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(54) REFRIGERATION CYCLE DEVICE

KÄLTEKREISLAUFVORRICHTUNG

DISPOSITIF À CYCLE FRIGORIFIQUE

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Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus, and more particularly, to suppression of liquid backflow during a defrosting operation.

Background Art

[0002] There have been known air-conditioning apparatuses configured to cool or heat water using a refrigeration cycle apparatus, and use thus obtained cold water or hot water to perform a cooling or heating operation, and other such apparatus. Air-cooled heat pump chillers correspond to those refrigeration cycle apparatus, for example.

[0003] In low-temperature outdoor air, when a refrigeration cycle apparatus is operated in a heating operation, specifically, when an air-heat exchanger (outdoor-side heat exchanger) configured to exchange heat between outdoor air and refrigerant is used as an evaporator, and a water-heat exchanger (indoor-side heat exchanger) is used as a condenser, for example, when hot water that is used for heating is produced, frost may be formed on the air-heat exchanger. The frost formed on the air-heat exchanger inhibits the heat exchange between the outdoor air and the refrigerant, thereby reducing performance for water heating on the water-heat exchanger side. Thus, it is necessary to immediately remove the frost formed on the air-heat exchanger (defrosting). Examples of a defrosting method include a hot-gas reverse type in which an air-heat exchanger operates as a condenser, an off cycle defrost type in which a refrigeration cycle apparatus is stopped, and a heater defrost type in which heat is generated by a heater installed near a heat exchanger. In particular, the air-cooled heat pump chillers employ the hot-gas reverse type defrosting operation.

[0004] In the air-cooled heat pump chiller, a refrigerant circuit includes, for example, a compressor, an air-heat exchanger, an expansion valve, a water-heat exchanger, a refrigerant tank, and a four-way valve that are connected by refrigerant pipes. The expansion valve provided between the air-heat exchanger and the water-heat exchanger is connected to the circuit in series. The refrigerant tank is installed between the expansion valve and the water-heat exchanger, and is connected in parallel to the refrigerant pipe connecting the expansion valve and the water heat exchanger to each other. The four-way valve is connected so that when one of the suction port side and the discharge port side of the compressor is connected to the air-heat exchanger, the other is connected to the water-heat exchanger, and that the connection may be reversed. In this refrigerant circuit, the four-way valve is switched so that refrigerant may circulate through the compressor, the water-heat exchanger, the expansion valve, and the air-heat exchanger in the stated order in the heating operation, with the result that hot water is produced in the water-heat exchanger. The four-way valve is switched in the cooling operation so that the refrigerant may circulate through the compressor, the air-heat exchanger, the expansion valve, and the water-heat exchanger in the stated order, with the result that cold water is produced in the water-heat exchanger.

[0005] In such a refrigerant circuit, frost may be formed on the air-heat exchanger that serves as an evaporator during the heating operation, and hence the hot-gas reverse type defrosting operation is performed. The hot-gas reverse type defrosting operation is a defrosting method involving sending high-temperature refrigerant gas (hot gas) discharged from the compressor to the air-heat exchanger on which frost is formed, to thereby melt the frost by the heat of the high-temperature refrigerant gas. At the start of defrosting, liquid refrigerant accumulated in the refrigerant tank, which is installed between the expansion valve and the water-heat exchanger, flows through the water-heat exchanger to the compressor and enters the suction port of the compressor. In short, back flow of liquid refrigerant, hereafter liquid backflow, to the compressor occurs. In a similar manner, when the defrosting operation is ended and the heating operation is started, liquid refrigerant accumulated in the air-heat exchanger enters the suction port of the compressor. In short, liquid backflow to the compressor occurs. Due to the foregoing, in the related art, an accumulator is installed in order to suppress liquid backflow, thereby preventing liquid backflow to the compressor. However, the capacity of the accumulator is large, and a large space is thus required in a machine chamber. Accordingly, in order to take measures for liquid backflow with small space, there has been examined a method for adjusting the amount of refrigerant that flows through a refrigerant circuit by a flow rate adjusting device through provision of a refrigerant tank.

[0006] In Patent Literature 1, there is disclosed a refrigerant circuit including a compressor, a condenser, an expansion device, and an evaporator that are connected by refrigerant pipes, in which the expansion device is provided in parallel to a circuit including a flow rate adjusting device and a receiver configured to accumulate surplus refrigerant in the refrigerant circuit that are connected in series.

[0007] In Patent Literature 2, there is disclosed a refrigeration cycle apparatus in which the discharge portion of a compressor and low-pressure refrigerant part of the refrigerant circuit after a solenoid valve are connected to each other by a hot gas bypass, a refrigerant circuit is divided into a low-pressure part and a high-pressure part in performing a defrosting operation, and an accumulator is connected to the suction side of the compressor.

[0008] In Patent Literature 3, there is disclosed a technology for reducing pressure on the high-pressure side in a refrigerant circuit by allowing, when the pressure on the high-pressure side of the refrigerant circuit in operation rises, refrigerant to flow to a refrigerant tank connected between a suction portion of the compressor and a solenoid valve.

