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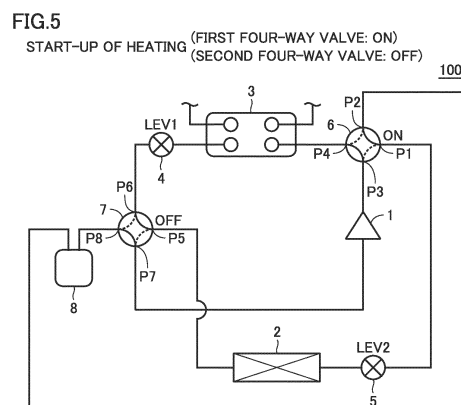
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(54) **REFRIGERATION CYCLE DEVICE**

(57) In a refrigeration cycle apparatus (100), at start-up of heating, a controller (10) sets a first four-way valve (6) to an ON state and sets a second four-way valve (7) to an OFF state so as to form a flow path in which refrigerant flows through a compressor (1), a load-side heat exchanger (3), a first expansion valve (4), a heat-source-side heat exchanger (2), and an accumulator (8A) and returns to the compressor (1), and during a

heating operation, the controller (10) sets the first four-way valve (6) to the ON state and sets the second four-way valve (7) to the ON state so as to form a flow path in which the refrigerant flows through the compressor (1), the load-side heat exchanger (3), the first expansion valve (4), the receiver (8B), and the heat-source-side heat exchanger (2) and returns to the compressor (1).



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Conventionally, a refrigeration cycle apparatus comprises a refrigerant circuit in which refrigerant circulates. PTL 1 discloses a refrigerant circuit in which a refrigerant container functions as an accumulator (liquid separator) until a predetermined time has elapsed from start-up of heating and the refrigerant container functions as a receiver (liquid receiver) after the predetermined time has elapsed.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 10-259963

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the conventional refrigeration cycle apparatus, switching between the accumulator (liquid separator) and the receiver (liquid receiver) is performed by controlling first flow path switching means and second flow path switching means. Since each of the first flow path switching means and the second flow path switching means is constituted of three electromagnetic valves, control is complicated and the apparatus is large in size.

[0005] It is an object of the present disclosure to provide a small refrigeration cycle apparatus in which control for switching between a liquid separator and a liquid receiver can be readily performed.

SOLUTION TO PROBLEM

[0006] A refrigeration cycle apparatus of the present disclosure is a refrigeration cycle apparatus in which refrigerant circulates. The refrigeration cycle apparatus comprises: a compressor; a first heat exchanger; a second heat exchanger; a first flow rate control valve; a first four-way valve configured to switch a flow path for the refrigerant by switching a state of the first four-way valve between a first state and a second state; a second four-way valve configured to switch a flow path for the refrigerant by switching a state of the second four-way valve between a third state and a fourth state; a refrigerant container; and a controller configured to control the first four-way valve and the second four-way valve. In the refrigeration cycle apparatus, at start-up of heating, the

controller sets the first four-way valve to the first state and sets the second four-way valve to the fourth state so as to form a flow path in which the refrigerant flows through the compressor, the second heat exchanger, the first flow rate control valve, the first heat exchanger, and the refrigerant container and returns to the compressor, and during a heating operation, the controller sets the first four-way valve to the first state and sets the second four-way valve to the third state so as to form a flow path in which the refrigerant flows through the compressor, the second heat exchanger, the first flow rate control valve, the refrigerant container, and the first heat exchanger and returns to the compressor.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present disclosure, there can be provided a small refrigeration cycle apparatus in which control for switching between a liquid separator and a liquid receiver can be readily performed.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a diagram showing a refrigeration cycle apparatus in a non-operational state according to a first embodiment.

Fig. 2 is a flowchart showing a flow of control in the non-operational state according to the first embodiment.

Fig. 3 is a simplified diagram of the refrigeration cycle apparatus in the non-operational state according to the first embodiment.

Fig. 4 is a diagram showing a refrigerant container. Fig. 5 is a diagram showing the refrigeration cycle apparatus at start-up of heating according to the first embodiment.

Fig. 6 is a flowchart showing a flow of control at the start-up of heating according to the first embodiment. Fig. 7 is a simplified diagram of the refrigeration cycle apparatus at the start-up of heating according to the first embodiment.

Fig. 8 is a diagram showing the refrigeration cycle apparatus during a heating operation according to the first embodiment.

Fig. 9 is a flowchart showing a flow of control during the heating operation according to the first embodiment.

Fig. 10 is a simplified diagram of the refrigeration cycle apparatus during the heating operation according to the first embodiment.

Fig. 11 is a diagram showing the refrigeration cycle apparatus at start-up of cooling according to the first embodiment.

Fig. 12 is a flowchart showing a flow of control at the start-up of cooling according to the first embodiment. Fig. 13 is a simplified diagram of the refrigeration

cycle apparatus at the start-up of cooling according to the first embodiment.

Fig. 14 is a diagram showing a refrigeration cycle apparatus in a non-operational state according to a second embodiment.

Fig. 15 is a simplified diagram of the refrigeration cycle apparatus at start-up of heating according to the second embodiment.

Fig. 16 is a simplified diagram of the refrigeration cycle apparatus during a heating operation according to the second embodiment.

Fig. 17 is a simplified diagram of the refrigeration cycle apparatus at start-up of cooling according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

[0009] Hereinafter, embodiments of the present disclosure will be described in detail with reference to figures. In the embodiments described below, when reference is made to number, amount, or the like, the scope of the present disclosure is not necessarily limited to the number, the amount, or the like unless particularly stated otherwise. The same components and corresponding components are denoted by the same reference characters, and the same explanation may not be described repeatedly. It is initially expected to combine and use configurations of the embodiments appropriately.

First Embodiment.

[0010] Fig. 1 is a diagram showing a refrigeration cycle apparatus 100 in a non-operational state according to a first embodiment. Fig. 2 is a flowchart showing a flow of control in the non-operational state according to the first embodiment. Fig. 3 is a simplified diagram of refrigeration cycle apparatus 100 in the non-operational state according to the first embodiment. Each of the figures described below functionally shows connection relation and arrangement configuration among devices in refrigeration cycle apparatus 100, and does not necessarily show an arrangement in a physical space.

<Configuration of Refrigeration Cycle Apparatus 100>

[0011] Refrigeration cycle apparatus 100 according to the first embodiment will be described. As shown in Fig. 1, refrigeration cycle apparatus 100 comprises a compressor 1, a heat-source-side heat exchanger 2 serving as a first heat exchanger, a load-side heat exchanger 3 serving as a second heat exchanger, a first expansion valve 4, a second expansion valve 5, a first four-way valve 6, a second four-way valve 7, a refrigerant container 8, and a controller 10.

[0012] Heat-source-side heat exchanger 2 exchanges heat between air and refrigerant using a fan (not shown). Load-side heat exchanger 3 is a plate heat exchanger that exchanges heat with a heat medium such as water

or brine. A pump, a heat exchanger, and a fan (each not shown) are connected to a utilization-side tube of load-side heat exchanger 3. A linear expansion valve (LEV) is used for each of first expansion valve 4 and second expansion valve 5. In the figure, first expansion valve 4 is represented as LEV1, and second expansion valve 5 is represented as LEV2. Each of first expansion valve 4 and second expansion valve 5 functions as a flow rate control valve configured to adjust a flow rate of the refrigerant. In the description below, first expansion valve 4 may be referred to as LEV1, and second expansion valve 5 may be referred to as LEV2.

[0013] First four-way valve 6 has a first port P1, a second port P2, a third port P3, and a fourth port P4. Second four-way valve 7 has a fifth port P5, a sixth port P6, a seventh port P7, and an eighth port P8.

[0014] Compressor 1, first expansion valve 4, second expansion valve 5, first four-way valve 6, second four-way valve 7, various types of sensors, and the like are connected to controller 10. Controller 10 adjusts the flow rate of the refrigerant by controlling a degree of opening of each of first expansion valve 4 and second expansion valve 5. Controller 10 switches a flow path for the refrigerant through control of switching the ports of first four-way valve 6 and second four-way valve 7.

[0015] First four-way valve 6 is switchable between a first state and a second state, the first state being a state in which first port P1 communicates with second port P2 and third port P3 communicates with fourth port P4, the second state being a state in which first port P1 communicates with third port P3 and second port P2 communicates with fourth port P4. Based on the control of controller 10, first four-way valve 6 is controlled to be in one of an ON state that is the first state and an OFF state that is the second state.

