(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) **EP 4 296 155 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
27.12.2023 Bulletin 2023/52

(21) Application number: **22780536.3**

(22) Date of filing: **25.03.2022**

(51) International Patent Classification (IPC):
B63B 25/16 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B63B 25/16

(86) International application number:
PCT/JP2022/014236

(87) International publication number:
WO 2022/210322 (06.10.2022 Gazette 2022/40)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **31.03.2021 JP 2021059785**

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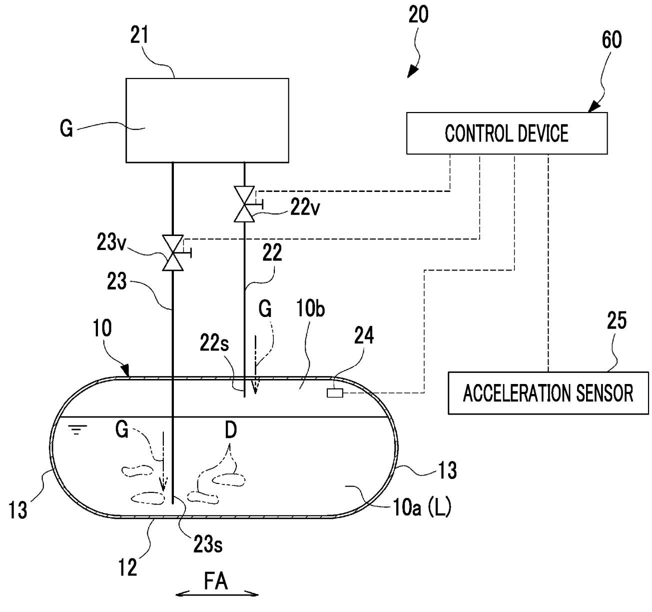
(54) **WATERCRAFT, AND METHOD FOR ADJUSTING PRESSURE OF TANK IN WATERCRAFT**

(57) This watercraft includes: a hull; a tank that is provided to the hull and stores liquefied carbon dioxide; and a carbon dioxide injection unit that is provided to the hull and can inject, into the tank, carbon dioxide gas which is at a higher temperature and a higher pressure than the carbon dioxide in the tank.

FIG. 2



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Description

Technical Field

[0001] The present disclosure relates to a watercraft and a method for adjusting a pressure of a tank in a watercraft.

[0002] This application claims priority to Japanese Patent Application No. 2021-059785, filed in Japan on March 31, 2021, the contents of which are incorporated herein by reference.

Background Art

[0003] PTL 1 discloses a configuration for transporting dry ice precipitated by spraying liquid carbon dioxide in a shipyard.

[0004] Further, PTL 2 discloses that carbon dioxide is transported in a state of compressed carbon dioxide gas at room temperature (for example, 0°C to 30°C) under a tank pressure of 15 kg/cm^2.

Citation List

Patent Literature

[0005]

[PTL 1] Japanese Unexamined Patent Application Publication No. H5-180394

[PTL 2] Japanese Unexamined Patent Application Publication No. 2004-125039

Summary of Invention

Technical Problem

[0006] Incidentally, in a case where the liquefied carbon dioxide is accommodated in the tank provided in the hull, the liquefied carbon dioxide may solidify to generate dry ice for the following reasons. That is, the pressure of the liquefied carbon dioxide in the tank corresponds to a tank operating pressure. In the liquefied carbon dioxide, the pressure at the triple point (triple point pressure) at which the gas phase, the liquid phase, and the solid phase coexist is higher than the triple point pressure of the liquefied natural gas (LNG) or liquefied petroleum gas (LPG), and may reach the triple point when the tank is depressurized during operation.

[0007] When the pressure of the liquefied carbon dioxide is equal to or lower than the triple point pressure, flash evaporation of the liquefied carbon dioxide may occur. Then, due to the latent heat of evaporation of the flash evaporation of the liquefied carbon dioxide, a decrease in temperature of the liquefied carbon dioxide remaining without evaporation occurs, and there is a possibility that the liquefied carbon dioxide solidifies in the tank to generate dry ice. Therefore, the tank operating pressure (tank design pressure) is set such that the pressure of the liquefied carbon dioxide does not fall below the triple point pressure. However, in a case where the tank operating pressure is set to be significantly higher than the triple point pressure of liquefied carbon dioxide, the tank itself and the pipes connected to the tank have to have a pressure-resistant structure according to the tank operating pressure (tank design pressure), which leads to an increase in cost.

[0008] Further, for example, in a case where the liquefied carbon dioxide in the tank shakes due to the swing of the hull, the dynamic pressure of the liquefied carbon dioxide is increased according to the flow velocity of the liquefied carbon dioxide, and the static pressure of the liquefied carbon dioxide is decreased. Due to the decrease in the static pressure of the liquefied carbon dioxide in the tank generated in this manner, there is a possibility that the liquefied carbon dioxide solidifies in the tank to generate dry ice.

[0009] Since the density of dry ice is higher than that of the liquefied carbon dioxide, in a case where the dry ice is formed in the tank, the dry ice settles and is accumulated on a tank bottom portion, and thus there is a possibility that it may take time for the dry ice to sublimate even after the pressure in the tank is restored.

[0010] The present disclosure has been made in order to solve the above subject, and has an object to provide a watercraft and a method for adjusting the pressure of the tank in the watercraft which can suppress the generation of the dry ice and smoothly operate the tank.

Solution to Problem

[0011] In order to solve the above subject, a watercraft according to the present disclosure includes a hull, a tank, and a carbon dioxide injection unit. The tank is provided in the hull. The tank stores liquefied carbon dioxide. The carbon dioxide injection unit is provided in the hull. The carbon dioxide injection unit is capable of injecting carbon dioxide gas which has a higher temperature and a higher pressure than those of carbon dioxide in the tank, into the tank.

[0012] A method for adjusting a pressure of a tank in a watercraft according to the present disclosure is a method for adjusting the pressure of the tank in the watercraft described above, and includes a step of acquiring information, and a step of injecting the carbon dioxide gas into the tank. In the step of acquiring the information, at least one of information regarding a pressure in the tank, and information regarding shaking of the liquefied carbon dioxide stored in the tank is acquired. In the step of injecting the carbon dioxide gas into the tank, the carbon dioxide gas is injected into the tank by the carbon dioxide injection unit on the basis of the acquired information.