Citation List

Patent Literature

[0009]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2014-119153
Patent Literature 2: Japanese Examined Patent Publication No. Hei 7-52052
Patent Literature 3: Japanese Unexamined Patent Application Publication No. Hei 5-288427

Summary of Invention

Technical Problem

[0010] In the technology disclosed in Patent Literature 1, the refrigerant circuit is configured to adjust a refrigerant flow rate depending on the necessary amount of refrigerant, and during power outage, control of opening the flow rate adjusting device to return refrigerant accumulated in the receiver to the refrigerant circuit is performed. This technology, however, is not conceived for control during a defrosting operation.

[0011] In the technology disclosed in Patent Literature 2, the hot gas bypass, which connects between the solenoid valve and the discharge side of the compressor so that hot gas may be allowed to flow from the solenoid valve to an evaporator, is provided, and during the defrosting operation, defrosting is performed by a circuit in which a valve provided downstream of a condenser is closed to connect the high-pressure side of the compressor and the evaporator to each other. This configuration prevents liquid backflow to the compressor by the accumulator provided between the evaporator and the suction port of the compressor, and requires a space for installing the accumulator. Further, the hot gas bypass is provided for defrosting. Thus, this technology has a problem in that a space in the machine chamber of the refrigeration cycle apparatus needs to be large.

[0012] In the refrigerant circuit of Patent Literature 3, the suction port of the compressor is connected to expansion valves, and the refrigerant tank is provided between the compressor and the expansion valve. When the circulation amount of refrigerant excessively increases to raise high pressure, the refrigerant is accumulated in the refrigerant tank. This configuration performs, when the pressure on the high-pressure side of the refrigerant circuit is higher than a defined value, control to open the solenoid valve so that the refrigerant may be accumulated in the refrigerant tank. This configuration, however, is not aimed at defrosting, and does not take measures to prevent liquid backflow to the compressor during a defrosting operation. Document JP-A-2014 119145 discloses a refrigeration cycle apparatus according to the preamble of claims 1 and 2.

[0013] The present invention has been made in order to overcome the above-mentioned problems, and it is an object of the present invention to enable suppression of liquid backflow in a refrigerant circuit including a refrigerant tank (high-pressure receiver) during a defrosting operation of the refrigerant circuit. Solution to Problem

[0014] According to one embodiment of the present invention, there is provided a refrigeration cycle apparatus including the features of claim 1.

[0015] According to an alternative embodiment of the present invention, there is provided a refrigeration cycle apparatus including the features of claim 2.

Advantageous Effects of Invention

[0016] According to one embodiment of the present invention, at the start of the defrosting operation, the sub-expansion valve and the solenoid valve are controlled so that a refrigerant amount in the refrigerant tank may be adjusted, and refrigerant may be discharged to the refrigerant circuit by an amount necessary for the defrosting operation. In this way, liquid backflow to the compressor that occurs during the defrosting operation can be suppressed.

Brief Description of Drawings

[0017]

Fig. 1 is a schematic diagram of a refrigerant circuit of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.
Fig. 2 is a schematic diagram of a refrigerant circuit of a refrigeration cycle apparatus according to the related art (Comparative Example).
Fig. 3 is a diagram of a control flow of the refrigeration cycle apparatus according to Embodiment 1.
Fig. 4 is an explanatory graph for showing the relationship of the operation of a solenoid valve that depends on the elapsed time and high-pressure-side pressure in the refrigerant circuit during a defrosting operation .
Fig. 5 is a diagram of a control flow of a refrigeration cycle apparatus according to Embodiment 2 of the present invention.

Description of Embodiments

Embodiment 1

[0018] Now, a refrigeration cycle apparatus 1 according to Embodiment 1 of the present invention is described with reference to the drawings.

[0019] Fig. 1 is a schematic diagram of a refrigerant circuit 2 of the refrigeration cycle apparatus 1 according to Embodiment 1. The refrigeration cycle apparatus 1 according to Embodiment 1 is, for example, an air-conditioning apparatus configured to use cold water or hot water, which is obtained by cooling or heating water, for a cooling or heating operation. The refrigeration cycle apparatus 1 corresponds to, for example, an air-cooled heat pump chiller.

[0020] The refrigerant circuit 2 of the refrigeration cycle apparatus 1 includes a compressor 21, an air-heat exchanger 22 corresponding to a heat source-side heat exchanger of the invention of the subject application, a main-expansion valve 24, a water-heat exchanger 25 corresponding to a use-side heat exchanger of the invention of the subject application, a sub-expansion valve 26, a refrigerant tank 27, a solenoid valve 28, and a four-way valve 29 corresponding to a flow switching valve of the invention of the subject application that are connected by refrigerant pipes. The sub-expansion valve 26, the refrigerant tank 27, and the solenoid valve 28 are connected in series in the refrigerant circuit. The sub-expansion valve 26, the refrigerant tank 27, and the solenoid valve 28, which are connected, are connected in parallel to the main-expansion valve 24 provided between the air-heat exchanger 22 and the water-heat exchanger 25.

