the detection value of the first pressure detection unit 111A is monitored while the carbon dioxide gas G in the first tank 11A is being transferred into the second tank 11B in the step S11. In the step S12, it is determined whether or not the pressure in the first tank 11A has become lower than the first threshold value set in advance, based on the detection value of the first pressure detection unit 111A. It is preferable that the first threshold value is set to a triple point or higher of the carbon dioxide gas.

When the detection value of the first pressure detection unit 111A has not become lower than the first threshold value (No in the step S12), the step S11 is continued, and the step S12 is repeatedly performed at predetermined time intervals.

When the detection value of the first pressure detection unit 111A has become lower than the first threshold value (Yes in the step S12), the process proceeds to the step S13 of switching the transfer of the carbon dioxide gas G to the return of the carbon dioxide gas G.

[0047]

In the step S13 of switching the transfer of the carbon dioxide gas G to the return of the carbon dioxide gas G (hereinafter, simply referred to as step S13), the transfer of the carbon dioxide gas G by the first transfer line 16A is switched to the return of the carbon dioxide gas G by the first return line 17A. Specifically, as shown in FIG. 4, the first opening/closing valve 122A and the third opening/closing valve 123 are set to a closed state, and the second opening/closing valve 122B and the fourth opening/closing valve 124 are set to an open state from the state as shown in FIG. 3. Therefore, the carbon dioxide gas G in the second tank 11B is sucked by using the compressor 31 through the second connection pipe 24 of the first return line 17A and is supplied to a portion of the first transfer line 16A on a side closer to the first tank 11A than the first pressure-feed unit 30. The carbon dioxide gas G supplied to the first transfer line 16A is

the second tank 11B through the connection line 15 is continued. As a result, the amount of the liquefied carbon dioxide L in the second tank 11B is increased, so that the pressure in the second tank 11B is increased and is suppressed from approaching the triple point.

[0055]

In the step S14, it is determined whether or not the pressure in the first tank 11A has become higher than the second threshold value determined in advance, based on the detection value of the first pressure detection unit 111A.

When the pressure in the first tank 11A has not become higher than the second threshold value set in advance (No in the step S14), the step S13 is continued.

When the pressure in the first tank 11A has become higher than the second threshold value set in advance (Yes in the step S14), the process proceeds to the step S15.

[0056]

In the step S15, the state shown in FIG. 6 is returned to the state shown in FIG. 5, and the liquefied carbon dioxide L in the first tank 11A is transferred into the second tank 11B. In this case, as shown in FIG. 5, the first opening/closing valve 122A and the second opening/closing valve 122B are set to a closed state, and the third opening/closing valve 123 and the fourth opening/closing valve 124 are set to an open state. Therefore, the carbon dioxide gas G in the second tank 11B can be pressurized by the compressor 31 through the second transfer line 18A, heated by the heater 32, and then returned to a state of being transferred into the first tank 11A. As a result, the inside of the first tank 11A is pressurized, and the liquefied carbon dioxide L in the first tank 11A is continuously transferred into the second tank 11B through the connection line 15.

[0057]

In the step S16, it is determined whether or not the transfer of the liquefied

FIG. 11 is a diagram showing a state in which the carbon dioxide gas flows through the first transfer line in the tank system according to the second embodiment of the present disclosure. FIG. 12 is a diagram showing a state in which the carbon dioxide gas flows through the first return line in the tank system according to the second embodiment of the present disclosure.

When the pressure in the first tank 11A detected by the first pressure detection unit 111A is lower than the first threshold value set in advance in a state in which the first transfer line 16A transfers the carbon dioxide gas G in the first tank 11A into the second tank 11B, the switching control unit 71 of the second embodiment causes the switching unit 120 to switch the transfer of the carbon dioxide gas G by the first transfer line 16A to the return of the carbon dioxide gas G by the first return line 17A, as shown in FIG. 11. In addition, when the pressure in the second tank 11B has become higher than the second threshold value set in advance in a state in which the first return line 17A takes out the carbon dioxide gas G in the second tank 11B, heat the carbon dioxide G, and returns the carbon dioxide G to the second tank 11B, the switching control unit 71 causes the switching unit 120 to switch the return of the carbon dioxide gas G by the first return line 17A to the transfer of the carbon dioxide gas G by the first transfer line 16A, as shown in FIG. 12.

