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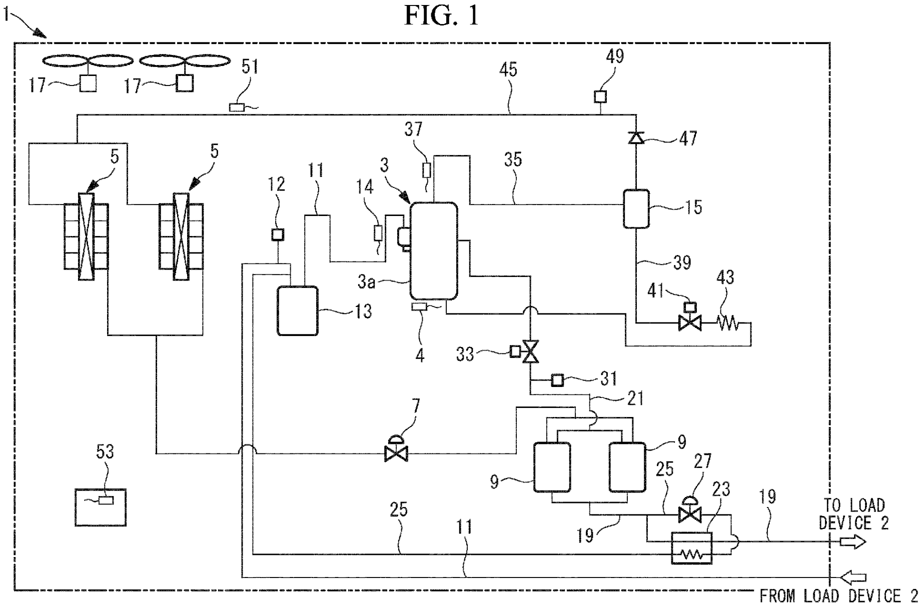
(54) FREEZING DEVICE, FREEZING SYSTEM, AND CONTROL METHOD OF FREEZING DEVICE

(57) Provided is a freezing device (1) that can improve thermal efficiency even in a low outside air temperature and obtain necessary freezing performance. The freezing device includes: a compressor (3) configured to compress a CO_2 refrigerant; a gas cooler (5) configured to cool a CO_2 refrigerant discharged from the compressor (3); and a control unit configured to set a high-pressure target value of the CO_2 refrigerant so that the CO_2 refrigerant in the gas cooler (5) becomes subcritical and perform subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than the critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator to which the CO_2 refrigerant cooled by the gas cooler (5) is guided via an expansion valve (7) is less than or equal to a second predetermined temperature.

FIG. 1



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Description

BACKGROUND

1. TECHNICAL FIELD

[0001] The present disclosure relates to a freezing device, a freezing system, and a control method of a freezing device.

2. DESCRIPTION OF RELATED ART

[0002] Japanese Patent Application Laid-Open No. 2008-530501 discloses a cooling circuit with use of a carbon dioxide (CO_2) refrigerant. The cooling circuit of Japanese Patent Application Laid-Open No. 2008-530501 performs control by switching the mode between a transcritical mode in which the CO_2 refrigerant is in a transcritical state in a gas cooler and a subcritical mode in which the CO_2 refrigerant is in a subcritical state.

[0003] Japanese Patent Application Laid-Open No. 2008-530501 is an example of the related art.

[0004] However, even when a higher pressure of the CO_2 refrigerant is set to be in the transcritical mode, when the outside air temperature is lower than the critical point of CO_2, the high-pressure value of the CO_2 refrigerant may be greater than is required relative to an amount of exhaust heat required to be removed by a gas cooler. Further, since the rotational rate of a compressor is increased in order to have the transcritical mode, power loss is increased. Due to the above, there is a drive state where the thermal efficiency is reduced in relation to the outside air temperature.

[0005] On the other hand, a target evaporation temperature in an evaporator is determined by a request from equipment that uses cold generated by the evaporator. Under the determined target evaporation temperature, it is required to ensure a difference between high and low pressures of a refrigerant required for obtaining predetermined freezing performance.

BRIEF SUMMARY

[0006] The present disclosure has been made in view of such circumstances, and an object is to provide a freezing device, a freezing system, and a control method of a freezing device that can improve thermal efficiency even in a low outside air temperature and obtain required freezing performance.

[0007] To achieve the above object, the freezing device, the freezing system, and the control method of the freezing device of the present disclosure employ the following solutions.

[0008] The freezing device of the present disclosure includes: a compressor configured to compress a CO_2 refrigerant; a gas cooler configured to cool a CO_2 refrigerant discharged from the compressor; and a control unit configured to set a high-pressure target value of the CO_2 refrigerant so that the CO_2 refrigerant in the gas cooler becomes subcritical and perform subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than the critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve is less than or equal to a second predetermined temperature.

[0009] The freezing system of the present disclosure includes: the freezing device described in any of the above; an expansion valve configured to expand a CO_2 refrigerant supplied from the gas cooler; and an evaporator configured to evaporate the CO_2 refrigerant guided from the expansion valve.

[0010] The control method of a freezing device of the present disclosure is a control method of a freezing device including a compressor configured to compress a CO_2 refrigerant, and a gas cooler configured to cool a CO_2 refrigerant discharged from the compressor, and the control method includes: setting a high-pressure target value of a CO_2 refrigerant so that a CO_2 refrigerant in the gas cooler becomes subcritical and performing subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than the critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve is less than or equal to a second predetermined temperature.