[0021] The four-way valve 29 is connected so that when one of the suction port side and the discharge port side of the compressor 21 is connected to the air-heat exchanger 22, the other may be connected to the water-heat exchanger 25, and that the connection may be reversed. The connection targets may be switched using a flow switching valve other than the four-way valve 29 as long as the respective connection targets of the suction port side and the discharge port side of the compressor 21 are switched to reverse a circulation direction of refrigerant in the refrigerant circuit 2. The main-expansion valve 24 serves as a pressure reducing device in the refrigerant circuit 2. The opening degree of the sub-expansion valve 26 can be switched among a fully-open opening degree, a fully-closed opening degree, and a throttled opening degree through change of its opening degree. When being fully opened, the sub-expansion valve 26 allows refrigerant to pass therethrough while the pressure of the refrigerant is not reduced or reduced by a small amount. When being fully closed, the sub-expansion valve 26 can block the flow of the refrigerant. The sub-expansion valve 26 with the throttled opening degree serves as a pressure reducing device in the refrigerant circuit 2, as in the main-expansion valve 24. The solenoid valve 28 can be controlled to be open or closed. When being open, the solenoid valve 28 allows refrigerant to flow therethrough while not reducing the pressure of the refrigerant or reducing the pressure of the refrigerant by a small amount, and when being closed, the solenoid valve 28 can block the flow of the refrigerant.

[0022] The refrigeration cycle apparatus 1 includes a pressure sensor 3 configured to measure pressure on the high-pressure side of the refrigerant circuit 2. Further, the refrigeration cycle apparatus 1 includes a controller 4. The controller 4 controls the operations of the compressor 21, the four-way valve 29, and the main-expansion valve 24, and controls opening and closing of the sub-expansion valve 26 and the solenoid valve 28 based on a value measured by the pressure sensor 3. The controller 4 comprises a microcomputer, for example. The relationships between the pressure on the high-pressure side of the refrigerant circuit 2, and the opening degree control for the sub-expansion valve 26 and the opening and closing control for the solenoid valve 28 are described later.

[0023] The air-heat exchanger 22 is provided with a fan 23. The fan 23 is configured to send air outside the refrigeration cycle apparatus 1 (outdoor air) into the air-heat exchanger 22 so that heat may be exchanged between refrigerant and the outdoor air. When frost is formed on the air-heat exchanger 22 during the heating operation, the frost prevents air sent by the fan 23 from entering the air-heat exchanger 22, leading to drop in heat exchange efficiency.

(Operation of Refrigeration Cycle Apparatus 1 during Heating Operation)

[0024] The flow of refrigerant in the refrigerant circuit 2 of the refrigeration cycle apparatus 1 and the operations of the elements in the refrigerant circuit during the heating operation, that is, when hot water is produced in the water-heat exchanger 25 are described.

[0025] Refrigerant flowing through the pipes of the refrigerant circuit 2 is compressed in the compressor 21 to have high-temperature and high-pressure, and then enters the four-way valve 29. The four-way valve 29 is switched as indicated by the dotted lines of Fig. 1 at the time of the heating operation, and the high-temperature and high-pressure refrigerant discharged from the discharge port of the compressor 21 flows into the water-heat exchanger 25. During the heating operation, the water-heat exchanger 25 serves as a condenser and exchanges heat between water and the refrigerant. The high-temperature and high-pressure refrigerant transfers heat to the water in the water-heat exchanger 25 to be condensed, thereby becoming liquid refrigerant.

[0026] The liquid refrigerant that has flowed out of the water-heat exchanger 25 is subjected to pressure reduction through the main-expansion valve 24 to become low-temperature and low-pressure two-phase gas-liquid refrigerant. During the heating operation, the solenoid valve 28 is generally opened, and hence the refrigerant that has flowed out of the water-heat exchanger 25 also flows to the refrigerant tank 27. The refrigerant tank has a role of accumulating surplus refrigerant during the heating operation. Further, the sub-expansion valve 26 connected to the refrigerant tank 27 has the throttled opening degree, and thus serves as a pressure reducing device for the refrigerant.

[0027] The refrigerant, which is now two-phase gas-liquid refrigerant through the main-expansion valve 24 and the sub-expansion valve 26, flows into the air-heat exchanger 22. During the heating operation, the air-heat exchanger 22 serves as an evaporator and exchanges heat between outdoor air and the refrigerant. The low-temperature and low-pressure two-phase gas-liquid refrigerant receives heat from the outdoor air in the air-heat exchanger 22 to become superheat gas. The refrigerant, which is now superheat gas, flows into the suction port of the compressor 21 through the four-way valve 29. After that, the refrigerant circulates again in the same route.

(Operation of Refrigeration Cycle Apparatus 1 during Defrosting Operation)

[0028] The flow of refrigerant in the refrigerant circuit 2 of the refrigeration cycle apparatus 1 and the operations of the elements in the refrigerant circuit during the defrosting operation are described.