[0016] Second four-way valve 7 is switchable between a third state and a fourth state, the third state being a state in which fifth port P5 communicates with seventh port P7 and sixth port P6 communicates with eighth port P8, the fourth state being a state in which fifth port P5 communicates with sixth port P6 and seventh port P7 communicates with eighth port P8. Based on the control of controller 10, second four-way valve 7 is controlled to be in one of an ON state that is the third state and an OFF state that is the fourth state.

[0017] The ON state is a state in which first four-way valve 6 or second four-way valve 7 is supplied with power. The OFF state is a state in which first four-way valve 6 or second four-way valve 7 is not supplied with power. Controller 10 switches between a cooling operation and a heating operation by switching the states of first four-way valve 6 and second four-way valve 7. Refrigerant container 8 functions as an accumulator (liquid separator) configured to separate gas from the refrigerant in accordance with an operation state of refrigeration cycle apparatus 100 or functions as a receiver (liquid receiver) configured to store liquefied refrigerant.

<As to Non-Operational State>

[0018] In the non-operational state of refrigeration cycle apparatus 100 as shown in Fig. 1, first four-way valve 6 is in the ON state and second four-way valve 7 is in the OFF state. In refrigeration cycle apparatus 100 in the non-operational state, refrigerant container 8 functions as the accumulator.

[0019] As shown in Fig. 2, controller 10 performs the following processes in the non-operational state. Controller 10 controls compressor 1 to be operated at a minimum frequency (step S11). In refrigeration cycle apparatus 100, when the state of second four-way valve 7 is switched by the process of step S11, a minimum operation differential pressure for stably operating the valve is secured. After step S11, in order to decompress LEV 1 serving as first expansion valve 4, controller 10 decreases the degree of opening of the valve (step S12). After step S12, controller 10 fully opens LEV2 serving as second expansion valve 5 (step S13).

[0020] After step S13, controller 10 determines whether or not second four-way valve 7 is in the ON state (step S14). When it is determined in step S14 that second four-way valve 7 is in the OFF state (No in step S14), controller 10 stops the operation of compressor 1 (step S16), and ends the process. When it is determined in step S14 that second four-way valve 7 is in the ON state (Yes in step S14), controller 10 controls second four-way valve 7 to be brought from the ON state to the OFF state (step S15). After step S15, controller 10 performs the process of step S16, and then ends the process.

[0021] In the non-operational state, controller 10 does not perform the process of determining whether the state of first four-way valve 6 is the ON state or the OFF state. Irrespective of whether the state of first four-way valve 6 is the ON state or the OFF state, refrigerant container 8 can be used as the accumulator.

[0022] When first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the OFF state by controller 10 in refrigeration cycle apparatus 100, the refrigerant circuit becomes one shown in Fig. 3 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 100 shown in Fig. 3 has a refrigerant circuit in which compressor 1, load-side heat exchanger 3, first expansion valve 4, heat-source-side heat exchanger 2, second expansion valve 5, and accumulator 8A are connected together in this order. Refrigerant container 8 is used as the accumulator in the non-operational state.

<Refrigerant Container 8>

[0023] Fig. 4 is a diagram showing refrigerant container 8. Refrigerant container 8 comprises an inflow tube 8a, an outflow tube 8b, an oil return hole 8c, and a straw tube 8d. A liquid mixture L of oil and the refrigerant is stored in refrigerant container 8. When refrigerant container 8 functions as the accumulator, gas of gas-liquid two-

phase refrigerant is separated and liquid refrigerant is accumulated therein.

[0024] In a low-flow rate region shown on the left side of Fig. 4 in refrigerant container 8, oil is returned from oil return hole 8c, thereby preventing the liquid refrigerant from returning to compressor 1 to result in liquid back that causes decreased performance and reliability of compressor 1. The diameter of oil return hole 8c is preferably made small in order to prevent occurrence of the liquid back. In a high-flow rate region shown on the right side of Fig. 4 in refrigerant container 8, an amount of returned oil only via oil return hole 8c is insufficient with respect to an amount of discharged oil from compressor 1, so that the amount of returned oil is secured by returned oil from straw tube 8d.

[0025] When refrigerant container 8 functions as the receiver, refrigerant container 8 stores the refrigerant discharged from the heat exchanger acting as a condenser, thereby appropriately maintaining an amount of refrigerant for the heat exchanger acting as an evaporator.

<As to Start-Up of Heating>

[0026] Fig. 5 is a diagram showing refrigeration cycle apparatus 100 at start-up of heating according to the first embodiment. Fig. 6 is a flowchart showing a flow of control at the start-up of heating according to the first embodiment. Fig. 7 is a simplified diagram of refrigeration cycle apparatus 100 at the start-up of heating according to the first embodiment.

[0027] In refrigeration cycle apparatus 100, first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the OFF state at the start-up of heating shown in Fig. 5. In refrigeration cycle apparatus 100 at the start-up of heating, refrigerant container 8 functions as the accumulator.

[0028] As shown in Fig. 6, controller 10 performs the following processes at the start-up of heating. Controller 10 controls to start up compressor 1 (step S21). After step S21, in order to decompress LEV1 serving as first expansion valve 4, controller 10 decreases the degree of opening of the valve (step S22). After step S22, controller 10 fully opens LEV2 serving as second expansion valve 5 (step S23).

[0029] After step S23, controller 10 determines whether or not first four-way valve 6 is in the ON state (step S24). When it is determined in step S24 that first four-way valve 6 is in the ON state (Yes in step S24), controller 10 ends the process. When it is determined in step S24 that first four-way valve 6 is in the OFF state (No in step S24), controller 10 controls first four-way valve 6 to be brought from the OFF state to the ON state (step S25), and ends the process.

[0030] In refrigeration cycle apparatus 100, when first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the OFF state by controller 10, the refrigerant circuit becomes one shown in Fig. 7 with first four-way valve 6 and second four-way

valve 7 being not illustrated therein. Refrigeration cycle apparatus 100 shown in Fig. 7 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, heat-source-side heat exchanger 2, second expansion valve 5, and accumulator 8A and returns to compressor 1. Refrigerant container 8 is used as the accumulator at the start-up of heating.

[0031] In refrigeration cycle apparatus 100 at the start-up of heating, high-temperature and high-pressure gas refrigerant discharged from compressor 1 is condensed by load-side heat exchanger 3. The liquid refrigerant condensed by load-side heat exchanger 3 is then decompressed by first expansion valve 4. The decompressed liquid refrigerant is then evaporated by heat-source-side heat exchanger 2. The gas-liquid two-phase refrigerant evaporated by heat-source-side heat exchanger 2 then passes through second expansion valve 5, is processed by accumulator 8A, and then the gas refrigerant is suctioned into compressor 1.

<As to Heating Operation>

[0032] Fig. 8 is a diagram showing refrigeration cycle apparatus 100 during a heating operation according to the first embodiment. Fig. 9 is a flowchart showing a flow of control during the heating operation according to the first embodiment. Fig. 10 is a simplified diagram of refrigeration cycle apparatus 100 during the heating operation according to the first embodiment.

[0033] In refrigeration cycle apparatus 100, first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the ON state during the heating operation shown in Fig. 8. In refrigeration cycle apparatus 100 during the heating operation, refrigerant container 8 functions as the receiver.

[0034] As shown in Fig. 9, controller 10 performs the following processes during the heating operation. Controller 10 determines whether or not a degree of superheat (SH) of the refrigerant at an inlet of accumulator 8A at the start-up of heating as shown in Fig. 7 is 2°C or more (step S31). Step S31 is a process at the start-up of heating before starting the heating operation. The degree of superheat refers to a temperature difference between superheated steam and dry saturated steam. The temperature of the superheated steam is measured by a temperature sensor (not shown). When the liquid back occurs, the liquid refrigerant is sent to compressor 1 to cause a decreased temperature of the refrigerant discharged from compressor 1, with the result that the degree of superheat is decreased accordingly. In refrigeration cycle apparatus 100, it is determined that the liquid back has occurred, when the degree of superheat becomes lower than a reference value of the degree of superheat set in advance.

[0035] When it is determined in step S31 that $\text{SH} \geq 2^{\circ}\text{C}$ is not satisfied (No in step S31), controller 10 repeats the process of step S31. When it is determined in step S31

that $\text{SH} \geq 2^{\circ}\text{C}$ is satisfied (Yes in step S31), controller 10 repeats the process of step S31.

[0036] When it is determined in step S31 that $\text{SH} \geq 2^{\circ}\text{C}$ is satisfied (Yes in step S31), controller 10 controls second four-way valve 7 to be brought from the OFF state to the ON state (step S32). After step S32, in order to decompress LEV1 serving as first expansion valve 4, controller 10 decreases the degree of opening of the valve (step S33). After step S33, in order to decompress LEV2 serving as second expansion valve 5, controller 10 decreases the degree of opening of the valve (step S34), and ends the process.