[0011] It is possible to improve thermal efficiency even in a low outside air temperature and obtain required freezing performance.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0012]

Fig. 1 is a schematic configuration diagram illustrating a refrigerant circuit of a condensing unit of a freezing system of the present disclosure.
Fig. 2 is a schematic configuration diagram illustrating a load device of the freezing system of the present disclosure.
Fig. 3 is a pressure-enthalpy (p-h) diagram of the freezing system of the present disclosure.
Fig. 4 is a flowchart illustrating an operation of the freezing system of the present disclosure.

DETAILED DESCRIPTION

[0013] The embodiments according to the present disclosure will be described below with reference to the drawings.

[0014] The freezing system of the present disclosure includes a condensing unit (freezing device) 1 and a load device 2. As illustrated in Fig. 1, a refrigerant circuit of the condensing unit 1 is illustrated. The condensing unit

1 supplies a liquid refrigerant to the load device 2. As the refrigerant, carbon dioxide (CO_2) is used. The CO_2 refrigerant is not limited to a single refrigerant in which the content of CO_2 is 100% and may be a mixture refrigerant whose main component is CO_2 as long as the refrigerant has mainly properties of a CO_2 refrigerant.

[0015] The load device 2 may be, for example, a refrigerator or a freezer that cools or refrigerates and stores products and refrigerating/freezing equipment such as a showcase that cools or refrigerates and displays products. The load device 2 can be any device that supplies cold and may be used for interior equipment of an air-conditioner, for example.

[0016] As illustrated in Fig. 2, the load device 2 is supplied with a liquid refrigerant from the condensing unit 1. The load device 2 includes an evaporator 6, a low-stage expansion valve 8, a temperature sensor (not illustrated), and the like. A target evaporation temperature set in the evaporator 6 is set by a user, for example, and is stored in a control unit (not illustrated). A plurality of load devices 2 may be provided in parallel to each other.

[0017] As illustrated in Fig. 1, the condensing unit 1 includes a compressor 3, gas coolers 5, a high-stage expansion valve 7, and intermediate-pressure receivers 9. The compressor 3, the gas coolers 5, the high-stage expansion valve 7, and the intermediate-pressure receivers 9 are connected to each other by refrigerant pipes.

[0018] The compressor 3 compresses the refrigerant supplied from the load device 2 via an accumulator 13 by an intake tube 11. The intake tube 11 includes a low-pressure sensor 12 on the inlet side of the accumulator 13 and includes an intake tube temperature sensor 14 on the inlet side of the compressor 3. Measurement values of the low-pressure sensor 12 and the intake tube temperature sensor 14 are transmitted to the control unit.

[0019] The compressor 3 is a two-stage compressor and includes a low-stage compressor on the first stage and a high-stage compressor on the second stage. The low-stage compressor compresses a drawn refrigerant guided from the accumulator 13 to an intermediate pressure. The high-stage compressor further compresses the refrigerant compressed to the intermediate pressure by the low-stage compressor to a high pressure. As the low-stage compressor, a rotary compressor is used, for example, and as the high-stage compressor, a scroll compressor is used, for example. The displacement volume of the low-stage compressor is 15 cc/rev, for example, and the displacement volume of the high-stage compressor is 13 cc/rev, for example. The inside of a housing 3a of the compressor 3 is filled with the intermediate-pressure refrigerant discharged from the low-stage compressor.

[0020] The compressor 3 includes an electric motor (not illustrated), and the rotational rate is variable with inverter control. The rotational rate of the compressor 3 is controlled by the control unit.

[0021] In the housing 3a of the compressor 3, an under-dome temperature sensor 4 is provided. A measurement value of the under-dome temperature sensor 4 is transmitted to the control unit.

[0022] After discharged from the compressor 3, a high-pressure and high-temperature refrigerant is supplied to the gas cooler 5 via an oil separator 15. The gas cooler 5 is a fin tube, for example, and performs heat exchange between the supplied high-pressure and high-temperature refrigerant and the air supplied by a fan 17 to cool the refrigerant. In the present embodiment, a plurality of (in the present embodiment, two) gas coolers are provided in parallel to each other.

[0023] The high-stage expansion valve 7 is provided on the inlet side of the intermediate-pressure receivers 9 and expands the refrigerant cooled in the gas coolers 5. The high-stage expansion valve 7 is an electronic expansion valve, and the opening is controlled by the control unit.

[0024] Each intermediate-pressure receiver 9 separates the refrigerant expanded in the high-stage expansion valve 7 into a gas refrigerant and a liquid refrigerant. In the present embodiment, the plurality of (in the present embodiment, two) intermediate-pressure receivers 9 are provided in parallel to each other. A liquid feeding tube 19 and an injection circuit 21 are connected to the intermediate-pressure receivers 9.

[0025] The liquid refrigerant separated in the intermediate-pressure receivers 9 is supplied to the external load device 2 through the liquid feeding tube 19. In the liquid feeding tube 19, a supercooling coil 23 is provided. In the supercooling coil 23, heat is exchanged with a refrigerant expanded by a supercooling coil electronic expansion valve 27 through a branch tube 25 branched from the liquid feeding tube 19. Accordingly, supercooling is provided to the liquid refrigerant fed to the external load device 2. The downstream end of the branch tube 25 passing through the supercooling coil 23 is connected to the accumulator 13.

