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(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus (1) includes a first circuit (10), a second circuit (20), and a control unit (6). The first circuit (10) includes a first compressor (11), a first heat exchanger (12), a first expansion mechanism (13), and a cascade heat exchanger (30). The first circuit (10) allows circulation of a first refrigerant. The second circuit (20) includes a second compressor (21), a second

heat exchanger (23), the cascade heat exchanger (30), a second expansion mechanism (24), and a third heat exchanger (25). The second circuit (20) allows circulation of a second refrigerant. The control unit (6) executes stop control of collecting the first refrigerant to the first heat exchanger (12) before stopping operation of the first circuit (10).

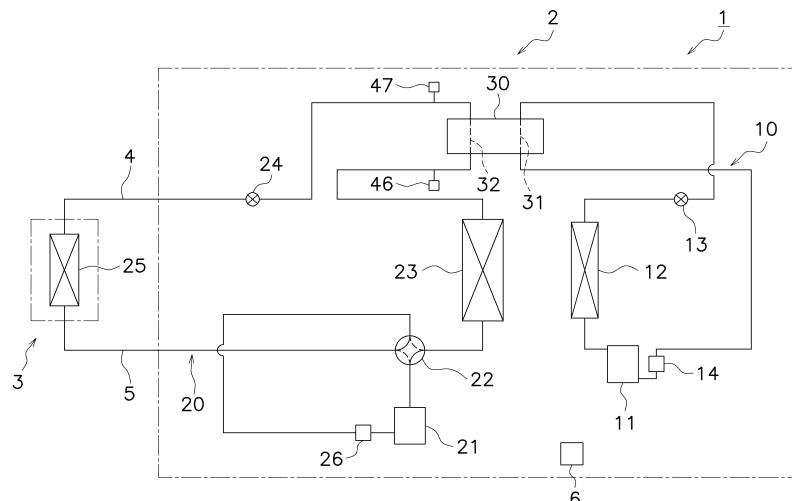


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Patent Literature 1 (Japanese Patent No. 5430604) discloses heat exchange in a cascade condenser between an evaporator in a high-order refrigeration cycle and a condenser in a low-order refrigeration cycle in a binary refrigeration apparatus including the low-order refrigeration cycle using carbon dioxide as a refrigerant and the high-order refrigeration cycle supporting heat radiation in the low-order refrigeration cycle.

SUMMARY OF THE INVENTION

<Technical Problem>

[0003] The present inventor has focused on a problem that a liquid refrigerant may flow into a compressor in the binary refrigeration apparatus according to Patent Literature 1.

<Solution to Problem>

[0004] The present inventor has found that this problem derives from the fact that the evaporator in the high-order refrigeration cycle in the cascade condenser is cooled and the refrigerant is liquefied when the high-order refrigeration cycle is stopped. If the high-order refrigeration cycle is operated in this state, the liquefied refrigerant flows into the compressor.

[0005] In view of this, a refrigeration cycle apparatus according to a first aspect includes a first circuit, a second circuit, and a control unit. The first circuit includes a first compressor, a first heat exchanger, a first expansion mechanism, and a cascade heat exchanger. The first circuit allows circulation of a first refrigerant. The second circuit includes a second compressor, a second heat exchanger, the cascade heat exchanger, a second expansion mechanism, and a third heat exchanger. The second circuit allows circulation of a second refrigerant. The control unit executes stop control of collecting the first refrigerant in the first heat exchanger before stopping operation of the first circuit.

[0006] In the refrigeration cycle apparatus according to the first aspect, the control unit executes stop control of collecting the first refrigerant in the first heat exchanger before stopping operation of the first circuit. Accordingly, the first refrigerant collected to the cascade heat exchanger can be decreased. This can inhibit liquefaction of the first refrigerant in the cascade heat exchanger while the first circuit is stopped. The first circuit is operated in this state, and the liquefied first refrigerant can thus be in-

hibited from flowing into the first compressor.

[0007] A refrigeration cycle apparatus according to a second aspect is the refrigeration cycle apparatus according to the first aspect, in which the control unit executes operation of the second circuit before operating the first circuit in cooling operation.

[0008] In the refrigeration cycle apparatus according to the second aspect, the control unit operates the second circuit before operating the first circuit. Accordingly, the second refrigerant, which has passed through the second heat exchanger in the second circuit and is passing through the cascade heat exchanger, can provide heat to the first refrigerant collected to the cascade heat exchanger. The first refrigerant can be heated with use of this heat, and the liquefied first refrigerant can thus be further inhibited from flowing into the first compressor.

[0009] A refrigeration cycle apparatus according to a third aspect is the refrigeration cycle apparatus according to the second aspect, in which operation of the first circuit starts when difference between inlet temperature and outlet temperature of the cascade heat exchanger in the second circuit reaches a certain value or less.

[0010] In the refrigeration cycle apparatus according to the third aspect, when the difference between the inlet temperature and the outlet temperature of the cascade heat exchanger in the second circuit reaches the certain value or less, it is determined that heat of the second refrigerant is transferred to the first refrigerant and the first refrigerant is gasified in the cascade heat exchanger. The first circuit is operated in this state, and the liquefied first refrigerant can thus be further inhibited from flowing into the first compressor.

[0011] A refrigeration cycle apparatus according to a fourth aspect is the refrigeration cycle apparatus according to the second aspect, in which the control unit starts operation of the first circuit after elapse of a predetermined period from starting operation of the second circuit.

[0012] In the refrigeration cycle apparatus according to the fourth aspect, when the predetermined period elapses from operation of the second circuit, it is determined that heat of the second refrigerant is transferred to the first refrigerant and the first refrigerant is gasified in the cascade heat exchanger. The first circuit is operated in this state, and the liquefied first refrigerant can thus be further inhibited from flowing into the first compressor.

[0013] A refrigeration cycle apparatus according to a fifth aspect is the refrigeration cycle apparatus according to any one of the first to fourth aspects, in which an opening degree of the first expansion mechanism is increased after activation of the first compressor.

[0014] In the refrigeration cycle apparatus according to the fifth aspect, the opening degree of the first expansion mechanism is not increased upon activation of the first compressor, so as to inhibit the first refrigerant in the first circuit from directly flowing into the first compressor. This can further inhibit the liquefied first refrigerant from flowing into the first compressor.

[0015] A refrigeration cycle apparatus according to a sixth aspect is the refrigeration cycle apparatus according to the fifth aspect, in which the control unit activates the second compressor, subsequently increases an opening degree of the second expansion mechanism, then activates the first compressor, and thereafter increases the opening degree of the first expansion mechanism.

[0016] When the second compressor, the second expansion mechanism, the first compressor, and the first expansion mechanism are controlled in the mentioned order as in the refrigeration cycle apparatus according to the sixth aspect, the first circuit and the second circuit can operate in the state where the liquefied first refrigerant is inhibited from flowing into the first compressor.

[0017] A refrigeration cycle apparatus according to a seventh aspect is the refrigeration cycle apparatus according to any one of the first to sixth aspects, in which the control unit controls operation of the first circuit and operation of the second circuit.

[0018] As in the refrigeration cycle apparatus according to the seventh aspect, the control unit for the second circuit may control the first circuit.

[0019] A refrigeration cycle apparatus according to an eighth aspect is the refrigeration cycle apparatus according to any one of the first to seventh aspects, in which the first heat exchanger is a flat porous tube.

[0020] In the refrigeration cycle apparatus according to the eighth aspect, the flat porous tube functioning as the first heat exchanger can be reduced in volume, so as to decrease quantity of the first refrigerant. This achieves a decrease in the first refrigerant collected to the cascade heat exchanger.

[0021] A refrigeration cycle apparatus according to a ninth aspect is the refrigeration cycle apparatus according to any one of the first to eighth aspects, and further includes a fan configured to send outdoor air to the first heat exchanger and the second heat exchanger.

[0022] The refrigeration cycle apparatus according to the ninth aspect includes the common fan configured to send outdoor air to the first heat exchanger and the second heat exchanger. Accordingly, outdoor air flows to the first heat exchanger while the second circuit is in operation even if the first circuit is stopped. Heat exchange is thus executed between the first refrigerant collected to the first heat exchanger and outdoor air, and the liquefied first refrigerant can be easily collected to the first heat exchanger. This can further inhibit the liquefied first refrigerant from flowing into the first compressor.

[0023] A refrigeration cycle apparatus according to a tenth aspect is the refrigeration cycle apparatus according to any one of the first to ninth aspects, in which the first circuit further includes an accumulator.

[0024] In the refrigeration cycle apparatus according to the tenth aspect, the liquefied first refrigerant can be reserved in the accumulator, so as to further inhibit the liquefied first refrigerant from flowing into the first com-

pressor.

[0025] A refrigeration cycle apparatus according to an eleventh aspect is the refrigeration cycle apparatus according to any one of the first to tenth aspects, in which the control unit fully closes the first expansion mechanism while the second circuit is in operation and the first circuit is stopped.

[0026] While the second circuit is in operation and the first circuit is stopped, the first refrigerant is likely to be cooled in the cascade heat exchanger. In this case, in the refrigeration cycle apparatus according to the eleventh aspect, the first expansion mechanism is fully closed so as to decrease the first refrigerant flowing into the cascade heat exchanger. This can further inhibit the liquefied first refrigerant from flowing into the first compressor.

[0027] A refrigeration cycle apparatus according to a twelfth aspect is the refrigeration cycle apparatus according to any one of the first to eleventh aspects, in which the control unit is configured to execute heating operation and cooling operation.

[0028] In the refrigeration cycle apparatus according to the twelfth aspect, operation of the first circuit is stopped during heating operation and the first refrigerant collected to the cascade heat exchanger is thus likely to be liquefied. This is likely to cause the problem that the liquefied first refrigerant flows into the first compressor. Even in a case where this problem is likely to arise, execution of stop control can inhibit the liquefied first refrigerant from flowing into the first compressor.

[0029] A refrigeration cycle apparatus according to a thirteenth aspect is the refrigeration cycle apparatus according to any one of the first to twelfth aspects, in which the first refrigerant is flammable, is toxic, or has a GWP (global warming potential) exceeding 500.

[0030] As in the refrigeration cycle apparatus according to the thirteenth aspect, there may be adopted the first refrigerant that is flammable, is toxic, or has a GWP exceeding 500.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

FIG. 1 is a schematic configuration diagram of a refrigeration cycle apparatus according to an embodiment of the present disclosure.

FIG. 2 is a pattern sectional view of an outdoor unit.

FIG. 3 is a schematic perspective view of a first heat exchanger.

FIG. 4 is a control block diagram of the refrigeration cycle apparatus.