[0029] Under low-temperature condition of outdoor air, when the refrigeration cycle apparatus 1 is operated in the heating operation, specifically, when the air-heat exchanger 22 configured to exchange heat between outdoor air and refrigerant is used as an evaporator, and the water-heat exchanger 25 is used as a condenser, for example, when hot water that is used for heating is produced, frost may be formed on the air-heat exchanger 22. The frost formed on the air-heat exchanger 22 inhibits the heat exchange between the outdoor air and the refrigerant in the air-heat exchanger 22, thereby reducing performance for water heating on the water-heat exchanger 25 side. Thus, the frost formed on the air-heat exchanger 22 is removed by the defrosting operation.

[0030] The refrigeration cycle apparatus 1 according to Embodiment 1 employs hot-gas reverse type defrosting. When the defrosting operation is started, the four-way valve 29 is switched as indicated by the solid lines of Fig. 1. High-temperature and high-pressure gas refrigerant discharged from the discharge port of the compressor 21 flows into the air-heat exchanger 22 on which frost is formed. As a result, the frost formed on the air-heat exchanger 22 is melted, that is, defrosting is achieved.

(Refrigeration Cycle Apparatus according to Comparative Example)

[0031] Fig. 2 is a schematic diagram of a refrigerant circuit 102 of a refrigeration cycle apparatus 101 according to the related art (Comparative Example). The refrigerant circuit 102 of the refrigeration cycle apparatus 101 includes a compressor 11, an air-heat exchanger 12, a main-expansion valve 14, a water-heat exchanger 15, a refrigerant tank 17, and a four-way valve 19 that are connected by refrigerant pipes. The refrigerant tank 17 is connected in parallel to the main-expansion valve 14 provided between the air-heat exchanger 12 and the water-heat exchanger 15. The four-way valve 19 is connected so that when one of the suction port side and the discharge port side of the compressor 11 is connected to the air-heat exchanger 12, the other may be connected to the water-heat exchanger 15, and that the connection may be reversed. The air-heat exchanger 12 is provided with a fan 13. The fan 13 is configured to send air outside the refrigeration cycle apparatus 101 (outdoor air) into the air-heat exchanger 12 so that heat may be exchanged between refrigerant and the outdoor air.

[0032] In general, in such a refrigerant circuit as the refrigerant circuit 102 of the refrigeration cycle apparatus 101, the internal volume of an air-heat exchanger is large as compared to a water-heat exchanger. During a heating operation, the water heat exchanger 15, which has a relatively small internal volume, serves as a condenser, and hence the necessary amount of refrigerant is small as compared to a cooling operation. As a result, surplus refrigerant is generated. Thus, during the heating operation, refrigerant is accumulated in the refrigerant tank 17. This also occurs in the refrigeration cycle apparatus 1 according to Embodiment 1.

[0033] During a defrosting operation, the discharge side of the compressor 11 is connected to the air-heat exchanger 12 and the suction side thereof is connected to the water-heat exchanger 15 so that refrigerant may circulate in a direction opposite to that in the heating operation. Thus, the entire refrigerant accumulated in the refrigerant tank 17 flows out on a main refrigerant circuit. When the entire surplus refrigerant flows out of the refrigerant tank 17, however, the amount of refrigerant is larger than a refrigerant amount necessary for the defrosting operation, and the liquid refrigerant accumulated in the refrigerant tank 17 flows into the suction side of the compressor 11 through the water-heat exchanger 15, resulting in liquid backflow. Thus, some measures for liquid backflow need to be taken in the refrigeration cycle apparatus 101 according to Comparative Example.

(Control of Refrigeration Cycle Apparatus 1 according to Embodiment 1)

[0034] Fig. 3 is a diagram of the control flow of the refrigeration cycle apparatus 1 according to Embodiment 1.

[0035] The measures for liquid backflow need to be taken in the refrigeration cycle apparatus 101 according to Comparative Example, and hence in Embodiment 1, such a refrigerant circuit as the refrigerant circuit 2 of the refrigeration cycle apparatus 1 is formed, and liquid backflow is prevented by control described below.

[0036] When the defrosting operation is started, the controller 4 installed in the refrigeration cycle apparatus 1 receives a value from the pressure sensor 3 configured to measure the pressure on the high-pressure side in the refrigerant circuit 2, for example, pressure in the refrigerant pipe from the discharge port of the compressor 21 to the four-way valve 29, detects a temporal change in pressure on the high-pressure side of the refrigerant circuit 2, and determines whether the high-pressure-side pressure is equal to or higher than reference high-pressure, which corresponds to a defined value of the invention of the subject application, or lower than the reference high-pressure (Control Step S1). When the high-pressure-side pressure is lower than the reference high-pressure, the controller 4 closes the solenoid valve 28 (Control Step S2) and fully opens the sub-expansion valve 26 (Control Step S3) so that refrigerant in the refrigerant tank 27 may be discharged into a main circuit 5. The main circuit 5 refers to a circuit portion for circulating refrigerant, in which the compressor 21, the four-way valve 29, the air-heat exchanger 22, the main-expansion valve 24, and the water-heat exchanger 25 are connected by the refrigerant pipes. The refrigerant in the refrigerant tank 27 is discharged to the main circuit 5, and hence shortage of a refrigerant amount in the main circuit 5 is eliminated. There is therefore provided an effect that failures including a superheat operation of the compressor 21 can be avoided.

