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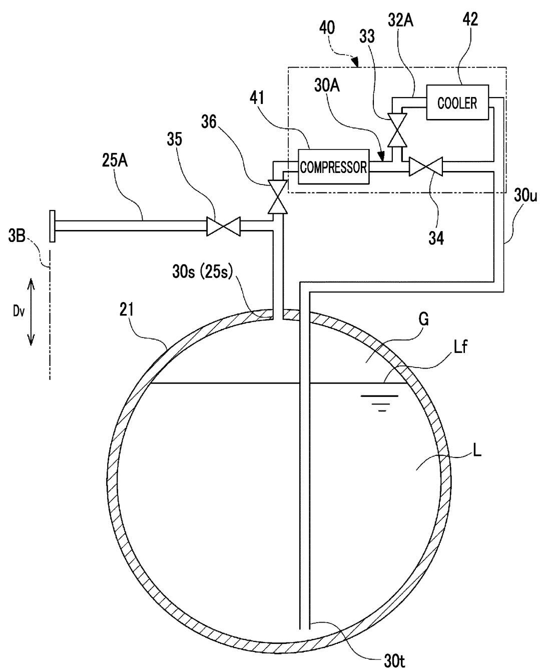
(54) **SHIP**

(57) This ship includes: a hull; a tank provided on the hull and capable of storing liquefied carbon dioxide; an external connection pipe that connects the top inside the tank to the outside of the hull; a circulation pipe that has one end connected to the inside of the tank and the other end connected to the inside of the tank via the outside of the tank; and a compressor provided partway through the circulation pipe outside the tank and capable of force-feeding fluid from one end to the other end.

FIG. 2



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Description

Technical Field

[0001] The present disclosure relates to a ship.

Background Art

[0002] For example, PTL 1 discloses a configuration in which a liquefied gas is stored in a tank in a ship. In PTL 1, a configuration is disclosed in which a pressure inside a loading pipe is adjusted in a case where the liquefied gas is loaded in a storage tank, in order to suppress evaporation of the liquefied gas when the liquefied gas is loaded in the tank.

Citation List

Patent Literature

[0003] [PTL 1] PCT Japanese Translation Patent Publication No. 2016-536209

Summary of Invention

Technical Problem

[0004] In recent years, there has been a demand for transporting liquefied carbon dioxide using a tank as described in PTL 1. However, in a case of the liquefied carbon dioxide, a pressure at a triple point where a gas phase, a liquid phase, and a solid phase coexist (triple point pressure) is higher compared to a triple point pressure of LNG or LPG, and has a small difference from a tank operating pressure during operation. As a result, depending on the tank operating pressure (design pressure of tank), the pressure of the liquefied carbon dioxide in the tank may be equal to or lower than the triple point pressure, and flash evaporation of the liquefied carbon dioxide may occur. When the flash evaporation of the liquefied carbon dioxide occurs as described above, a temperature of the liquefied carbon dioxide remaining without being evaporated is lowered due to an evaporation latent heat, and there is a possibility that the liquefied carbon dioxide is solidified to generate dry ice in the tank.

[0005] If the dry ice is generated in the tank, there is a possibility that it is difficult to discharge the liquefied carbon dioxide or the dry ice from the tank to an outboard facility.

[0006] The present disclosure has been made to solve above problems, and an object of the present disclosure is to provide a ship in which even in a case where the dry ice is generated in the tank, the liquefied carbon dioxide can be favorably discharged from the tank.

Solution to Problem

[0007] In order to solve the above problems, a ship according to the present disclosure includes a hull, a tank, an external connection pipe, a circulation pipe, and a compressor. The tank is provided in the hull. The tank is capable of storing liquefied carbon dioxide. The external connection pipe connects an upper portion in the tank and an outside of the hull. One end of the circulation pipe is connected to the tank. The other end of the circulation pipe is connected to an inside of the tank via the outside of the tank. The compressor is provided outside the tank in a middle of the circulation pipe. The compressor is capable of pressure-feeding a fluid from one end toward the other end.

[0008] A ship according to the present disclosure includes a hull, a tank, an external connection pipe, a circulation pipe, and a compressor. The tank is provided in the hull. The tank is capable of storing liquefied carbon dioxide. The external connection pipe connects an upper portion in the tank and an outside of the hull. The circulation pipe is loop-shaped and provided such that a fluid circulates throughout an inside and an outside of the tank. The compressor is provided outside the tank in a middle of the circulation pipe. The compressor is capable of pressure-feeding the fluid in the circulation pipe.

Advantageous Effects of Invention

[0009] According to the ship of the present disclosure, even in a case where the dry ice is generated in the tank, the liquefied carbon dioxide can be favorably discharged from the tank.

Brief Description of Drawings

[0010]

Fig. 1 is a plan view of a ship according to an embodiment of the present disclosure.

Fig. 2 is a view showing a layout of a tank, a circulation pipe, an external connection pipe, and a compressor provided in the ship according to a first embodiment of the present disclosure.

Fig. 3 is a view showing a flow of a carbon dioxide gas when the carbon dioxide gas in the tank is cooled by a cooler, in the ship according to the first embodiment of the present disclosure.

Fig. 4 is a view showing a flow of a carbon dioxide gas when the carbon dioxide gas in the tank is discharged, in the ship according to the first embodiment of the present disclosure.

Fig. 5 is a view showing a layout of a tank, a circulation pipe, an external connection pipe, and a compressor provided in a ship according to a second embodiment of the present disclosure.

Fig. 6 is a view showing a flow of a carbon dioxide gas when the carbon dioxide gas in the tank is cooled by a cooler, in the ship according to the second embodiment of the present disclosure.

Fig. 7 is a view showing a flow of a carbon dioxide gas when the carbon dioxide gas is sent to the circulation pipe in a case where the carbon dioxide gas in the tank is discharged, in the ship according to the second embodiment of the present disclosure.

Fig. 8 is a view showing a flow of a carbon dioxide gas when the carbon dioxide gas in the tank is discharged, in the ship according to the second embodiment of the present disclosure.

Description of Embodiments

<First Embodiment>

[0011] Hereinafter, a ship according to an embodiment of the present disclosure will be described with reference to Figs. 1 to 8.

(Hull Configuration of Ship)

[0012] As shown in Fig. 1, a ship 1A of the embodiment of the present disclosure transports liquefied carbon dioxide or various liquefied gases including the liquefied carbon dioxide. The ship 1A includes at least a hull 2, a tank 21, or a liquefied gas storage tank 22. The tank 21 can store liquefied carbon dioxide therein. The liquefied gas storage tank 22 can store, for example, a liquefied gas such as a liquefied natural gas (LNG) or liquefied ethane therein, which has a lower density than that of liquefied carbon dioxide.

(Configuration of Hull)

[0013] The hull 2 has a pair of broad sides 3A and 3B, a bottom (not shown), and an upper deck 5, which form an outer shell thereof. The broad sides 3A and 3B include a pair of broad side skins respectively forming right and left broad sides. The bottom (not shown) includes a bottom skin connecting the broad sides 3A and 3B. With the pair of broad sides 3A and 3B and the bottom (not shown), the outer shell of the hull 2 forms a U-shape in a cross section orthogonal to a bow-stern direction Da. The upper deck 5 is a completely open deck exposed outward. In the hull 2, a superstructure 7 having an accommodation space is formed on the upper deck 5 on a stern 2b side.

[0014] A tank storage compartment (hold) 8 is formed on a bow 2a side of the superstructure (accommodation space) 7 in the hull 2. The tank storage compartment 8 is a closed compartment that is recessed toward the bottom (not shown) below the upper deck 5 and that is covered with a tank cover (not shown) to protrude upward, or a closed compartment with the upper deck 5 as a ceiling. The tank storage compartment 8 accommodates a plurality of tanks 21 and a liquefied gas storage tank 22. In the embodiment of the present disclosure, two tanks 21 and two liquefied gas storage tanks 22 are accommodated in the tank storage compartment 8. The number or disposition of the tanks 21 and the liquefied gas storage tanks 22 accommodated in the tank storage compartment 8 can be appropriately changed.

(Configuration of Tank)

[0015] As shown in Fig. 2, the tank 21 has a space (hereinafter, simply referred to as inside of tank 21) in which a liquefied carbon dioxide L is accommodated therein. A carbon dioxide gas G generated by vaporizing the liquefied carbon dioxide L is also accommodated in the tank 21. The liquefied carbon dioxide L is accommodated in a lower portion in the tank 21, and the carbon dioxide gas G is accommodated in an upper portion in the tank 21. The liquefied carbon dioxide L in the tank 21 may include dry ice in which the liquefied carbon dioxide L is solidified. The liquefied carbon dioxide L in the tank 21 may be entirely solidified. In the embodiment of the present disclosure, the tank 21 is, for example, a spherical shape. The tank 21 may have a cylindrical shape extending in a horizontal direction (specifically, bow-stern direction).

[0016] The ship 1A further includes a circulation pipe 30A, a compressor 41, a bypass pipe 32A, a cooler 42, and an external connection pipe 25A in addition to the tank 21.

[0017] The circulation pipe 30A is configured to include one end 30s, an intermediate portion 30u, and the other end 30t. The one end 30s and the other end 30t of the circulation pipe 30A communicate with the inside of the tank 21, respectively. The intermediate portion 30u is a portion of the circulation pipe 30A between the one end 30s and the other end 30t, and is disposed outside the tank 21. That is, the circulation pipe 30A forms a flow path that returns to the inside of the tank 21 again from the inside of the tank 21 via the outside of the tank 21.