FIG. 5 is a diagram indicating behavior during heating operation of the refrigeration cycle apparatus.

FIG. 6 is a diagram indicating behavior during cooling operation of the refrigeration cycle apparatus.

FIG. 7 is a flowchart of stop control.

FIG. 8 is a flowchart of start control.

FIG. 9 is a flowchart of start control according to

modification example 1.

DESCRIPTION OF EMBODIMENTS

(1) Entire configuration

[0032] As depicted in FIG. 1, a refrigeration cycle apparatus 1 according to an embodiment of the present disclosure is configured to execute vapor compression refrigeration cycle operation to be applied for cooling or heating an indoor space of a building or the like.

[0033] The refrigeration cycle apparatus 1 includes a first circuit 10, a second circuit 20, and a control unit 6. The refrigeration cycle apparatus 1 according to the present embodiment includes a binary refrigerant circuit consisting of the first circuit 10 of a vapor compression type and the second circuit 20 of the vapor compression type, and achieves a binary refrigeration cycle.

[0034] The first circuit 10 allows circulation of a first refrigerant. The second circuit 20 allows circulation of a second refrigerant. The first circuit 10 and the second circuit 20 are thermally connected to each other via a cascade heat exchanger 30.

[0035] The refrigeration cycle apparatus 1 includes an outdoor unit 2 and an indoor unit 3. The refrigeration cycle apparatus 1 includes the outdoor unit 2 and the indoor unit 3 connected to each other via connection pipes 4 and 5.

[0036] The control unit 6 executes stop control of collecting the first refrigerant to a first heat exchanger 12 before stopping operation of the first circuit 10.

(2) Detailed configurations

(2-1) First circuit

[0037] The first refrigerant flowing in the first circuit 10 is not limited, and is flammable, is toxic, or has a GWP exceeding 500 herein. Examples of the first refrigerant include a hydrocarbon refrigerant, R1234yf, R1234ze, and R32, and the present embodiment adopts R290.

[0038] The first circuit 10 constitutes a subcooling circuit during cooling operation. The first circuit functions as an assist circuit configured to support capability of the second circuit 20 during cooling operation.

[0039] The first circuit 10 includes a first compressor 11, the first heat exchanger 12, a first expansion mechanism 13, a first accumulator 14, and the cascade heat exchanger 30.

[0040] The first compressor 11 is configured to compress the first refrigerant, and is exemplarily constituted as a positive displacement compressor of a scroll type configured to inverter control a compressor motor to have variable operating capacity.

[0041] The first heat exchanger 12 is configured to cause heat exchange between the first refrigerant and outdoor air. The first refrigerant in the first heat exchanger 12 receives low temperature heat or high temperature

heat from outdoor air. Examples of the first heat exchanger 12 include a flat porous tube depicted in FIG. 3.

[0042] The first expansion mechanism 13 is configured to decompress the first refrigerant, and is exemplarily constituted as an electrically powered expansion valve. The first expansion mechanism 13 is disposed between the first heat exchanger 12 and the cascade heat exchanger 30.

[0043] The first accumulator 14 is provided at a halfway position of a suction flow path connecting the cascade heat exchanger 30 and a suction side of the first compressor 11. The first accumulator 14 separates an incoming refrigerant into a liquid refrigerant and a gas refrigerant, and sends only the gas refrigerant to the suction side of the first compressor 11.

[0044] The first accumulator 14 according to the present embodiment functions as a sub-accumulator accompanying an ordinary accumulator not provided. Specifically, the first accumulator 14 has half or less the volume of a second accumulator 26 included in the second circuit 20 to be described later.

[0045] The cascade heat exchanger 30 is configured to cause heat exchange between the first refrigerant and the second refrigerant without mixing the refrigerants. The cascade heat exchanger 30 is exemplarily constituted as a plate heat exchanger. The cascade heat exchanger 30 includes a first flow path 31 belonging to the first circuit 10, and a second flow path 32 belonging to the second circuit 20. The first flow path 31 has a gas side connected to the first compressor 11, and a liquid side connected to the first expansion mechanism 13.

[0046] In a case where the first heat exchanger 12 functions as a radiator and a second heat exchanger 23 included in the second circuit 20 to be described later functions as a radiator, the cascade heat exchanger 30 has an object of subcooling the second refrigerant cooled in the second heat exchanger 23, and functions as an assistant of the second circuit 20.

(2-2) Second circuit

[0047] The second refrigerant flowing in the second circuit 20 is not limited, and may be the same as or different from the first refrigerant. The second refrigerant is incombustible, is nontoxic, or has a GWP equal to or less than 500 herein. Examples of the second refrigerant include a natural refrigerant, and the present embodiment adopts carbon dioxide.

[0048] The second circuit 20 is a main circuit configured to cause the second refrigerant to heat or cool indoor air.

[0049] The second circuit 20 includes a second compressor 21, a switching mechanism 22, the second heat exchanger 23, the cascade heat exchanger 30, a second expansion mechanism 24, a third heat exchanger 25, and the second accumulator 26.

[0050] The second compressor 21 is configured to compress the second refrigerant, and is exemplarily

constituted as a positive displacement compressor of a scroll type configured to inverter control a compressor motor to have variable operating capacity.

[0051] The switching mechanism 22 is configured to switch between a first state (see solid lines in the switching mechanism 22 in FIG. 1) where the second heat exchanger 23 functions as a radiator for the second refrigerant and the third heat exchanger 25 functions as an evaporator for the second refrigerant, and a second state (see broken lines in the switching mechanism 22 in FIG. 1) where the second heat exchanger 23 functions as an evaporator for the second refrigerant and the third heat exchanger 25 functions as a radiator for the second refrigerant. The switching mechanism 22 is exemplarily constituted as a four-way switching valve. The switching mechanism 22 in the first state connects a discharge side of the second compressor 21 and a gas side of the second heat exchanger 23, and connects a suction side of the second compressor 21 and a gas side of the third heat exchanger 25. The switching mechanism 22 in the second state connects the discharge side of the second compressor 21 and the gas side of the third heat exchanger 25, and connects the suction side of the second compressor 21 and the gas side of the second heat exchanger 23.

[0052] The second heat exchanger 23 is configured to cause heat exchange between the second refrigerant and outdoor air. The second refrigerant in the second heat exchanger 23 receives low temperature heat or high temperature heat from outdoor air. The second heat exchanger 23 is exemplarily of a cross-fin tube type.

[0053] The second circuit 20 includes the second flow path 32 of the cascade heat exchanger 30. In the second state, the second flow path 32 has a gas side connected to the second heat exchanger 23, and a liquid side connected to the third heat exchanger 25.

[0054] The second expansion mechanism 24 is configured to decompress the second refrigerant, and is exemplarily constituted as an electrically powered expansion valve.

[0055] The third heat exchanger 25 is configured to cause heat exchange between the second refrigerant and indoor air, and is exemplarily constituted as a fin-and-tube heat exchanger.

[0056] The second accumulator 26 is provided at a halfway position of a suction flow path connecting the switching mechanism 22 and the suction side of the second compressor 21. The second accumulator 26 separates an incoming refrigerant into a liquid refrigerant and a gas refrigerant, and sends only the gas refrigerant to the suction side of the second compressor 21.

(2-3) Outdoor unit

[0057] The following description appropriately includes expressions indicating directions such as "upward", "downward", and "forward", which indicate directions in a state where the outdoor unit 2 is disposed

outdoors and is used ordinarily. An up and down direction in the present embodiment is a vertical direction.

[0058] The outdoor unit 2 is disposed in a space different from a space provided with the indoor unit 3. The outdoor unit 2 is disposed outdoors (on a roof of a building, adjacent to a wall surface of a building, or the like).

[0059] The outdoor unit 2 includes the first circuit 10, part of the second circuit 20, a casing 41, an electric component unit 42, a fan 43, a partition plate 44, a separator plate 45, and various sensors. Specifically, the outdoor unit 2 includes the first compressor 11, the first heat exchanger 12, the first expansion mechanism 13, the second compressor 21, the switching mechanism 22, the second heat exchanger 23, the second expansion mechanism 24, the second accumulator 26, the cascade heat exchanger 30, an inlet temperature sensor 46, and an outlet temperature sensor 47, which are depicted in FIG. 1, as well as the casing 41, the electric component unit 42, the fan 43, the partition plate 44, and the separator plate 45, which are depicted in FIG. 2.

[0060] The casing 41 accommodates the first compressor 11, the first heat exchanger 12, the first expansion mechanism 13, the second compressor 21, the switching mechanism 22, the second heat exchanger 23, the second expansion mechanism 24, the second accumulator 26, the cascade heat exchanger 30, the electric component unit 42, the fan 43, the partition plate 44, the separator plate 45, and various sensors.

[0061] The casing 41 depicted in FIG. 2 has a substantially rectangular parallelepiped shape. Specifically, the casing 41 includes a front panel 411, a top panel 412, a bottom plate 413, and a side plate 414.

[0062] The front panel 411 is a plate-shaped member constituting a front surface of the casing 41. The front panel 411 is provided with a blow-out port. The blow-out port is an opening allowing outdoor air imported into the casing 41 from outside to blow out of the casing 41.

[0063] The top panel 412 is a plate-shaped member constituting an upper surface of the casing 41. The bottom plate 413 is a plate-shaped member constituting a lower surface of the casing 41. The top panel 412 and the bottom plate 413 face each other.

[0064] The side plate 414 is a plate-shaped member constituting a side surface of the casing 41. The side plate 414 has a lower portion fixed to the bottom plate 413.

[0065] The electric component unit 42 includes a substrate and an electric component mounted onto the substrate. The electric component controls control targets such as the first compressor 11, the second compressor 21, the first expansion mechanism 13, the switching mechanism 22, and the second expansion mechanism 24.

[0066] The fan 43 causes air to flow into the first heat exchanger 12 and the second heat exchanger 23. The fan 43 according to the present embodiment causes outdoor air to flow into both the first heat exchanger 12 and the second heat exchanger 23. Herein, the fan 43 generates an air flow by guiding outdoor air into the first

heat exchanger 12 and the second heat exchanger 23, allowing heat exchange between the outdoor air and the first refrigerant in the first heat exchanger 12 and allowing heat exchange between the outdoor air and the second refrigerant in the second heat exchanger 23, and then allowing the air to flow outdoors. As depicted in FIG. 2, the fan 43 in a front view is overlapped with the first heat exchanger 12 and the second heat exchanger 23. The fan 43 is driven by a fan motor.

[0067] Alternatively, there may be provided a fan configured to send air to the first heat exchanger 12 and a separate fan configured to send air to the second heat exchanger 23.