[0037] In the conventional refrigeration cycle apparatus, since a phenomenon (refrigerant stagnation) of accumulation of the refrigerant in the heat-source-side heat exchanger occurs when outside air is low in temperature (for example, outside air at -20°C) and liquid refrigerant may flow into the compressor immediately after the start-up of heating, a compressor frequency cannot be increased, with the result that it takes a time to reach a steady operation.

[0038] In refrigeration cycle apparatus 100, since refrigerant container 8 functions as accumulator 8A at the start-up of heating, the refrigerant is stored in refrigerant container 8 and therefore the liquid refrigerant can be prevented from flowing into compressor 1. Since refrigeration cycle apparatus 100 can perform a steady heating operation by increasing the frequency of compressor 1 under the condition that the degree of superheat (SH) satisfies $\text{SH} \geq 2^{\circ}\text{C}$ in the process of step S31, a time for the start-up of heating when the outside air is low in temperature can be short.

[0039] In refrigeration cycle apparatus 100, when first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the ON state by controller 10, the refrigerant circuit becomes one shown in Fig. 10 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 100 shown in Fig. 10 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, receiver 8B, second expansion valve 5, and heat-source-side heat exchanger 2 and returns to compressor 1. Refrigerant container 8 is used as the receiver during the heating operation.

[0040] In refrigeration cycle apparatus 100 during the heating operation, high-temperature and high-pressure gas refrigerant discharged from compressor 1 is condensed by load-side heat exchanger 3. The liquid refrigerant condensed by the load-side heat exchanger 3 is then decompressed by first expansion valve 4. The decompressed liquid refrigerant then passes through receiver 8B, is further decompressed by second expansion valve 5, and is evaporated by heat-source-side heat exchanger 2. The gas refrigerant evaporated by heat-source-side heat exchanger 2 is suctioned into compressor 1.

[0041] During the heating operation, an amount of re-

refrigerant used in the refrigerant circuit is smaller than that during a cooling operation. Receiver 8B can store an excess of refrigerant during the heating operation. Controller 10 controls first expansion valve 4 to adjust the amount of refrigerant stored in receiver 8B. The amount of refrigerant used can be adjusted to an optimum amount, thereby securing performance of load-side heat exchanger 3.

<As to Start-Up of Cooling>

[0042] Fig. 11 is a diagram showing refrigeration cycle apparatus 100 at start-up of cooling according to the first embodiment. Fig. 12 is a flowchart showing a flow of control at the start-up of cooling according to the first embodiment. Fig. 13 is a simplified diagram of refrigeration cycle apparatus 100 at the start-up of cooling according to the first embodiment.

[0043] In refrigeration cycle apparatus 100, first four-way valve 6 is brought into the OFF state and second four-way valve 7 is brought into the OFF state at the start-up of cooling shown in Fig. 11. In refrigeration cycle apparatus 100 at the start-up of cooling, refrigerant container 8 functions as the accumulator.

[0044] As shown in Fig. 12, controller 10 performs the following processes at the start-up of refrigerant. Controller 10 controls to start up compressor 1 (step S41). After step S41, in order to decompress LEV1 serving as first expansion valve 4, controller 10 decreases the degree of opening of the valve (step S42). After step S42, controller 10 fully opens LEV2 serving as second expansion valve 5 (step S43).

[0045] After step S43, controller 10 determines whether or not first four-way valve 6 is in the ON state (step S44). When it is determined in step S44 that first four-way valve 6 is in the OFF state (No in step S44), controller 10 ends the process. When it is determined in step S44 that first four-way valve 6 is in the ON state (Yes in step S44), controller 10 controls first four-way valve 6 to be brought from the ON state to the OFF state (step S45), and ends the process.

[0046] In refrigeration cycle apparatus 100, when first four-way valve 6 is brought into the OFF state and second four-way valve 7 is brought into the OFF state by controller 10, the refrigerant circuit becomes one shown in Fig. 13 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 100 shown in Fig. 13 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, second expansion valve 5, heat-source-side heat exchanger 2, first expansion valve 4, load-side heat exchanger 3, and accumulator 8A and returns to compressor 1. Refrigerant container 8 is used as the accumulator at the start-up of cooling.

[0047] In refrigeration cycle apparatus 100 at the start-up of cooling, high-temperature and high-pressure gas refrigerant discharged from compressor 1 is condensed by heat-source-side heat exchanger 2. The liquid refrigerant condensed by heat-source-side heat exchanger 2

is then decompressed by first expansion valve 4. The decompressed liquid refrigerant is then evaporated by load-side heat exchanger 3. The gas-liquid two-phase refrigerant evaporated by load-side heat exchanger 3 is thereafter processed by accumulator 8A, and the gas refrigerant is then suctioned into compressor 1.

<As to Cooling Operation>

[0048] During the cooling operation, refrigeration cycle apparatus 100 forms the same refrigerant circuit as the refrigerant circuit at the start-up of cooling. During the cooling operation, an amount of refrigerant used in the refrigerant circuit is larger than that during the heating operation. In refrigeration cycle apparatus 100 during the cooling operation, the high-temperature and high-pressure gas refrigerant discharged from compressor 1 is condensed by heat-source-side heat exchanger 2. The liquid refrigerant condensed by heat-source-side heat exchanger 2 is then decompressed by first expansion valve 4. The decompressed liquid refrigerant is then evaporated by load-side heat exchanger 3. The gas-liquid two-phase refrigerant evaporated by load-side heat exchanger 3 is thereafter processed by accumulator 8A, and the gas refrigerant is then suctioned into compressor 1.

Second Embodiment.

[0049] Fig. 14 is a diagram showing a refrigeration cycle apparatus 200 at start-up of heating according to a second embodiment. Fig. 15 is a simplified diagram of refrigeration cycle apparatus 200 at the start-up of heating according to the second embodiment. Fig. 16 is a simplified diagram of refrigeration cycle apparatus 200 during a heating operation according to the second embodiment. Fig. 17 is a simplified diagram of refrigeration cycle apparatus 200 at start-up of cooling according to the second embodiment.

<Configuration of Refrigeration Cycle Apparatus 200>

[0050] Various types of devices used in refrigeration cycle apparatus 200 according to the second embodiment are the same as the various types of devices used in refrigeration cycle apparatus 100 according to the first embodiment. Refrigeration cycle apparatus 200 is different from refrigeration cycle apparatus 100 in terms of the position of second expansion valve 5. In refrigeration cycle apparatus 100, second expansion valve 5 is located between first four-way valve 6 and heat-source-side heat exchanger 2. In refrigeration cycle apparatus 200, second expansion valve 5 is located between first four-way valve 6 and refrigerant container 8.

<As to Start-Up of Heating>

[0051] In refrigeration cycle apparatus 200, when first

four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the OFF state by controller 10, the refrigerant circuit becomes one shown in Fig. 15 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 200 shown in Fig. 15 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, heat-source-side heat exchanger 2, second expansion valve 5, and accumulator 8A and returns to compressor 1. Refrigerant container 8 is used as the accumulator at the start-up of heating. In refrigeration cycle apparatus 200 shown in Fig. 15, the arrangements of the devices are the same as those in the refrigerant circuit shown in Fig. 7.

<As to Heating Operation>

[0052] In refrigeration cycle apparatus 200, when first four-way valve 6 is brought into the ON state and second four-way valve 7 is brought into the ON state by controller 10, the refrigerant circuit becomes one shown in Fig. 16 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 200 shown in Fig. 16 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, receiver 8B, second expansion valve 5, and heat-source-side heat exchanger 2 and returns to compressor 1. Refrigerant container 8 is used as the receiver during the heating operation. In refrigeration cycle apparatus 200 shown in Fig. 16, the arrangements of the devices are the same as those in the refrigerant circuit shown in Fig. 10.

<As to Start-Up of Cooling>

[0053] In refrigeration cycle apparatus 200, when first four-way valve 6 is brought into the OFF state and second four-way valve 7 is brought into the OFF state by controller 10, the refrigerant circuit becomes one shown in Fig. 17 with first four-way valve 6 and second four-way valve 7 being not illustrated therein. Refrigeration cycle apparatus 200 shown in Fig. 17 has a refrigerant circuit that forms a flow path in which the refrigerant flows through compressor 1, heat-source-side heat exchanger 2, first expansion valve 4, load-side heat exchanger 3, second expansion valve 5, and accumulator 8A and returns to compressor 1. Refrigerant container 8 is used as the accumulator at the start-up of cooling. Refrigeration cycle apparatus 200 shown in Fig. 17 is different from the refrigerant circuit shown in Fig. 13 in terms of the position of second expansion valve 5, but has the same function.