[0037] When the high-pressure-side pressure is equal to or higher than the reference high-pressure, the controller 4 opens the solenoid valve 28 (Control Step S4) and fully closes the sub-expansion valve 26 (Control Step S5) so that refrigerant in the main circuit 5 may be charged to the refrigerant tank 27 from the solenoid valve 28 side. As a result, the refrigerant can be discharged to the main circuit 5 by an amount necessary for defrosting, and there is therefore provided an effect that failures including liquid backflow to the compressor 21, which occur due to surplus refrigerant in the main circuit 5, can be avoided.

[0038] After performing Control Steps S2 and S3 or Control Steps S4 and S5, the controller 4 determines whether or not defrosting-operation end conditions are satisfied (Control Step S6). When the defrosting-operation end conditions are not satisfied, the controller 4 returns to Control Step S1 again. When the defrosting-operation end conditions are satisfied, the control for the defrosting operation is ended. Whether or not the defrosting-operation end conditions are satisfied is determined by, for example, determining whether or not the temperature of the air-heat exchanger 22 becomes equal to or higher than a defined value or elapsed time from the start of the defrosting operation becomes equal to or longer than a defined value, or both the conditions are satisfied.

[0039] Fig. 4 is an explanatory graph for showing the relationship of the operation of the solenoid valve 28 that depends on the elapsed time and change in high-pressure-side pressure in the refrigerant circuit 2 during the defrosting operation .

[0040] The pressure shown in Fig. 4 is the pressure on the high-pressure side in the refrigerant circuit 2. Specifically, the pressure of refrigerant on the discharge side of the compressor 21, that is, at a point in the section from the compressor 21 to the four-way valve 29 is measured. When the refrigeration cycle apparatus 1 is switched to the defrosting operation, pressure in the refrigerant circuit 2 increases as time elapses. When the increase rate of the pressure in the refrigerant circuit 2 with respect to elapsed time is larger than a defined value, that is, the slope of the straight line of Fig. 4 is larger than the defined value, the controller 4 determines that the pressure is high pressure. When the increase rate of the pressure in the refrigerant circuit 2 with respect to elapsed time is smaller than the defined value, that is, the slope of the straight line of Fig. 4 is smaller than the defined value, the controller 4 determines that the pressure is low pressure. The controller 4 controls the sub-expansion valve 26 and the solenoid valve 28 to be open or closed as described above, based on the determination.

[0041] When the high-pressure-side pressure is lower than the reference high-pressure, the controller 4 can also perform control of closing the solenoid valve 28 and reducing the opening degree of the sub-expansion valve 26 . When the sub-expansion valve 26 is fully opened through control, pressure in the main circuit 5 may increase rapidly, and control of fully closing the sub-expansion valve 26 and opening the solenoid valve 28 is performed again when the high-pressure-side pressure becomes equal to or higher than the reference high-pressure. Consequently, the opening and closing control for the sub-expansion valve 26 and the solenoid valve 28 is required to be frequently performed, resulting in unstable operation. Through reduction in opening degree of the sub-expansion valve 26, however, the flow rate of the refrigerant from the refrigerant tank 27 to the main circuit 5 can be controlled, and fluctuations in pressure in the main circuit 5 can be reduced. As a result, the frequency at which the sub-expansion valve 26 and the solenoid valve 28 are opened or closed can be reduced, and there is therefore provided an effect that the defrosting operation of the refrigeration cycle apparatus 1 can be stably performed.

Embodiment 2

[0042] In Embodiment 2 of the present invention, to the refrigerant circuit 2 and its control in Embodiment 1, steps of controlling the sub-expansion valve 26 and the solenoid valve 28 are further added after the start of the defrosting operation and before the end of the defrosting operation. In the following, points changed from Embodiment 1 are mainly described.

[0043] Fig. 5 is a diagram of a control flow of the refrigeration cycle apparatus 1 according to Embodiment 1.

[0044] The refrigeration cycle apparatus 1 according to Embodiment 2 performs the heating operation under a state in which the sub-expansion valve 26 is throttled in opening degree and the solenoid valve 28 is opened. At the start of the defrosting operation, the refrigeration cycle apparatus 1 switches the four-way valve 29 so that the circulation direction of refrigerant may be changed. After that, the controller 4 fully opens the sub-expansion valve 26 and closes the solenoid valve 28 (Control Step S0). Then, the controller 4 proceeds to Control Step S1 to detect a change in pressure on the high-pressure side of the refrigerant circuit 2 with respect to time, and determine whether the high-pressure-side pressure is equal to or higher than the reference high-pressure, which corresponds to the defined value of the invention of the subject application, or lower than the reference high-pressure. In short, the same Control Steps S1 to S6 as in Embodiment 1 are performed.