[0068] The partition plate 44 is a plate-shaped member extending vertically. The partition plate 44 has a lower portion fixed to the bottom plate 413 of the casing 41.

[0069] The partition plate 44 divides the interior of the casing 41 into a first chamber S1 and a second chamber S2. Each of the first chamber S1 and the second chamber S2 is a space defined by the front panel 411, the top panel 412, the bottom plate 413, and the side plate 414 of the casing 41 and the partition plate 44.

[0070] Herein, the first chamber S1 serves as a blast chamber, and is an air guide duct allowing air sucked via a blow-in port of the outdoor unit 2 to flow to the blow-out port. The first chamber S1 according to the present embodiment accommodates the first heat exchanger 12, the second heat exchanger 23, the fan 43, and the like.

[0071] The second chamber S2 serves as a machine chamber. The second chamber S2 accommodates the first compressor 11, the second compressor 21, the switching mechanism 22, the first expansion mechanism 13, the second expansion mechanism 24, the second accumulator 26, the cascade heat exchanger 30, the electric component unit 42, and the like.

[0072] The separator plate 45 divides the second chamber S2 into a first machine chamber S21 constituting the first circuit 10 and a second machine chamber S22 constituting the second circuit 20. The separator plate 45 is a plate-shaped member extending vertically. The separator plate 45 has a lower portion fixed to the bottom plate 413 of the casing 41. Herein, the first machine chamber S21, which is defined by the front panel 411, the top panel 412, the bottom plate 413, the side plate 414, and the separator plate 45, accommodates the first compressor 11, the first expansion mechanism 13, the cascade heat exchanger 30, and the like. The second machine chamber S22, which is defined by the front panel 411, the top panel 412, the bottom plate 413, the partition plate 44, and the separator plate 45, accommodates the second compressor 21, the switching mechanism 22, the second expansion mechanism 24, the second accumulator 26, the electric component unit 42, and the like.

[0073] The inlet temperature sensor 46 detects temperature of the second refrigerant that is to flow into the cascade heat exchanger 30 during cooling operation.

The outlet temperature sensor 47 detects temperature of the second refrigerant that has passed through the cascade heat exchanger 30 during cooling operation.

5 (2-4) Indoor unit

[0074] The indoor unit 3 is installed indoors (in a building). The indoor unit 3 is connected to the outdoor unit 2 via the connection pipes 4 and 5 as described above, and constitutes part of the second circuit 20.

[0075] As depicted in FIG. 1, the indoor unit 3 includes the third heat exchanger 25. Herein, the indoor unit 3 is installed by being embedded in or being suspended from a ceiling in an indoor space of a building or the like, or by being hung on a wall surface in the indoor space, or the like.

(2-5) Connection pipes

[0076] The connection pipes 4 and 5 are refrigerant pipes constructed onsite when the refrigeration cycle apparatus 1 is installed at an installation site such as a building. The connection pipe 4 on a liquid side has a first end connected to a liquid side end portion of the outdoor unit 2, and a second end connected to a liquid side end portion of the third heat exchanger 25 in the indoor unit 3. The connection pipe 5 on a gas side has a first end connected to a gas side end portion of the outdoor unit 2, and a second end connected to a gas side end portion of the third heat exchanger 25 in the indoor unit 3.

(2-6) Control unit

(2-6-1) Outline

[0077] The outdoor unit 2 and the indoor unit 3 each include constituent devices that are controlled by the control unit 6. The control unit 6 is constituted by the electric component unit 42 and the like included in the outdoor unit 2 and a control board and the like (not depicted) included in the indoor unit 3, which are communicably connected.

[0078] As depicted in FIG. 4, the control unit 6 controls constituent devices of the refrigeration cycle apparatus 1 (the outdoor unit 2 and the indoor unit 3 herein). In other words, the control unit 6 is configured to control operation of the entire refrigeration cycle apparatus 1. The control unit 6 according to the present embodiment thus controls operation of the first circuit 10 and operation of the second circuit 20. Herein, the control unit 6 is provided in a unit (the second machine chamber S22 in FIG. 2) constituting the second circuit 20, and starts operation of the first circuit 10 in accordance with an operation start of the second circuit 20.

[0079] The control unit 6 is embodied by a computer. The control unit 6 includes a control arithmetic device and a storage device. Examples of the control arithmetic device can include a processor such as a CPU or a

GPU. The control arithmetic device reads a program stored in the storage device and executes predetermined image processing or arithmetic processing in accordance with the program. The control arithmetic device is further configured to write an arithmetic result to the storage device and read information stored in the storage device in accordance with the program.

(2-6-2) Stop control

[0080] The control unit 6 executes stop control of collecting the first refrigerant to the first heat exchanger 12 before stopping operation of the first circuit 10. Stop control includes, when the control unit 6 receives a command to stop the first compressor 11, operating the first compressor 11 to push the first refrigerant in the first circuit 10 into the first heat exchanger 12, and then stopping the first compressor 11. Accordingly, even upon receipt of the command to stop the first compressor 11, the control unit 6 does not readily stop the first compressor 11 but continuously operates the first compressor 11 for a while to push the first refrigerant into the first heat exchanger 12, and then stops the first compressor 11.

[0081] In stop control, operation of the first compressor 11 is stopped at timing such as after a predetermined period elapses from receipt of a command to stop operation of the first circuit 10, when pressure or pressure equivalent temperature on a high pressure side reaches a predetermined value or more, or when pressure or pressure equivalent temperature on a low pressure side reaches a predetermined value or less.

[0082] The control unit 6 according to the present embodiment fully closes the first expansion mechanism 13 while the second circuit 20 is executing heating operation and the first circuit 10 is stopped.

(2-6-3) Start control

[0083] The control unit 6 executes start control of operating the second circuit 20 before operating the first circuit 10 in cooling operation. Start control includes, when the control unit 6 receives a command to activate the first circuit 10, activating the second compressor 21 before activating the first compressor 11.

[0084] Specifically, the control unit 6 starts operation of the first circuit 10 when difference between inlet temperature and outlet temperature of the cascade heat exchanger 30 in the second circuit 20 reaches a certain value or less. Herein, the control unit 6 acquires temperature of the second refrigerant that is to flow into the cascade heat exchanger 30 from the inlet temperature sensor 46, and temperature of the second refrigerant that has flowed out of the cascade heat exchanger 30 from the outlet temperature sensor 47. The control unit 6 calculates temperature difference between the inlet temperature and the outlet temperature thus acquired of the second refrigerant in the cascade heat exchanger 30 and judges whether or not the temperature difference has the certain

value or less. The temperature difference is exemplarily 5°C or less, and is preferably 2°C or less. In a case where the control unit 6 judges that the temperature difference thus calculated has the certain value or less, the control unit 6 activates the first compressor 11. In another case where the control unit 6 judges that the temperature difference thus calculated does not have the certain value or less, the control unit 6 does not activate the first compressor 11.

[0085] The control unit 6 increases an opening degree of the first expansion mechanism 13 after the first compressor 11 is activated. Herein, in order to prevent the first refrigerant accumulated in the first flow path 31 of the cascade heat exchanger 30 from collectively flowing and the liquefied first refrigerant from flowing into the first compressor 11, the control unit 6 slightly opens the first expansion mechanism 13 to have a smaller opening degree in comparison to cooling operation. The control unit 6 controls the opening degree of the first expansion mechanism 13 in accordance with a load after the first refrigerant starts circulation.

[0086] The control unit 6 according to the present embodiment activates the second compressor 21, subsequently increases an opening degree of the second expansion mechanism 24, then activates the first compressor 11, and thereafter increases the opening degree of the first expansion mechanism 13. In this case, the first expansion mechanism 13 is smaller in opening degree than the second expansion mechanism 24.

(3) Behavior

[0087] Description is made to behavior of the refrigeration cycle apparatus 1 with reference to FIG. 1 to FIG. 8. The refrigeration cycle apparatus 1 is configured to execute heating operation of heating indoor air and cooling operation of cooling indoor air to condition indoor air. The control unit 6 controls behavior of the refrigeration cycle apparatus 1 during heating operation and cooling operation.

(3-1) Heating operation

[0088] As depicted in FIG. 5, during heating operation, the switching mechanism 22 is switched into the second state (where the switching mechanism 22 is in the state indicated by the broken lines) such that the second heat exchanger 23 functions as an evaporator for the second refrigerant and the third heat exchanger 25 functions as a radiator for the second refrigerant. Heating operation includes neither activation of the first compressor 11 nor circulation of the first refrigerant in the first circuit 10. The first expansion mechanism 13 is fully closed herein.

[0089] In the second circuit 20, the second refrigerant discharged from the second compressor 21 passes through the switching mechanism 22 and flows out of the outdoor unit 2.

[0090] The refrigerant having flowed out of the outdoor unit 2 passes through the connection pipe 5 on the gas side and flows into the indoor unit 3. The second refrigerant is sent to the third heat exchanger 25 in the indoor unit 3. The second refrigerant sent to the third heat exchanger 25 is cooled through heat exchange with indoor air to radiate heat. The second refrigerant having radiated heat in the third heat exchanger 25 flows out of the indoor unit 3.

[0091] The second refrigerant having flowed out of the indoor unit 3 passes through the connection pipe 4 on the liquid side and flows into the outdoor unit 2. In the outdoor unit 2, the second refrigerant passes through the second expansion mechanism 24 and the second flow path 32 of the cascade heat exchanger 30 and is sent to the second heat exchanger 23. The second refrigerant sent to the second heat exchanger 23 is heated to evaporate through heat exchange with outdoor air supplied from the fan 43. The second refrigerant having evaporated in the second heat exchanger 23 passes through the switching mechanism 22 and the second accumulator 26 and is sucked again into the second compressor 21.

(3-2) Cooling operation

[0092] As depicted in FIG. 6, during cooling operation, the switching mechanism 22 is switched into the first state (where the switching mechanism 22 is in the state indicated by the solid lines) such that the second heat exchanger 23 functions as a radiator for the second refrigerant and the third heat exchanger 25 functions as an evaporator for the second refrigerant.

[0093] In the second circuit 20, the second refrigerant discharged from the second compressor 21 passes through the switching mechanism 22 and is sent to the second heat exchanger 23. The second refrigerant sent to the second heat exchanger 23 is cooled to radiate heat through heat exchange with outdoor air supplied from the fan 43. The second refrigerant having radiated heat in the second heat exchanger 23 is sent to the second flow path 32 of the cascade heat exchanger 30. The second refrigerant sent to the second flow path 32 is further cooled in the cascade heat exchanger 30 through heat exchange with the first refrigerant flowing in the first flow path 31. The second refrigerant further cooled in the cascade heat exchanger 30 is decompressed by the second expansion mechanism 24 and then flows out of the outdoor unit 2.