[0069]

FIG. 13 is a diagram showing a state in which the carbon dioxide gas flows through the second transfer line in the tank system according to the second embodiment of the present disclosure. FIG. 14 is a diagram showing a state in which the carbon dioxide gas flows through the second return line in the tank system according to the second embodiment of the present disclosure.

When the pressure in the second tank 11B detected by the second pressure

detection unit 111B is lower than the first threshold value set in advance in a state in which the second transfer line 18A transfers the carbon dioxide gas G in the second tank 11B into the first tank 11A, the switching control unit 71 causes the switching unit 120 to switch the transfer of the carbon dioxide gas G by the second transfer line 18A to the return of the carbon dioxide gas G by the second return line 19A, as shown in FIG. 13. In addition, when the pressure in the first tank 11A has become higher than the second threshold value set in advance in a state in which the second return line 19A takes out the carbon dioxide gas G in the first tank 11A, heats the carbon dioxide G, and returns the carbon dioxide G to the first tank 11A, the switching control unit 71 causes the switching unit 120 to switch the return of the carbon dioxide gas G by the second return line 19A to the transfer of the carbon dioxide gas G by the second transfer line 18A, as shown in FIG. 14.

[0070]

The signal output unit 72 outputs a command signal for controlling the operations of the switching unit 120 and the compressor 31 to the switching unit 120 and the compressor 31 by the control in the switching control unit 71.

[0071]

(Procedure of Method for Transferring Liquefied Carbon Dioxide)

In the tank system 10B, the liquefied carbon dioxide L in the first tank 11A and the second tank 11B is discharged to the outside through the first discharge line 13A and the second discharge line 13B.

In a case where any one of the pump 132A of the first tank 11A or the pump 132B of the second tank 11B fails when the liquefied carbon dioxide L in the first tank 11A and the second tank 11B is discharged to the outside, the control device 60 receives a signal indicating that the pump 132A and the pump 132B are not operating normally.

In a case where the control device 60 receives the signal indicating that the pump 132A and the pump 132B are not operating normally, the control device 60 performs control of transferring the liquefied carbon dioxide between the first tank 11A and the second tank 11B in the following procedure based on a program set in advance.

[0072]

As shown in FIG. 7, the method S20 for transferring the liquefied carbon dioxide L in the tank system 10B according to the second embodiment described above includes a step S21 of transferring the liquefied carbon dioxide L, a step S22 of determining whether a pressure in a tank has become lower than a first threshold value, a step S23 of switching from transfer of the carbon dioxide gas G to return of the carbon dioxide gas G, a step S24 of determining whether the pressure in the tank has become higher than a second threshold value, a step S25 of returning the process from return of the carbon dioxide gas G to transfer of the carbon dioxide gas G, and a step S26 of determining whether transfer of the liquefied carbon dioxide L has ended.

[0073]

Hereinafter, for example, a case will be described in which the pump 132B of the second tank 11B fails when the liquefied carbon dioxide L in the first tank 11A and the second tank 11B is discharged to the outside.

(Case Where Pump of Second Tank Fails)

In the step S21 of transferring the liquefied carbon dioxide L (hereinafter, simply referred to as step S21), when the pump 132B of the second tank 11B fails, the control device 60 transfers the liquefied carbon dioxide L in the second tank 11B into the first tank 11A. In this case, as shown in FIG. 11, the carbon dioxide gas G in the first tank 11A is transferred into the second tank 11B through the first transfer line 16A to pressurize the inside of the second tank 11B. In the step S21, the opening/closing valve

121 is opened, the third opening/closing valve 123 and the fourth opening/closing valve 124 are set to a closed state, the first opening/closing valve 122A and the second opening/closing valve 122B are set to an open state, and the compressor 31 is operated.