[0045] Immediately after the start of the defrosting operation, that is, in Control Step S0, the pressure on the high-pressure side of the refrigerant circuit 2 is low, and hence refrigerant accumulated in the refrigerant tank 27 flows out to the main circuit 5 through the sub-expansion valve 26. The pressure on the high-pressure side of the refrigerant circuit 2 increases when the refrigerant flows to the main circuit 5 by a sufficient amount. When the increase rate of the pressure in the refrigerant circuit 2 with respect to the elapsed time exceeds the defined value, that is, the slope of the straight line of Fig. 4 is larger than the defined value, due to the increase in pressure, the controller 4 performs control of opening the solenoid valve 28 and closing the sub-expansion valve 26. In short, the control in Control Steps S4 and S5 is performed through Control Step S1. In this case, refrigerant in the refrigerant circuit 2 flows into the refrigerant tank 27 through the solenoid valve 28. As a result, the amount of refrigerant, which has now high pressure, in the refrigerant circuit 2 is reduced and the pressure in the refrigerant circuit 2 is reduced.

[0046] Even when the refrigerant flows out to the main circuit 5, as long as the pressure on the high-pressure side of the refrigerant circuit 2 is lower than the defined value, the controller 4 opens the sub-expansion valve 26 and closes the solenoid valve 28.

[0047] When reaching Control Step S6 through control similar to that of Embodiment 1, the controller 4 determines whether or not the defrosting-operation end conditions are satisfied. When the defrosting-operation end conditions are not satisfied, the controller 4 returns to Control Step S1 again. When the defrosting-operation end conditions are satisfied, the controller 4 performs control of fully opening the sub-expansion valve 26 and closing the solenoid valve 28 (Control Step S7). After that, the four-way valve 29 is switched, and the heating operation is restarted. During the heating operation, the air-heat exchanger 22 side of the refrigerant circuit 2 corresponds to a low-pressure side, but immediately after the start of the heating operation, liquid refrigerant exists in the air-heat exchanger 22 due to the defrosting operation. However, the sub-expansion valve 26 is fully opened and the solenoid valve 28 is closed, and thus refrigerant in the main circuit 5 flows into the refrigerant tank 27. As a result, it no longer occurs that the liquid refrigerant existing in the air-heat exchanger 22 flows to the compressor 21.

[0048] Timing to proceed to Control Step S7 may be set to time that is a predetermined period of time before the end of the defrosting operation (before the restart of the heating operation) depending on the specifications of the refrigeration cycle apparatus 1, for example. In this case, Control Step S7 is ended after the predetermined period of time elapses to end the defrosting control. After that, the heating operation is restarted. Further, for example, a change in pressure in the refrigerant circuit 2 is detected, and the processing proceeds to Control Step S7 when the pressure satisfies predetermined conditions. Control Step S7 is ended to end the defrosting control when the pressure is reduced to the defined value.

[0049] Through the control described above, the refrigerant amount in the main circuit 5 is kept appropriate, and the pressure is also kept at an appropriate value. As a result, it is possible to prevent liquid backflow to the compressor 21 from occurring in switching from the heating operation to the defrosting operation and switching from the defrosting operation to the heating operation.

Reference Signs List

[0050] 1 refrigeration cycle apparatus 2 refrigerant circuit 3 pressure sensor 4 controller 5 main circuit 11 compressor 12 air-heat exchanger 13 fan 14 main-expansion valve 15 water-heat exchanger 17 refrigerant tank 18 solenoid valve 19 four-way valve 21 compressor 22 air-heat exchanger 23 fan 24 main-expansion valve 25 water-heat exchanger 26 sub-expansion valve 27 refrigerant tank 28 solenoid valve 29 four-way valve 101 refrigeration cycle apparatus 102 refrigerant circuit

Claims

1. A refrigeration cycle apparatus (1) comprising:

 a refrigerant circuit including a compressor (11), a flow switching valve (19), a heat source-side heat exchanger (22), a main-expansion valve (24), and a use-side heat exchanger (25) that are connected by refrigerant pipes, and being configured to perform a defrosting operation of a hot-gas reverse type,
 a pressure sensor (3) configured to measure pressure on a high-pressure side in the refrigerant circuit; and
 a controller (4) configured to control the compressor (11), the flow switching valve (19), and the main-expansion valve (24),
 wherein the main-expansion valve (24) is connected between the heat source-side heat exchanger (22) and the use-side heat exchanger (25) and is connected in parallel to a series circuit in which a sub-expansion valve (26) having a variable opening degree, a refrigerant tank configured to accumulate surplus refrigerant, and a solenoid valve (28) are connected in series,
 wherein the controller (4) is configured to control the opening degree of the sub-expansion valve (26) and opening and closing of the solenoid valve (28), based on the pressure measured by

the pressure sensor (3), and **characterised in that**
when the pressure is lower than a defined value, the sub-expansion valve (26) is opened and the solenoid valve (28) is closed, whereas when the pressure is equal to or higher than the defined value, the sub-expansion valve (26) is fully closed and the solenoid valve (28) is opened.