[0094] The second refrigerant having flowed out of the outdoor unit 2 passes through the connection pipe 4 on the liquid side and flows into the indoor unit 3. The second refrigerant is sent to the third heat exchanger 25 in the indoor unit 3. The second refrigerant sent to the third heat exchanger 25 is heated to evaporate through heat exchange with indoor air. The second refrigerant having evaporated in the third heat exchanger 25 flows out of the indoor unit 3.

[0095] The second refrigerant having flowed out of the

indoor unit 3 passes through the connection pipe 5 on the gas side and flows into the outdoor unit 2. In the outdoor unit 2, the second refrigerant passes through the switching mechanism 22 and the second accumulator 26 and is sucked again into the second compressor 21.

[0096] In the first circuit 10, the first refrigerant discharged from the first compressor 11 is sent to the first heat exchanger 12. The first refrigerant sent to the first heat exchanger 12 is cooled to radiate heat through heat exchange with outdoor air supplied from the fan 43. The first refrigerant having radiated heat in the first heat exchanger 12 is decompressed by the first expansion mechanism 13, and is then sent to the first flow path 31 of the cascade heat exchanger 30. The first refrigerant sent to the first flow path 31 is heated to evaporate in the cascade heat exchanger 30 through heat exchange with the second refrigerant flowing in the second flow path 32. The first refrigerant having evaporated in the cascade heat exchanger 30 passes through the first accumulator 14 and is sucked again into the first compressor 11.

(3-3) Stopping operation of first circuit

[0097] When a remote controller or the like issues a command to stop cooling operation, the control unit 6 stops operation of the first circuit 10 and operation of the second circuit 20.

[0098] Specifically, the control unit 6 having received the command stops the second compressor 21, but continues operation of the first compressor 11 as depicted in FIG. 7 (step S101). This achieves collection of the first refrigerant to the first heat exchanger 12.

[0099] The control unit 6 further decreases the opening degree of the first expansion mechanism 13 (step S102). The first expansion mechanism 13 is fully closed herein.

[0100] When the control unit 6 judges that the first refrigerant is collected to the first heat exchanger 12, the control unit 6 stops the first compressor 11 (step S103). Operation of the first circuit 10 can thus be stopped.

[0101] The opening degree of the first expansion mechanism 13 being fully closed may be slightly increased after the first compressor 11 stops.

(3-4) Starting operation of first circuit

[0102] When the remote controller or the like issues a command to start cooling operation, the control unit 6 starts operation of the second circuit 20 before starting the first circuit 10.

[0103] Specifically, the control unit 6 having received the command activates the second compressor 21 as depicted in FIG. 8 (step S111). The control unit 6 subsequently increases the opening degree of the second expansion mechanism 24 (step S112). The second refrigerant circulating in the second circuit 20 in step S111 and step S112 heats the liquefied first refrigerant in the cascade heat exchanger 30.

[0104] The control unit 6 subsequently judges whether or not the difference between the inlet temperature and the outlet temperature of the cascade heat exchanger 30 in the second circuit 20 reaches the certain value or less (step S113). In step S103, the control unit 6 judges in accordance with temperature difference between inlet temperature detected by the inlet temperature sensor 46 and outlet temperature detected by the outlet temperature sensor 47.

[0105] In a case where the control unit 6 judges that the temperature difference does not have the certain value or less in step S113, the control unit 6 determines that the first refrigerant in the cascade heat exchanger 30 is liquefied, and continues operation of the second circuit 20 without starting operation of the first circuit 10.

[0106] In another case where the control unit 6 judges that the temperature difference has the certain value or less in step S113, the control unit 6 determines that the first refrigerant in the cascade heat exchanger 30 is gasified, and starts operation of the first circuit 10. In order to start operation of the first circuit 10, the control unit 6 initially activates the first compressor 11 herein (step S114). The control unit 6 subsequently increases the opening degree of the first expansion mechanism 13 (step S115).

(4) Characteristics

[0107] (4-1) The refrigeration cycle apparatus 1 according to the present embodiment includes the first circuit 10, the second circuit 20, and the control unit 6. The first circuit 10 includes the first compressor 11, the first heat exchanger 12, the first expansion mechanism 13, and the cascade heat exchanger 30. The first circuit 10 allows circulation of the first refrigerant. The second circuit 20 includes the second compressor 21, the second heat exchanger 23, the cascade heat exchanger 30, the second expansion mechanism 24, and the third heat exchanger 25. The second circuit 20 allows circulation of the second refrigerant. The control unit 6 executes stop control of collecting the first refrigerant to the first heat exchanger 12 before stopping operation of the first circuit 10.

[0108] In the refrigeration cycle apparatus 1 according to the present embodiment, the control unit 6 executes stop control of collecting the first refrigerant to the first heat exchanger 12 before stopping operation of the first circuit 10, so as to decrease the first refrigerant collected to the cascade heat exchanger 30. This can inhibit cooling to liquefy the first refrigerant in the cascade heat exchanger 30 while the first circuit 10 is stopped. The first circuit 10 is operated in this state, and the liquefied first refrigerant can thus be inhibited from flowing into the first compressor 11. The first compressor 11 can thus be inhibited from compressing (liquid compression) the liquefied first refrigerant, to reduce malfunction of the first compressor 11.

[0109] (4-2) The refrigeration cycle apparatus 1 ac-

cording to the present embodiment is the refrigeration cycle apparatus 1 according to (4-1) described above, in which the control unit 6 executes operation of the second circuit 20 before operating the first circuit 10 in cooling operation.

[0110] Herein, the control unit 6 operates the second circuit 20 before operating the first circuit 10. Accordingly, the second refrigerant, which has high pressure, has passed through the second heat exchanger 23 in the second circuit 20, and is passing through the cascade heat exchanger 30, can provide heat to the first refrigerant collected to the cascade heat exchanger 30. The first refrigerant can be heated with such heat. The liquefied first refrigerant can thus be gasified. Accordingly, this can further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0111] In particular, the control unit 6 preferably operates the second circuit 20 before operating the first circuit 10 in (during) initial cooling operation subsequent to heating operation. Described below is a reason therefor.

[0112] Operating the second circuit 20 without operating the first circuit 10 during heating operation causes the cooled second refrigerant to flow to the second flow path 32 belonging to the second circuit 20 in the cascade heat exchanger 30. Accordingly, the first refrigerant reserved in the first flow path 31 belonging to the first circuit 10 in the cascade heat exchanger 30 is cooled and liquefied. If operation of the first circuit 10 starts in initial cooling operation subsequent to heating operation in this state, the liquefied first refrigerant in the first flow path 31 of the cascade heat exchanger 30 flows into the first compressor 11. However, operating the second circuit 20 before operation of the first circuit 10 in initial cooling operation subsequent to heating operation can allow the liquefied first refrigerant in the first flow path 31 of the cascade heat exchanger 30 to be gasified when the second refrigerant having high pressure and having passed through the second heat exchanger 23 passes through the second flow path 32 of the cascade heat exchanger 30.

[0113] (4-3) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to (4-2) described above, in which operation of the first circuit 10 starts when the difference between the inlet temperature and the outlet temperature of the cascade heat exchanger 30 in the second circuit 20 reaches the certain value or less.

[0114] Herein, when the difference between the inlet temperature and the outlet temperature of the cascade heat exchanger 30 in the second circuit 20 reaches the certain value or less, it is determined that heat of the second refrigerant is transferred to the first refrigerant and the first refrigerant is gasified in the cascade heat exchanger 30. The first circuit 10 is operated in this state, and the liquefied first refrigerant can thus be further inhibited from flowing into the first compressor 11.

[0115] (4-4) The refrigeration cycle apparatus according to the present embodiment is the refrigeration cycle apparatus according to any one of (4-1) to (4-3) described

above, in which the first expansion mechanism 13 is increased in opening degree after activation of the first compressor 11.

[0116] Herein, the opening degree of the first expansion mechanism 13 is slightly opened or fully closed upon activation of the first compressor 11, so as to inhibit the first refrigerant in the first circuit 10 from directly flowing into the first compressor 11. This can further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0117] (4-5) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to (4-4) described above, in which the control unit 6 activates the second compressor 21, subsequently increases the opening degree of the second expansion mechanism 24, then activates the first compressor 11, and thereafter increases the opening degree of the first expansion mechanism 13.

[0118] In this manner, when the second compressor 21, the second expansion mechanism 24, the first compressor 11, and the first expansion mechanism 13 are controlled in the mentioned order, the first circuit 10 and the second circuit 20 can operate in the state where the liquefied first refrigerant is inhibited from flowing into the first compressor 11.

[0119] (4-6) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-5) described above, in which the control unit 6 controls operation of the first circuit 10 and operation of the second circuit 20.

[0120] In this manner, in the refrigeration cycle apparatus 1 according to the present disclosure, the control unit for the second circuit 20 may control the first circuit 10.

[0121] (4-7) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-6) described above, in which the first heat exchanger 12 is a flat porous tube.

[0122] Herein, the flat porous tube functioning as the first heat exchanger 12 can be reduced in volume, so as to decrease quantity of the first refrigerant. This achieves a decrease in the first refrigerant collected to the cascade heat exchanger 30.

[0123] (4-8) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-7) described above, and further includes the fan 43 configured to send outdoor air to the first heat exchanger 12 and the second heat exchanger 23.

[0124] Herein, the fan 43 is commonly provided to send outdoor air to the first heat exchanger 12 and the second heat exchanger 23. Accordingly, outdoor air flows to the first heat exchanger 12 while the second circuit 20 is in operation even if the first circuit 10 is stopped. Heat exchange is thus executed between the first refrigerant collected to the first heat exchanger 12 and outdoor air,

and the liquefied first refrigerant can be easily collected to the first heat exchanger 12. This can further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0125] (4-9) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-8) described above, in which the first circuit 10 further includes the first accumulator 14.

[0126] Herein, the liquefied first refrigerant can be reserved in the first accumulator 14, so as to further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0127] The liquid refrigerant cannot be perfectly prevented from flowing into the first compressor 11 even when first circuit 10 includes the first accumulator 14, to achieve inhibition of liquid compression through execution of stop control according to the present embodiment.

[0128] (4-10) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-9) described above, in which the control unit 6 fully closes the first expansion mechanism 13 while the second circuit 20 is executing heating operation and the first circuit 10 is stopped.