[0018] The one end 30s of the circulation pipe 30A is connected to the upper portion of the tank 21. The one end 30s of the circulation pipe 30A is disposed above a liquid level Lf of the liquefied carbon dioxide L stored in the tank 21 in a vertical direction Dv. The one end 30s of the circulation pipe 30A is open downward in the vertical direction Dv at a top of the tank 21.

[0019] The other end 30t of the circulation pipe 30A communicates with the inside of the tank 21. The other end 30t of the circulation pipe 30A is disposed in a vicinity of a bottom portion of the tank 21. The vicinity of the bottom portion is a position that is closer to the bottom portion than a center of the tank 21 is in the vertical direction Dv. In Fig. 2, a situation is shown, in which the other end 30t of the circulation pipe 30A is immersed in the liquefied carbon dioxide L stored in the tank 21. Accordingly, a part of the circulation pipe 30A is disposed below the liquid level Lf of the liquefied carbon dioxide L stored in the tank 21 in the vertical direction Dv. In addition, in Fig. 2, the other end 30t is open downward, but an opening direction is not limited to a downward direction.

(Configuration of Compressor)

[0020] The compressor 41 is provided in the intermediate portion 30u that is a middle of the circulation pipe 30A. The compressor 41 pressure-feeds a fluid from the one end 30s toward the other end 30t. Here, the fluid to be a target pressure-fed by the compressor 41 is the carbon dioxide gas G stored in the tank 21. When the carbon dioxide gas G is pressure-fed by the compressor 41, the carbon dioxide gas G is compressed and a temperature thereof rises (adiabatic compression). As a result, the carbon dioxide gas G heated more than the carbon dioxide gas G stored in the tank 21, is returned to the tank 21 from the other end 30t of the circulation pipe 30A.

(Configuration of Bypass Pipe)

[0021] The bypass pipe 32A is formed to partially bypass the circulation pipe 30A outside the tank 21. The bypass pipe 32A is connected to a downstream side with respect to the compressor 41 of the circulation pipe 30A in a flow direction of the carbon dioxide gas G. In other words, in the circulation pipe 30A, the bypass pipe 32A is connected to the compressor 41 and the other end 30t of the circulation pipe 30A. The bypass pipe 32A branches from the circulation pipe 30A on the downstream side with respect to the compressor 41, and merges with the circulation pipe 30A on the downstream side in the flow direction with respect to the position where the circulation pipe 30A branches, and on an upstream side in the flow direction with respect to the other end 30t.

(Configuration of Cooler)

[0022] The cooler 42 is provided in a middle of the bypass pipe 32A. The cooler 42 cools the carbon dioxide gas G passing through the compressor 41 and flowing through the bypass pipe 32A. The cooler 42 cools the carbon dioxide gas G by exchanging heat between the carbon dioxide gas G flowing through the bypass pipe 32A and a medium having a temperature lower than that of the carbon dioxide gas G. As a low-temperature medium for cooling the carbon dioxide gas G in the cooler 42, for example, a liquefied gas stored in another liquefied gas storage tank 22 may be used. The low-temperature medium used in the cooler 42 may be a medium other than the liquefied gas stored in the liquefied gas storage tank 22.

[0023] The compressor 41 and the cooler 42 may be components that configure a refrigeration device 40 for suppressing a temperature rise of the liquefied carbon dioxide L in the tank 21.

[0024] The bypass pipe 32A includes a first opening-closing valve 33 that opens and closes a flow path in the bypass pipe 32A on the upstream side with respect to the cooler 42. In addition, the circulation pipe 30A includes a second opening-closing valve 34 that opens and closes a flow path in the circulation pipe 30A on a downstream side of a branch portion on a side close to a branch portion between the circulation pipe 30A and the bypass pipe 32A.

(Configuration of External Connection Pipe)

[0025] The external connection pipe 25A connects the upper portion in the tank 21 and the outside of the hull 2. The external connection pipe 25A allows an onshore liquefied carbon dioxide supply facility, a bunker ship, or the like and the upper portion in the tank 21 to communicate with each other. The external connection pipe 25A may be used to discharge the liquefied carbon dioxide to the outside of the hull 2, or may be used to load the liquefied carbon dioxide L supplied from the outside of the hull 2 into the tank 21. In the present embodiment, a case is shown, in which the external connection pipe 25A shares a tank side end portion 25s connected to the upper portion of the tank 21 with the one end 30s of the circulation pipe 30A. Then, the external connection pipe 25A in the present embodiment is branched from the circulation pipe 30A between the one end 30s of the circulation pipe 30A and the compressor 41. The external connection pipe 25A extends toward the broad side 3A, and a pipe (not shown) on a land side is connectable to a broad side end portion 25t.

[0026] The external connection pipe 25A includes a third opening-closing valve 35 on a downstream side close to the branch portion between the external connection pipe 25A and the circulation pipe 30A. In contrast, the circulation pipe 30A includes a fourth opening-closing valve 36 on the downstream side close to the branch portion between the external connection pipe 25A and the circulation pipe 30A.

[0027] As shown in Fig. 3, in the ship 1A as described above, the third opening-closing valve 35 is in a closed state during navigation. In the ship 1A, during the navigation, the fourth opening-closing valve 36 is set as an opened state as necessary, and the carbon dioxide gas G generated by vaporizing the liquefied carbon dioxide L in the tank 21 is cooled by the cooler 42. In addition, the first opening-closing valve 33 is set as the opened state, and the second opening-closing valve 34 is set as the closed state. Accordingly, the carbon dioxide gas G that has passed through the compressor 41 can be guided to the bypass pipe 32A. The carbon dioxide gas G guided to the bypass pipe 32A is cooled by the cooler 42, and then returned to the lower portion in the tank 21 through the bypass pipe 32A and the circulation pipe 30A.

[0028] In the ship 1A described above, for example, in a case where the ship 1A is docked and the liquefied carbon dioxide L in the tank 21 is discharged to the outside of the ship, the ship 1A is set as shown in Fig. 4. Specifically, the third opening-closing valve 35 and the fourth opening-closing valve 36 are set as the opened state. Further, the first opening-closing valve 33 and the second opening-closing valve 34 are set as the opened state. As a result, the carbon dioxide gas G in the tank 21 enters a state of being able to be discharged to the outside of the ship through the external connection pipe 25A. Then, when the carbon dioxide gas G in the circulation pipe 30A is pressure-fed by the compressor 41, a part of the carbon dioxide gas G discharged from the tank 21 is sucked into the circulation pipe 30A from the one end 30s of the circulation pipe 30A. The carbon dioxide gas G sucked into the circulation pipe 30A is compressed by the compressor 41, and the temperature thereof rises. The carbon dioxide gas G in which the temperature has risen, is returned from the other end 30t of the circulation pipe 30A into the liquefied carbon dioxide L (solid-liquid mixture including dry ice) stored in the lower portion in the tank 21.

(Effects of Action)

[0029] In the ship 1A of the first embodiment, the compressor 41 provided in the circulation pipe 30A pressure-feeds the carbon dioxide gas G in the tank 21. The temperature of the carbon dioxide gas G rises by being compressed by the compressor 41. The carbon dioxide gas G in which the temperature has risen, is returned to the tank 21 from the other end 30t of the circulation pipe 30A. Accordingly, even in a case where the temperature of the liquefied carbon dioxide L in the tank 21 has risen so that the dry ice has been generated in the tank 21, the dry ice can be heated, liquefied, or sublimated. In addition, the liquefied carbon dioxide L can be heated and vaporized by the carbon dioxide gas G flowing from the other end 30t into the tank 21. Then, the carbon dioxide gas G in the tank 21 can be discharged to the outside of the hull 2 via the external connection pipe 25A. Therefore, even in a case where the dry ice is generated in the tank 21, it is possible to favorably discharge the liquefied carbon dioxide L stored in the tank 21.

[0030] In the above-described embodiment, the one end 30s of the circulation pipe 30A is disposed in the upper portion in the tank 21. Therefore, only the carbon dioxide gas G stored in the upper portion in the tank 21 can be sucked into the circulation pipe 30A as the fluid. As a result, the discharge and compression of the carbon dioxide gas G can be smoothly performed.

[0031] In the above-described embodiment, the other end 30t of the circulation pipe 30A is disposed below the liquid level Lf of the liquefied carbon dioxide L stored in the tank 21 in the vertical direction Dv. As a result, the carbon dioxide gas G that has passed through the compressor 41 so that the temperature has risen, is returned to the liquefied carbon dioxide L in the tank 21 from the other end 30t of the circulation pipe 30A. Accordingly, the liquefied carbon dioxide L can be efficiently heated. Therefore, even in a case where the dry ice has been generated, the carbon dioxide gas G can be smoothly generated in the tank 21.

[0032] In the above-described embodiment, the external connection pipe 25A is branched from the circulation pipe 30A between the one end 30s of the circulation pipe 30A and the compressor 41. Accordingly, it is not necessary to separately connect the external connection pipe 25A and the circulation pipe 30A to the tank 21, so that a time and effort of pipe installation and a length of a needed pipe can be reduced. Further, since a space for connecting the external connection pipe 25A to the tank 21 is not required, the space can be effectively used for other purposes.

[0033] In the above-described embodiment, the ship 1A includes the cooler 42 provided in the bypass pipe 32A. As a result, the carbon dioxide gas G compressed by the compressor 41 is cooled by the cooler 42 and returned to the tank 21, so that a temperature rise of the liquefied carbon dioxide L in the tank 21 is suppressed. Therefore, it is possible to suppress the vaporization of the liquefied carbon dioxide L in the tank 21 during the navigation (transportation).