[0026] The gas refrigerant separated in the intermediate-pressure receiver 9 is guided to the inside of the housing 3a of the compressor 3 via the injection circuit 21. In the injection circuit 21, an intermediate-pressure sensor 31 and an intermediate-pressure intake electromagnetic valve 33 are provided. A measurement value of the intermediate-pressure sensor 31 is transmitted to the control unit. Opening and closing of the intermediate-pressure intake electromagnetic valve 33 is controlled by the control unit.

[0027] The oil separator 15 is provided in a discharge tube 35 connected to the discharge side of the high-stage compressor of the compressor 3. In the discharge tube 35, a discharge temperature sensor 37 is provided, and a measurement value of the discharge temperature sensor 37 is transmitted to the control unit. The oil separator 15 collects a lubricating oil included in a discharge refrigerant. The upstream end of an oil return tube 39 is connected to the bottom of the oil separator 15. The downstream end that is the other end of the oil return tube 39 is connected to the compressor 3. In the oil return tube

39, an oil return electromagnetic valve 41 and a capillary 43 as a regulation unit are provided. Opening and closing of the oil return electromagnetic valve 41 is controlled by the control unit.

[0028] A high-pressure refrigerant from which the lubricating oil has been removed by the oil separator 15 is guided to the gas cooler 5 via a high-pressure gas pipe 45. In the high-pressure gas pipe 45, a check valve 47, and a high-pressure sensor 49 are provided in this order from the upstream. Further, a gas cooler inlet temperature sensor 51 is provided on the gas cooler 5 side of the high-pressure gas pipe 45. Measurement values of the high-pressure sensor 49 and the gas cooler inlet temperature sensor 51 are transmitted to the control unit.

[0029] The condensing unit 1 includes an outside air temperature sensor 53 that measures an outside air temperature. A measurement value of the outside air temperature sensor 53 is transmitted to the control unit.

[0030] The control unit is formed of a central processing unit (CPU), a random access memory (RAM), a read only memory (ROM), a computer readable storage medium, and the like, for example. Further, a series of processes for implementing respective functions is stored in a storage medium or the like in a form of a program as one example, and when the CPU loads the program into the RAM or the like and performs a processing and calculation process on information, respective functions are implemented. Note that an applicable form of the program may be a form in which a program is installed in advance in a ROM or another storage medium, a form in which a program is provided in a state of being stored in a computer readable storage medium, a form in which a program is delivered via a wired or wireless communication scheme, or the like. The computer readable storage medium may be a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, or the like.

[0031] The operation of the freezing device described above will be described with reference to Fig. 3.

[Supercritical control]

[0032] First, as a basic operation mode of the freezing device, the transcritical control will be described. Fig. 3 is a pressure-enthalpy (p-h) diagram in which the horizontal axis corresponds to a specific enthalpy, and the vertical axis corresponds to a pressure, and illustrates the operation of the freezing device.

[0033] The transcritical control is illustrated by the dashed line in Fig. 3, which means that the refrigerant (CO_2 refrigerant) is in the transcritical state in the gas cooler 5. In Fig. 3, the dash-dot line represents a saturation vapor line and a saturation liquid line of CO_2. When the pressure is higher than or equal to the critical point CP, CO_2 is in the transcritical state in the gas cooler 5.

[0034] The refrigerant guided via the intake tube 11 is drawn into the low-stage compressor of the compressor 3 under intake pressure P1 (state S1). The pressure of the drawn refrigerant is increased to intermediate pressure P2 in the low-stage compressor (state S2). The refrigerant whose pressure has been increased to intermediate pressure P2 is discharged into the housing 3a. On the other hand, the intermediate-pressure refrigerant guided from the intermediate-pressure receiver 9 via the injection circuit 21 is guided into the housing 3a.

[0035] The pressure of the intermediate-pressure refrigerant in the housing 3a is increased to high pressure P3 by the high-stage compressor (state S3). The high-pressure refrigerant whose pressure has been increased is guided to the oil separator 15 via the discharge tube 35 and a lubricating oil in the refrigerant is separated therefrom. The refrigerant from which the oil has been removed by the oil separator 15 passes through the high-pressure gas pipe 45 and is guided to the gas cooler 5.

[0036] In the gas cooler 5, the refrigerant is cooled by being subjected to heat exchange with air (outside air) supplied by the fan 17 (state S4). At this time, the refrigerant is in the transcritical state.

[0037] The refrigerant that has left from the gas cooler 5 is expanded to intermediate pressure P2 by the high-stage expansion valve 7 and guided to the intermediate-pressure receiver 9. The liquid refrigerant taken out from the intermediate-pressure receiver 9 passes through the liquid feeding tube 19 and is then supercooled by the supercooling coil 23 (state S5). The liquid refrigerant is then fed to the external load device 2.

[0038] In the load device 2, the liquid refrigerant is expanded to intake pressure P1 by the low-stage expansion valve 8 (state S6) and fed to the evaporator 6. In the evaporator 6, the refrigerant removes heat from the load and evaporates into a gas refrigerant. Evaporation latent heat generated in the evaporator 6 is taken out as a freezing load. The gas refrigerant that has left from the evaporator 6 is returned to the condensing unit 1 and again fed to the compressor 3 via the intake tube 11.