[0129] While the second circuit 20 is executing heating operation, the second refrigerant having low pressure passes through the second flow path 32 of the cascade heat exchanger 30. Accordingly, while the second circuit 20 is executing heating operation and the first circuit 10 is stopped, the first refrigerant collected to the first flow path 31 of the cascade heat exchanger 30 is likely to be cooled and liquefied. Herein, the first expansion mechanism 13 is fully closed in this case so as to decrease the first refrigerant flowing into the cascade heat exchanger 30 to be liquefied. This can further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0130] (4-11) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-10) described above, in which the control unit 6 is configured to execute heating operation and cooling operation.

[0131] Herein, the first refrigerant collected to the cascade heat exchanger 30 is likely to be liquefied when operation of the first circuit 10 is stopped during heating operation. This is likely to cause a problem that the liquefied first refrigerant flows into the first compressor 11. Even in a case where this problem is likely to arise, execution of stop control can inhibit the liquefied first refrigerant from flowing into the first compressor 11.

[0132] (4-12) The refrigeration cycle apparatus 1 according to the present embodiment is the refrigeration cycle apparatus 1 according to any one of (4-1) to (4-11) described above, in which the first refrigerant is flammable, is toxic, or has a GWP exceeding 500.

[0133] In this manner, the first refrigerant may be flammable, be toxic, or have a GWP exceeding 500.

[0134] (4-13) The refrigeration cycle apparatus 1 ac-

cording to the present embodiment is the refrigeration cycle apparatus 1 according to (4-12) described above, in which the first refrigerant is R290 and the second refrigerant is carbon dioxide.

[0135] Carbon dioxide as a refrigerant has a low GWP and can thus contribute to inhibition of global warming, but is less likely to exert capability during cooling operation at high outdoor air temperature. In contrast, the refrigeration cycle apparatus 1 according to the present embodiment includes the first circuit 10 functioning as a subcooling circuit and allowing circulation of R290, and can thus exert higher capability.

(5) Modification examples

(5-1) Modification example 1

(5-1-1) Start control

[0136] The embodiment described above exemplarily describes the case where the control unit 6 executes start control upon cooling operation by starting operation of the first circuit 10 when the difference between the inlet temperature and the outlet temperature of the cascade heat exchanger 30 in the second circuit 20 reaches the certain value or less. However, the present disclosure is not limited to this case. According to the present modification example, the control unit 6 starts operation of the first circuit 10 after elapse of the predetermined period from starting operation of the second circuit 20. The predetermined period may be three minutes or more, and is preferably ten minutes or more.

[0137] As depicted in FIG. 9, the control unit 6 judges whether or not the predetermined period has elapsed after activation of the second compressor 21 (step S116). In a case where the control unit 6 judges that the predetermined period has elapsed, the control unit 6 activates the first compressor 11 (step S114). In another case where the control unit 6 judges that the predetermined period has not elapsed, the control unit 6 does not activate the first compressor 11.

(5-1-2) Characteristics

[0138] A refrigeration cycle apparatus according to the present modification example is the refrigeration cycle apparatus according to (4-2) described above, in which the control unit 6 starts operation of the first circuit 10 after the predetermined period has elapsed from starting operation of the second circuit 20.

[0139] Herein, when the predetermined period elapses from operation of the second circuit 20, it is determined that heat of the second refrigerant is transferred to the first refrigerant and the first refrigerant is gasified in the cascade heat exchanger 30. The first circuit 10 is operated in this state, and the liquefied first refrigerant can thus be further inhibited from flowing into the first compressor 11.

(5-2) Modification example 2

[0140] The above embodiment exemplarily describes control of fully closing the first expansion mechanism 13 while the second circuit 20 is executing heating operation and the first circuit 10 is stopped. However, the present disclosure is not limited to this case. The first expansion mechanism 13 may be fully closed also while the first circuit 10 is stopped because the second circuit 20 is executing cooling operation.

[0141] In this manner, the control unit 6 according to the present modification example fully closes the first expansion mechanism 13 while the second circuit 20 is in operation and the first circuit 10 is stopped.

[0142] While the second circuit 20 is in operation and the first circuit 10 is stopped, the first refrigerant is likely to be cooled in the cascade heat exchanger 30. In this case, in a refrigeration cycle apparatus according to the present modification example, the first expansion mechanism 13 is fully closed so as to decrease the first refrigerant flowing into the cascade heat exchanger 30. This can further inhibit the liquefied first refrigerant from flowing into the first compressor 11.

(5-3) Modification example 3

[0143] The above embodiment exemplarily describes executing start control and stop control when cooling operation starts and is stopped. Such start control and stop control may be applied to a case of stopping or starting operation of the first circuit 10 during cooling operation.

[0144] Specifically, the control unit 6 may control to operate the first circuit 10 in accordance with a load during cooling operation. More specifically, the control unit 6 does not operate the first circuit 10 when the load is low during cooling operation, and operates the first circuit 10 when the load is high during cooling operation. In this case, the control unit 6 executes start control described above to operate the first circuit 10 when the load is high during cooling operation. The control unit 6 executes stop control described above to stop operation of the first circuit 10 when the load is low during cooling operation.

(5-4) Modification example 4

[0145] The above embodiment exemplarily describes that the control unit 6 is provided in the second machine chamber S22 of the second circuit 20, and starts operation of the first circuit 10 in accordance with an operation start of the second circuit 20. However, the present disclosure is not limited to this case.

[0146] The control unit according to the present modification example includes a first control unit configured to control operation of the first circuit 10 and a second control unit configured to control operation of the second circuit 20, and the first control unit starts operation of the first circuit 10 in accordance with a command from the

second control unit.

(5-5) Modification example 5

[0147] The first circuit 10 according to the above embodiment includes the first accumulator 14. However, the present disclosure is not limited to this case. The first circuit according to the present disclosure may include an accumulator and a sub-accumulator.

[0148] The first circuit according to the present modification example includes neither an accumulator nor a sub-accumulator. This achieves a further decrease in quantity of the first refrigerant filled into the first circuit 10. The refrigeration cycle apparatus 1 is therefore quite useful in a case of adopting an extremely flammable (A3) refrigerant such as R290.

(5-6) Modification example 6

[0149] The above embodiment exemplarily describes that the common fan 43 sends outdoor air to the first heat exchanger 12 and the second heat exchanger 23. However, the present disclosure is not limited to the case. A refrigeration cycle apparatus according to the present modification example includes a first fan configured to send outdoor air to the first heat exchanger 12 and a second fan configured to send outdoor air to the second heat exchanger 23, and the first fan and the second fan are provided separately from each other.

(5-7) Modification example 7

[0150] The above embodiment exemplarily describes the refrigeration cycle apparatus 1 including the single indoor unit 3 connected to the single outdoor unit 2. However, the present disclosure is not limited to the case. A refrigeration cycle apparatus according to the present modification example includes a plurality of indoor units connected to a single outdoor unit.

(5-8) Modification example 8

[0151] The above embodiment exemplarily describes the refrigeration cycle apparatus 1 configured to execute cooling operation and heating operation. However, the present disclosure is not limited to the case. The refrigeration cycle apparatus according to the present disclosure may be configured to further execute dehumidifying operation. During dehumidifying operation, stop control and start control are executed as in cooling operation according to the above embodiment. The refrigeration cycle apparatus according to the present disclosure may alternatively be constituted as an air conditioner dedicated to cooling.

[0152] The embodiment of the present disclosure has been described above. Various changes in modes and details should be available without departing from the object and the scope of the present disclosure recited in

the patent claims.

REFERENCE SIGNS LIST

5	[0153]	
1	refrigeration cycle apparatus	
6	control unit	
10	first circuit	
10	11	first compressor
12	first heat exchanger	
13	first expansion mechanism	
14	first accumulator (accumulator)	
20	second circuit	
15	21	second compressor
23	second heat exchanger	
24	second expansion mechanism	
25	third heat exchanger	
30	cascade heat exchanger	
20	43	fan

CITATION LIST

PATENT LITERATURE

25	[0154] Patent Literature 1: Japanese Patent No. 5430604
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30 Claims

1. A refrigeration cycle apparatus (1) comprising:

35	a first circuit (10) including a first compressor (11), a first heat exchanger (12), a first expansion mechanism (13), and a cascade heat exchanger (30), and configured to allow circulation of a first refrigerant;
40	a second circuit (20) including a second compressor (21), a second heat exchanger (23), the cascade heat exchanger (30), a second expansion mechanism (24), and a third heat exchanger (25), and configured to allow circulation of a second refrigerant; and
45	a control unit (6) configured to execute stop control of collecting the first refrigerant to the first heat exchanger before stopping operation of the first circuit.

50	2. The refrigeration cycle apparatus according to claim 1, wherein the control unit executes operation of the second circuit before operating the first circuit in cooling operation.
----	--

55	3. The refrigeration cycle apparatus according to claim 2, wherein the control unit starts operation of the first circuit
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when difference between inlet temperature and outlet temperature of the cascade heat exchanger in the second circuit reaches a certain value or less.

4. The refrigeration cycle apparatus according to claim 2, wherein
the control unit starts operation of the first circuit after elapse of a predetermined period from starting operation of the second circuit. 5
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5. The refrigeration cycle apparatus according to any one of claims 1 to 4, wherein
the control unit increases an opening degree of the first expansion mechanism after activation of the first compressor. 15
6. The refrigeration cycle apparatus according to claim 5, wherein
the control unit activates the second compressor, subsequently increases an opening degree of the second expansion mechanism, then activates the first compressor, and thereafter increases the opening degree of the first expansion mechanism. 20
7. The refrigeration cycle apparatus according to any one of claims 1 to 6, wherein
the control unit controls operation of the first circuit and operation of the second circuit. 25
8. The refrigeration cycle apparatus according to any one of claims 1 to 7, wherein
the first heat exchanger is a flat porous tube. 30
9. The refrigeration cycle apparatus according to any one of claims 1 to 8, the refrigeration cycle apparatus further comprising
a fan (43) configured to send outdoor air to the first heat exchanger and the second heat exchanger. 35
10. The refrigeration cycle apparatus according to any one of claims 1 to 9, wherein
the first circuit further includes an accumulator (14). 40
11. The refrigeration cycle apparatus according to any one of claims 1 to 10, wherein
the control unit fully closes the first expansion mechanism while the second circuit is in operation and the first circuit is stopped. 45
12. The refrigeration cycle apparatus according to any one of claims 1 to 11, wherein
the control unit is configured to execute heating operation and cooling operation. 50
13. The refrigeration cycle apparatus according to any one of claims 1 to 12, wherein
the first refrigerant is flammable, is toxic, or has a GWP exceeding 500. 55