[0034] In the above-described embodiment, the ship 1A further includes the liquefied gas storage tank 22 capable of storing a liquefied gas having a boiling point lower than that of the liquefied carbon dioxide L. As a result, the liquefied gas stored in the liquefied gas storage tank 22 and the liquefied carbon dioxide L stored in the tank 21 can be mixed to be transported. The liquefied carbon dioxide L in the tank 21 is achieved to be cooled by a cold heat of the liquefied gas having the boiling point lower than that of the liquefied carbon dioxide L, and a generation of the carbon dioxide gas G in the tank 21 is suppressed, so that the pressure in the tank 21 can be suppressed from rising.

<Second Embodiment>

[0035] Next, a ship according to a second embodiment of the present disclosure will be described with reference to Figs. 5 to 8. In the second embodiment of the present disclosure to be described below, only a configuration of the circulation pipe 30B is different from that of the first embodiment of the present disclosure. Therefore, the same parts as those of the first embodiment will be denoted by the same reference numerals and will not be redundantly described.

(Hull Configuration of Ship)

[0036] As shown in Fig. 1, a ship 1B of the embodiment of the present disclosure includes at least a hull 2, a tank 21, or a liquefied gas storage tank 22.

(Configuration of Tank)

[0037] As shown in Fig. 5, the ship 1B includes a circulation pipe 30B, a compressor 41, a bypass pipe 32B, a cooler 42, an external connection pipe 25B, and a connection pipe 48.

[0038] The circulation pipe 30B is provided in a loop shape (endless shape) such that a fluid circulates throughout an inside and an outside of the tank 21. A heat exchange part 30m that is a part of the circulation pipe 30B is disposed inside the tank 21. The heat exchange part 30m is disposed below a liquid level Lf of a liquefied carbon dioxide L stored in the tank 21 in a vertical direction Dv. In the liquefied carbon dioxide L in the tank 21, in order to increase a contact surface with the liquefied carbon dioxide L, for example, the heat exchange part 30m of the circulation pipe 30B may be formed in a spiral shape or a zigzag shape, or may include a plurality of fins. A remaining portion 30n of the circulation pipe 30B is disposed outside the tank 21.

(Configuration of Compressor)

[0039] The compressor 41 is disposed in the remaining portion 30n of the circulation pipe 30B. That is, the compressor 41 is disposed outside the tank 21. The compressor 41 pressure-feeds the fluid of the circulation pipe 30B. The fluid pressure-fed by the compressor 41 is the carbon dioxide gas G in the tank 21. When the carbon dioxide gas G is pressure-fed by the compressor 41, the carbon dioxide gas G is compressed and a temperature thereof rises (adiabatic compression).

(Configuration of Bypass Pipe)

[0040] The bypass pipe 32B is formed to partially bypass the remaining portion 30n of the circulation pipe 30B. The bypass pipe 32B is connected to the circulation pipe 30B on a downstream side with respect to the compressor 41 in the circulation pipe 30B, in a flow direction of the carbon dioxide gas G. In other words, in the remaining portion 30n of the circulation pipe 30B, the bypass pipe 32B branches from the remaining portion 30n on the downstream side with respect to the compressor 41, and merges with the remaining portion 30n on a downstream side with respect to a position in which the bypass pipe 32B branches, in the flow direction.

(Configuration of Cooler)

[0041] The cooler 42 cools the carbon dioxide gas G passing through the compressor 41 and flowing through the bypass pipe 32B.

[0042] The cooler 42 is provided in a middle of the bypass pipe 32B. The cooler 42 cools the carbon dioxide gas G passing through the compressor 41 and flowing through the bypass pipe 32A, as in the first embodiment. The cooler 42 cools the carbon dioxide gas G by exchanging heat between the carbon dioxide gas G flowing through the bypass pipe 32A and a medium having a temperature lower than that of the carbon dioxide gas G.

[0043] The bypass pipe 32B includes a first opening-closing valve 33 on an upstream side of the cooler 42. In addition, the remaining portion 30n of the circulation pipe 30B includes a second opening-closing valve 34 that opens and closes a flow path in the circulation pipe 30B on a downstream side of a branch portion on a side close to a branch portion between the remaining portion 30n and the bypass pipe 32B.

(Configuration of External Connection Pipe)

[0044] The external connection pipe 25B connects the upper portion in the tank 21 and the outside of the hull 2. The external connection pipe 25B has a tank side end portion 25v and a broad side end portion 25w. The tank side end portion 25v is connected to the upper portion of the tank 21. The external connection pipe 25B extends from the tank side end portion 25v toward a broad side 3B. A pipe (not shown) on a ship outer side is set to be connectable to the broad side end portion 25w.

[0045] The connection pipe 48 connects the external connection pipe 25B and the circulation pipe 30B. The connection pipe 48 connects the remaining portion 30n of the circulation pipe 30B and the external connection pipe 25B on an upstream side of the compressor 41. The external connection pipe 25B includes a third opening-closing valve 35 that opens and closes a flow path inside the external connection pipe 25B on a side closer to the broad side end portion 25w than a branch portion between the external connection pipe 25B and the connection pipe 48. In addition, the connection pipe 48 includes a connection pipe opening-closing valve 49 that opens and closes a flow path inside the connection pipe 48.

[0046] In the above-described ship 1B, during navigation, the third opening-closing valve 35 and the second opening-closing valve 34 are in a closed state, and the first opening-closing valve 33 is in an opened state. In the ship 1B, the compressor 41 and the cooler 42 are operated as necessary during navigation to cool the liquefied carbon dioxide L and the carbon dioxide gas G in the tank 21. In addition, as shown in Fig. 6, first, the connection pipe opening-closing valve 49 is set as the opened state, and the compressor 41 is operated. Then, a part of the carbon dioxide gas G in the tank 21 is sucked into the circulation pipe 30B through the external connection pipe 25B and the connection pipe 48. After the carbon dioxide gas G in the tank 21 is sucked, the connection pipe opening-closing valve 49 is set as the closed state. As a result, a closed loop is formed in the circulation pipe 30B. In a case where the carbon dioxide gas G inside the closed loop is insufficient, the connection pipe opening-closing valve 49 may be set as the opened state to replenish the carbon dioxide gas G. The carbon dioxide gas G sucked into the circulation pipe 30B circulates inside the closed loop formed by the circulation pipe 30B and the bypass pipe 32. In this case, the carbon dioxide gas G flowing into the bypass pipe 32B is cooled by the cooler 42, and then returns to the compressor 41 by exchanging heat with the liquefied carbon dioxide L and the carbon dioxide gas G in the tank 21, with the heat exchange part 30m. Accordingly, a temperature rise of the liquefied carbon dioxide L and the carbon dioxide gas G in the tank 21 is suppressed.

[0047] In the ship 1B described above, for example, in a case where the ship is docked and the liquefied carbon dioxide L in the tank 21 is discharged to the outside of the ship, the third opening-closing valve 35 and the connection pipe opening-closing valve 49 are set as the opened state as shown in Fig. 7. In addition, the first opening-closing valve 33 is set as the closed state, and the second opening-closing valve 34 is set as the opened state. Then, the carbon dioxide gas G in the tank 21 enters a state of being able to be discharged to the outside of the ship through the external connection pipe 25B.

[0048] On the other hand, when the carbon dioxide gas G in the circulation pipe 30B is pressure-fed by the compressor 41, a part of the carbon dioxide gas G discharged from the tank 21 is sucked into the circulation pipe 30B through the connection pipe 48. After the carbon dioxide gas G in the tank 21 is sucked into the circulation pipe 30B, the connection pipe opening-closing valve 49 is set as the closed state as shown in Fig. 8. As a result, a closed loop is formed in the circulation pipe 30B. The carbon dioxide gas G sucked into the circulation pipe 30B circulates inside the circulation pipe 30B. The carbon dioxide gas G inside the circulation pipe 30B is compressed by the compressor 41, so that the temperature of the carbon dioxide gas G rises. The carbon dioxide gas G in which the temperature has risen, exchanges heat with the liquefied carbon dioxide L around the circulation pipe 30B in the heat exchange part 30m of the circulation pipe 30B immersed in the liquefied carbon dioxide L in the tank 21. As a result, the temperature of the liquefied carbon dioxide L in the tank 21 rises.

(Effects of Action)

[0049] In the ship 1B of the above-described second embodiment, the compressor 41 pressure-feeds the carbon dioxide gas G in the circulation pipe 30B, so that the carbon dioxide gas G circulates through the loop-shaped circulation pipe 30B. The temperature of the carbon dioxide gas G rises by being compressed by the compressor 41. As a result, the temperature of the liquefied carbon dioxide L in the tank 21 rises. As a result, in a case where the dry ice is generated in the tank 21, the dry ice can be heated to be liquefied or be sublimated. In addition, when the liquefied carbon dioxide L in the tank 21 is discharged to the outside of the ship, the liquefied carbon dioxide L in the tank 21 can be vaporized and discharged from the upper portion in the tank 21 to the outside of the hull 2 through the external connection pipe 25B. Therefore, even in a case where the dry ice is generated in the tank 21, the liquefied carbon dioxide L can be favorably discharged from the tank 21.

[0050] In the second embodiment, the heat exchange part 30m of the circulation pipe 30B is disposed below the liquid level Lf with respect to the liquefied carbon dioxide L stored in the tank 21 in the vertical direction Dv. As a result, the circulation pipe 30B through which a fluid having a risen temperature circulates can be brought into direct contact with the liquefied carbon dioxide L. Therefore, the liquefied carbon dioxide L in the tank 21 can be efficiently heated, and the dry ice can be liquefied or be sublimated.