Advantageous Effects of Invention

[0013] According to the watercraft and the method for adjusting the pressure of the tank in the watercraft according to the present disclosure, it is possible to suppress the generation of the dry ice and smoothly operate the tank.

Brief Description of Drawings

[0014]

Fig. 1 is a plan view illustrating a schematic configuration of a watercraft according to an embodiment of the present disclosure.
Fig. 2 is a diagram illustrating a schematic configuration of a carbon dioxide injection unit according to the embodiment of the present disclosure.
Fig. 3 is a diagram illustrating a hardware configuration of a control device of the carbon dioxide injection unit according to the embodiment of the present disclosure.
Fig. 4 is a functional block diagram of the control device according to the embodiment of the present disclosure.
Fig. 5 is a flowchart illustrating a procedure of a method for adjusting a pressure of a tank in the watercraft according to the embodiment of the present disclosure. Description of Embodiments

[0015] Hereinafter, a watercraft according to an embodiment of the present disclosure will be described with reference to the drawings.

(Overall configuration of watercraft)

[0016] Fig. 1 is a plan view illustrating a schematic configuration of the watercraft according to the embodiment of the present disclosure. Fig. 2 is a diagram illustrating a schematic configuration of a carbon dioxide injection unit according to the embodiment of the present disclosure.

[0017] As illustrated in Figs. 1 and 2, a watercraft 1 of the embodiment mainly includes a hull 2, a tank 10, and a carbon dioxide injection unit 20. The watercraft 1 carries the liquefied carbon dioxide.

[0018] As illustrated in Fig. 1, the hull 2 has a pair of broadsides 3A and 3B, and a watercraft bottom (not illustrated), which form the outer shell of the hull 2. The broadsides 3A and 3B include a pair of broadside skins respectively forming right and left broadsides. The watercraft bottom (not illustrated) is provided with a watercraft bottom skin connecting the broadsides 3A and 3B. The pair of broadsides 3A and 3B and the watercraft bottom (not illustrated) cause the outer shell of the hull 2 to have a U-shape in a cross section orthogonal to a bow-stern direction FA.

[0019] The hull 2 further includes an upper deck 5 that is a through deck which is disposed in the uppermost layer. A superstructure 7 is formed on the upper deck 5. An accommodation space and the like are provided in the superstructure 7. In the watercraft 1 of the present embodiment, for example, a cargo space 8 for loading cargo is provided on the side closer to a bow 2a than the superstructure 7 in the bow-stern direction FA.

(Configuration of tank)

[0020] The tank 10 is provided in the hull 2. A plurality of tanks 10 are disposed in the cargo space 8 along the bow-stern direction FA. In the embodiment of the present disclosure, two tanks 10 are disposed at an interval in the bow-stern direction FA. As illustrated in Fig. 2, the tank 10 stores liquefied carbon dioxide L inside the tank 10. The pressure in the tank 10 is, for example, about 0.55 to 2.0 MPaG. The temperature of the liquefied carbon dioxide L stored in the tank 10 is, for example, about -50°C to -20°C.

[0021] The tank 10 has, for example, a cylindrical shape extending in the horizontal direction. The tank 10 includes a tubular portion 12, and an end spherical portion 13. The tubular portion 12 extends in the horizontal direction as a longitudinal direction. In the present embodiment, the tubular portion 12 is formed in a cylindrical shape having a circular cross-sectional shape orthogonal to the longitudinal direction. The end spherical portions 13 are respectively disposed at both end portions of the tubular portion 12 in the longitudinal direction. Each end spherical portion 13 has a hemispherical shape, and blocks an opening at both ends of the tubular portion 12 in the longitudinal direction. The tank 10 is not limited to a cylindrical shape, and the tank 10 may have a spherical shape, a square shape, or the like.

(Configuration of carbon dioxide injection unit)

[0022] As illustrated in Fig. 2, the carbon dioxide injection unit 20 is configured to be capable of injecting carbon dioxide gas G having a higher temperature and a higher pressure than those of the carbon dioxide (liquid phase 10a and gas phase 10b) in the tank 10, into the tank 10. The carbon dioxide injection unit 20 is provided in the hull 2. The carbon dioxide injection unit 20 includes a gas tank 21, a first injection pipe 22, a second injection pipe 23, a pressure sensor 24, an acceleration sensor 25, and a control device 60.

[0023] The gas tank 21 accommodates the carbon dioxide gas G. The pressure of the carbon dioxide gas G stored in the gas tank 21 is, for example, 5 to 15.7 MPaG. The temperature of the carbon dioxide gas G stored in the gas tank 21 is room temperature, for example, about 15°C to 45°C. Since the gas tank 21 accommodates the carbon dioxide gas G at room temperature, the gas tank 21 does not necessarily have to be heat-resistant. The gas tank 21 may be provided in the cargo space 8, or may be appropriately provided in another place such as above the upper deck 5.

[0024] Each of the first injection pipe 22 and the second injection pipe 23 forms a flow path for injecting the carbon dioxide gas G in the gas tank 21 into the tank 10. The base end portion of the first injection pipe 22 and the base end portion of the second injection pipe 23 are respectively connected to the gas tank 21. The tip portion 22s of the first injection pipe 22 is open into the gas phase 10b in the tank 10 at the upper portion in the tank 10. The tip portion 23s of the second injection pipe 23 is open into the liquid phase 10a (liquefied carbon dioxide L) in the tank 10 at the bottom portion of the tank 10.

[0025] The first injection pipe 22 includes an opening-closing valve 22v, and the second injection pipe 23 includes an opening-closing valve 23v. By opening and closing the opening-closing valve 22v, the injection of the carbon dioxide gas G into the tank 10 by the first injection pipe 22 is intermittent, and by opening and closing the opening-closing valve 23v, the injection of the carbon dioxide gas G into the tank 10 by the second injection pipe 23 is intermittent. In this embodiment, the opening and closing operation of the opening-closing valves 22v and 23v is automatically controlled by the control device 60. The opening and closing operation of the opening-closing valves 22v and 23v may be manually performed by, for example, an operator.

[0026] The pressure sensor 24 acquires information regarding the pressure in the tank 10. More specifically, the pressure sensor 24 detects the pressure of the gas phase 10b in the tank 10. The pressure sensor 24 outputs the detected pressure data toward the control device 60.