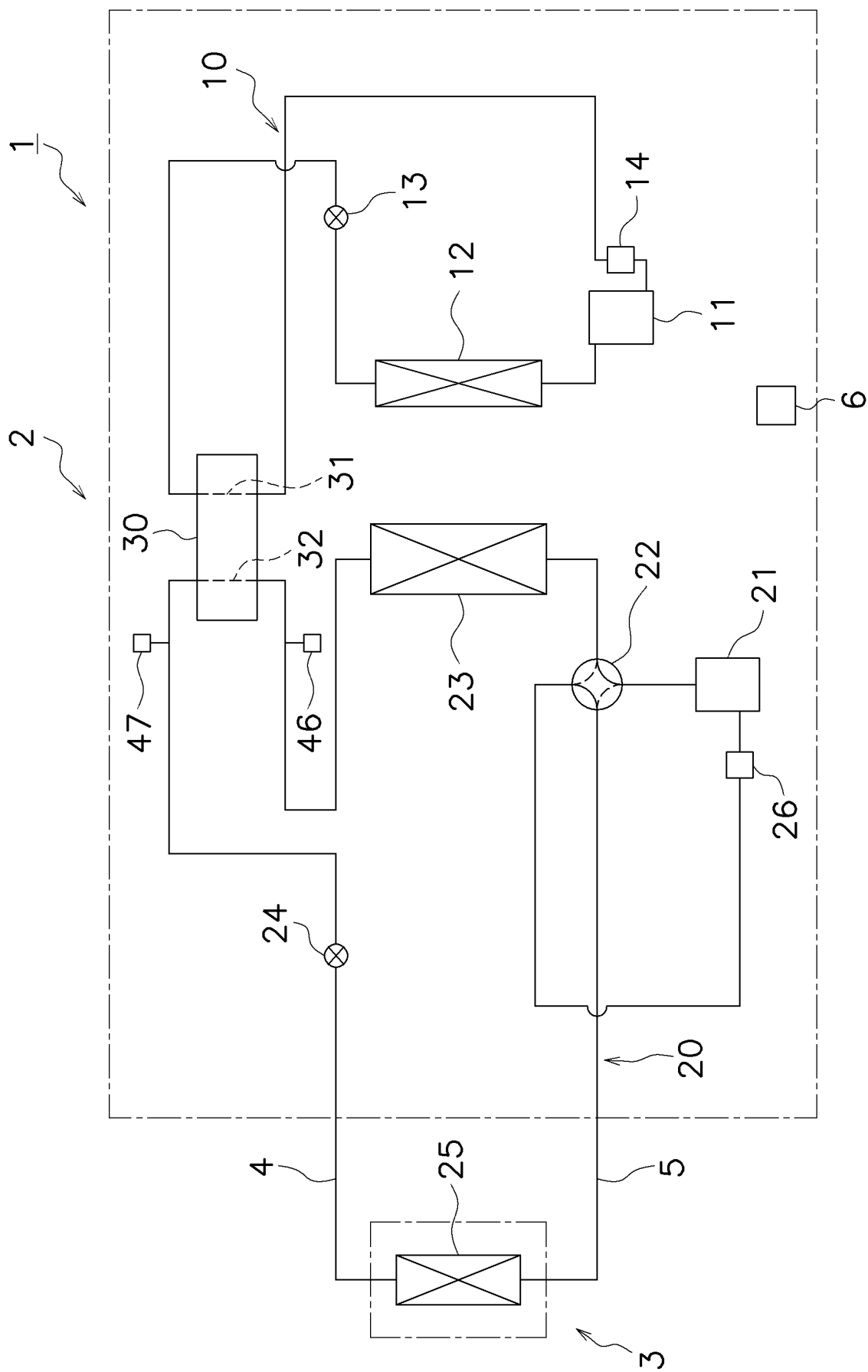


FIG. 1

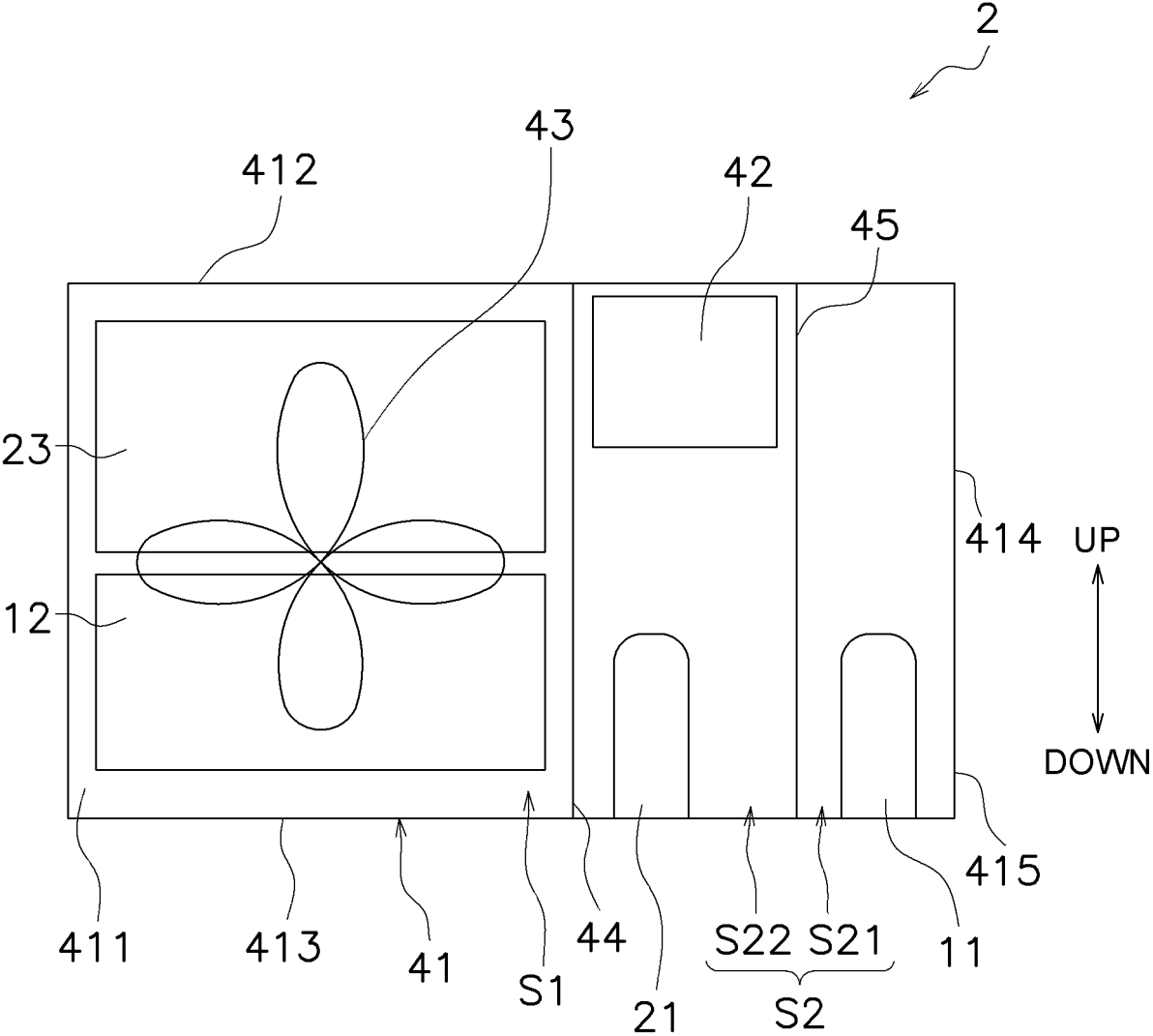


FIG. 2

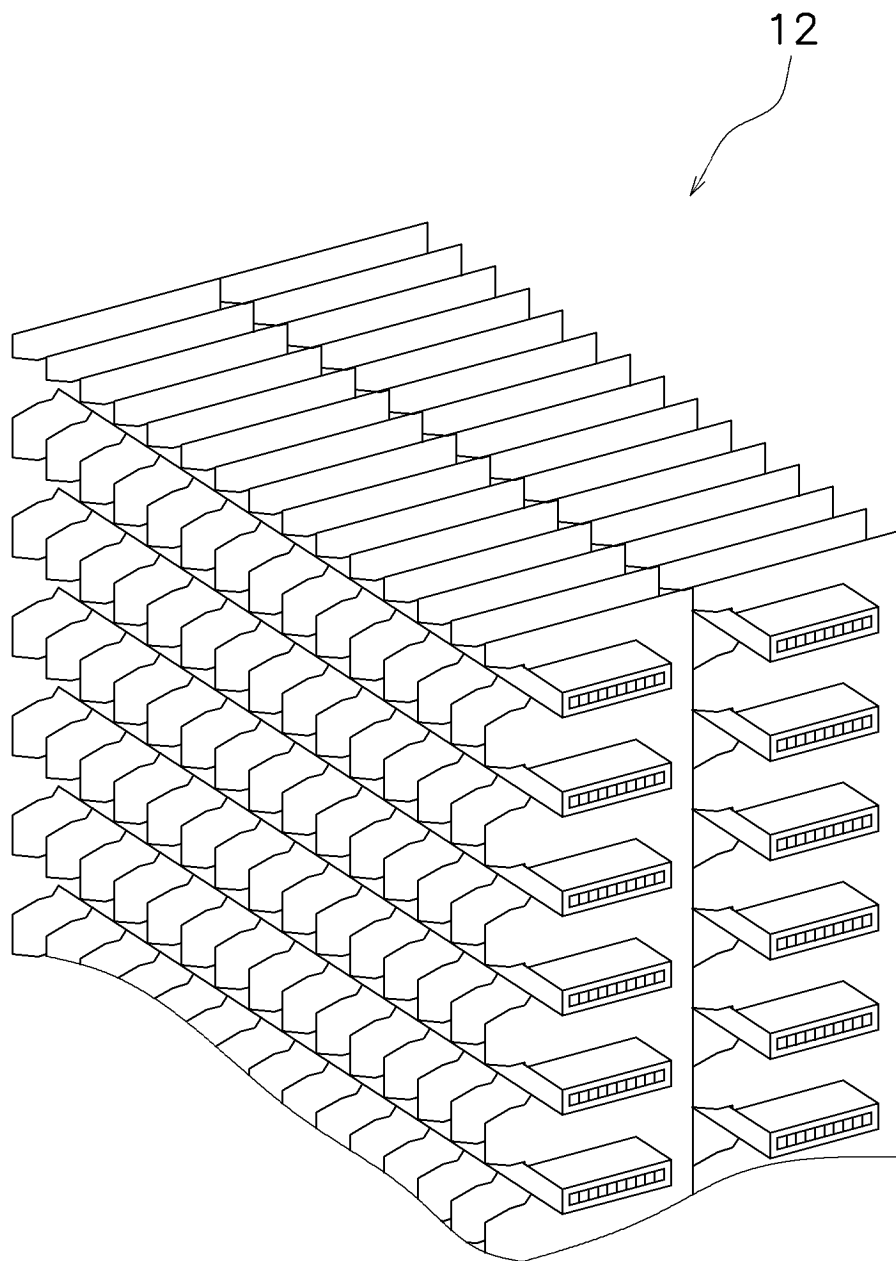


FIG. 3

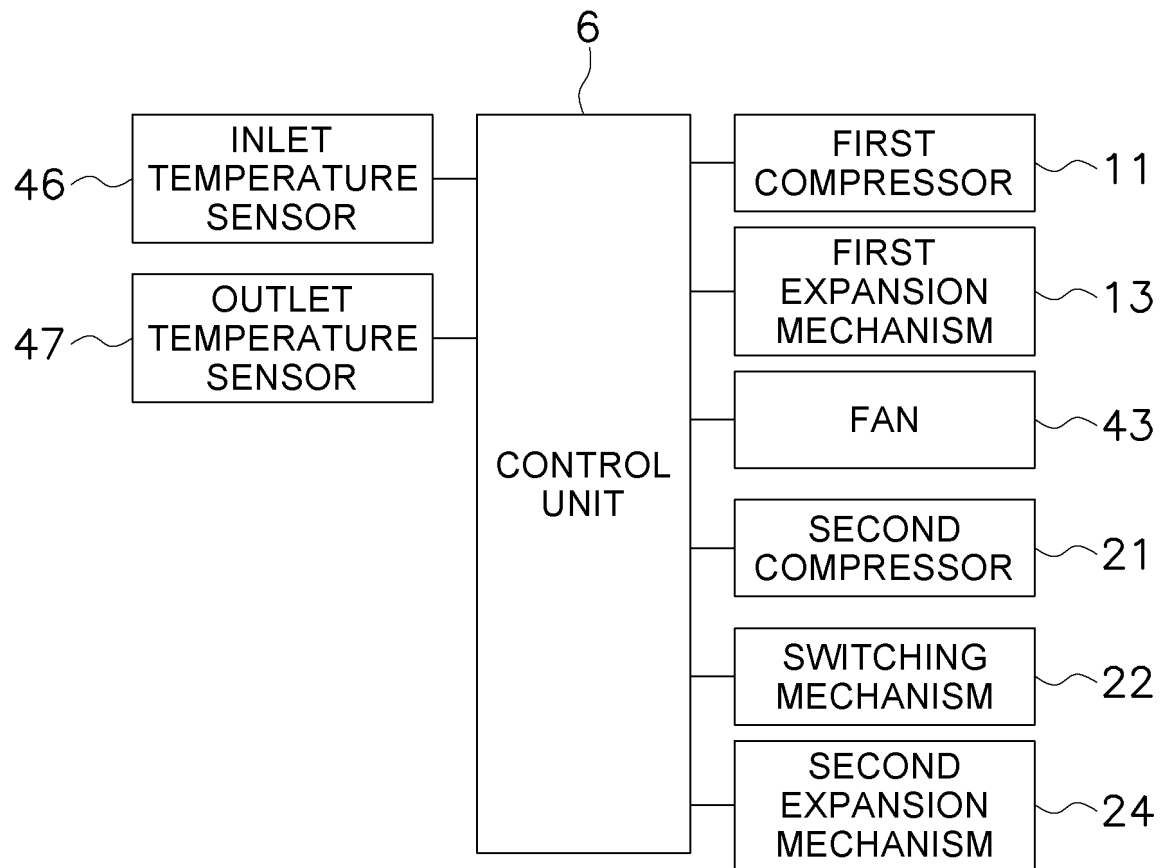


FIG. 4

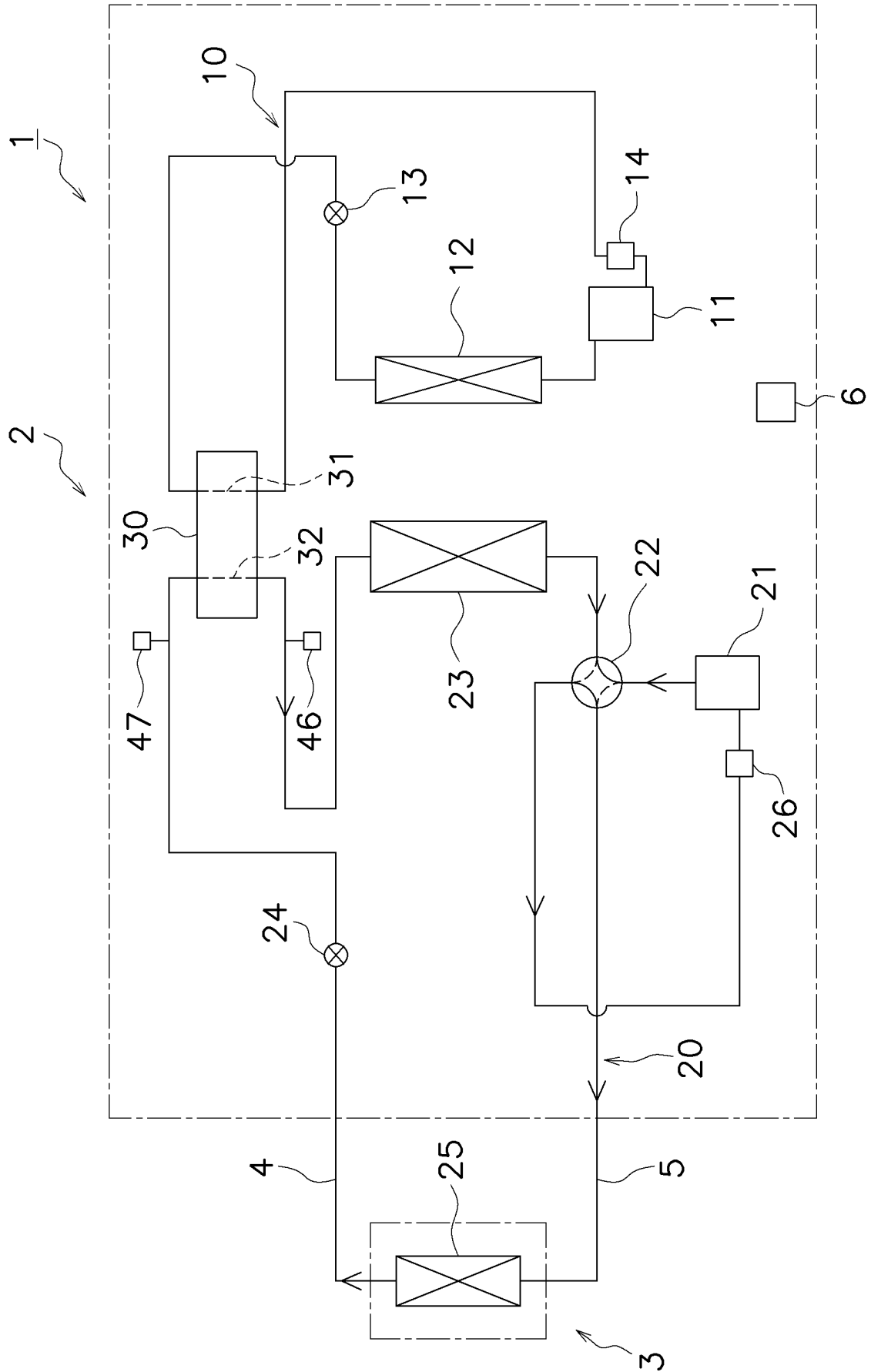


FIG. 5

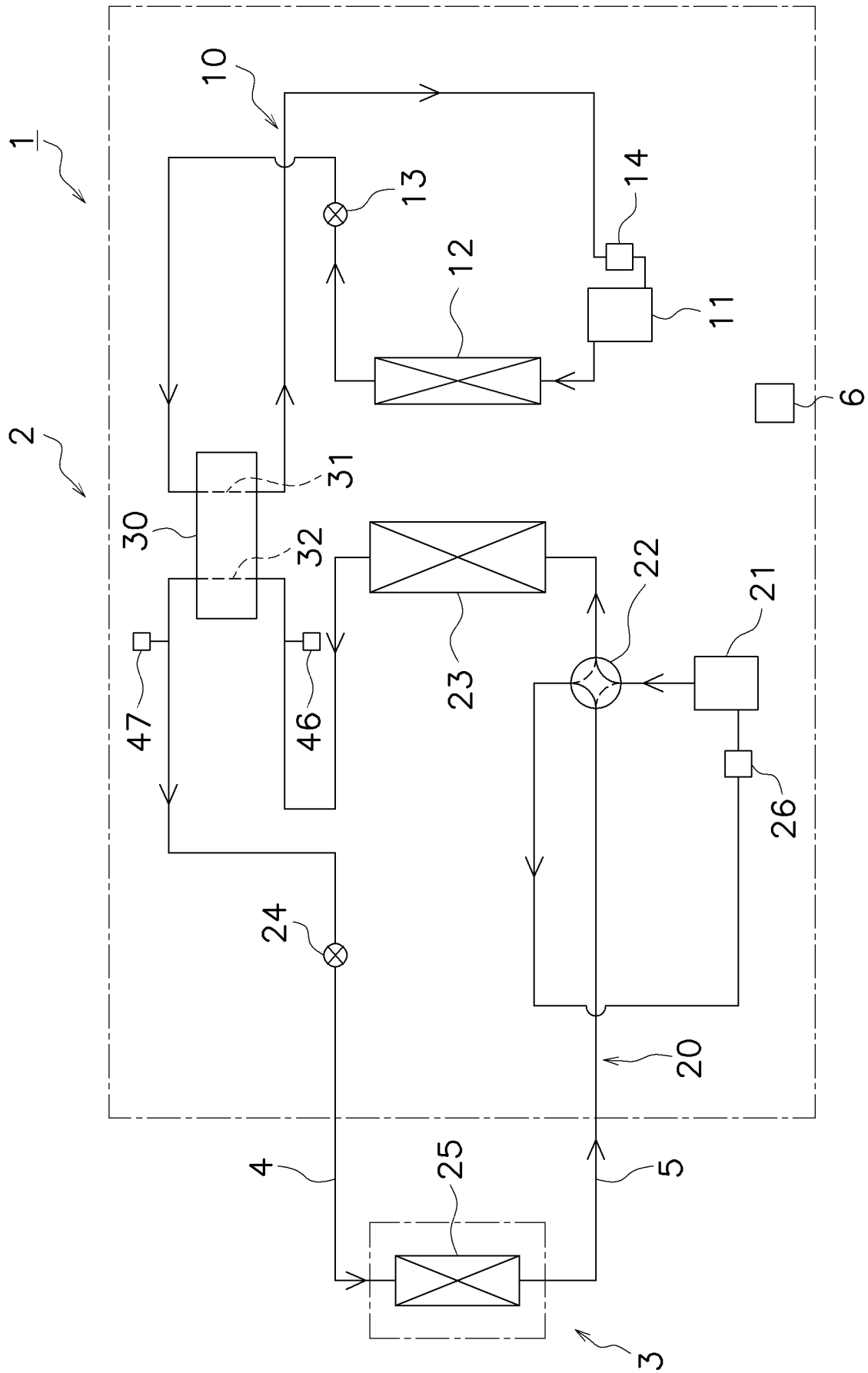


FIG. 6

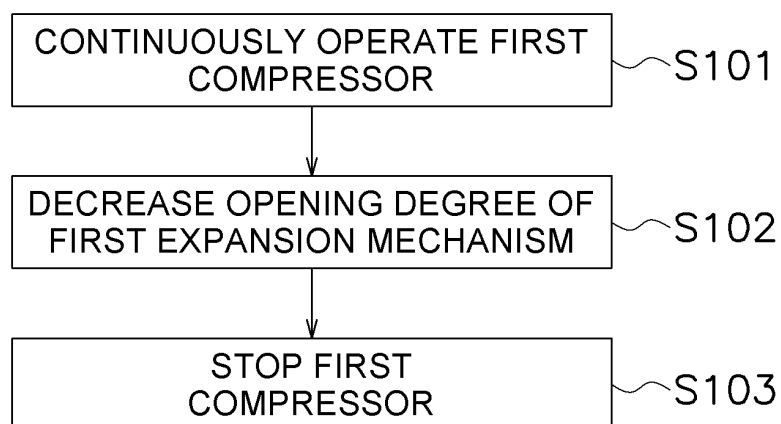


FIG. 7

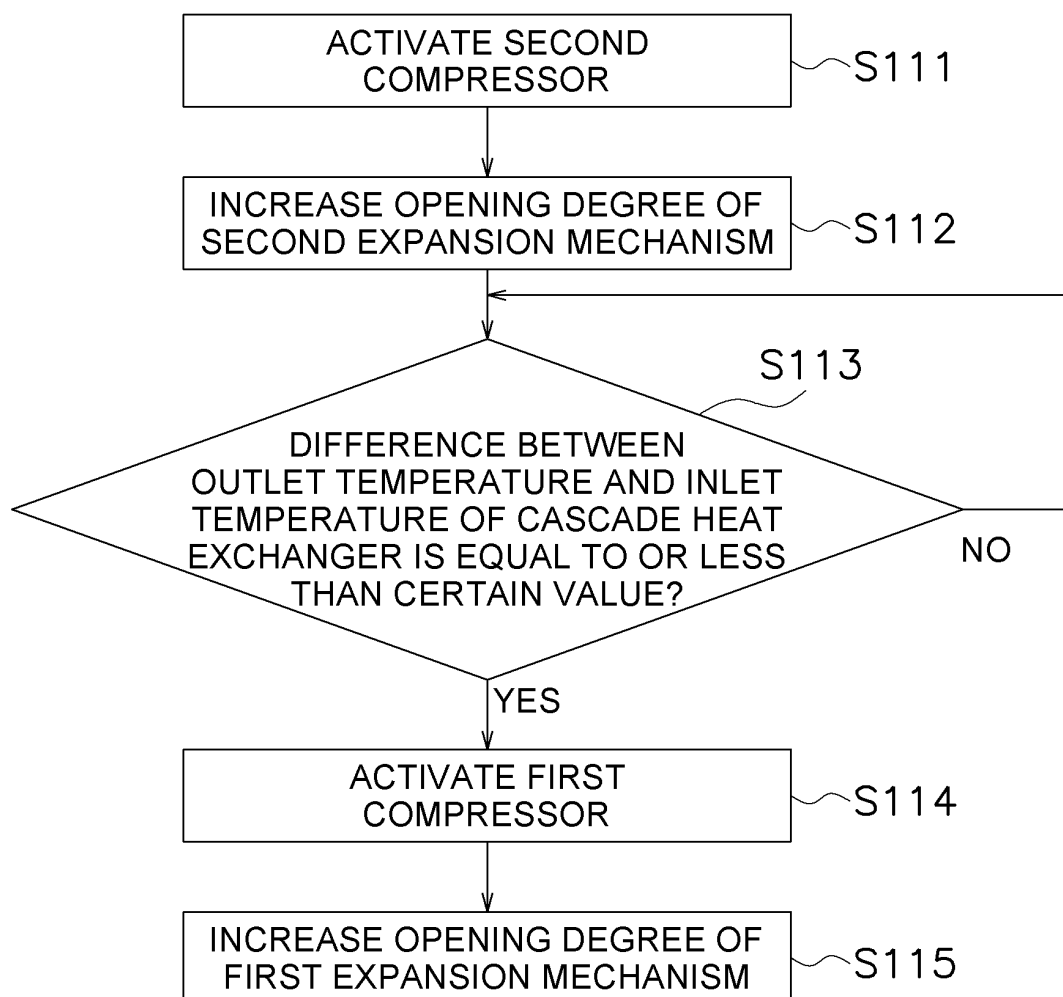


FIG. 8

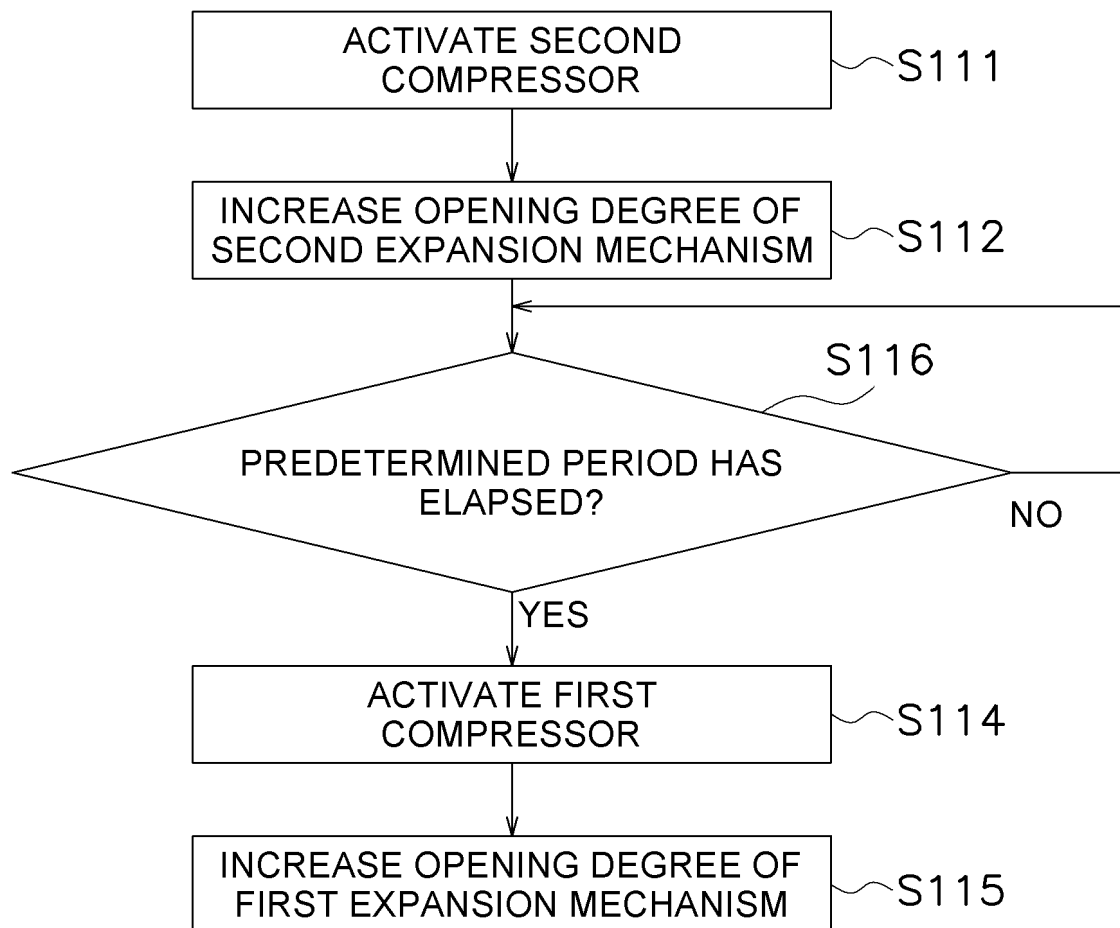


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/020170

A. CLASSIFICATION OF SUBJECT MATTER**F25B 7/00**(2006.01)i; **F25B 1/00**(2006.01)i

FI: F25B7/00 D; F25B1/00 391

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)

F25B7/00; F25B1/00; F25B25/00

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 1971-2024
 Registered utility model specifications of Japan 1996-2024