[0051] In the second embodiment, the ship 1B includes the connection pipe 48 that connects the circulation pipe 30B and the external connection pipe 25B, and the connection pipe opening-closing valve 49 that opens and closes the connection pipe 48. Accordingly, when the connection pipe opening-closing valve 49 is opened, the carbon dioxide gas G in the upper portion in the tank 21 can be introduced as a fluid, from the external connection pipe 25B connected to the upper portion in the tank 21 into the circulation pipe 30B, via the connection pipe 48. Thereafter, the connection pipe opening-closing valve 49 is closed, and the carbon dioxide gas G is pressure-fed by the compressor 41, so that the carbon dioxide gas G can be circulated while being heated in the circulation pipe 30B.

[0052] In the above-described second embodiment, the ship 1B includes the cooler 42 provided in the bypass pipe 32B. Accordingly, the carbon dioxide gas G compressed by the compressor 41 is cooled by the cooler 42, and the temperature rise of the liquefied carbon dioxide L in the tank 21 is suppressed by passing the cooled carbon dioxide gas G through the heat exchange part 30m. Accordingly, the liquefied carbon dioxide L in the tank 21 is suppressed from being vaporized during the navigation (transportation).

[0053] In addition, the ship 1B further includes the liquefied gas storage tank 22 capable of storing a liquefied gas having a lower boiling point than that of the liquefied carbon dioxide L. As a result, the liquefied gas stored in the liquefied gas storage tank 22 and the liquefied carbon dioxide L stored in the tank 21 can be mixed to be transported. The liquefied carbon dioxide L in the tank 21 can be achieved to be cooled by the cold heat of the liquefied gas having the lower boiling point than that of the liquefied carbon dioxide L, so that a suppression of a generation of dry ice, a suppression of a pressure rise of the tank 21 due to a sublimation of the dry ice, and a liquefaction of the carbon dioxide gas G vaporized in the tank 21 can be achieved.

(Modification Example of Second Embodiment)

[0054] In the second embodiment, the external connection pipe 25B and the circulation pipe 30B are connected via the connection pipe 48. However, the present disclosure is not limited thereto. The external connection pipe 25B and the circulation pipe 30B may be systems independent to each other, without being connected via the connection pipe 48. In that case, the circulation pipe 30B may introduce, for example, another fluid such as steam generated in a ship, not limited to the carbon dioxide gas G in the tank 21.

(Other Embodiments)

[0055] The embodiments of the present disclosure have been described in detail with reference to the drawings. However, the specific configuration is not limited to the embodiments of the present disclosure, and includes design changes and the like without departing from the gist of the present disclosure.

[0056] In the embodiments described above, a configuration is made in which the tank 21 is provided in the tank storage compartment 8 formed in the hull 2. However, the configuration is not limited thereto, for example, the tank 21 may be, for example, provided on the upper deck 5.

<Additional Notes>

[0057] The ships 1A and 1B described in each embodiment can be understood as follows, for example.

[0058]

(1) A ship 1A according to a first aspect including: a hull 2; a tank 21 provided in the hull 2 and capable of storing liquefied carbon dioxide L; an external connection pipe 25A connecting an upper portion in the tank 21 and an outside of the hull 2; a circulation pipe 30A of which one end 30s communicates with an inside of the tank 21 and of which the other end 30t communicates with the inside of the tank 21 via an outside of the tank 21; and a compressor 41 provided in a middle of the circulation pipe 30A outside the tank 21 and capable of pressure-feeding a fluid from the one end 30s to the other end 30t.

[0059] Examples of the fluid include a carbon dioxide gas G in which the liquefied carbon dioxide L in the tank 21 is vaporized.

[0060] In the ship 1A, when the compressor 41 pressure-feeds the fluid in the circulation pipe 30A, the fluid in the tank 21 (carbon dioxide gas G in which liquefied carbon dioxide L in tank 21 is vaporized) is sucked into the circulation pipe 30A from the one end 30s of the circulation pipe 30A. The carbon dioxide gas G sucked into the circulation pipe 30A passes through the compressor 41 and is returned to the inside of the tank 21 from the other end 30t of the circulation pipe 30A. The temperature of the carbon dioxide gas G rises by being compressed by the compressor 41. In this way, the carbon dioxide gas G that has passed through the compressor 41 so that the temperature has risen, is returned to the inside of the tank 21 from the other end 30t of the circulation pipe 30A. As a result, the temperature of the liquefied carbon dioxide L in the tank 21 rises. Accordingly, in a case where the dry ice is generated in the tank 21, the dry ice can be heated to be liquefied or be sublimated. When the liquefied carbon dioxide L in the tank 21 is discharged to the outside of the ship, the liquefied carbon dioxide L in the tank 21 is vaporized and discharged from the upper portion in the tank 21 to the outside of the hull 2 through the external connection pipe 25A. In this way, even in a case where the dry ice is generated in the tank 21, it is possible to favorably discharge the liquefied carbon dioxide L from the tank 21.

[0061] (2) The ship 1A according to a second aspect, which is the ship 1A of (1), in which the one end 30s of the circulation pipe 30A is disposed above a liquid level Lf of the liquefied carbon dioxide L stored in the tank 21, in the upper portion in the tank 21.

[0062] Accordingly, the liquefied carbon dioxide L is stored in the lower portion in the tank 21, and the carbon dioxide gas G in which the liquefied carbon dioxide L is vaporized is stored in the upper portion in the tank 21. The one end 30s of the circulation pipe 30A is disposed in the upper portion in the tank 21. Therefore, the carbon dioxide gas G in the upper portion in the tank 21 is sucked into the circulation pipe 30A as the fluid. The temperature of the carbon dioxide gas G is higher than the temperature of the liquefied carbon dioxide L in the tank 21. By compressing the above-described carbon dioxide gas G with the compressor 41, the carbon dioxide gas G having a higher temperature can be returned from the other end 30t of the circulation pipe 30A into the tank 21. Therefore, the dry ice in the tank 21 can be more efficiently heated to be liquefied or be sublimated.

[0063] (3) The ship 1A according to a third aspect, which is the ship 1A of (1) or (2), in which the other end 30t of the circulation pipe 30A is disposed below a liquid level Lf of the liquefied carbon dioxide L stored in the tank 21.

[0064] As a result, the fluid (carbon dioxide gas G in which the liquefied carbon dioxide L in the tank 21 is vaporized) that has passed through the compressor 41 so that the temperature has risen, is returned into the liquefied carbon dioxide L in the tank 21 from the other end 30t of the circulation pipe 30A. Accordingly, in a case where the dry ice is generated in the tank 21, the dry ice can be efficiently heated to be liquefied or be sublimated.

[0065] (4) The ship 1A according to a fourth aspect, which is the ship 1A of any one of (1) to (3), in which the external connection pipe 25A branches from the circulation pipe 30A between the one end 30s of the circulation pipe 30A and the compressor 41.

[0066] Accordingly, it is not necessary to separately connect the external connection pipe 25A and the one end 30s of the circulation pipe 30A to the tank 21, so that a time and effort of pipe installation and a pipe cost can be reduced.

[0067] (5) A ship 1B according to a fifth aspect including: a hull 2; a tank 21 provided in the hull 2 and capable of storing liquefied carbon dioxide L; an external connection pipe 25B connecting an upper portion in the tank 21 and an outside of the hull 2, a loop-shaped circulation pipe 30B provided such that a fluid circulates throughout an inside and an outside of the tank 21; and a compressor 41 provided in a middle of the circulation pipe 30B outside the tank 21 and capable of pressure-feeding the fluid in the circulation pipe 30B. Examples of the fluid include carbon dioxide gas G in which the liquefied carbon dioxide L in the tank 21 is vaporized, or steam used in a ship.

[0068] Accordingly, in the ship 1B, the compressor 41 pressure-feeds the fluid in the circulation pipe 30B, so that the fluid circulates in the loop-shaped circulation pipe 30B. The temperature of the fluid rises by being compressed by the compressor 41. The fluid in which the temperature has risen, circulates in the circulation pipe 30B, so that the temperature of the liquefied carbon dioxide L in the tank 21 rises. Accordingly, in a case where the dry ice is generated in the tank 21, the dry ice can be heated to be liquefied or be sublimated. When the liquefied carbon dioxide L in the tank 21 is discharged to the outside of the ship, the liquefied carbon dioxide L in the tank 21 is vaporized and discharged from the upper portion in the tank 21 to the outside of the hull 2 through the external connection pipe 25B. In this way, even in a case where the dry ice is generated in the tank 21, it is possible to favorably discharge the liquefied carbon dioxide L from the tank 21.

[0069] (6) The ship 1B according to a sixth aspect, which is the ship 1B of (5), in which a part 30m of the circulation pipe 30B is disposed below a liquid level Lf of the liquefied carbon dioxide L stored in the tank 21.

[0070] As a result, the circulation pipe 30B through which a fluid having a risen temperature circulates can be brought into direct contact with the liquefied carbon dioxide L. As a result, the liquefied carbon dioxide L in the tank 21 can be efficiently heated, and the dry ice can be liquefied or be sublimated.

[0071] (7) The ship 1B according to a seventh aspect, which is the ship 1B of (5) or (6), further including: the connection pipe 48 connecting the circulation pipe 30B and the external connection pipe 25B; and the connection pipe opening-closing valve 49 opening and closing the connection pipe 48.