[Subcritical Control]

[0039] The subcritical control is illustrated by the solid line in Fig. 3, which means that the refrigerant (CO_2 refrigerant) is in a subcritical state in the gas cooler 5. That is, in the subcritical control, high pressure P3' is a pressure lower than that at the critical point CP, and a gas-liquid two-phase state is in the gas cooler 5.

[0040] Since the operation on the pressure-enthalpy (p-h) diagram in the subcritical control is the same as the transcritical control except for a difference in high pressure P3', the description thereof is omitted.

[Switching control]

[0041] Switching control for performing switching from the transcritical control to the subcritical control will be described with reference to Fig. 4.

[0042] If the temperature measured by the outside air temperature sensor 53 is less than a first predetermined temperature (step 102) and a target evaporation temperature is less than or equal to a second predetermined temperature (step 103) in the operation under the transcritical control (step 101), the control is switched to the subcritical control after step 104 by an instruction from the control unit.

[0043] The first predetermined temperature is 18 °C, for example. Note that the first predetermined temperature is variable in accordance with the capacity of the freezing system or the like and is set to a temperature that is less than the critical temperature (31.1 °C) of CO_2 and at which the thermal efficiency of the freezing system is greater than that in the transcritical control. The first predetermined temperature is determined by a test operation or a simulation in advance, for example. When the outside air temperature is greater than or equal to the first predetermined temperature, the process returns to step 101 from step 102, and the transcritical control is maintained.

[0044] The second predetermined temperature is -10 °C, for example. The second predetermined temperature is a temperature set by the user and is set as a target value for the control unit. When the target evaporation temperature is greater than the second predetermined temperature, a difference between high and low pressures is small, the bore diameter of an expansion valve is insufficient, and a differential pressure required for the operation of the compressor is not ensured. In such a case, the process returns to step 101 from step 103, and the transcritical control is maintained.

[0045] If the target evaporation temperature is less than or equal to the second predetermined temperature in step 103 and the control is switched to the subcritical control, the process proceeds to step 104, and the control unit sets a high-pressure target value to the value for the subcritical state. Specifically, as illustrated in Fig. 3, the control unit sets a high-pressure target value from high pressure P3 to high pressure P3'. The high-pressure target value that is a set value is stored in the control unit.

[0046] The process proceeds to step 105, and the rotational rate of the fan 17 is adjusted by an instruction from the control unit. When the CO_2 refrigerant is operated under the subcritical state, since the work of the compressor decreases compared to a case of being operated under the transcritical state, the amount of exhaust heat from the gas cooler also decreases. Since electric power consumption is determined by the work of the compressor and the fan, the fan rotational rate is adjusted so that the electric power consumption decreases.

[0047] In the subcritical control compared to the transcritical control, the pressure in the gas cooler 5 decreases from high pressure P3 to high pressure P3', and intermediate pressure P2 also tends to decrease. Since the temperature in the compressor 3 decreases in response to a decrease in intermediate pressure P2, an oil temperature in the compressor 3 decreases. When the oil temperature decreases, the refrigerant is easily dissolved, and the dilution ratio increases. When the dilution ratio increases, the viscosity of the oil decreases, and an oil film is not ensured, and this may lead to damage of a sliding portion. In the present embodiment, to ensure the oil temperature, a threshold is set to the degree of under-dome superheat (= under-dome temperature - intermediate-pressure saturation temperature) obtained by the measurement value of the under-dome temperature sensor 4, and protection control to stop the compressor 3 is performed when the degree of under-dome superheat is out of the threshold. This protection control makes it possible not only to protect the compressor 3 but also to prevent liquid back where a liquid refrigerant is drawn into the intake side of the compressor 3.

[0048] The effects and advantages of the present embodiment described above are as following.

[0049] When the outside air temperature is less than the first predetermined temperature (for example, -18 °C) that is lower than the critical point CP of CO_2, even if the operation is performed so that the CO_2 refrigerant in the gas cooler 5 becomes transcritical, the difference between high and low pressures of the CO_2 refrigerant may be greater than is required and the thermal efficiency may decrease. Accordingly, when the target evaporation temperature in the evaporator is less than or equal to the second predetermined temperature (for example, -10 °C) and the difference between high and low pressures of the CO_2 refrigerant can be ensured, a thermally efficient operation can be realized by setting the high-pressure target value of the CO_2 refrigerant to be lower so that the CO_2 refrigerant in the gas cooler 5 becomes subcritical and reducing the load on the compressor 3.

[0050] When the CO_2 refrigerant is operated under the subcritical state, since the amount of heat absorption in the evaporator becomes relatively small compared to a case of the operation under the transcritical state, the amount of exhaust heat in the gas cooler 5 also decreases. Accordingly, it is possible to reduce the amount of exhaust heat to maintain heat balance by adjusting the rotational rate of the fan 17.

[0051] The freezing device, the freezing system, and the control method of a freezing device according to respective embodiments described above are recognized as follows, for example.

[0052] The freezing device of the present disclosure includes: a compressor (3) configured to compress a CO_2 refrigerant; a gas cooler (5) configured to cool a CO_2 refrigerant discharged from the compressor (3); and a control unit configured to set a high-pressure target value of the CO_2 refrigerant so that the CO_2 refrigerant in the gas cooler becomes subcritical and perform subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than the critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator (6) to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve (7, 8) is less than or equal to a second predetermined temperature.