[0027] The acceleration sensor 25 acquires information regarding the shaking (sloshing) of the liquid phase 10a in the tank 10. In this embodiment, the acceleration sensor 25 detects the acceleration caused by the shaking of the hull 2, as the information regarding the shaking of the liquid phase 10a in the tank 10. The acceleration sensor 25 detects, for example, the acceleration caused by the shaking (pitching) of the hull 2 in the bow-stern direction FA and the shaking (rolling) of the hull 2 in the watercraft width direction. The acceleration sensor 25 may be provided at a plurality of places on the hull 2. The acceleration sensor 25 outputs the detected acceleration data toward the control device 60.

(Hardware configuration diagram)

[0028] As illustrated in Fig. 3, the control device 60 is a computer that includes a central processing unit (CPU) 61, a read only memory (ROM) 62, a random access memory (RAM) 63, a hard disk drive (HDD) 64, and a signal receiving module 65. The signal receiving module 65 receives the detection signal from the pressure sensor 24 and the acceleration sensor 25.

(Functional block diagram)

[0029] As illustrated in Fig. 4, the CPU 61 of the control device 60 executes a program stored in the HDD 64, the ROM 62, or the like in advance to realize a functional configuration of each of a signal input unit 70, a determination unit 71, an opening and closing control unit 72, and an output unit 75.

[0030] The signal input unit 70 receives the detection signal from the pressure sensor 24 and the acceleration sensor 25, that is, data of the detection value of the pressure of the gas phase 10b in the tank 10 and the data of the detection value of the acceleration generated by the shaking of the hull 2, via the signal receiving module 65.

[0031] The determination unit 71 determines the necessity of the injection of the carbon dioxide gas G from the gas tank 21 to the tank 10, on the basis of the detection signals from the pressure sensor 24 and the acceleration sensor 25 received by the signal input unit 70.

[0032] The opening and closing control unit 72 controls opening and closing of the opening-closing valve 22v and opening and closing of the opening-closing valve 23v on the basis of the determination result of the necessity of the injection of the carbon dioxide gas G in the determination unit 71. The opening and closing control unit 72 sends a control signal for opening and closing the opening-closing valves 22v and 23v to the output unit 75.

[0033] The output unit 75 outputs the control signal sent from the opening and closing control unit 72 to the opening-closing valve 22v and the opening-closing valve 23v.

(Procedure of method for adjusting pressure of tank)

[0034] As illustrated in Fig. 5, a method S1 for adjusting the pressure of the tank 10 according to the embodiment of the present disclosure includes a step S2 of acquiring information, a step S3 of determining the necessity of the injection, a step S4 of injecting the carbon dioxide gas into the tank, and a step S5 of stopping the injection of the carbon dioxide gas.

[0035] In step S2 of acquiring information, the control device 60 acquires detection signals from the pressure sensor 24 and the acceleration sensor 25. The detection signals from the pressure sensor 24 and the acceleration sensor 25 are received by the signal input unit 70. The control device 60 acquires the detection value of the pressure of the gas phase 10b in the tank 10 from the pressure sensor 24, as the information regarding the pressure in the tank 10. The control device 60 acquires the detection value of the acceleration due to the shaking of the hull 2 from the acceleration sensor 25, as the information regarding the shaking of the liquefied carbon dioxide L stored in the tank 10.

[0036] In step S3 of determining the necessity of the injection, the control device 60 determines the necessity of the injection of the carbon dioxide gas G from the gas tank 21 to the tank 10 by the determination unit 71. The determination unit 71 determines the necessity of the injection of the carbon dioxide gas G on the basis of at least one of the information regarding the pressure in the tank 10 acquired in step S2 and the information regarding the shaking of the liquefied carbon dioxide L stored in the tank 10.

[0037] For example, in a case where the pressure in the tank 10 is equal to or lower than a predetermined pressure lower limit value, the determination unit 71 determines that the injection of the carbon dioxide gas G into the tank 10 is necessary. The predetermined pressure lower limit value is set to be equal to or higher than the triple point pressure of the liquefied carbon dioxide L. Furthermore, for example, in a case where the acceleration generated in the hull 2 is equal to or higher than a predetermined threshold value, the determination unit 71 determines that the injection of the carbon dioxide gas G into the tank 10 is necessary.

[0038] Here, a state in which the acceleration generated in the hull 2 is equal to or higher than a predetermined threshold value is a state in which the shaking of the liquefied carbon dioxide L stored in the tank 10 is equal to or greater than a predetermined level. In a state where the shaking of the liquefied carbon dioxide L stored in the tank 10 is equal to or greater than a predetermined level in this manner, there is a possibility that the shaking of the liquefied carbon dioxide L stored in the tank 10 causes a decrease in the static pressure in the tank, and thus the liquefied carbon dioxide L in the tank solidifies. In other words, for example, in a case where the acceleration generated in the hull 2 is smaller than a predetermined threshold value, the solidification of the liquefied carbon dioxide L caused by the shaking of the liquefied carbon dioxide L stored in the tank 10 does not substantially occur.

[0039] That is, for example, in a case where the acceleration generated in the hull 2 is equal to or higher than the threshold value even in a case where the pressure in the tank 10 is not equal to or lower than the pressure lower limit value, the determination unit 71 determines that the injection of the carbon dioxide gas G into the tank 10 is necessary. Then, even in a case where the acceleration generated in the hull 2 is not equal to or higher than the threshold value, in a case where the pressure in the tank 10 is equal to or lower than the pressure lower limit value, the determination unit 71 determines that the injection of the carbon dioxide gas G into the tank 10 is necessary. In a case where the pressure in the tank 10 is equal to or lower than the pressure lower limit value and the acceleration generated in the hull 2 is equal to or higher than the threshold value, the determination unit 71 may determine that the injection of the carbon dioxide gas G into the tank 10 is necessary. Further, the determination unit 71 may determine the necessity of the injection of the carbon dioxide gas G on the basis of a map, a table, a mathematical formula, or the like that is set in advance on the basis of a correlation between the pressure in the tank 10 and the acceleration generated in the hull 2.

[0040] In a case where it is determined as a result of the determination in step S3 that the injection of the carbon dioxide gas G into the tank 10 is not necessary ("No" in Fig. 5), the processing returns to step S2 described above. On the other hand, in a case where it is determined as a result of the determination in step S3 that the injection of the carbon dioxide gas G into the tank 10 is necessary ("Yes" in Fig. 5), the processing proceeds to step S4 of injecting the carbon dioxide gas into the tank.