<As to Cooling Operation>

[0054] During the cooling operation, refrigeration cycle

apparatus 200 forms the same refrigerant circuit as the refrigerant circuit at the start-up of cooling. During the cooling operation, an amount of refrigerant used in the refrigerant circuit is larger than that during the heating operation. In refrigeration cycle apparatus 200 during the cooling operation, the high-temperature and high-pressure gas refrigerant discharged from compressor 1 is condensed by heat-source-side heat exchanger 2. The liquid refrigerant condensed in heat-source-side heat exchanger 2 is then decompressed by first expansion valve 4. The decompressed liquid refrigerant is then evaporated in load-side heat exchanger 3. The gas-liquid two-phase refrigerant evaporated in load-side heat exchanger 3 is thereafter processed by accumulator 8A, and the gas refrigerant is then suctioned into compressor 1.

<Conclusion>

[0055] The present disclosure relates to a refrigeration cycle apparatus 100 in which refrigerant circulates. Refrigeration cycle apparatus 100 comprises: a compressor 1; a heat-source-side heat exchanger 2; a load-side heat exchanger 3; a first expansion valve 4 serving as a first flow rate control valve; a first four-way valve 6 configured to switch a flow path for the refrigerant by switching a state of first four-way valve 6 between an ON state serving as a first state and an OFF state serving as a second state; a second four-way valve 7 configured to switch a flow path for the refrigerant by switching a state of second four-way valve 7 between an ON state serving as a third state and an OFF state serving as a fourth state; a refrigerant container 8; and a controller 10 configured to control first four-way valve 6 and second four-way valve 7. In refrigeration cycle apparatus 100, at start-up of heating, controller 10 sets first four-way valve 6 to the ON state and sets second four-way valve 7 to the OFF state so as to form a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, heat-source-side heat exchanger 2, and refrigerant container 8 functioning as an accumulator 8A, and returns to compressor 1, and during a heating operation, controller 10 sets first four-way valve 6 to the ON state and sets second four-way valve 7 to the ON state so as to form a flow path in which the refrigerant flows through compressor 1, load-side heat exchanger 3, first expansion valve 4, refrigerant container 8 functioning as receiver 8B, and heat-source-side heat exchanger 2 and returns to compressor 1.

[0056] With such a configuration, refrigeration cycle apparatus 100 can readily switch refrigerant container 8 between accumulator 8A that is a liquid separator and receiver 8B that is a liquid receiver. Therefore, refrigeration cycle apparatus 100 can be a small and suitable refrigeration cycle apparatus that can be brought into an operation state by simple control for switching between first four-way valve 6 and second four-way valve 7.

[0057] Preferably, in refrigeration cycle apparatus 100, at start-up of cooling, controller 10 sets first four-way

valve 6 to the OFF state and sets second four-way valve 7 to the OFF state so as to form a flow path in which the refrigerant flows through compressor 1, heat-source-side heat exchanger 2, first expansion valve 4, load-side heat exchanger 3, and refrigerant container 8 functioning as accumulator 8A and returns to compressor 1.

[0058] With such a configuration, refrigeration cycle apparatus 100 can be a small and suitable refrigeration cycle apparatus that can be brought into an operation state by simple control for switching between first four-way valve 6 and second four-way valve 7.

[0059] Preferably, at each of the start-up of heating and the start-up of cooling, refrigerant container 8 is used as an accumulator 8A serving as a liquid separator configured to separate a liquid and a gas included in the refrigerant, and during the heating operation, refrigerant container 8 is used as a receiver 8B serving as a liquid receiver configured to store the liquid included in the refrigerant.

[0060] With such a configuration, since the functions of refrigerant container 8 can be switched between accumulator 8A and receiver 8B in accordance with an operation state, the refrigeration cycle apparatus can be small in size as compared with a case where the accumulator and the receiver are provided separately.

[0061] Preferably, refrigeration cycle apparatus 100 further comprises a second expansion valve 5 serving as a second flow rate control valve. At the start-up of cooling, as shown in Fig. 13, first expansion valve 4 is disposed between heat-source-side heat exchanger 2 and load-side heat exchanger 3, and second expansion valve 5 is disposed between compressor 1 and heat-source-side heat exchanger 2. More specifically, at the start-up of cooling, first expansion valve 4 is disposed between second four-way valve 7 and load-side heat exchanger 3, and second expansion valve 5 is disposed between first four-way valve 6 and heat-source-side heat exchanger 2 as shown in Fig. 11.

[0062] With such a configuration, in refrigeration cycle apparatus 100, the positions of first expansion valve 4 and second expansion valve 5 can be appropriate positions at each of which the flow rate of the refrigerant can be controlled in accordance with an operation state.

[0063] Preferably, refrigeration cycle apparatus 200 further comprises a second expansion valve 5 serving as a second flow rate control valve. At the start-up of cooling, first expansion valve 4 is disposed between heat-source-side heat exchanger 2 and load-side heat exchanger 3, and second expansion valve 5 is disposed between load-side heat exchanger 3 and refrigerant container 8 functioning as accumulator 8A as shown in Fig. 17. More specifically, at the start-up of cooling, first expansion valve 4 is disposed between second four-way valve 7 and load-side heat exchanger 3, and second expansion valve 5 is disposed between first four-way valve 6 and refrigerant container 8 functioning as accumulator 8A as shown in Fig. 14.

[0064] With such a configuration, in refrigeration cycle

apparatus 100, the positions of first expansion valve 4 and second expansion valve 5 can be appropriate positions at each of which the flow rate of the refrigerant can be controlled in accordance with an operation state.

[0065] Preferably, controller 10 controls a degree of opening of first expansion valve 4 and a degree of opening of second expansion valve 5, and at each of the start-up of heating and the start-up of refrigerant, controller 10 sets the degree of opening of first expansion valve 4 to be smaller than a fully opened state and sets the degree of opening of second expansion valve 5 to the fully opened state as shown in Figs. 6 and 12.

[0066] With such a configuration, refrigeration cycle apparatus 100 can suitably adjust the degree of opening of first expansion valve 4 and the degree of opening of second expansion valve 5 in accordance with an operation state.

[0067] Preferably, during the heating operation, controller 10 sets the degree of opening of first expansion valve 4 to be smaller than the fully opened state, and sets the degree of opening of second expansion valve 5 to be smaller than the fully opened state as shown in Fig. 9.

[0068] With such a configuration, refrigeration cycle apparatus 100 can suitably adjust the degree of opening of first expansion valve 4 and the degree of opening of second expansion valve 5 in accordance with an operation state.

[0069] Preferably, controller 10 controls second four-way valve 7 to the ON state when a degree of superheat (SH) of a suction side of compressor 1 becomes 2°C or more at the start-up of heating as shown in step S31 of Fig. 9.

[0070] With such a configuration, since refrigeration cycle apparatus 100 can perform a steady heating operation by increasing a frequency of compressor 1 under the condition that the degree of superheat (SH) satisfies $SH \geq 2^\circ\text{C}$, a time for the start-up of heating when outside air is low in temperature can be short.

<Modification>

[0071] Refrigeration cycle apparatus 100 may have a refrigerant circuit comprising only first expansion valve 4 with second expansion valve 5 being not provided.

[0072] Various types of heat exchangers other than the plate heat exchanger may be used as load-side heat exchanger 3.

[0073] The embodiments disclosed herein are illustrative and non-restrictive in any respect. The scope of the present disclosure is defined by the terms of the claims, rather than the embodiments described above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0074] 1: compressor; 2: heat-source-side heat ex-

changer; 3: load-side heat exchanger; 4: first expansion valve; 5: second expansion valve; 6: first four-way valve; 7: second four-way valve; 8: refrigerant container; 8A: accumulator; 8B: receiver; 8a: inflow tube; 8b: outflow tube; 8c: oil return hole; 8d: straw tube; 10: controller; 100, 200: refrigeration cycle apparatus; L: liquid mixture; P1: first port; P2: second port; P3: third port; P4: fourth port; P5: fifth port; P6: sixth port; P7: seventh port; P8: eighth port.

Claims

1. A refrigeration cycle apparatus in which refrigerant circulates, the refrigeration cycle apparatus comprising:

a compressor;
 a first heat exchanger;
 a second heat exchanger;
 a first flow rate control valve;
 a first four-way valve configured to switch a flow path for the refrigerant by switching a state of the first four-way valve between a first state and a second state;
 a second four-way valve configured to switch a flow path for the refrigerant by switching a state of the second four-way valve between a third state and a fourth state;
 a refrigerant container; and
 a controller configured to control the first four-way valve and the second four-way valve, wherein
 at start-up of heating, the controller sets the first four-way valve to the first state and sets the second four-way valve to the fourth state so as to form a flow path in which the refrigerant flows through the compressor, the second heat exchanger, the first flow rate control valve, the first heat exchanger, and the refrigerant container and returns to the compressor, and
 during a heating operation, the controller sets the first four-way valve to the first state and sets the second four-way valve to the third state so as to form a flow path in which the refrigerant flows through the compressor, the second heat exchanger, the first flow rate control valve, the refrigerant container, and the first heat exchanger and returns to the compressor.