2. A refrigeration cycle apparatus (1) comprising:

a refrigerant circuit including a compressor (11), a flow switching valve (19), a heat source-side heat exchanger (22), a main-expansion valve (24), and a use-side heat exchanger (25) that are connected by refrigerant pipes, and being configured to perform a defrosting operation of a hot-gas reverse type,
a pressure sensor (3) configured to measure pressure on a high-pressure side in the refrigerant circuit; and
a controller (4) configured to control the compressor (11), the flow switching valve (19), and the main-expansion valve (24),
wherein the main-expansion valve (24) is connected between the heat source-side heat exchanger (22) and the use-side heat exchanger (25) and is connected in parallel to a series circuit in which a sub-expansion valve (26) having a variable opening degree, a refrigerant tank configured to accumulate surplus refrigerant, and a solenoid valve (28) are connected in series,
wherein the controller (4) is configured to control the opening degree of the sub-expansion valve (26) and opening and closing of the solenoid valve (28), based on the pressure measured by the pressure sensor (3), and **characterised in that**
when the pressure is lower than a defined value, the opening degree of the sub-expansion valve (26) is reduced and the solenoid valve (28) is closed, whereas when the pressure is equal to or higher than the defined value, the sub-expansion valve (26) is fully closed and the solenoid valve (28) is opened.

3. The refrigeration cycle apparatus (1) of any one of claims 1 or 2, wherein the sub-expansion valve (26) is fully opened and the solenoid valve (28) is closed in a period from after start of the defrosting operation to when the pressure reaches a defined value.

4. The refrigeration cycle apparatus (1) of any one of claims 1 to 3, wherein the sub-expansion valve (26) is fully opened and the solenoid valve (28) is closed in a predetermined period of time before end of the defrosting operation.

Patentansprüche

1. Kältekreislaufvorrichtung (1), die Folgendes umfasst:

einen Kühlmittelkreislauf, umfassend einen Kompressor (11), ein Durchflussumschaltventil (19), einen wärmequellenseitigen Wärmetauscher (22), ein Hauptentspannungsventil (24) und einen nutzungsseitigen Wärmetauscher (25), die mittels Kältemittelrohren verbunden sind, und die konfiguriert sind, um einen Abtauvorgang eines Heißgas-Umkehrkreislauftyps durchzuführen,
einen Drucksensor (3), der konfiguriert ist, um Druck auf einer Hochdruckseite im Kühlmittelkreislauf zu messen; und
eine Steuerung (4), die konfiguriert ist, um den Kompressor (11), das Durchflussumschaltventil (19) und das Hauptentspannungsventil (24) zu steuern,
wobei das Hauptentspannungsventil (24) zwischen den wärmequellenseitigen Wärmetauscher (22) und den nutzungsseitigen Wärmetauscher (25) geschaltet ist und mit einer Reihenschaltung parallelgeschaltet ist, in der ein Unterentspannungsventil (26) mit einem variablen Öffnungsgrad, ein Kühlmitteltank, der konfiguriert ist, um überschüssiges Kühlmittel zu sammeln, und ein Solenoid-Ventil (28) in Reihe geschaltet sind,
wobei die Steuerung (4) konfiguriert ist, um den Öffnungsgrad des Unterentspannungsventils (26) und die Öffnung und Schließung des Solenoid-Ventils (28) auf Basis des durch den Drucksensor (3) gemessenen Drucks zu steuern, und **dadurch gekennzeichnet, dass**
wenn der Druck unter einem definierten Wert liegt, das Unterentspannungsventil (26) geöffnet und das Solenoid-Ventil (28) geschlossen wird, wohingegen, wenn der Druck gleich dem definierten Wert ist oder über diesem liegt, das Unterentspannungsventil (26) vollständig geschlossen und das Solenoid-Ventil (28) geöffnet wird.

2. Kältekreislaufvorrichtung (1), die Folgendes umfasst:

einen Kühlmittelkreislauf, umfassend einen Kompressor (11), ein Durchflussumschaltventil (19), einen wärmequellenseitigen Wärmetauscher (22), ein Hauptentspannungsventil (24) und einen nutzungsseitigen Wärmetauscher (25), die mittels Kältemittelrohren verbunden sind, und die konfiguriert sind, um einen Abtauvorgang eines Heißgas-Umkehrkreislauftyps durchzuführen, einen Drucksensor (3), der konfiguriert ist, um Druck auf einer Hochdruckseite im Kühlmittelkreislauf zu messen; und

eine Steuerung (4), die konfiguriert ist, um den Kompressor (11), das Durchflussumschaltventil (19) und das Hauptentspannungsventil (24) zu steuern,

wobei das Hauptentspannungsventil (24) zwischen den wärmequellenseitigen Wärmetauscher (22) und den nutzungsseitigen Wärmetauscher (25) geschaltet ist und mit einer Reihenschaltung parallelgeschaltet ist, in der ein Unterentspannungsventil (26) mit einem variablen Öffnungsgrad, ein Kühlmitteltank, der konfiguriert ist, um überschüssiges Kühlmittel zu sammeln, und ein Solenoid-Ventil (28) in Reihe geschaltet sind,

wobei die Steuerung (4) konfiguriert ist, um den Öffnungsgrad des Unterentspannungsventils (26) und die Öffnung und Schließung des Solenoid-Ventils (28) auf Basis des durch den Drucksensor (3) gemessenen Drucks zu steuern, und **dadurch gekennzeichnet, dass**

wenn der Druck unter einem definierten Wert liegt, der Öffnungsgrad des Unterentspannungsventils (26) verringert und das Solenoid-Ventil (28) geschlossen wird, wohingegen, wenn der Druck gleich dem definierten Wert ist oder über diesem liegt, das Unterentspannungsventil (26) vollständig geschlossen und das Solenoid-Ventil (28) geöffnet wird.