[0053] When the outside air temperature is less than the first predetermined temperature that is lower than the critical point of CO_2, if the operation under a high pressure is performed so that the CO_2 refrigerant becomes transcritical in the gas cooler, the difference between high and low pressures of the CO_2 refrigerant may be greater than is required and the thermal efficiency may decrease. Accordingly, when the target evaporation temperature in the evaporator is less than or equal to the second predetermined temperature and the difference between high and low pressures of the CO_2 refrigerant can be ensured, a thermally efficient operation is realized by setting the high-pressure target value of the CO_2 refrigerant to be lower so that the CO_2 refrigerant in the gas cooler becomes subcritical, performing the subcritical control, and reducing the load on the compressor.

[0054] The first predetermined temperature may be, for example, 18 °C, and the second predetermined temperature may be, for example, -10 °C.

[0055] Note that the CO_2 refrigerant is not limited to a single refrigerant in which the content of CO_2 is 100% and may be a mixture refrigerant whose main component is CO_2 as long as the refrigerant has mainly properties of a CO_2 refrigerant.

[0056] In the freezing device of the present disclosure, when the outside air temperature is greater than or equal to the first predetermined temperature, the control unit sets the high-pressure target value so that the CO_2 refrigerant in the gas cooler becomes transcritical and performs transcritical control.

[0057] When the outside air temperature is greater than or equal to the first predetermined temperature, the high-pressure target value is increased to obtain a difference between the high and low pressures corresponding to the amount of exhaust heat required for the gas cooler, and the CO_2 refrigerant is operated under the transcritical state.

[0058] The freezing device of the present disclosure includes a fan (17) configured to supply cooling air to the gas cooler, and when the subcritical control is performed, the control unit adjusts rotational rate of the fan.

[0059] When the CO_2 refrigerant is operated under the subcritical state, since the work of the compressor decreases compared to a case of an operation under the transcritical state, the amount of exhaust heat from the gas cooler also decreases. Since electric power consumption is determined by the work of the compressor and the fan, the fan rotational rate is adjusted so that the electric power consumption decreases.

[0060] In the freezing device of the present disclosure, the compressor includes a low-stage compressor configured to compress a refrigerant guided from the evaporator to an intermediate pressure and a high-stage compressor configured to draw in and compress the refrigerant, which was compressed to the intermediate pressure by the low-stage compressor, to a high pressure, and the control unit performs control so that discharge pressure of the high-stage compressor becomes the high-pressure target value.

[0061] When the compressor is a two-stage compressor including a low-stage compressor and a high-stage compressor, the discharge pressure of the high-stage compressor is controlled to become a high-pressure target value.

[0062] The freezing system of the present disclosure includes: the freezing device described in any of the above; an expansion valve configured to expand a CO_2 refrigerant supplied from the gas cooler; and an evaporator configured to evaporate the CO_2 refrigerant guided from the expansion valve.

[0063] The control method of a freezing device of the present disclosure is a control method of a freezing device including a compressor configured to compress a CO_2 refrigerant, and a gas cooler configured to cool a CO_2 refrigerant discharged from the compressor, and the control method includes: setting a high-pressure target value of a CO_2 refrigerant so that a CO_2 refrigerant in the gas cooler becomes subcritical and performing subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than the critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve is less than or equal to a second predetermined temperature.

[List of Reference Symbols]

[0064]

1	condensing unit (freezing device)
2	load device
3	compressor
3a	housing
4	under-dome temperature sensor
5	gas cooler
6	evaporator
7	high-stage expansion valve
8	low-stage expansion valve
9	intermediate-pressure receiver
11	intake tube
12	low-pressure sensor
13	accumulator
14	intake tube temperature sensor
15	oil separator
17	fan
19	liquid feeding tube
21	injection circuit
23	supercooling coil
25	branch tube
27	supercooling coil electronic expansion valve
31	intermediate-pressure sensor
33	intermediate-pressure intake electromagnetic valve
35	discharge tube
37	discharge temperature sensor
39	oil return tube

41 oil return electromagnetic valve
43 capillary
45 high-pressure gas pipe
47 check valve
49 high-pressure sensor
51 gas cooler inlet temperature sensor
53 outside air temperature sensor
CP critical point
P1 intake pressure
P2 intermediate pressure
P3 high pressure (transcritical)
P3' high pressure (subcritical)

Claims

1. A freezing device (1) comprising:

a compressor (3) configured to compress a CO_2 refrigerant;
a gas cooler (5) configured to cool a CO_2 refrigerant discharged from the compressor; and
a control unit configured to set a high-pressure target value of the CO_2 refrigerant so that the CO_2 refrigerant in the gas cooler becomes subcritical and perform subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than a critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator (6) to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve (7,8) is less than or equal to a second predetermined temperature.

2. The freezing device according to claim 1, wherein when the outside air temperature is greater than or equal to the first predetermined temperature, the control unit sets the high-pressure target value so that the CO_2 refrigerant in the gas cooler becomes transcritical and performs transcritical control.

3. The freezing device according to claim 1 or 2 further comprising a fan (17) configured to supply cooling air to the gas cooler (5),
wherein when the subcritical control is performed, the control unit adjusts rotational rate of the fan.