2. The refrigeration cycle apparatus according to claim 1, wherein at start-up of cooling, the controller sets the first four-way valve to the second state and sets the second four-way valve to the fourth state so as to form a flow path in which the refrigerant flows through the compressor, the first heat exchanger, the first flow rate control valve, the second heat exchanger, and the refrigerant container and returns

to the compressor.

3. The refrigeration cycle apparatus according to claim 2, wherein at each of the start-up of heating and the start-up of cooling, the refrigerant container is used as a liquid separator configured to separate a liquid and a gas included in the refrigerant, and during the heating operation, the refrigerant container is used as a liquid receiver configured to store the liquid included in the refrigerant.

4. The refrigeration cycle apparatus according to claim 2 or 3, further comprising a second flow rate control valve, wherein
 at the start-up of cooling, the first flow rate control valve is disposed between the first heat exchanger and the second heat exchanger, and the second flow rate control valve is disposed between the compressor and the first heat exchanger.

5. The refrigeration cycle apparatus according to claim 2 or 3, further comprising a second flow rate control valve, wherein
 at the start-up of cooling, the first flow rate control valve is disposed between the first heat exchanger and the second heat exchanger, and the second flow rate control valve is disposed between the second heat exchanger and the refrigerant container.

6. The refrigeration cycle apparatus according to claim 4 or 5, wherein

the controller controls a degree of opening of the first flow rate control valve and a degree of opening of the second flow rate control valve, and

at each of the start-up of heating and the start-up of refrigerant, the controller sets the degree of opening of the first flow rate control valve to be smaller than a fully opened state and sets the degree of opening of the second flow rate control valve to the fully opened state.

7. The refrigeration cycle apparatus according to claim 6, wherein during the heating operation, the controller sets the degree of opening of the first flow rate control valve to be smaller than the fully opened state, and sets the degree of opening of the second flow rate control valve to be smaller than the fully opened state.

8. The refrigeration cycle apparatus according to any one of claims 1 to 7, wherein the controller controls the second four-way valve to the third state when a degree of superheat of a suction side of the compressor becomes 2°C or more at the start-up of heating.