[0074]

Then, the first transfer line 16A sucks the carbon dioxide gas G in the first tank 11A and pressurizes the carbon dioxide gas G into the second tank 11B. In this case, the first transfer line 16A pressurizes (compresses) the carbon dioxide gas G by using the compressor 31 and heats the carbon dioxide gas G by using the heater 32 to expand the carbon dioxide gas G in the first tank 11A. Therefore, the pressure in the second tank 11B is increased, and the pressure difference between the inside of the first tank 11A and the inside of the second tank 11B is increased. Due to the pressure difference between the inside of the first tank 11A and the inside of the second tank 11B, the liquefied carbon dioxide L in the second tank 11B is pushed out through the liquid transfer pipe 21 of the connection line 15 and is transferred into the first tank 11A.

[0075]

In the step S22 of determining whether or not the pressure in the tank has become lower than the first threshold value (hereinafter, simply referred to as step S22), the switching control unit 71 monitors the detection value of the first pressure detection unit 111A while the carbon dioxide gas G in the first tank 11A is being transferred into the second tank 11B in the step S21. In the step S22, the switching control unit 71 determines whether or not the pressure in the first tank 11A has become lower than the first threshold value set in advance, based on the detection value of the first pressure detection unit 111A. It is preferable that the first threshold value is set to a triple point

dioxide gas G by the second transfer line 18A to the return of the carbon dioxide gas G by the second return line 19A as shown in FIG. 14. Specifically, the switching control unit 71 sets the second opening/closing valve 122B and the fourth opening/closing valve 124 to a closed state, and sets the first opening/closing valve 122A and the third opening/closing valve 123 to an open state. As a result, the carbon dioxide gas G in the first tank 11A is sucked by using the compressor 31 through the second return line 19A, pressurized by the compressor 31, heated by the heater 32, and then returned to the first tank 11A. In this manner, the carbon dioxide gas G is expanded and returned to the first tank 11A, so that the pressure in the first tank 11A can be increased. By increasing the pressure in the first tank 11A, the pressure difference between the pressure in the first tank 11A and the pressure in the second tank 11B is secured, and the transfer of the liquefied carbon dioxide L in the first tank 11A to the second tank 11B through the connection line 15 is continued. As a result, the amount of the liquefied carbon dioxide L in the second tank 11B is increased, so that the pressure in the second tank 11B is increased and is suppressed from approaching the triple point.

[0085]

In the step S24, the switching control unit 71 determines whether or not the pressure in the first tank 11A has become higher than the second threshold value determined in advance, based on the detection values of the first pressure detection unit 111A.

When the pressure in the first tank 11A has not become higher than the second threshold value set in advance (No in the step S24), the switching control unit 71 continues the step S23.

When the pressure in the first tank 11A has become higher than the second threshold value set in advance (Yes in the step S24), the switching control unit 71

than the first threshold value, the control device 60 can automatically switch the transfer of the carbon dioxide gas G by the first transfer line 16A to the return of the carbon dioxide gas G by the first return line 17A. Similarly, when the pressure in the second tank 11B has become lower than the first threshold value, the control device 60 can automatically switch the transfer of the carbon dioxide gas G by the second transfer line 18A to the return of the carbon dioxide gas G by the second return line 19A. Therefore, as in the first embodiment, in a case where the pressure in the first tank 11A or the pressure in the second tank 11B, which is the transfer destination, approaches the triple point, the transfer of the liquefied carbon dioxide L using the pressure difference between the tanks can be automatically continued while the take-out of the carbon dioxide gas G from the first tank 11A or the second tank 11B, which is the transfer destination, is automatically stopped. Therefore, it is possible to reduce a burden on the operator while enabling rapid transfer of liquefied carbon dioxide L.