 Published registered utility model applications of Japan 1994-2024

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.
X	JP 3-263556 A (SANYO ELECTRIC CO., LTD.) 25 November 1991 (1991-11-25) page 2, upper left column, line 19 to page 4, lower left column, line 20, fig. 1-2	1, 10
Y		5, 7-8, 10, 12-13
A		2-4, 6, 9, 11
Y	JP 2023-66634 A (DAIKIN INDUSTRIES, LTD.) 16 May 2023 (2023-05-16) paragraphs [0079]-[0080]	5, 7-8, 10, 12-13
Y	JP 2023-115228 A (DAIKIN INDUSTRIES, LTD.) 18 August 2023 (2023-08-18) paragraph [0067], fig. 1	7-8, 10, 12-13
A		9
Y	WO 2022/118844 A1 (DAIKIN INDUSTRIES, LTD.) 09 June 2022 (2022-06-09) paragraphs [0023]-[0024], fig. 1	12-13



Further documents are listed in the continuation of Box C.



See patent family annex.

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

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

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

“&” document member of the same patent family

Date of the actual completion of the international search

06 August 2024

Date of mailing of the international search report

20 August 2024

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/020170

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JP	2023-66634	A	16 May 2023	(Family: none)	
JP	2023-115228	A	18 August 2023	US 2024/0027104	A1
				paragraph [0035], fig. 1	
				WO 2022/211078	A1
				EP 4317846	A1
				CN 117157496	A
WO	2022/118844	A1	09 June 2022	US 2023/0324086	A1
				paragraphs [0016]-[0017], fig. 1	
				EP 4257892	A1
				CN 116529542	A

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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