FIG.1

NON-OPERATIONAL STATE (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

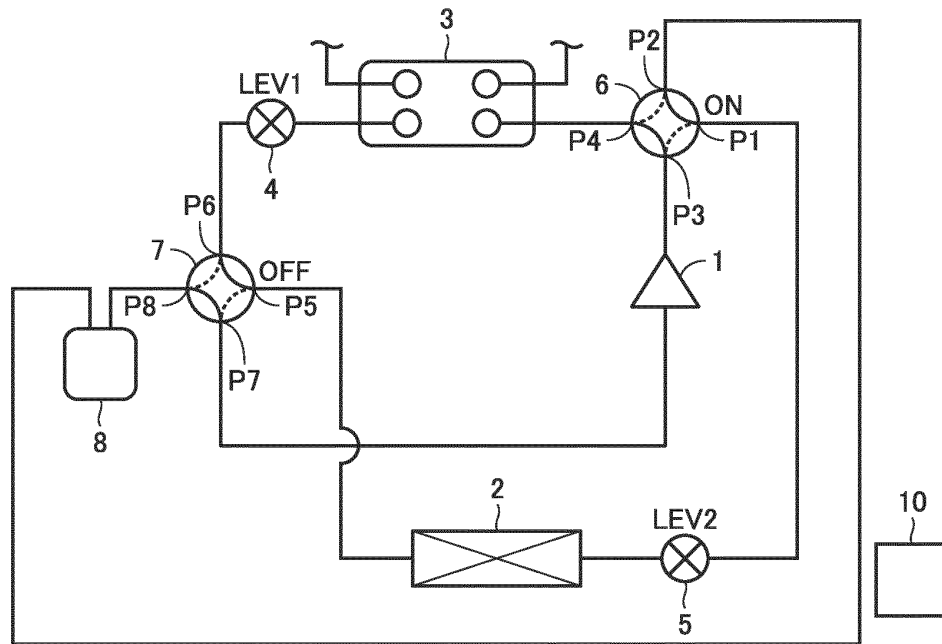


FIG.2

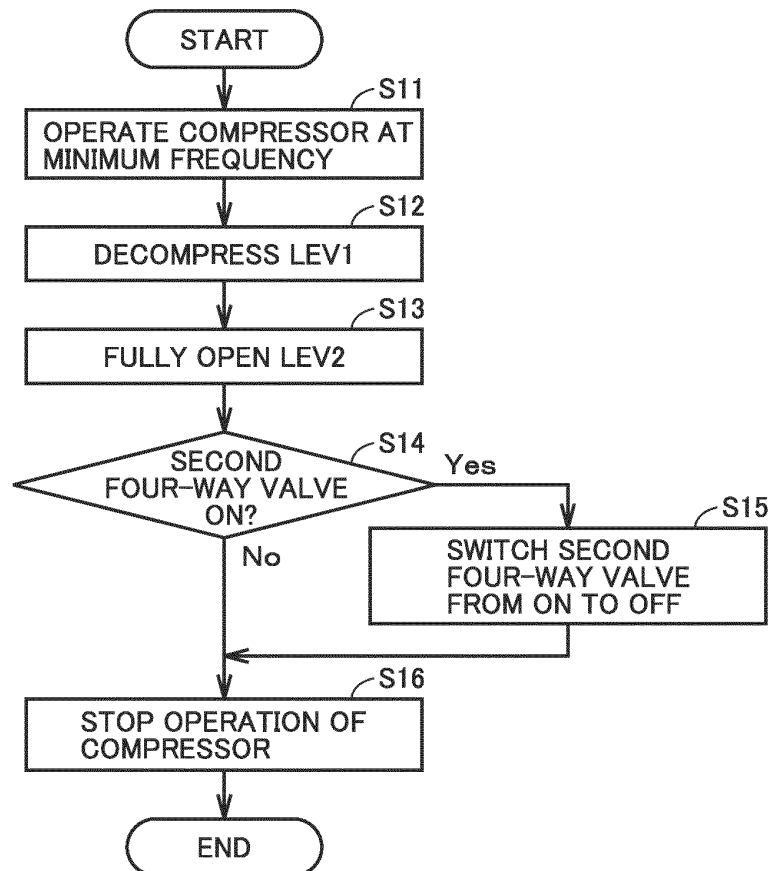


FIG.3

NON-OPERATIONAL STATE (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

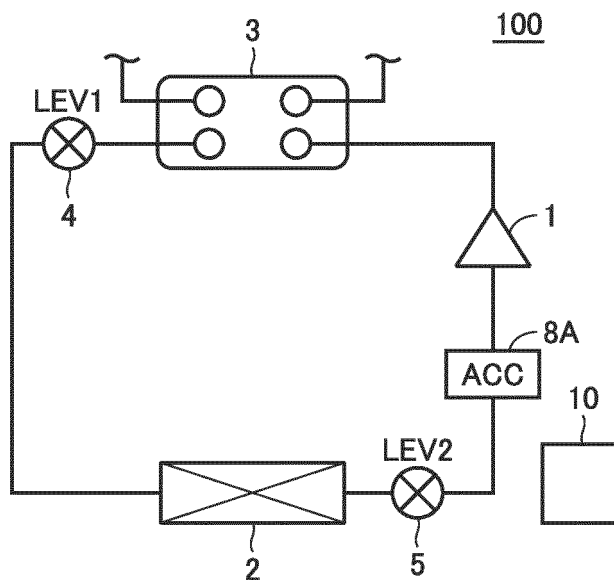


FIG.4

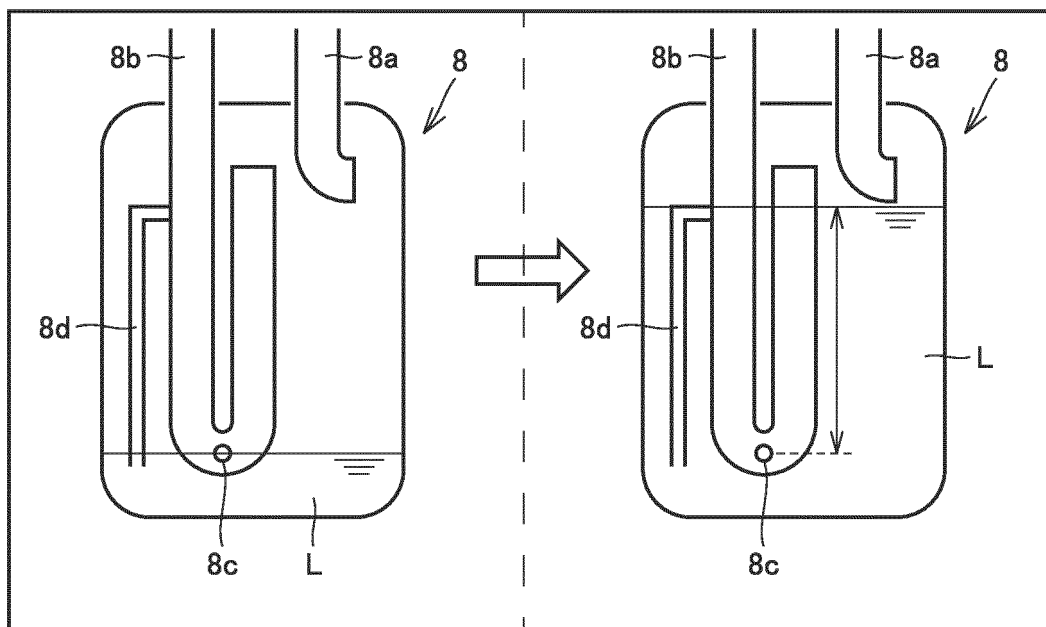


FIG.5

START-UP OF HEATING (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

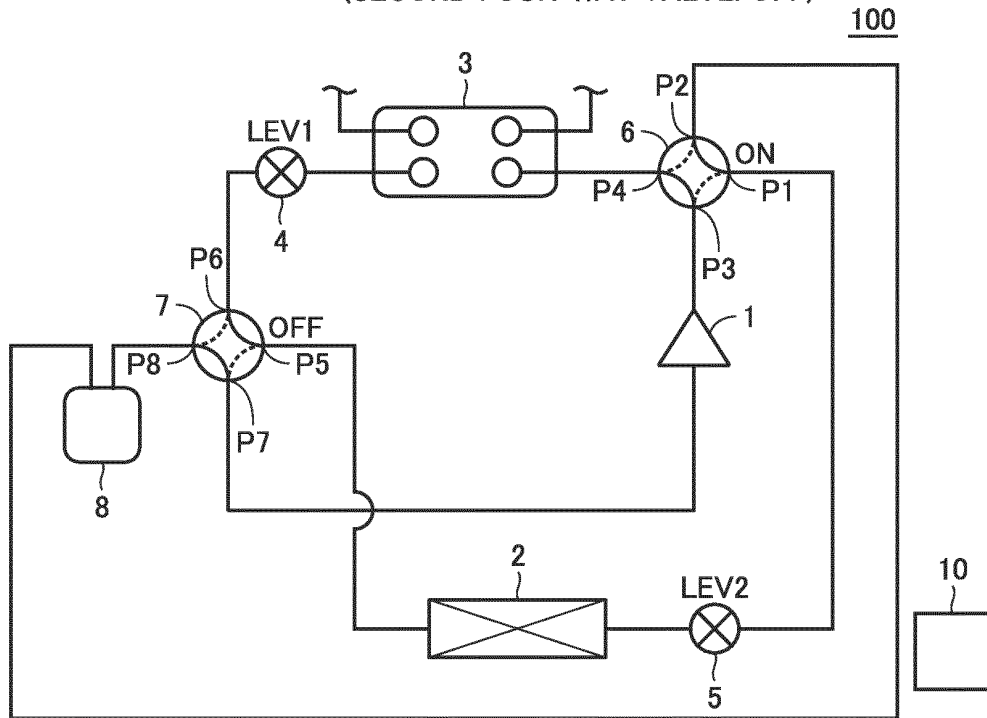


FIG.6

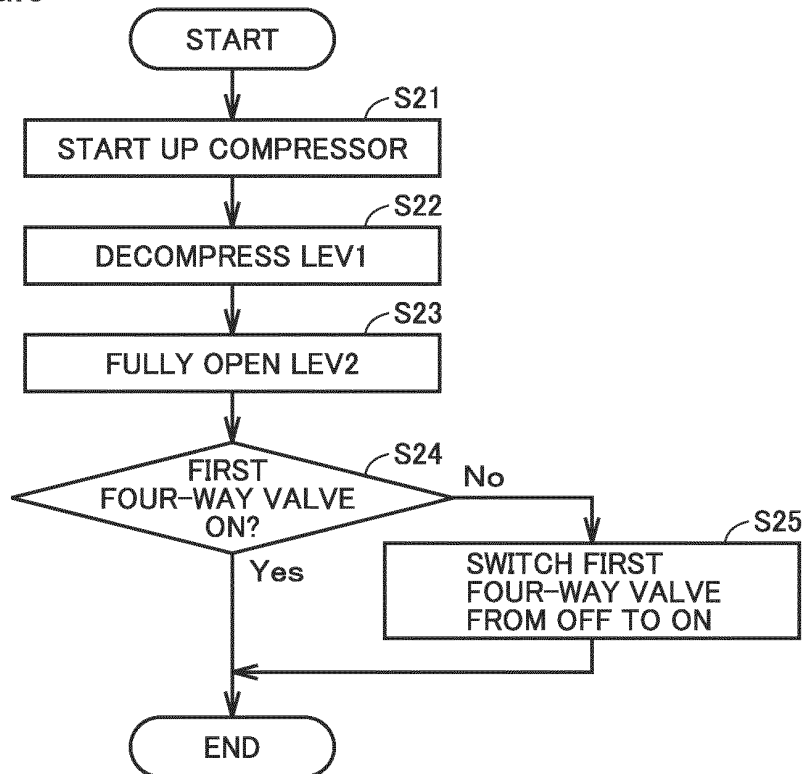
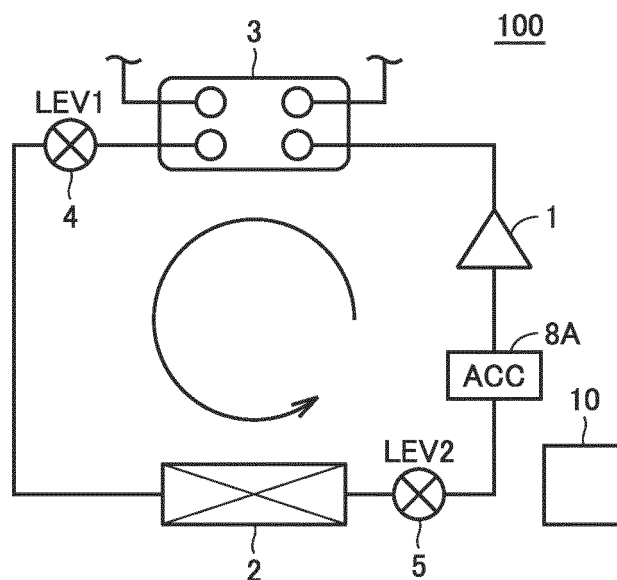


FIG.7

START-UP OF HEATING (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

**FIG.8**

HEATING OPERATION (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: ON)