[0072] The liquefied carbon dioxide L is stored in a lower portion in the tank 21, and the carbon dioxide gas G in which the liquefied carbon dioxide L is vaporized is stored in an upper portion of the tank 21. When the connection pipe opening-closing valve 49 is opened, the carbon dioxide gas G in the upper portion in the tank 21 flows into the circulation pipe 30B as a fluid via the connection pipe 48 from the external connection pipe 25B connected to the upper portion in the tank 21. Thereafter, the connection pipe opening-closing valve 49 is closed and the fluid is pressure-fed by the compressor 41, so that the fluid can be circulated while being heated in the circulation pipe 30B.

[0073] (8) The ships 1A and 1B according to an eighth aspect, which are the ships 1A and 1B of any one of (1) to (7), further including: bypass pipes 32A and 32B provided to be bypassed from circulation pipes 30A and 30B on a downstream side in a flow direction of the fluid in the circulation pipes 30A and 30B with respect to the compressor 41; and the cooler 42 provided in the bypass pipes 32A and 32B and cools the fluid that has passed through the compressor 41.

[0074] As a result, the fluid compressed by the compressor 41 is cooled by the cooler 42 and is returned to the tank 21, so that the temperature rise of the liquefied carbon dioxide L in the tank 21 is suppressed. Accordingly, the liquefied carbon dioxide L in the tank 21 is suppressed from being vaporized.

[0075] (9) The ships 1A and 1B according to a ninth aspect, which are the ships 1A and 1B of any one of (1) to (8), further including: the liquefied gas storage tank 22 provided in the hull 2 and capable of storing a liquefied gas having a lower boiling point than that of the liquefied carbon dioxide L.

[0076] As a result, the liquefied gas stored in the liquefied gas storage tank 22 and the liquefied carbon dioxide L stored in the tank 21 can be mixed to be transported. The liquefied carbon dioxide L in the tank 21 can be achieved to be cooled by the cold heat of the liquefied gas having the lower boiling point than that of the liquefied carbon dioxide L, so that a suppression of a generation of dry ice, a suppression of a pressure rise of the tank 21 due to a sublimation of the dry ice, and a liquefaction of the carbon dioxide gas G vaporized in the tank 21 can be achieved.

Industrial Applicability

[0077] According to the ship of the present disclosure, even in a case where the dry ice is generated in the tank, the liquefied carbon dioxide can be favorably discharged from the tank.

Reference Signs List

[0078]

1A, 1B:	ship
2:	hull
2a:	bow
2b:	stern
3A, 3B:	broad side
5:	upper deck
7:	superstructure
8:	tank storage compartment
21:	tank
22:	liquefied gas storage tank
25A, 25B:	external connection pipe
25s, 25v:	tank side end portion
25t, 25w:	broad side end portion
30A, 30B:	circulation pipe
30m:	heat exchange part (part)
30n:	remaining portion
30s:	one end
30t:	the other end
30u:	intermediate portion
32A, 32B:	bypass pipe
33:	first opening-closing valve
34:	second opening-closing valve

35:	third opening-closing valve
36:	fourth opening-closing valve
40:	refrigeration device
41:	compressor
42:	cooler
48:	connection pipe
49:	connection pipe opening-closing valve
Da:	bow-stern direction
Dv:	vertical direction
G:	carbon dioxide gas
L:	liquefied carbon dioxide
Lf:	liquid level

Claims

1. A ship comprising:

a hull;
a tank provided in the hull and capable of storing liquefied carbon dioxide;
an external connection pipe connecting an upper portion in the tank and an outside of the hull;
a circulation pipe of which one end communicates with an inside of the tank and of which the other end communicates with the inside of the tank via an outside of the tank; and
a compressor provided in a middle of the circulation pipe outside the tank and capable of pressure-feeding a fluid from the one end toward the other end.

2. The ship according to Claim 1,
wherein the one end of the circulation pipe is disposed above a liquid level of the liquefied carbon dioxide stored in the tank, in the upper portion in the tank.

3. The ship according to Claim 1 or 2,
wherein the other end of the circulation pipe is disposed below a liquid level of the liquefied carbon dioxide stored in the tank.

4. The ship according to any one of Claims 1 to 3,
wherein the external connection pipe branches from the circulation pipe between the one end of the circulation pipe and the compressor.

5. A ship comprising:

a hull;
a tank provided in the hull and capable of storing liquefied carbon dioxide;
an external connection pipe connecting an upper portion in the tank and an outside of the hull;
a loop-shaped circulation pipe provided such that a fluid circulates throughout an inside and an outside of the tank; and
a compressor provided in a middle of the circulation pipe outside the tank and capable of pressure-feeding the fluid in the circulation pipe.

6. The ship according to Claim 5,
wherein a part of the circulation pipe is disposed below a liquid level of the liquefied carbon dioxide stored in the tank.

7. The ship according to Claim 5 or 6, further comprising:

a connection pipe connecting the circulation pipe and the external connection pipe; and
a connection pipe opening-closing valve opening and closing the connection pipe.

8. The ship according to any one of Claims 1 to 7, further comprising:

a bypass pipe provided to be bypassed from the circulation pipe on a downstream side in a flow direction of the fluid in the circulation pipe with respect to the compressor; and
a cooler provided to the bypass pipe and cooling the fluid that has passed through the compressor.

9. The ship according to any one of Claims 1 to 8, further comprising:
a liquefied gas storage tank provided in the hull and capable of storing a liquefied gas having a boiling point lower than a boiling point of the liquefied carbon dioxide.

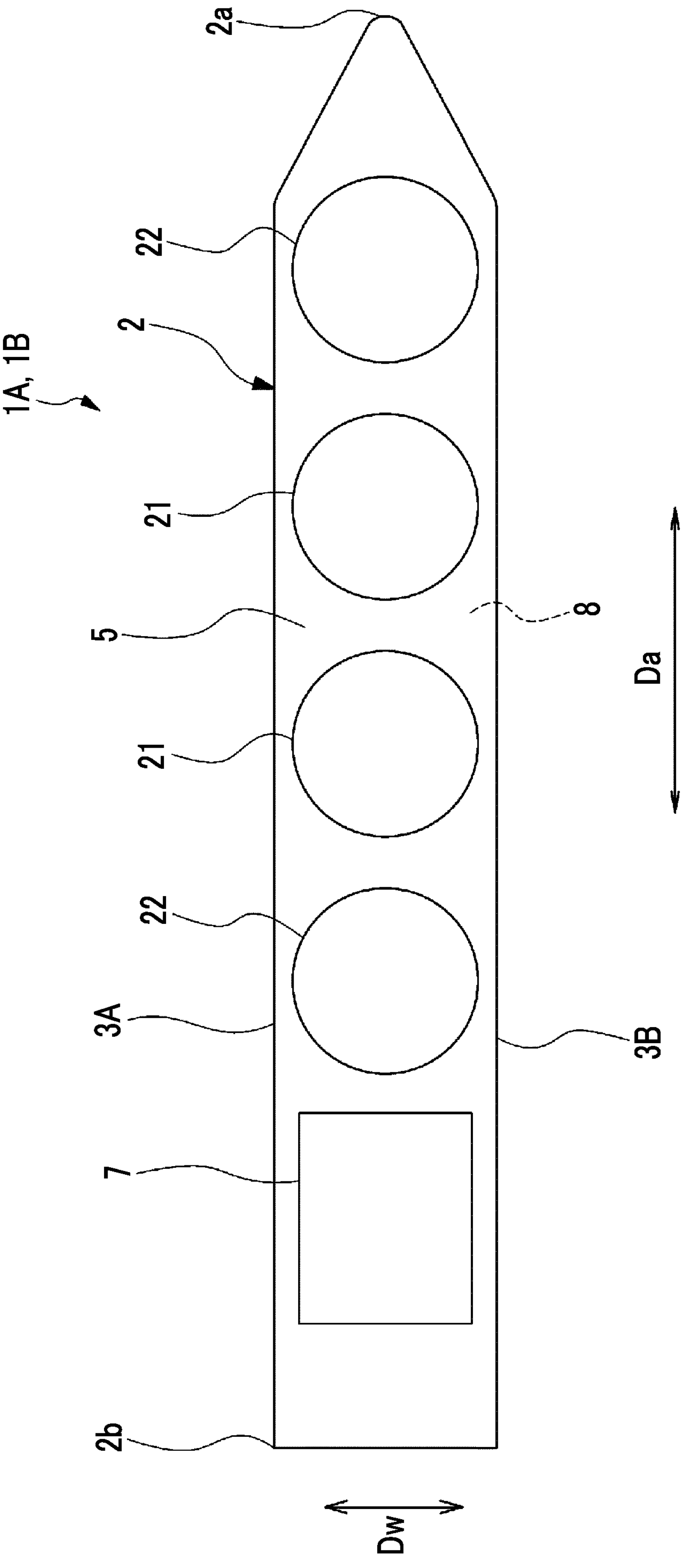
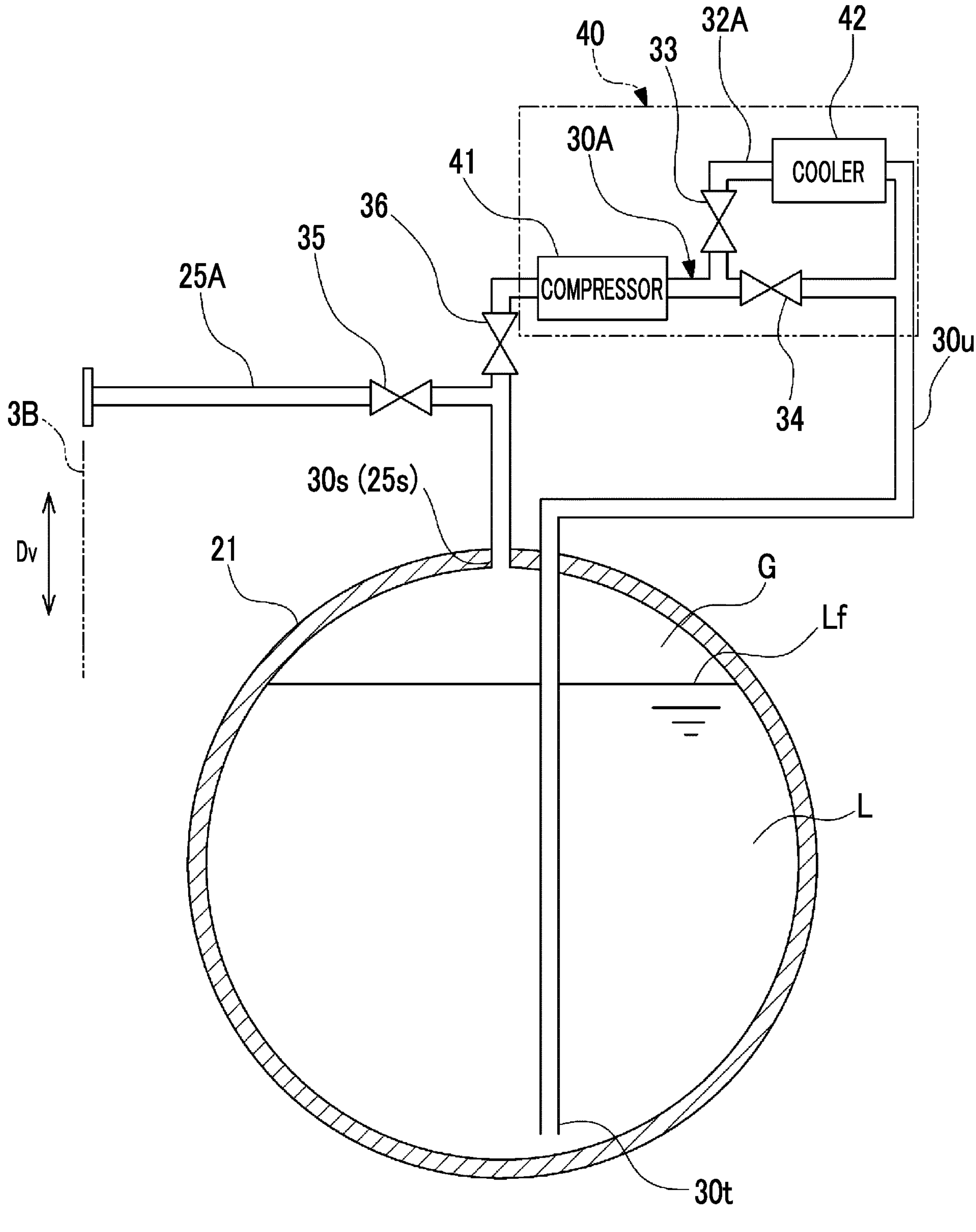