4. The freezing device according to any one of claims 1 to 3,

wherein the compressor (3) comprises a low-stage compressor configured to compress a refrigerant guided from the evaporator to an intermediate pressure and a high-stage compressor configured to draw in and compress the refrigerant, which was compressed to the intermediate pressure by the low-stage compressor, to a high pressure, and
wherein the control unit performs control so that a discharge pressure of the high-stage compressor becomes the high-pressure target value.

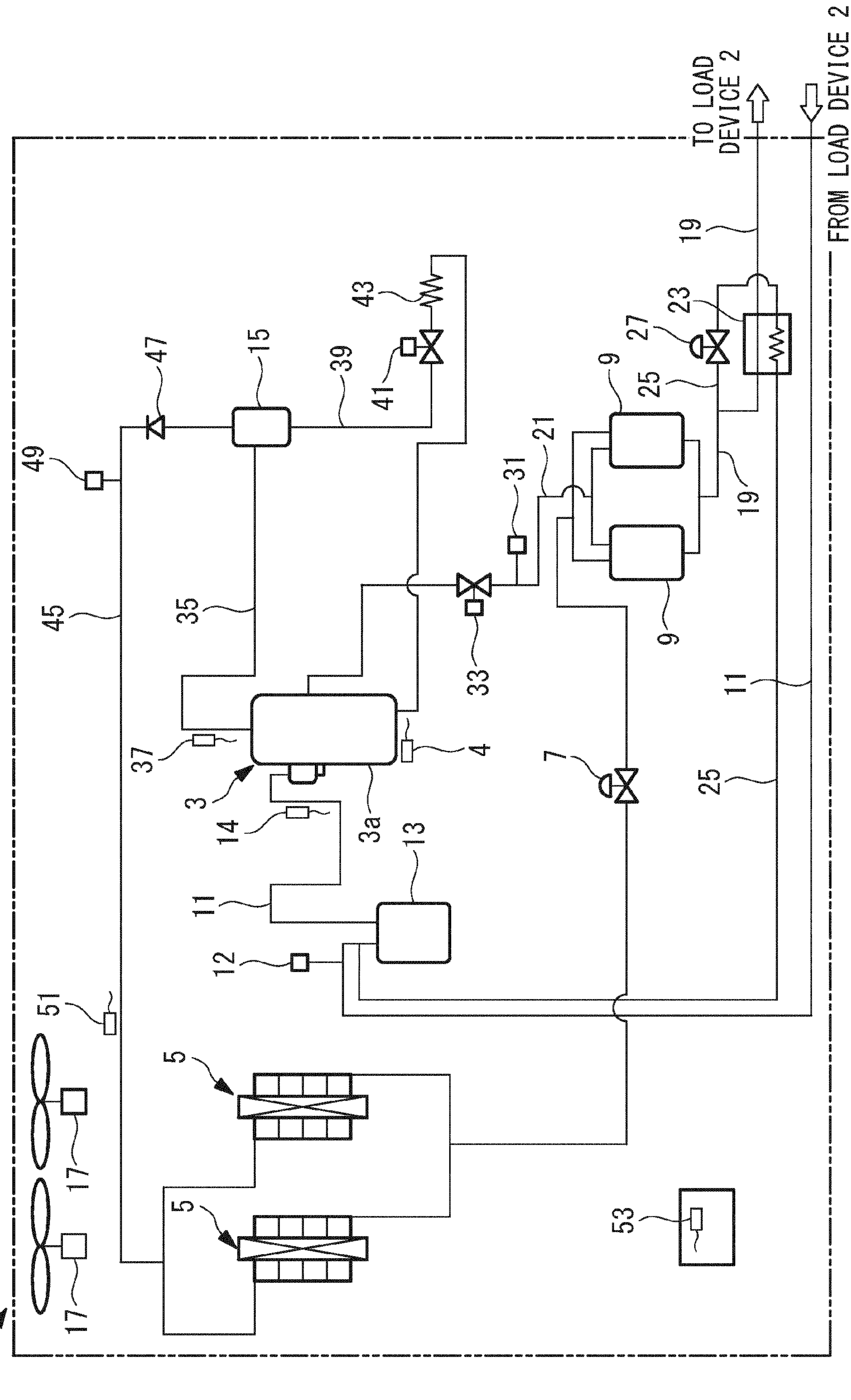
5. A freezing system comprising:

the freezing device (1) according to any one of claims 1 to 4;
an expansion valve (7,8) configured to expand a CO_2 refrigerant supplied from the gas cooler (5); and
an evaporator (6) configured to evaporate the CO_2 refrigerant guided from the expansion valve.

6. A control method of a freezing device comprising

a compressor (3) configured to compress a CO_2 refrigerant, and
a gas cooler (5) configured to cool a CO_2 refrigerant discharged from the compressor,
the control method comprising:
setting a high-pressure target value of the CO_2 refrigerant so that the CO_2 refrigerant in the gas cooler becomes subcritical and performing subcritical control when an outside air temperature is less than a first predetermined temperature, which is lower than a critical point of the CO_2 refrigerant, and a target evaporation temperature in an evaporator to which the CO_2 refrigerant cooled by the gas cooler is guided via an expansion valve is less than or equal to a second predetermined temperature.