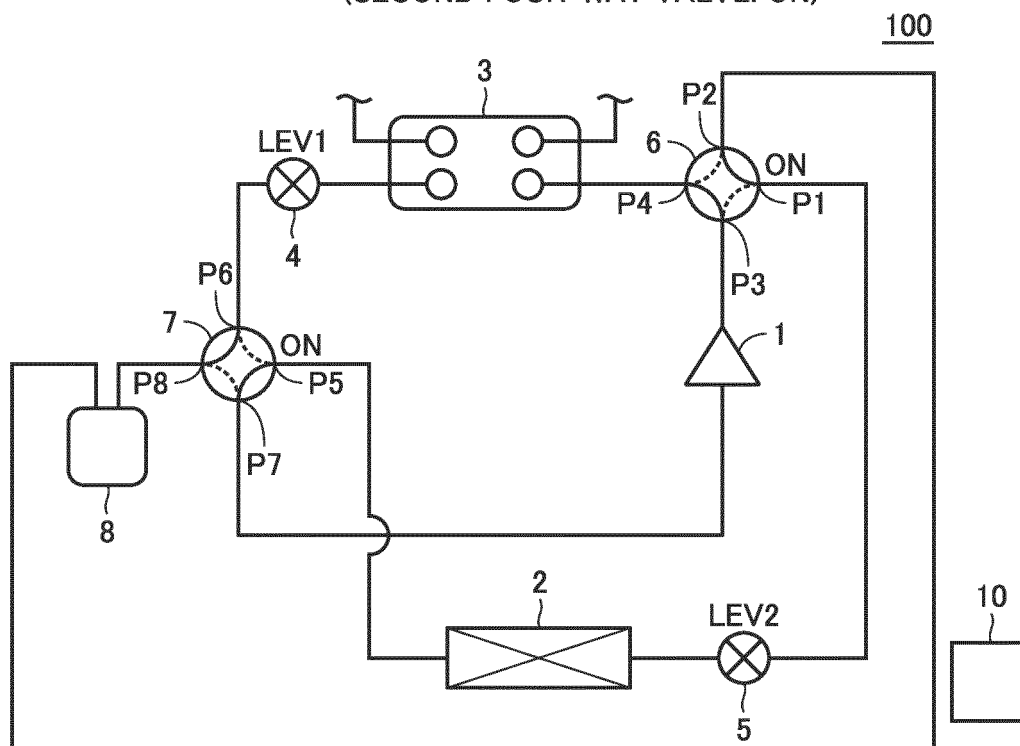


FIG.9

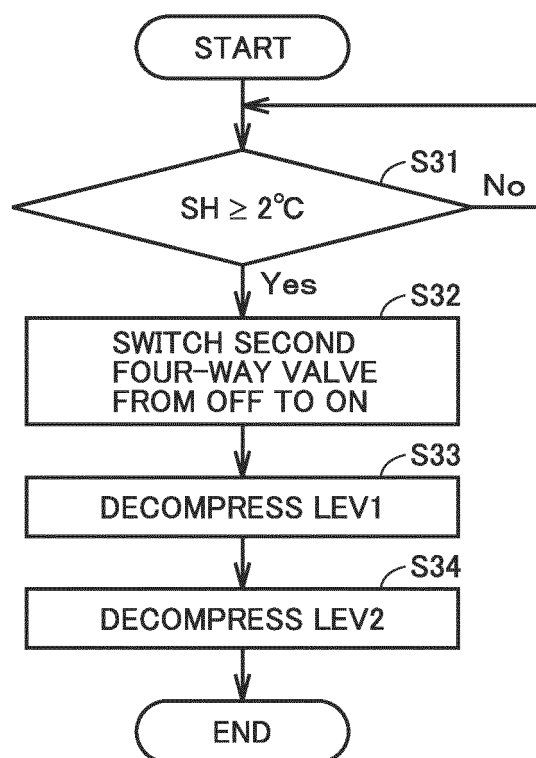


FIG.10

HEATING OPERATION (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: ON)

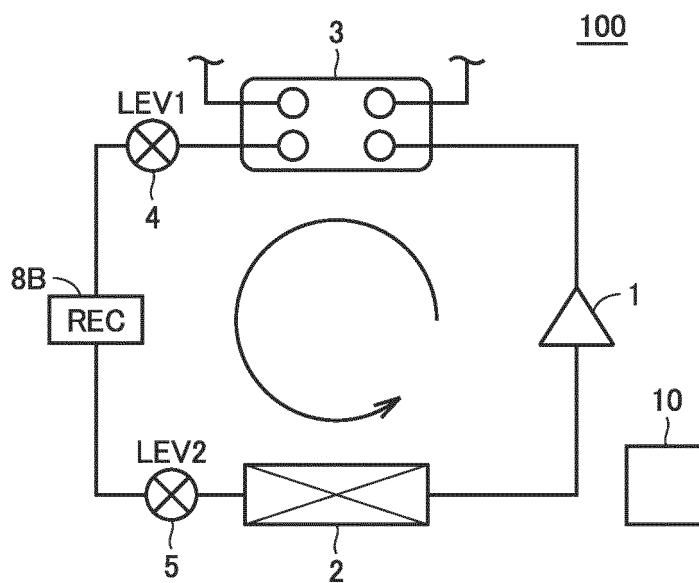


FIG.11

START-UP OF COOLING (FIRST FOUR-WAY VALVE: OFF)
(SECOND FOUR-WAY VALVE: OFF)

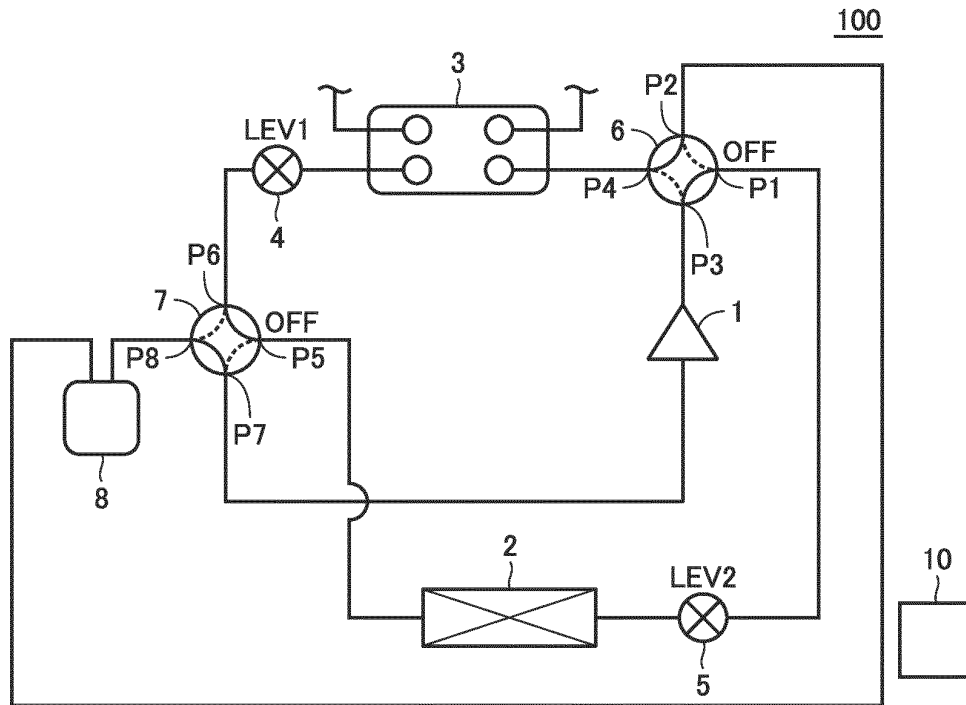


FIG.12

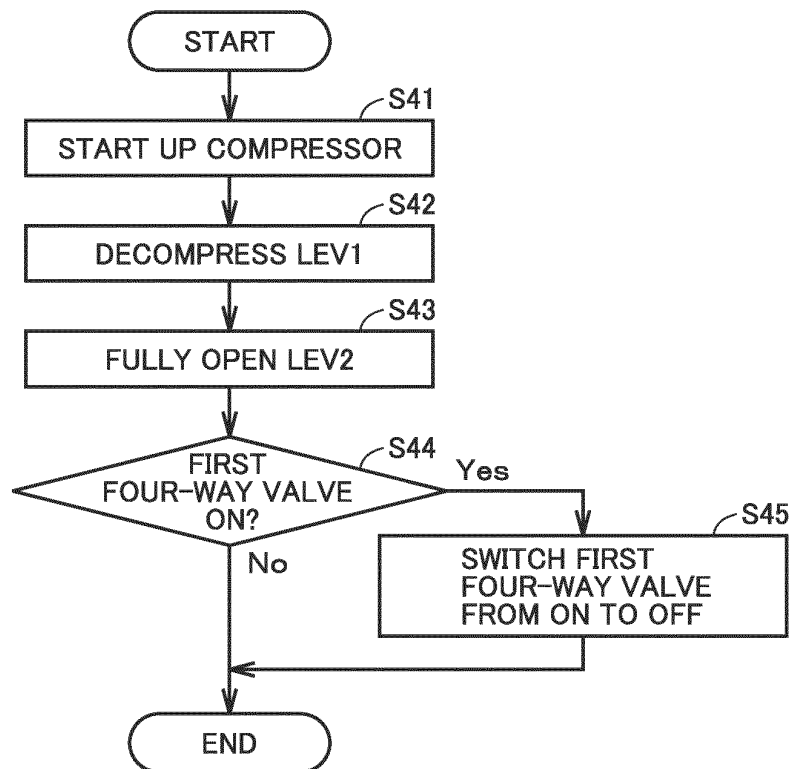


FIG.13

START-UP OF COOLING (FIRST FOUR-WAY VALVE: OFF)
(SECOND FOUR-WAY VALVE: OFF)