[0041] In the step S4 of injecting the carbon dioxide gas into the tank, the carbon dioxide gas G is injected from the gas tank 21 to the tank 10. For this purpose, the opening and closing control unit 72 outputs a control signal for opening the opening-closing valves 22v and 23v to the opening-closing valves 22v and 23v via the output unit 75.

[0042] Here, the opening and closing control unit 72 may open both the opening-closing valves 22v and 23v, and inject the carbon dioxide gas G from the gas tank 21 to the tank 10 through both the first injection pipe 22 and the second injection pipe 23. Further, the opening and closing control unit 72 may open only the opening-closing valve 22v, and inject the carbon dioxide gas G from the gas tank 21 into the gas phase 10b of the tank 10 through only the first injection pipe 22. The opening and closing control unit 72 may further open only the opening-closing valve 23v, and inject the carbon dioxide gas G from the gas tank 21 into the liquid phase 10a at the bottom portion of the tank 10 through only the second injection pipe 23.

[0043] In a case where the carbon dioxide gas G is injected into the tank 10, since the carbon dioxide gas G has a higher temperature and a higher pressure than the carbon dioxide (including both the liquid phase 10a and the gas phase 10b) in the tank 10, the temperature and the pressure in the tank 10 are increased. In a case where the dry ice D is generated in the tank 10, the dry ice D is sublimated by the increase in the temperature and the pressure in the tank 10.

[0044] In step S5 of stopping the injection of the carbon dioxide gas, in a case where an injection end condition set in advance is satisfied, the injection of the carbon dioxide gas G from the gas tank 21 to the tank 10 is stopped. For example, in a case where the pressure in the tank 10 detected by the pressure sensor 24 exceeds the pressure lower limit value or in a case where the pressure in the tank 10 detected by the pressure sensor 24 exceeds a set value set to be equal to or higher than the pressure lower limit value, the control device 60 stops the injection of the carbon dioxide gas G. When the injection of the carbon dioxide gas G is stopped, the opening and closing control unit 72 outputs a control signal for closing the opening-closing valves 22v and 23v to the opening-closing valves 22v and 23v via the output unit 75. In a case where the opening-closing valves 22v and 23v are closed, the injection of the carbon dioxide gas G from the gas tank 21 to the tank 10 is stopped. In a case where the injection of the carbon dioxide gas G in the step S5 is stopped, the processing returns to step S2, and the series of steps described above is repeated.

(Effects)

[0045] The watercraft 1 of the embodiment described above includes the hull 2; the tank 10 that is provided in the hull 2, and stores the liquefied carbon dioxide L; and the carbon dioxide injection unit 20 that is provided in the hull 2, and is capable of injecting the carbon dioxide gas G having a higher temperature and a higher pressure than those of the carbon dioxide (liquid phase 10a and gas phase 10b) in the tank 10, into the tank 10.

[0046] With such a watercraft 1, in a case where the dry ice D is generated in the liquefied carbon dioxide L stored in the tank 10, the carbon dioxide gas G can be injected into the tank 10 by the carbon dioxide injection unit 20. Since the carbon dioxide gas G has a higher temperature and a higher pressure than those of the carbon dioxide (including both the liquid phase 10a and the gas phase 10b) in the tank 10, it is possible to suppress a decrease in the pressure in the tank 10. In addition, in a case where the dry ice D has been generated in the tank 10, the dry ice D can be sublimated by the carbon dioxide gas G.

[0047] Therefore, it is possible to suppress the generation of the dry ice D and smoothly operate the tank 10.

[0048] In the watercraft 1 of the embodiment described above, the carbon dioxide injection unit 20 is further configured to be capable of injecting the carbon dioxide gas G into the gas phase 10b of the carbon dioxide in the tank 10.

[0049] Therefore, it is possible to immediately increase the pressure in the tank 10 by injecting the carbon dioxide gas G into the gas phase 10b of the carbon dioxide in the tank 10 by the carbon dioxide injection unit 20.

[0050] In the watercraft 1 of the embodiment described above, the carbon dioxide injection unit 20 is further configured to be capable of injecting the carbon dioxide gas G into the liquid phase 10a of the carbon dioxide in the tank 10.

[0051] Therefore, in a case where the dry ice D has been generated in the liquid phase 10a of the carbon dioxide, the carbon dioxide gas G can be sent around the dry ice D by injecting the carbon dioxide gas G into the liquid phase 10a of the carbon dioxide in the tank 10 by the carbon dioxide injection unit 20. Then, the liquid phase 10a of the carbon dioxide around the dry ice D is gasified by the injected carbon dioxide gas G, so that the pressure in the tank 10 can be increased, and the sublimation of the dry ice D can be promoted.

[0052] Further, in the embodiment described above, the tip portion 23s of the second injection pipe 23 of the carbon dioxide injection unit 20 is open into the liquid phase 10a (liquefied carbon dioxide L) in the tank 10 at the bottom portion of the tank 10.

[0053] For example, in a case where the dry ice D is generated in the tank 10, the dry ice D has a higher density than the liquefied carbon dioxide, and therefore tends to be accumulated on the bottom portion of the tank 10. On the other hand, as described above, since the tip portion 23s of the second injection pipe 23 of the carbon dioxide injection unit 20 is open at the bottom portion of the tank 10, the carbon dioxide gas G can be injected to a position closer to the dry ice D accumulated on the bottom portion, and thus it is possible to quickly sublimate the dry ice D accumulated on the bottom portion.

[0054] In the watercraft 1 of the embodiment described above, in a case where the pressure in the tank 10 is equal to or lower than the pressure lower limit value set to be equal to or higher than the triple point pressure of the liquefied carbon dioxide L, the carbon dioxide injection unit 20 further injects the carbon dioxide gas G into the tank 10.

[0055] In this way, in a case where the pressure in the tank 10 is equal to or lower than the pressure lower limit value so that the dry ice D is likely to be generated in the tank 10, it is possible to suppress the generation of the dry ice D in the tank 10 by injecting the carbon dioxide gas G into the tank 10.

[0056] In the watercraft 1 of the embodiment described above, in a case where the shaking of the liquefied carbon dioxide L stored in the tank 10 is equal to or greater than a predetermined level, the carbon dioxide gas G is injected into the tank 10.

[0057] Therefore, in a case where the shaking of the liquefied carbon dioxide L stored in the tank 10 is equal to or greater than a predetermined level, it is possible to increase the pressure in the tank 10, and thereby it is possible to suppress the generation of the dry ice D in the tank 10.