[0091]

Further, in the second embodiment, when the pressure in the second tank 11B has become higher than the second threshold value, the control device 60 can automatically switch the return of the carbon dioxide gas G by the first return line 17A to the transfer of the carbon dioxide gas G by the first transfer line 16A. Accordingly, it is possible to further reduce the burden on the operator.

[0092]

(First Modification Example of Embodiment)

In each of the above embodiments, the transfer pipe unit 20A includes one set of the first pressure-feed unit 30 (compressor 31 and heater 32), and the first pressure-feed unit 30 is shared by the first transfer line 16A and the first return line 17A. However, the present disclosure is not limited thereto.

(9) The tank system 10B according to a ninth aspect is the tank system 10B according to (8), further including a second pressure detection unit 111B configured to detect a pressure in the second tank 11B, in which the control device 60 is configured to cause the switching unit 120 to switch from the return of the carbon dioxide gas G by the first return line 17A to the transfer of the carbon dioxide gas G by the first transfer line 16A, when the pressure in the second tank 11B detected by the second pressure detection unit 111B becomes higher than a preset second threshold value in a state in which the first return line 17A takes out the carbon dioxide gas G in the second tank 11B, heats the carbon dioxide gas G, and returns the carbon dioxide gas G to the second tank 11B.

[0128]

Accordingly, when the pressure in the second tank 11B has become higher than the second threshold value, the return of the carbon dioxide gas G by the first return line 17A can be automatically switched to the transfer of the carbon dioxide gas G by the first transfer line 16A.

[0129]

(10) A floating body 1 according to a tenth aspect including: a floating body main body 2; and the tank system 10A, 10B according to any one of (1) to (9) provided on the floating body main body 2.

[0130]

With such a configuration, it is possible to provide the floating body 1 including the tank system 10A or 10B capable of rapidly transferring the liquefied carbon dioxide L in the tank to the outside while suppressing the generation of dry ice.

Examples of the floating body 1 include a vessel or an offshore floating facility. Examples of the floating body main body 2 include a hull or a floating body main body 2 of an offshore floating facility.

[0131]

(11) A method for transferring liquefied carbon dioxide according to an eleventh aspect is the method S10, S20 for transferring liquefied carbon dioxide L in the tank system 10A, 10B according to any one of (1) to (9), the method including: a step S11, S21 of transferring the carbon dioxide gas G in the first tank 11A into the second tank 11B through the first transfer line 16A to increase a pressure in the second tank 11B, and transferring the liquefied carbon dioxide L in the second tank 11B into the first tank 11A through the connection line 15 by a pressure difference between the pressure in the second tank 11B and a pressure in the first tank 11A; and a step S13, S23 of switching from the transfer of the carbon dioxide gas G by the first transfer line 16A to the return of the carbon dioxide gas G by the first return line 17A, when the pressure in the first tank 11A becomes lower than a preset first threshold value in a state in which the carbon dioxide gas G in the first tank 11A is transferred into the second tank 11B.

[0132]

In the method S10, S20 for transferring the liquefied carbon dioxide L, when the pressure in the first tank 11A has become lower than the first threshold value set in advance in a state in which the carbon dioxide gas G in the first tank 11A is transferred into the second tank 11B, the transfer of the carbon dioxide gas G by the first transfer line 16A is switched to the return of the carbon dioxide gas G by the first return line 17A. Therefore, the pressure in the second tank 11B increases, the pressure difference between the pressure in the first tank 11A and the pressure in the second tank 11B increases, and the liquefied carbon dioxide L inside the second tank 11B is sent to the inside of the first tank 11A through the connection line 15. In this manner, it is possible to rapidly transfer the liquefied carbon dioxide L in the tank to the outside while suppressing the generation of dry ice.