FIG. 1

FIG. 2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32A
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30A
COOLER
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COMPRESSOR
25A
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3B
30s (25s)
Dv
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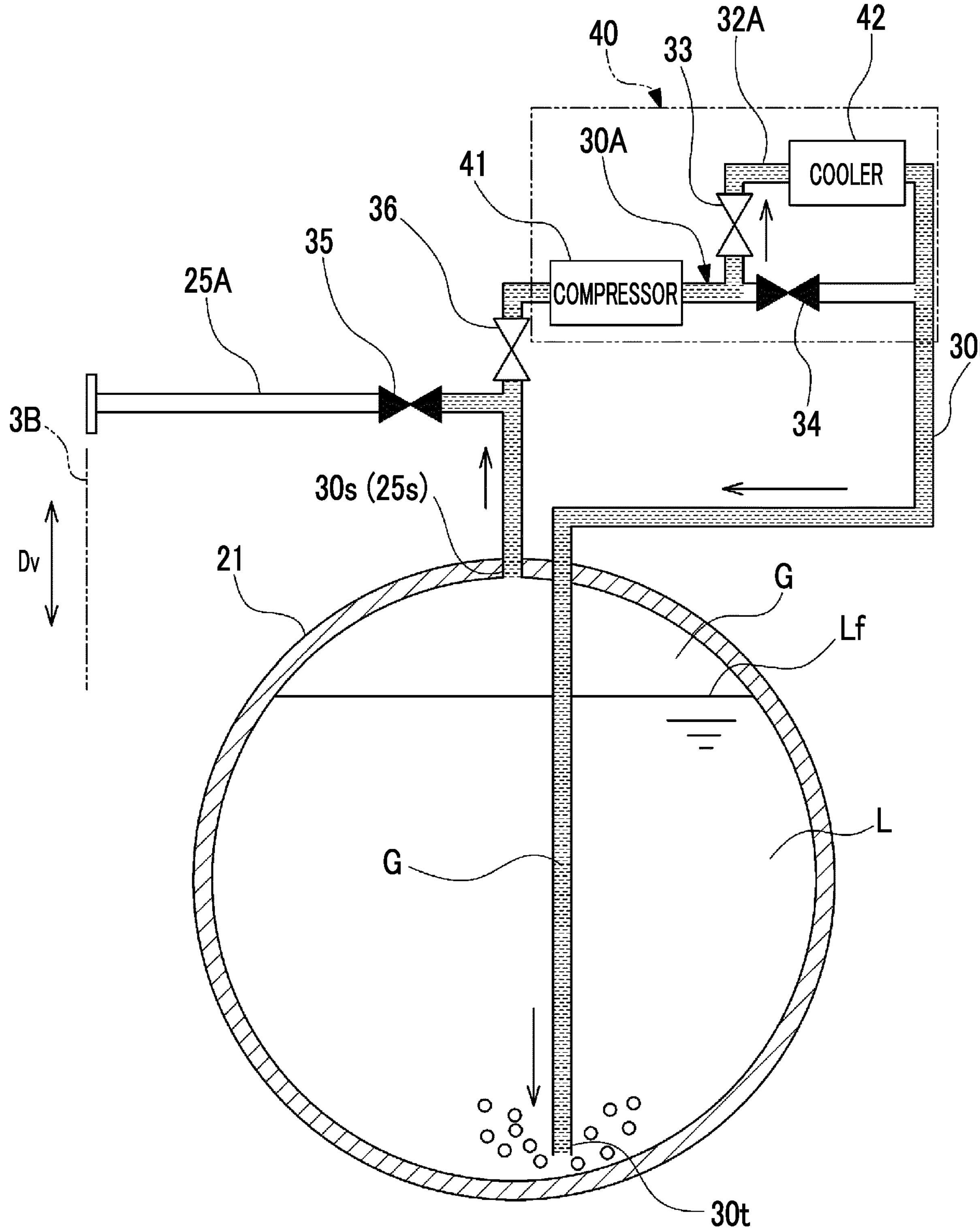
G
Lf
L
30t

FIG. 3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Lf
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FIG. 4

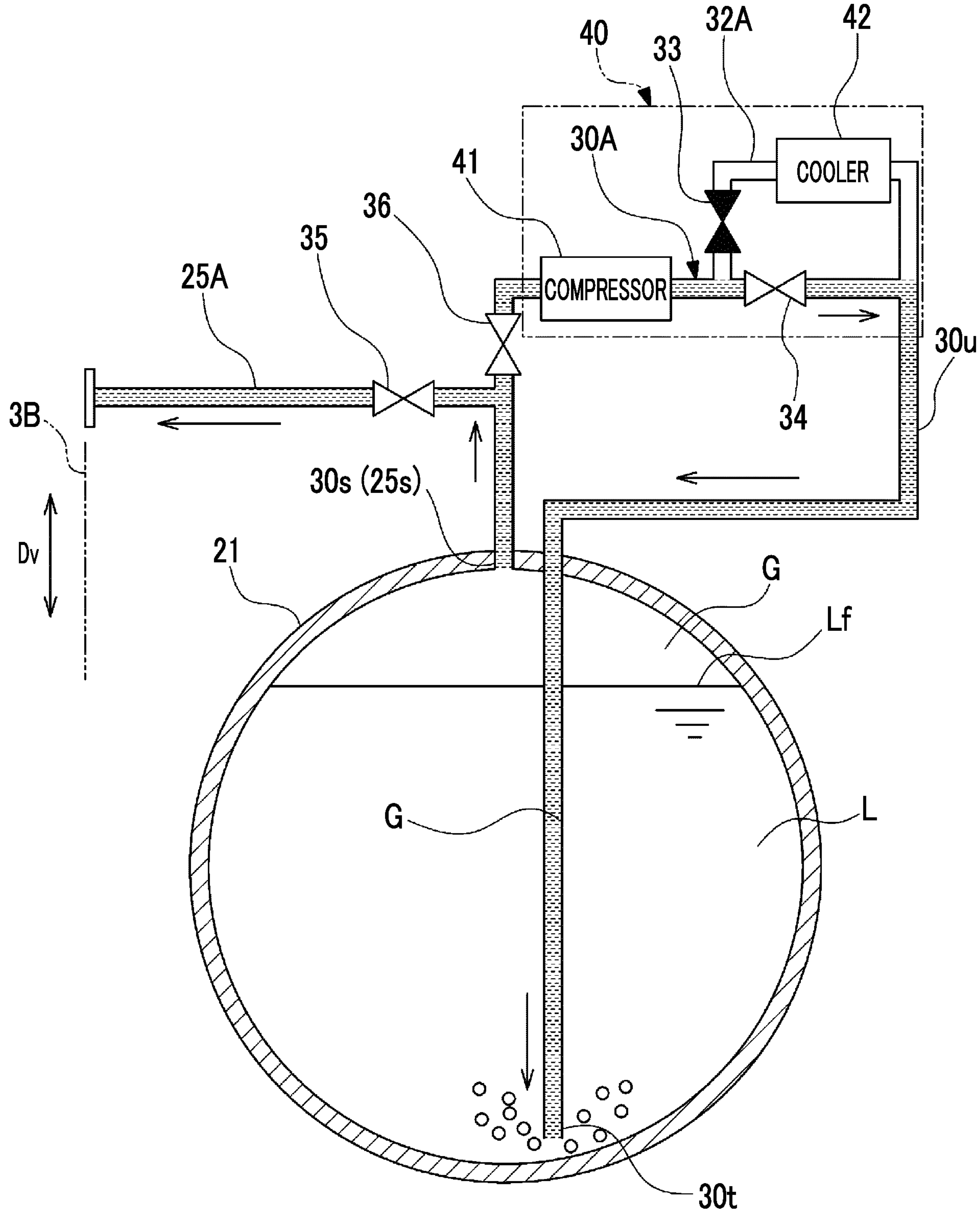
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FIG. 5