[0058] The method S1 for adjusting the pressure of the tank 10 of the embodiment described above includes the step S2 of acquiring at least one of the information regarding the pressure in the tank 10 and the information regarding the shaking of the liquefied carbon dioxide L stored in the tank 10, and the step S4 of injecting the carbon dioxide gas G into the tank 10 by the carbon dioxide injection unit 20 on the basis of the acquired information.

[0059] In this way, since it is possible to inject the carbon dioxide gas G into the tank 10 on the basis of the pressure in the tank 10 and the shaking state of the liquefied carbon dioxide stored in the tank 10, it is possible to suppress the generation of the dry ice D, and it is possible to smoothly operate the tank 10.

(Other embodiments)

[0060] Above, the embodiments of the present disclosure have been described in detail with reference to the drawings, but the specific configuration is not limited to the embodiments, and includes design changes and the like within a scope not departing from the gist of the present disclosure.

[0061] In the watercraft 1 of the embodiment described above, the first injection pipe 22 and the second injection pipe 23 are provided, but only one of the first injection pipe 22 and the second injection pipe 23 may be provided.

[0062] The watercraft 1 of the embodiment described above includes the pressure sensor 24 in order to acquire the information regarding the pressure in the tank 10, but not only the pressure in the tank 10, but also the temperature of the gas phase 10b in the tank 10 may be detected, and the necessity of the injection of the carbon dioxide gas G into the tank 10 may be determined on the basis of the pressure and the temperature in the tank 10.

[0063] The watercraft 1 of the embodiment described above includes the acceleration sensor 25 in order to acquire the information regarding the shaking (sloshing) of the liquid phase 10a in the tank 10, but any configuration that can detect the shaking of the liquid phase 10a in the tank 10 may be used, and for example, the displacement of the liquid level of the liquid phase 10a in the tank 10 may be detected.

[0064] In the procedure of the method for adjusting the pressure of the tank described above, specific determination contents, the order of procedures, and the like can be appropriately changed.

<Additional notes>

[0065] The watercraft 1 and the method S1 for adjusting the pressure of the tank 10 in the watercraft 1 described in the embodiments are understood as follows, for example.

[0066]

(1) A watercraft 1 according to a first aspect includes a hull 2; a tank 10 that is provided in the hull 2, and stores liquefied carbon dioxide L; and a carbon dioxide injection unit 20 that is provided in the hull 2, and is capable of injecting carbon dioxide gas G which has a higher temperature and a higher pressure than those of carbon dioxide in the tank 10, into the tank 10.

[0067] With the watercraft 1, the carbon dioxide injection unit 20 is capable of injecting the carbon dioxide gas G having a higher temperature and a higher pressure than those of the carbon dioxide in the tank 10, into the tank 10. In a case where dry ice D is generated in the liquefied carbon dioxide L stored in the tank 10, the carbon dioxide gas G is injected into the tank 10 by the carbon dioxide injection unit 20. Since the carbon dioxide gas G has a higher temperature and a higher pressure than those of the carbon dioxide (including both the liquid phase 10a and the gas phase 10b) in the tank 10, it is possible to suppress a decrease in the pressure in the tank 10. In addition, in a case where the dry ice D has been generated in the tank 10, the dry ice D can be sublimated by the carbon dioxide gas G.

[0068] Therefore, it is possible to suppress the generation of the dry ice D and smoothly operate the tank 10.

[0069] (2) The watercraft 1 according to a second aspect is the watercraft 1 in (1), and the carbon dioxide injection unit 20 injects the carbon dioxide gas G into a gas phase 10b of the carbon dioxide in the tank 10.

[0070] Accordingly, it is possible to immediately increase the pressure in the tank 10 by injecting the carbon dioxide gas G into the gas phase 10b of the carbon dioxide in the tank 10 by the carbon dioxide injection unit 20.

[0071] (3) The watercraft 1 according to a third aspect is the watercraft 1 in (1) or (2), and the carbon dioxide injection unit 20 injects the carbon dioxide gas G into a liquid phase 10a of the carbon dioxide in the tank 10.

[0072] Accordingly, in a case where the dry ice D has been generated in the liquid phase 10a of the carbon dioxide, the carbon dioxide gas G can be sent around the dry ice D by injecting the carbon dioxide gas G into the liquid phase 10a of the carbon dioxide in the tank 10 by the carbon dioxide injection unit 20. The liquid phase 10a of the carbon dioxide around the dry ice D is gasified by the injected carbon dioxide gas G, so that the pressure in the tank 10 can be increased, and the sublimation of the dry ice D can be promoted.

[0073] (4) The watercraft 1 according to a fourth aspect is the watercraft 1 in any one of (1) to (3), and in a case where a pressure in the tank 10 is equal to or lower than a pressure lower limit value set to be equal to or higher than a triple point pressure of the liquefied carbon dioxide L, the carbon dioxide injection unit 20 injects the carbon dioxide gas G into the tank 10.

[0074] Accordingly, in a case where the pressure in the tank 10 is equal to or lower than the pressure lower limit value so that the dry ice D is likely to be generated in the tank 10, it is possible to suppress the generation of the dry ice D in the tank 10 by injecting the carbon dioxide gas G into the tank 10.

[0075] (5) The watercraft 1 according to a fifth aspect is the watercraft 1 in any one of (1) to (4), and in a case where shaking of the liquefied carbon dioxide L stored in the tank 10 reaches a predetermined level, the carbon dioxide injection unit 20 injects the carbon dioxide gas G into the tank 10.

[0076] Accordingly, in a case where the shaking of the liquefied carbon dioxide L stored in the tank 10 is equal to or greater than the predetermined level, it is possible to increase the pressure in the tank 10 by injecting the carbon dioxide gas G into the tank 10, and thereby it is possible to suppress the generation of the dry ice D in the tank 10.

[0077] The shaking of the liquefied carbon dioxide L stored in the tank 10 is detected by detecting the acceleration caused by the shaking of the hull 2 and by detecting the displacement of the liquid level of the liquefied carbon dioxide L in the tank 10.

[0078] (6) A method S1 for adjusting a pressure of a tank 10 in a watercraft 1 according to a sixth aspect is a method S1 for adjusting the pressure of the tank 10 in the watercraft 1 in any one of (1) to (5), the method includes a step S2 of acquiring at least one of information regarding a pressure in the tank 10, and information regarding shaking of the liquefied carbon dioxide L stored in the tank 10; and a step S4 of injecting the carbon dioxide gas G into the tank 10 by the carbon dioxide injection unit 20 on the basis of the acquired information.