FIG. 1


TO LOAD DEVICE 2
FROM LOAD DEVICE 2
1
3
3a
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5
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FIG. 2

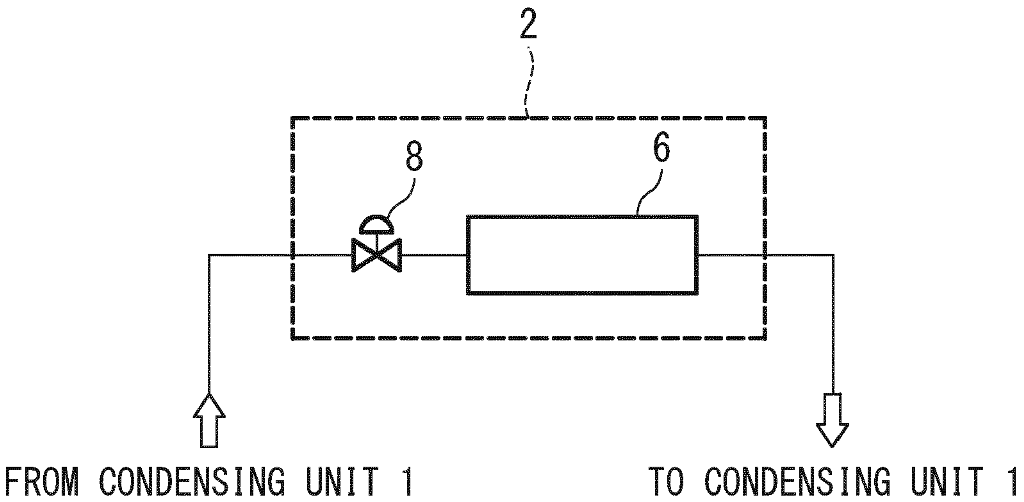


FIG. 3

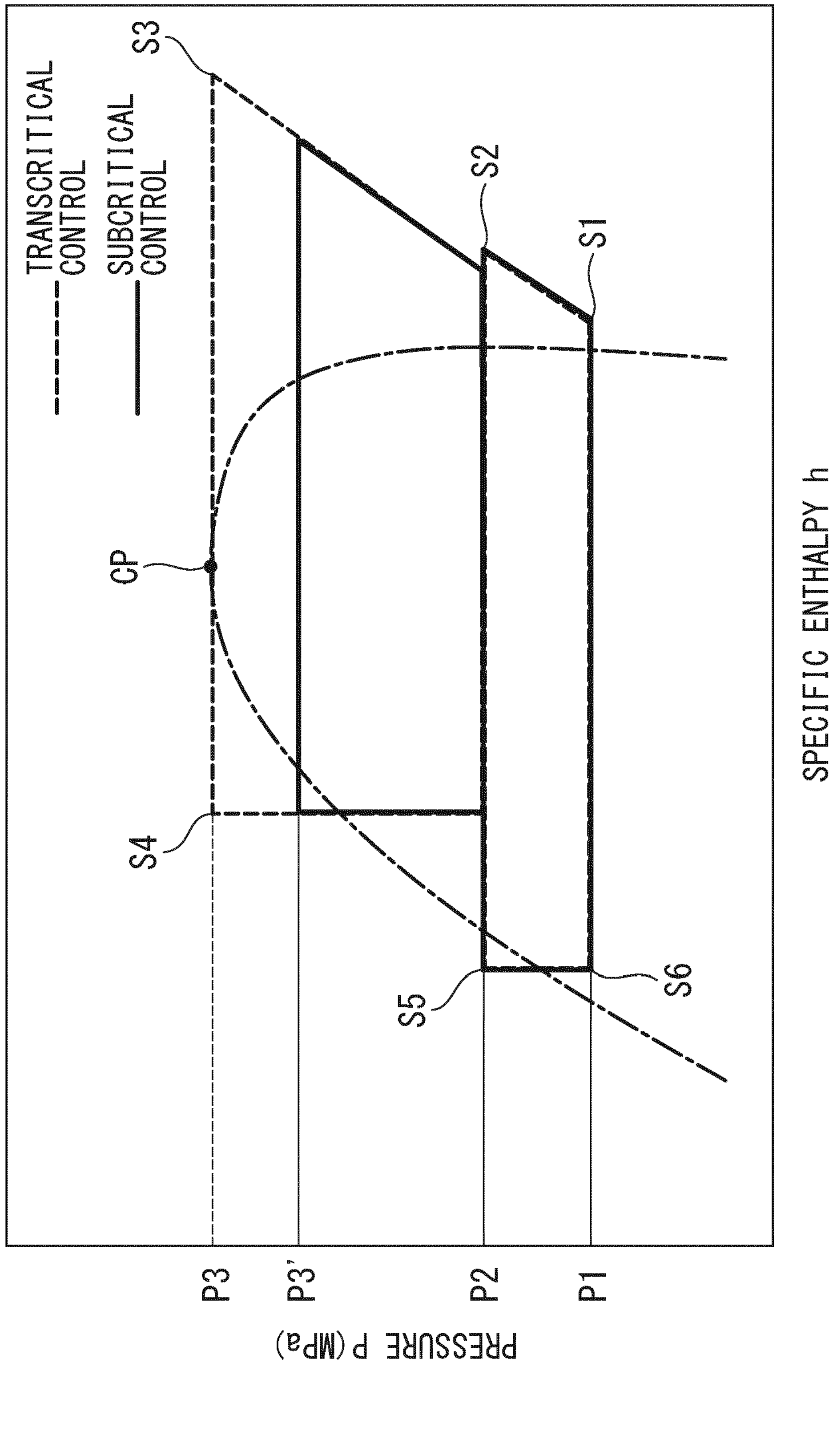
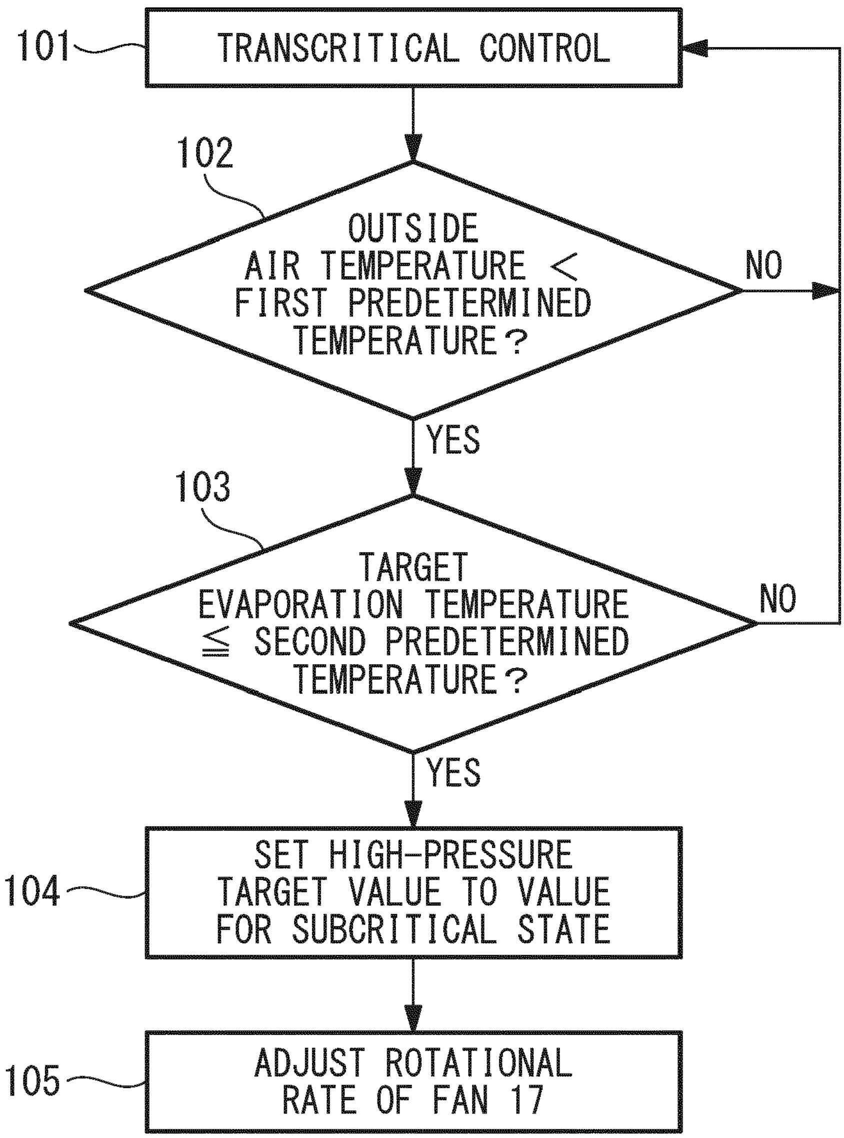