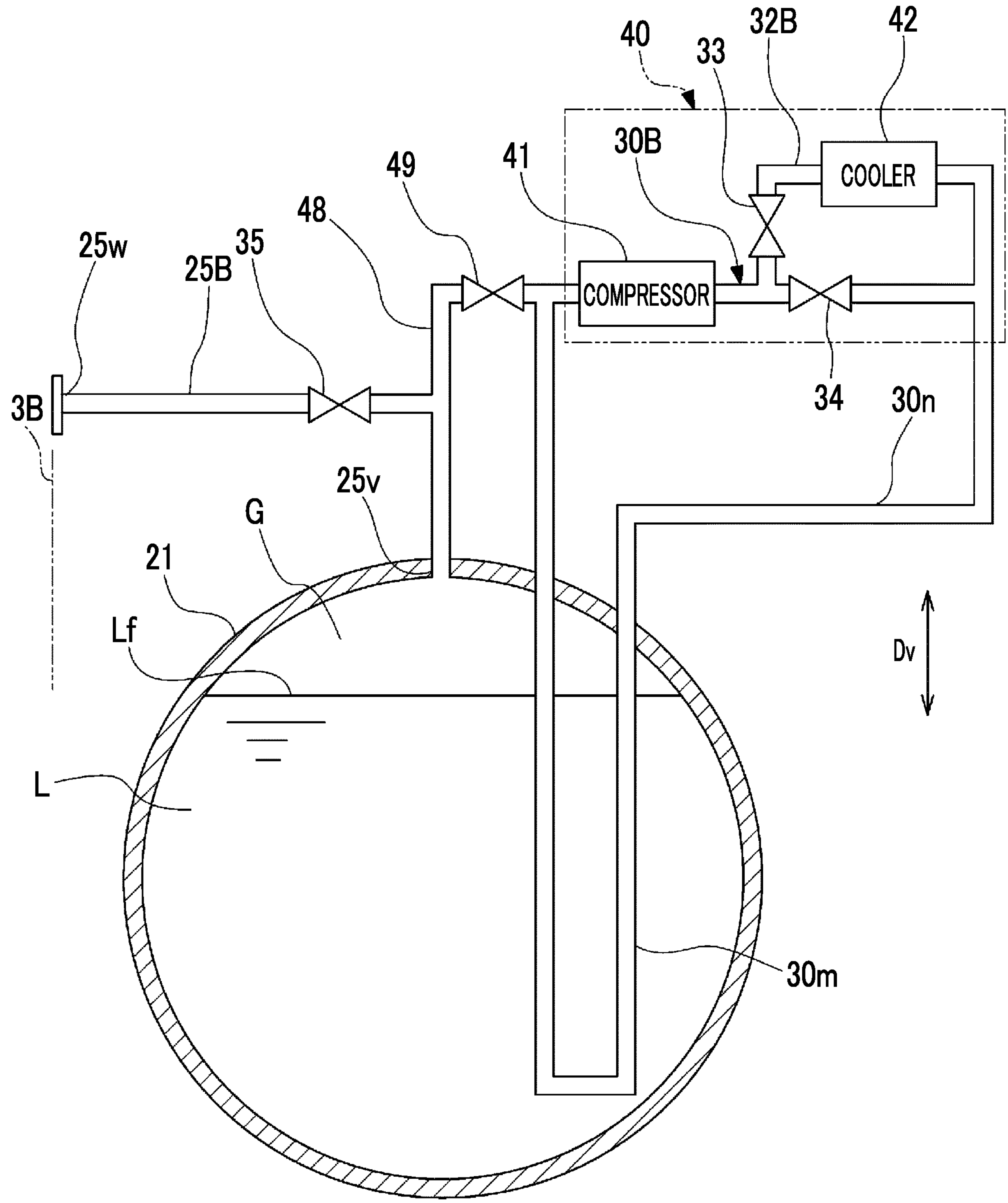
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FIG. 6

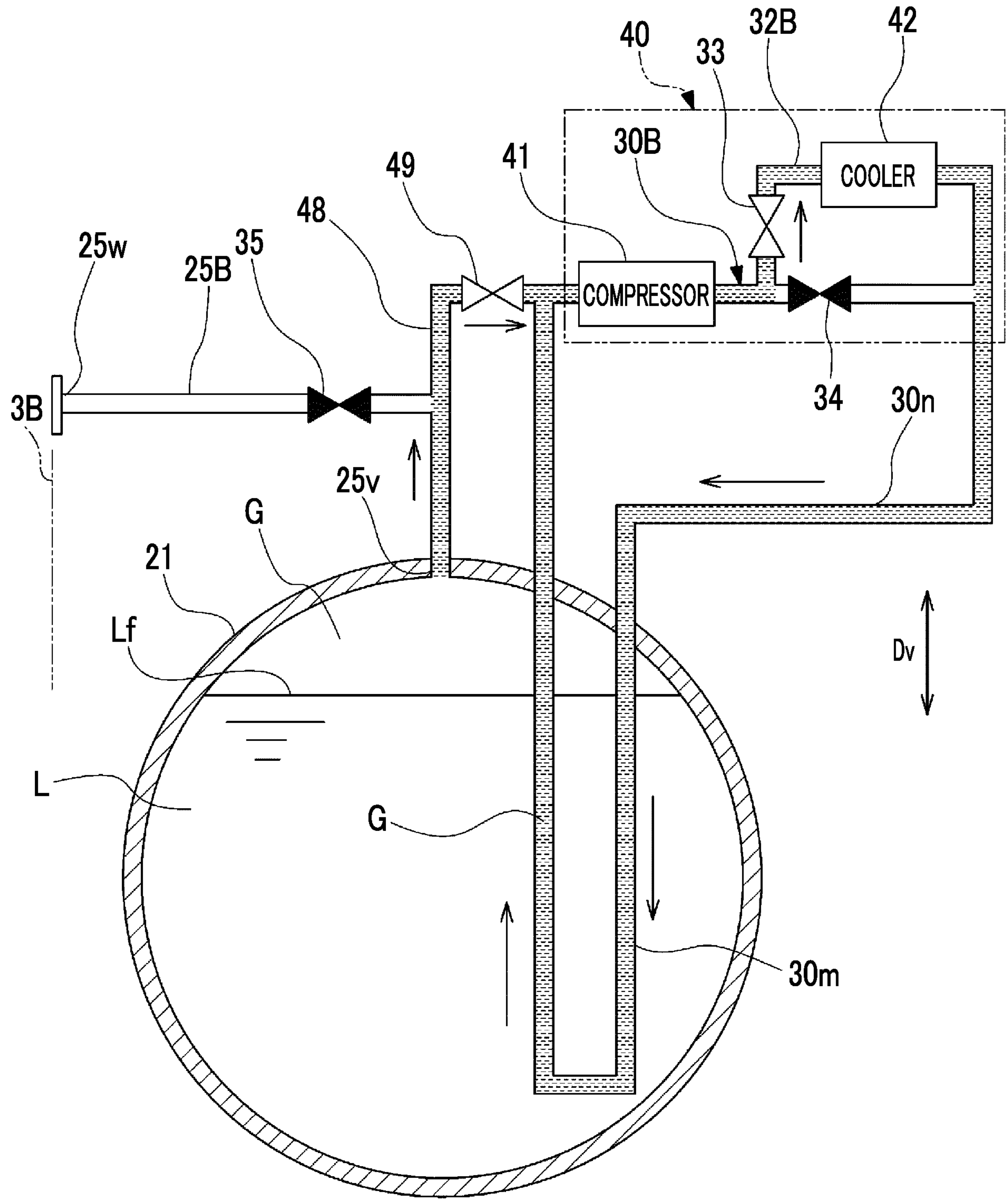
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FIG. 7