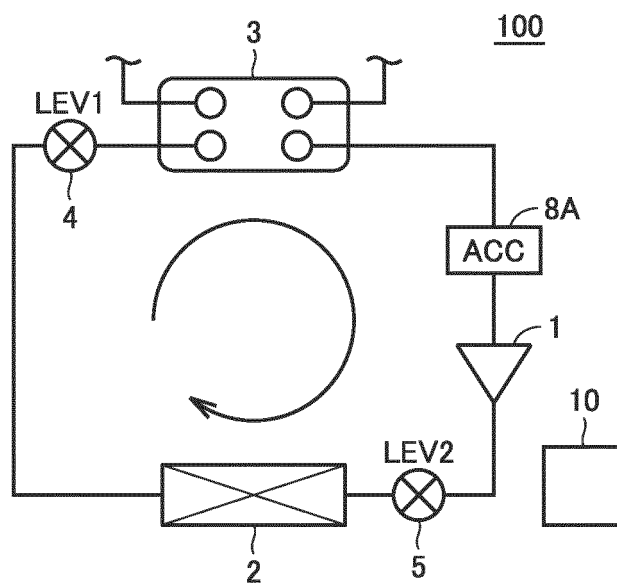


FIG.14

START-UP OF HEATING (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

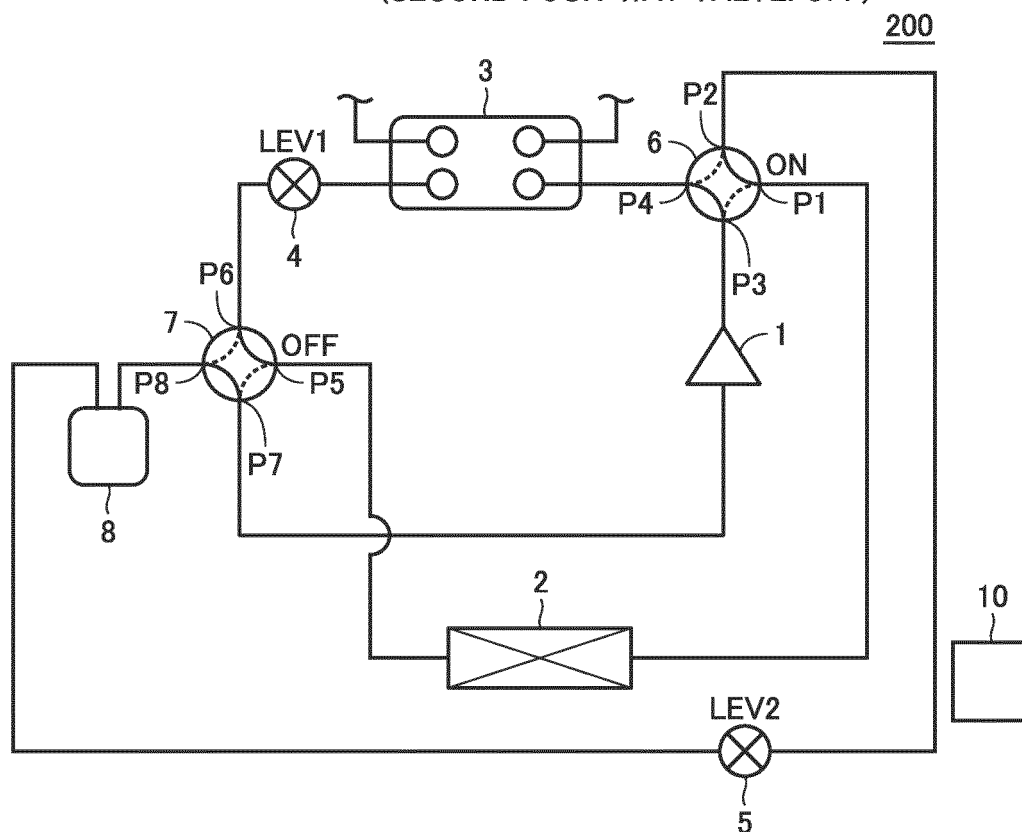


FIG.15

START-UP OF HEATING (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: OFF)

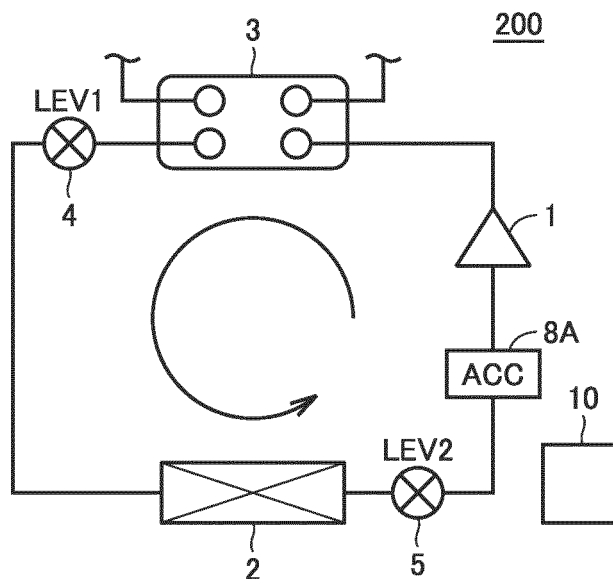


FIG.16

HEATING OPERATION (FIRST FOUR-WAY VALVE: ON)
(SECOND FOUR-WAY VALVE: ON)

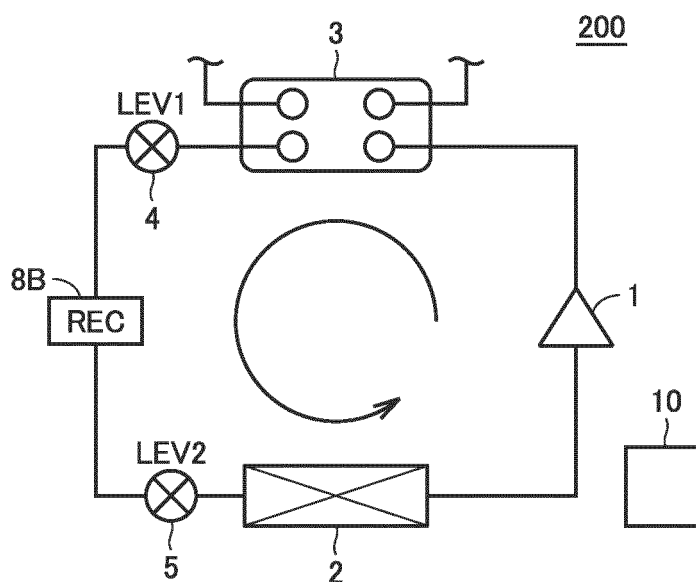
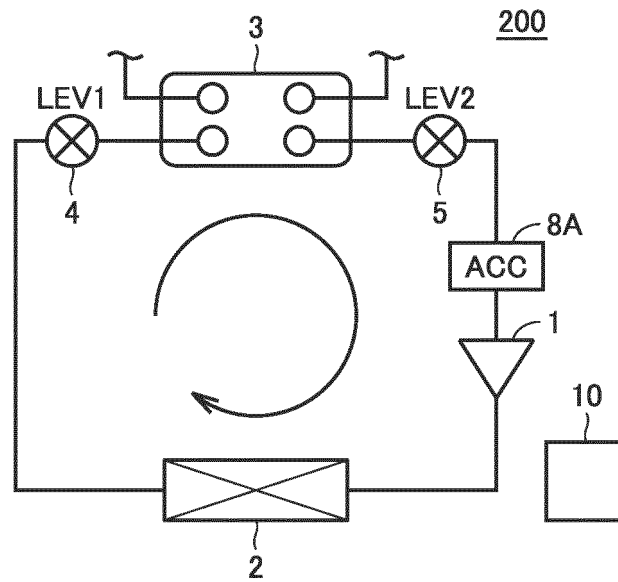


FIG.17

START-UP OF COOLING (FIRST FOUR-WAY VALVE: OFF)
(SECOND FOUR-WAY VALVE: OFF)



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/000100

A. CLASSIFICATION OF SUBJECT MATTER

F25B 13/00 (2006.01) i; F25B 43/00 (2006.01) i; F25B 1/00 (2006.01) i
 FI: F25B13/00 361; F25B1/00 391; F25B43/00 B; F25B43/00 L; F25B1/00 351A

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)
 F25B13/00; F25B43/00; F25B1/00

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	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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.
A	JP 10-259963 A (MITSUBISHI ELECTRIC CORP.) 29 September 1998 (1998-09-29) entire text, all drawings	1-8

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

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"A" document defining the general state of the art which is not considered to be of particular relevance	"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
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Date of the actual completion of the international search
 09 February 2021 (09.02.2021)

Date of mailing of the international search report
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 Japan Patent Office
 3-4-3, Kasumigaseki, Chiyoda-ku,
 Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No. PCT/JP2021/000100
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 10-259963 A	29 Sep. 1998	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10259963 A [0003]