TRANSCRITICAL CONTROL
SUBCRITICAL CONTROL
S1
S2
S3
S4
S5
S6
CP
P1
P2
P3'
P3
PRESSURE P (MPa)
SPECIFIC ENTHALPY h

FIG. 4


101
TRANSCRITICAL CONTROL
102
OUTSIDE AIR TEMPERATURE < FIRST PREDETERMINED TEMPERATURE?
NO
YES
103
TARGET EVAPORATION TEMPERATURE ≦ SECOND PREDETERMINED TEMPERATURE?
NO
YES
104
SET HIGH-PRESSURE TARGET VALUE TO VALUE FOR SUBCRITICAL STATE
105
ADJUST ROTATIONAL RATE OF FAN 17

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Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 18 1615

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	PUROHIT NILESH ET AL: "Energetic and economic analysis of trans-critical CO2booster system for refrigeration in warm climatic condition", INTERNATIONAL JOURNAL OF REFRIGERATION, ELSEVIER, AMSTERDAM, NL, vol. 80, 2 May 2017 (2017-05-02), pages 182-196, XP085130818, ISSN: 0140-7007, DOI: 10.1016/J.IJREFRIG.2017.04.023 * page 186, paragraph 3 - page 189; figure 9 * -----	1-6	INV. F25B9/00 F25B49/02
A	WO 03/019085 A1 (MAERSK CONTAINER IND AS [DK]; LODAM ELEKTRONIK AS [DK] ET AL.) 6 March 2003 (2003-03-06) * pages 10-12; figures 4-8 * -----	1-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	8 November 2022	Weisser, Meinrad

CATEGORY OF CITED DOCUMENTS

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08-11-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03019085 A1	06-03-2003	NONE	

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Patent documents cited in the description

- JP 2008530501 A **[0002] [0003]**