[0079] Accordingly, by injecting the carbon dioxide gas G into the tank 10 on the basis of the pressure in the tank

10 and the shaking state of the liquefied carbon dioxide stored in the tank 10, it is possible to suppress the generation of the dry ice D, and it is possible to smoothly operate the tank 10.

[0080] Examples of the information regarding the pressure in the tank 10 include a pressure value in the tank 10, and a temperature of the gas phase 10b in the tank 10.

[0081] Examples of the information regarding the shaking of the liquefied carbon dioxide L stored in the tank 10 include a detection value of the acceleration caused by the shaking of the hull 2, and a detection value of the displacement of the liquid level of the liquefied carbon dioxide L in the tank 10.

Industrial Applicability

[0082] According to the above aspects, it is possible to suppress the generation of the dry ice, and it is possible to smoothly operate the tank.

Reference Signs List

[0083]

1:	watercraft
2:	hull
2a:	bow
3A, 3B:	broadside
5:	upper deck
7:	superstructure
8:	cargo space
10:	tank
10a:	liquid phase
10b:	gas phase
12:	tubular portion
13:	end spherical portion
20:	carbon dioxide injection unit
21:	gas tank
22:	first injection pipe
22s:	tip portion
22v:	opening-closing valve
23:	second injection pipe
23s:	tip portion
23v:	opening-closing valve
24:	pressure sensor
25:	acceleration sensor
60:	control device
61:	CPU
62:	ROM
63:	RAM
64:	HDD
65:	signal receiving module
70:	signal input unit
71:	determination unit
72:	opening and closing control unit
75:	output unit
FA:	bow-stern direction
D:	dry ice
G:	carbon dioxide gas
L:	liquefied carbon dioxide

Claims

1. A watercraft comprising:

   a hull;
   a tank that is provided in the hull, and stores liquefied carbon dioxide; and
   a carbon dioxide injection unit that is provided in the hull, and is capable of injecting carbon dioxide gas which has a higher temperature and a higher pressure than those of carbon dioxide in the tank, into the tank.

2. The watercraft according to claim 1, wherein the carbon dioxide injection unit injects the carbon dioxide gas into a gas phase of the carbon dioxide in the tank.

3. The watercraft according to claim 1 or 2, wherein the carbon dioxide injection unit injects the carbon dioxide gas into a liquid phase of the carbon dioxide in the tank.

4. The watercraft according to any one of claims 1 to 3, wherein in a case where a pressure in the tank is equal to or lower than a pressure lower limit value set to be equal to or higher than a triple point pressure of the liquefied carbon dioxide, the carbon dioxide injection unit injects the carbon dioxide gas into the tank.

5. The watercraft according to any one of claims 1 to 4, wherein in a case where shaking of the liquefied carbon dioxide stored in the tank reaches a predetermined level, the carbon dioxide injection unit injects the carbon dioxide gas into the tank.

6. A method for adjusting a pressure of a tank in the watercraft according to any one of claims 1 to 5, the method comprising:

   a step of acquiring at least one of information regarding a pressure in the tank, and information regarding shaking of the liquefied carbon dioxide stored in the tank; and
   a step of injecting the carbon dioxide gas into the tank by the carbon dioxide injection unit on the basis of the acquired information.