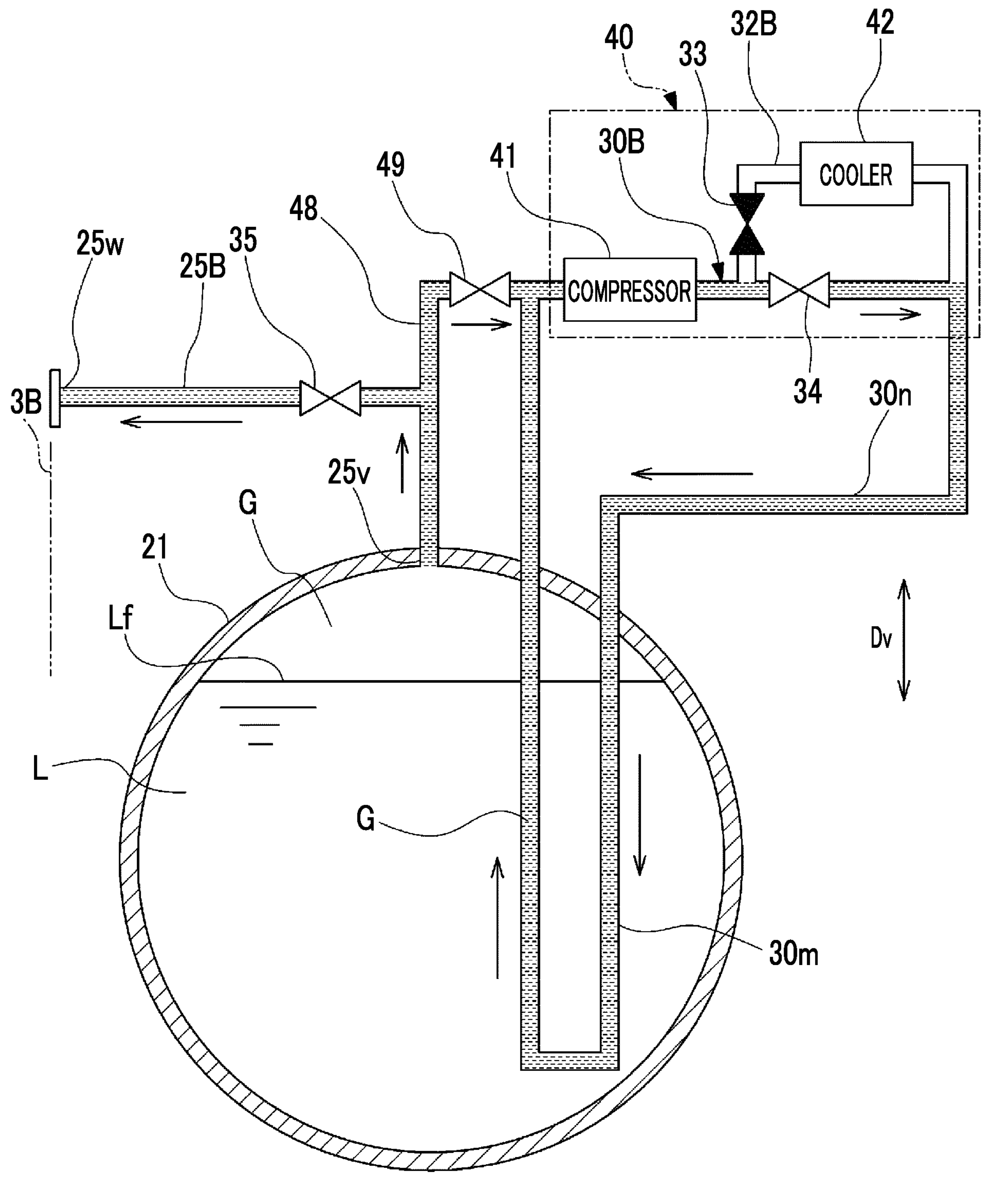
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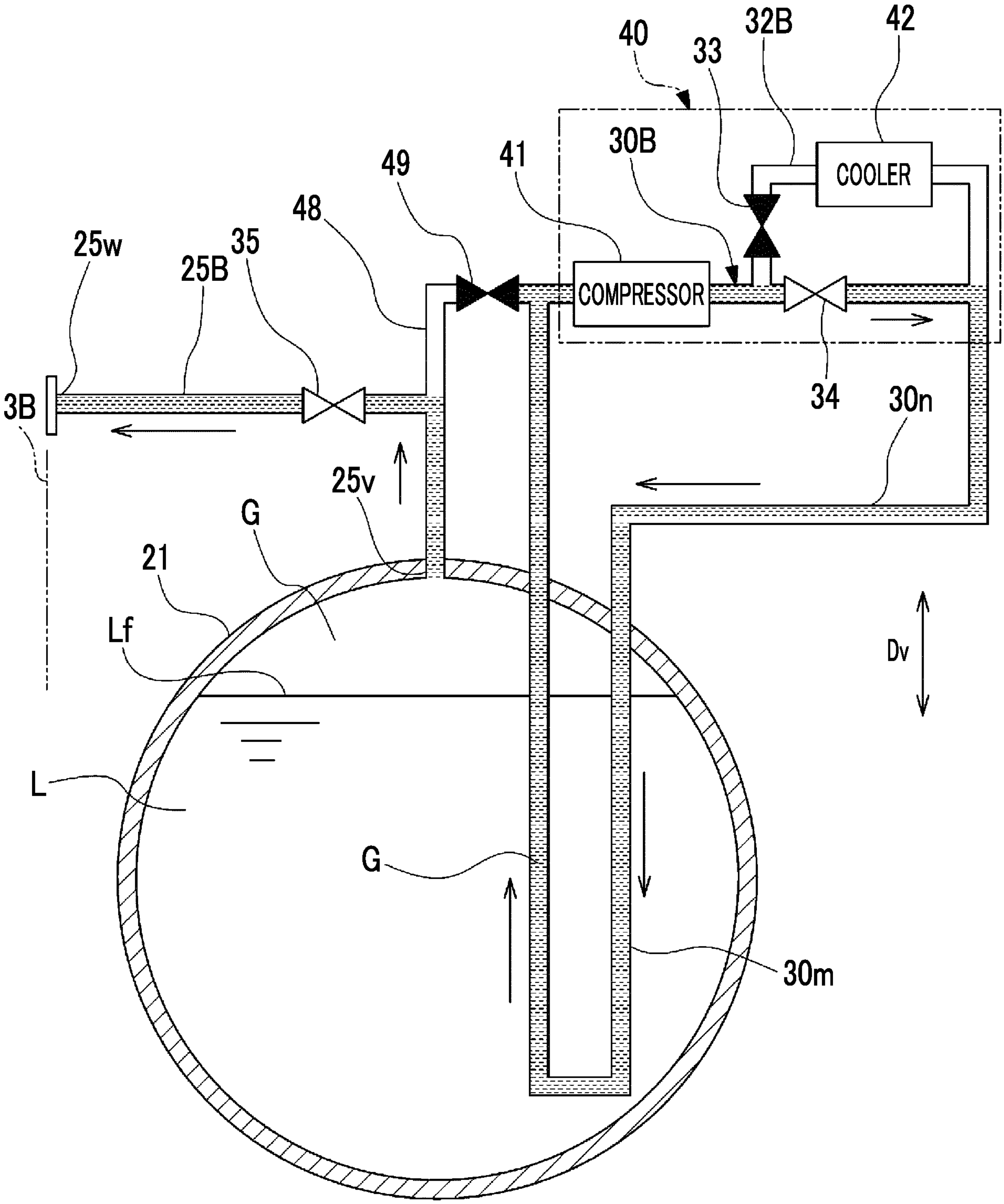
FIG. 8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COMPRESSOR
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/040614

A. CLASSIFICATION OF SUBJECT MATTER

B63B 25/08(2006.01)i
FI: B63B25/08 B

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)

B63B25/08

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-1751857 B1 (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 28 June 2017 (2017-06-28) paragraphs [0029]-[0053], fig. 1	1-4, 9
Y	KR 10-2011-0048264 A (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 11 May 2011 (2011-05-11) paragraphs [0030]-[0056], fig. 1-6	1-4, 9
A	JP 2019-518909 A (INNOVATIVE CRYOGENIC SYSTEMS, INC.) 04 July 2019 (2019-07-04) entire text, all drawings	5-9

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

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Date of the actual completion of the international search	Date of mailing of the international search report
07 January 2022	**18 January 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/040614

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	上野トランステック株式会社,日揮株式会社,千代田化工建設株式会社,国立大学法人東京大学,大成建設株式会社. 環境配慮型CCS実証事業—輸送技術について—. CCUSの早期社会実装会議(第3回)資料1-2. Ministry of the Environment, 03 August 2021, pp. 2-12, (UYENO TRANSTECH LTD., JGC HOLDINGS CORPORATION, CHIYODA CORPORATION, THE UNIVERSITY OF TOKYO, TAISEI CORPORATION), non-official translation (Environmentally Conscious CCS Demonstration Business: Shipping Technologies. International CCUS Symposium for Low-Carbon Society (III), Handout 1-2.) pp. 6-9	1-9
A	Shipping CO2 - UK Cost Estimation Study Final report, Element Energy Limited, November 2018, pp. 1-61 pp. 6-19	1-9
E, X	JP 2021-176728 A (MITSUBISHI SHIPBUILDING CO., LTD.) 11 November 2021 (2021-11-11) claims 1-9	1-9

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/040614

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
KR 10-1751857 B1	28 June 2017	(Family: none)	
KR 10-2011-0048264 A	11 May 2011	(Family: none)	
JP 2019-518909 A	04 July 2019	WO 2017/192137 A1 entire text, all drawings KR 10-2018-0028414 A CN 109563968 A	
JP 2021-176728 A	11 November 2021	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2016536209 W **[0003]**