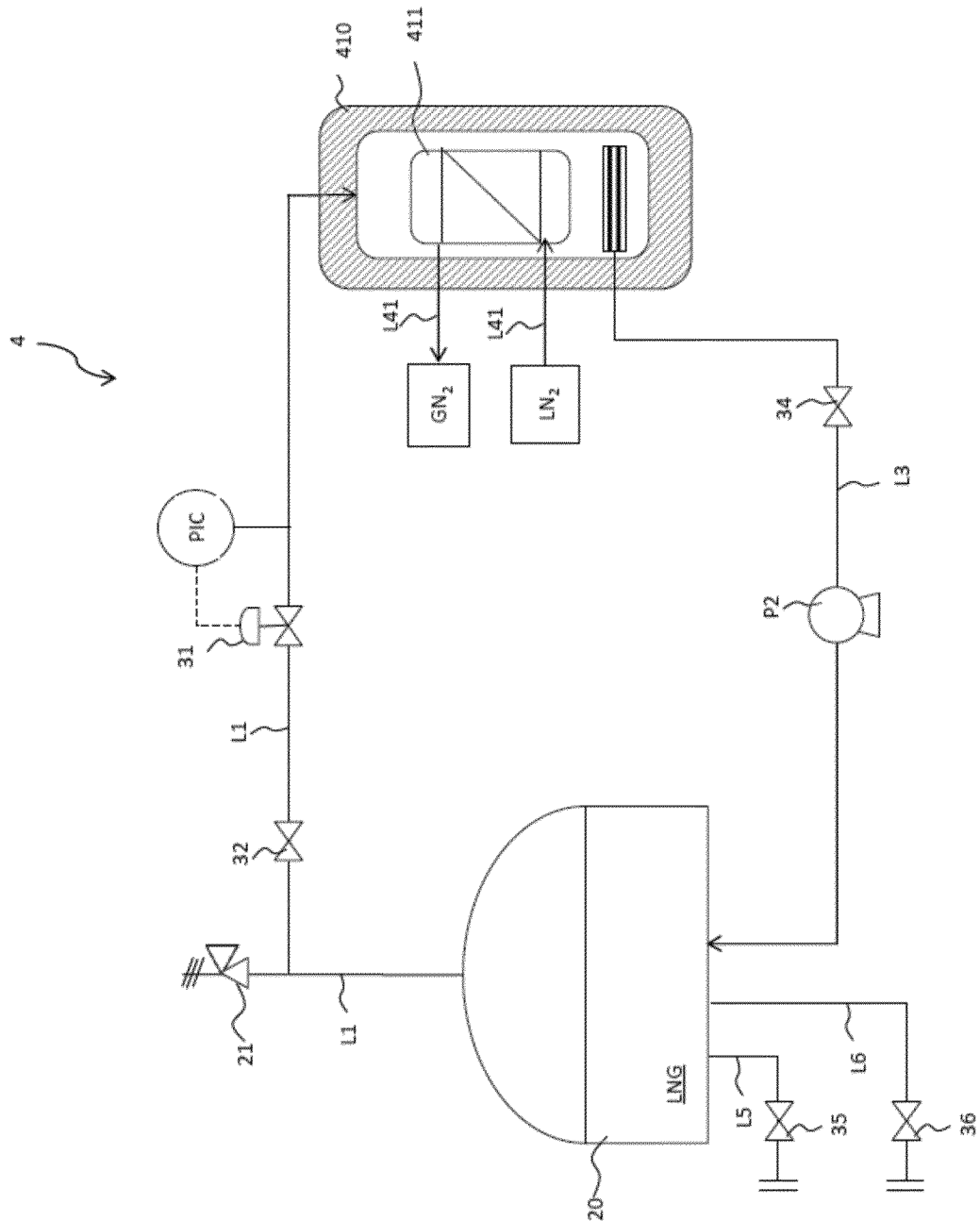


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/079062

A. CLASSIFICATION OF SUBJECT MATTER
INV. F25J1/00
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)
F25J

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	US 2015/000334 A1 (EDWARDS DAVID [GB]) 1 January 2015 (2015-01-01) paragraph [0048] - paragraph [0051]; claims 1,6; figure 3 -----	1,2,6
A	US 7 493 778 B2 (CHICAGO BRIDGE & IRON CO) 24 February 2009 (2009-02-24) cited in the application claims 1,6; figure 1 -----	1
X	US 2012/000242 A1 (BAUDAT NED P [US]) 5 January 2012 (2012-01-05) figure 3 -----	3-5
X	US 2 944 405 A (BASORE CLEBURNE A ET AL) 12 July 1960 (1960-07-12) figure 1 ----- -/-	3-5



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 April 2018

Date of mailing of the international search report

09/05/2018

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Schopfer, Georg

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/079062

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 196 722 A1 (MITSUBISHI HEAVY IND LTD [JP]; CHUBU ELECTRIC POWER [JP]) 16 June 2010 (2010-06-16) figures 1,2B -----	3-5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/079062

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1, 2(completely); 6(partially)

Searched Invention (Boil off gas reliquefaction by subcooled LNG)

2. claims: 3-5(completely); 6(partially)

Boil off gas reliquefaction with external coolant

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2017/079062

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015000334 A1	01-01-2015	GB 2515741 A US 2015000334 A1	07-01-2015 01-01-2015
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