FIG. 1

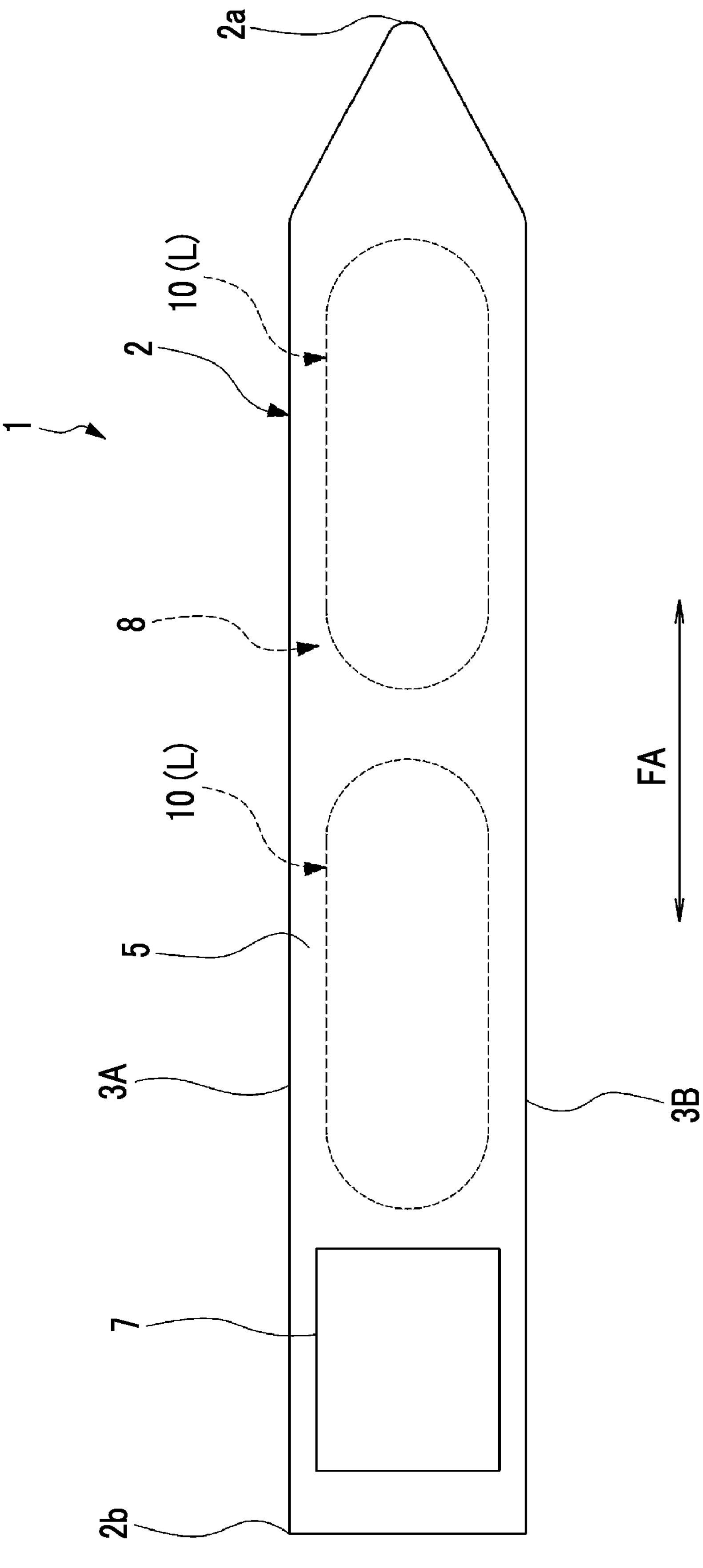


FIG. 2

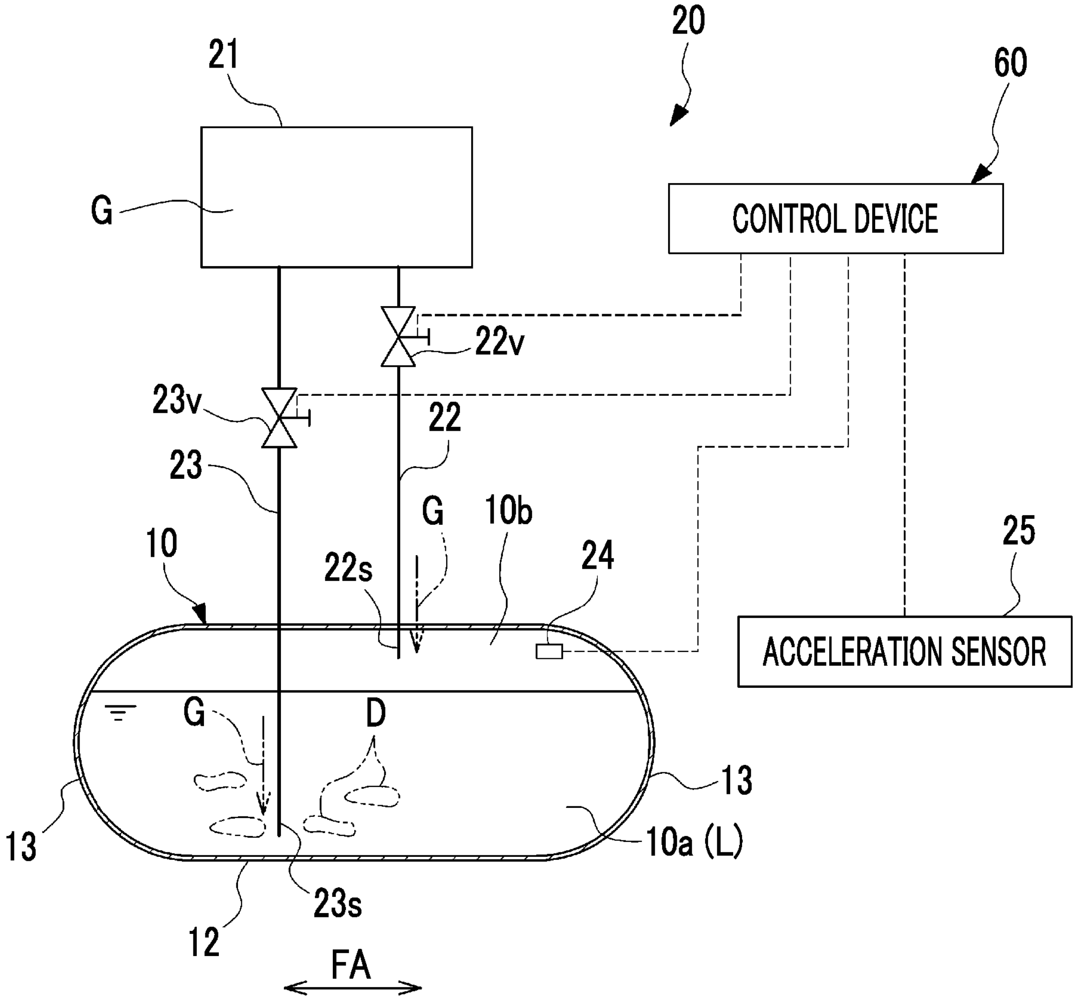

20
21
60
G
CONTROL DEVICE
22v
23v
22
23
G
10b
10
22s
24
25
ACCELERATION SENSOR
G
D
13
13
10a (L)
23s
12
FA

FIG. 3

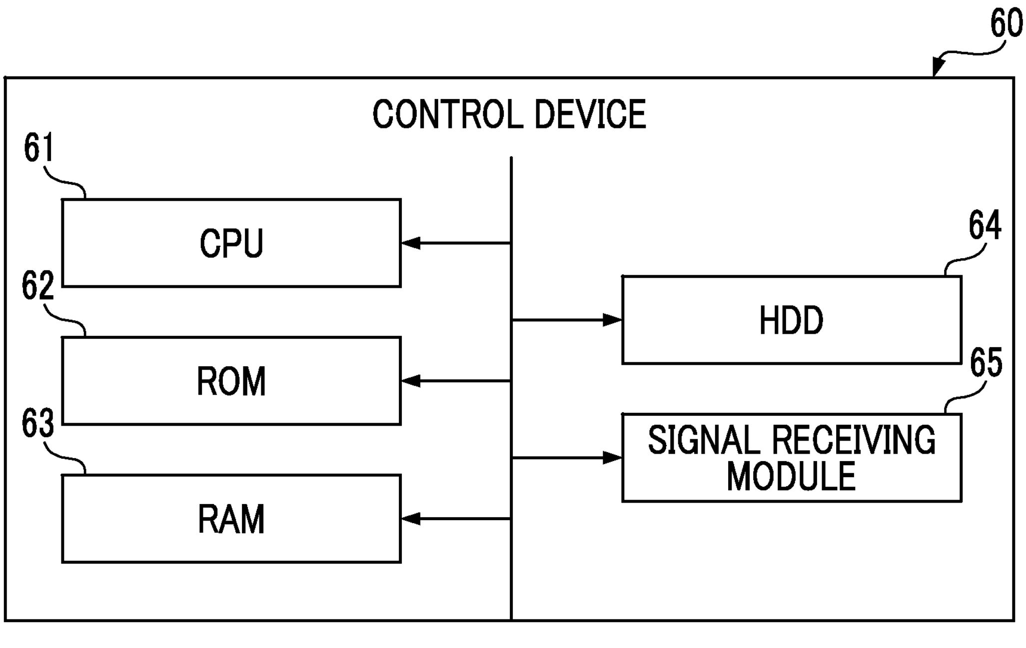

60
CONTROL DEVICE
61
CPU
64
HDD
62
ROM
65
SIGNAL RECEIVING MODULE
63
RAM

FIG. 4

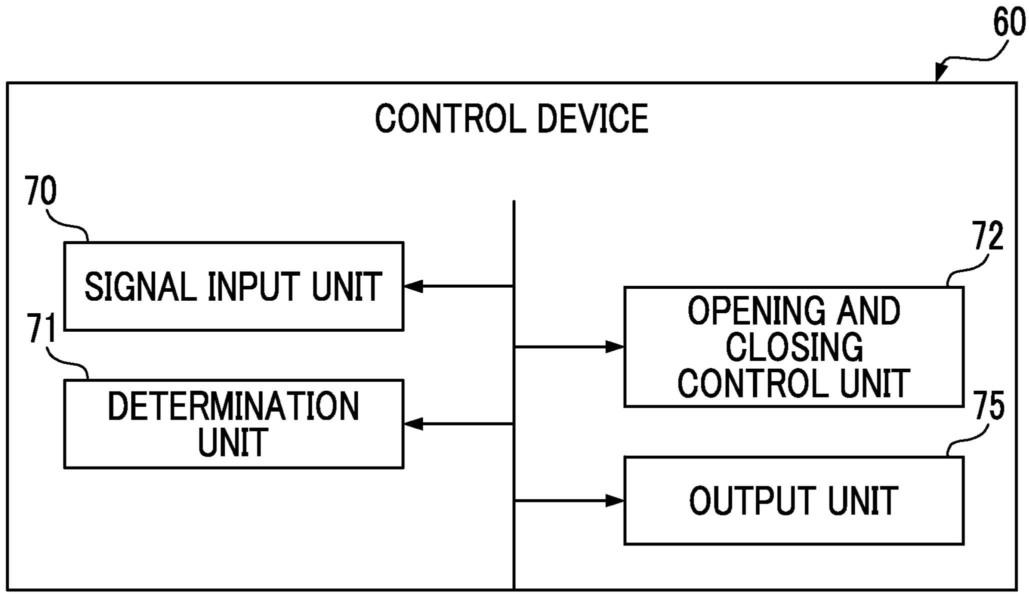
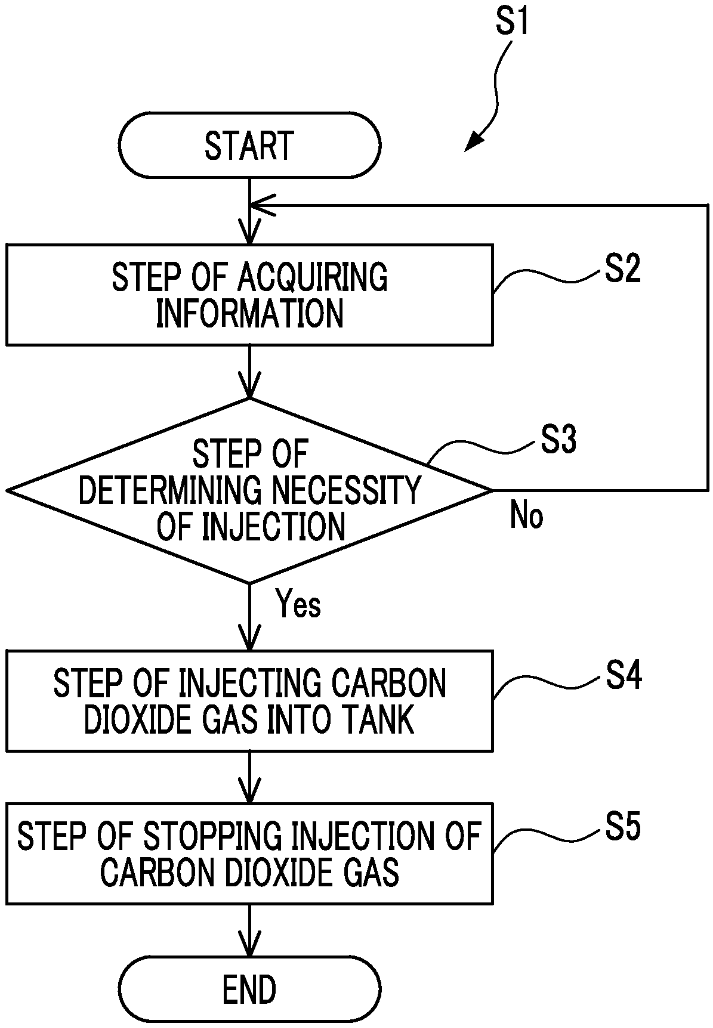

60
CONTROL DEVICE
70
SIGNAL INPUT UNIT
71
DETERMINATION UNIT
72
OPENING AND CLOSING CONTROL UNIT
75
OUTPUT UNIT

FIG. 5


S1
START
STEP OF ACQUIRING INFORMATION
S2
STEP OF DETERMINING NECESSITY OF INJECTION
S3
No
Yes
STEP OF INJECTING CARBON DIOXIDE GAS INTO TANK
S4
STEP OF STOPPING INJECTION OF CARBON DIOXIDE GAS
S5
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/014236

A. CLASSIFICATION OF SUBJECT MATTER

B63B 25/16(2006.01)i
FI: B63B25/16 G; B63B25/16 H

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)

B63B25/08-25/16; F17C1/00-13/12; F17D1/00-5/08

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 A	KR 10-2014-0017800 A (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 12 February 2014 (2014-02-12) paragraphs [0037]-[0069], fig. 2-6	1-2, 4, 6 3, 5
Y A	KR 10-2011-0048266 A (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 11 May 2011 (2011-05-11) paragraphs [0005], [0010], [0011], [0039]-[0054], fig. 1, 2	1-2, 4, 6 3, 5
A	JP 2002-349793 A (MITSUBISHI HEAVY IND., LTD.) 04 December 2002 (2002-12-04) entire text, all drawings	1-6

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 June 2022	**14 June 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.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/014236

Patent document cited in search report		Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
KR 10-2014-0017800	A	12 February 2014	(Family: none)	
KR 10-2011-0048266	A	11 May 2011	(Family: none)	
JP 2002-349793	A	04 December 2002	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2021059785 A **[0002]**
- JP H5180394 A **[0005]**
- JP 2004125039 A **[0005]**