3. Kältekreislaufvorrichtung (1) nach einem der Ansprüche 1 oder 2, wobei in einem Zeitraum ab dem Beginn des Auftauvorgangs bis zu dem Zeitpunkt, an dem der Druck einen definierten Wert erreicht, das Unterentspannungsventil (26) vollständig geöffnet und das Solenoid-Ventil (28) geschlossen ist.

4. Kältekreislaufvorrichtung (1) nach einem der Ansprüche 1 bis 3, wobei in einem vorbestimmten Zeitraum vor dem Ende des Auftauvorgangs das Unterentspannungsventil (26) vollständig geöffnet und das Solenoid-Ventil (28) geschlossen ist.

Revendications

1. Appareil à cycle frigorifique (1) comprenant :

un circuit de réfrigérant incluant un compresseur (11), une soupape de commutation de trajet d'écoulement (19) ; un échangeur de chaleur côté source de chaleur (22) ; un détendeur principal (24) et un échangeur de chaleur côté utilisation (25) qui sont raccordés par des conduites de réfrigérant, et étant configuré pour effectuer une opération de dégivrage d'un type inverse à gaz chaud,

un capteur de pression (3) configuré pour mesurer la pression sur un côté haute pression dans le circuit de réfrigérant ; et

un dispositif de commande (4) configuré pour commander le compresseur (11), la soupape de commutation de trajet d'écoulement (19) et le détendeur principal (24),

dans lequel le détendeur principal (24) est raccordé entre l'échangeur de chaleur côté source de chaleur (22) et l'échangeur de chaleur côté utilisation (25) et est raccordé en parallèle à un circuit en série dans lequel un détendeur secondaire (26) ayant un degré d'ouverture variable, un réservoir de réfrigérant configuré pour stocker l'excès de réfrigérant et une électrovanne (28) sont raccordés en série,

dans lequel le dispositif de commande (4) est configuré pour commander le degré d'ouverture du détendeur secondaire (26) et l'ouverture et la fermeture de l'électrovanne (28), sur la base de la pression mesurée par le capteur de pression (3), et **caractérisé en ce que** lorsque la pression est inférieure à une valeur définie, le détendeur secondaire ((26) est ouvert et l'électrovanne (28) est fermée, tandis que lorsque la pression est supérieure ou égale à la valeur définie, le détendeur secondaire (28) est complètement fermé et l'électrovanne (28) est ouverte.

2. Appareil à cycle frigorifique (1), comprenant :

un circuit de réfrigérant incluant un compresseur (11), une soupape de commutation de trajet d'écoulement (19), un échangeur de chaleur côté source de chaleur (22), un détendeur principal (24) et un échangeur de chaleur côté utilisation (25) qui sont raccordés par des conduites de réfrigérant, et étant configuré pour effectuer une opération de dégivrage d'un type inverse à gaz chaud,

un capteur de pression (3) configuré pour mesurer la pression sur un côté haute pression dans le circuit de réfrigérant ; et

un dispositif de commande (4) configuré pour commander le compresseur (11), la soupape de commutation de trajet d'écoulement (19) et le détendeur principal (24),

dans lequel le détendeur principal (24) est raccordé entre l'échangeur de chaleur côté source de chaleur (22) et l'échangeur de chaleur côté utilisation (25) et est raccordé en parallèle à un circuit en série dans lequel un détendeur secondaire (26) ayant un degré d'ouverture variable, un réservoir de réfrigérant configuré pour stocker l'excès de réfrigérant et une électrovanne (28) sont raccordés en série,

dans lequel le dispositif de commande (4) est configuré pour commander le degré d'ouverture du détendeur secondaire (26) et l'ouverture et la fermeture de l'électrovanne (28), sur la base de la pression mesurée par le capteur de pression (3), et **caractérisé en ce que** lorsque la pression est inférieure à une valeur définie, le degré d'ouverture du détendeur secondaire (26) est réduit et l'électrovanne (28) est fermée, tandis que lorsque la pression est supérieure ou égale à la valeur définie, le détendeur secondaire (28) est complètement fermé et l'électrovanne (28) est ouverte.

3. Appareil à cycle frigorifique (1) selon l'une quelconque des revendications 1 ou 2, dans lequel le détendeur secondaire (26) est complètement ouvert et l'électrovanne (28) est fermée dans une période partant du début de l'opération de dégivrage jusqu'au moment où la pression atteint une valeur définie.

4. Appareil à cycle frigorifique (1) selon l'une quelconque des revendications 1 à 3, dans lequel le détendeur secondaire (26) est complètement ouvert et l'électrovanne (28) est fermée dans une période de temps prédéterminée avant la fin de l'opération de dégivrage.

FIG. 1

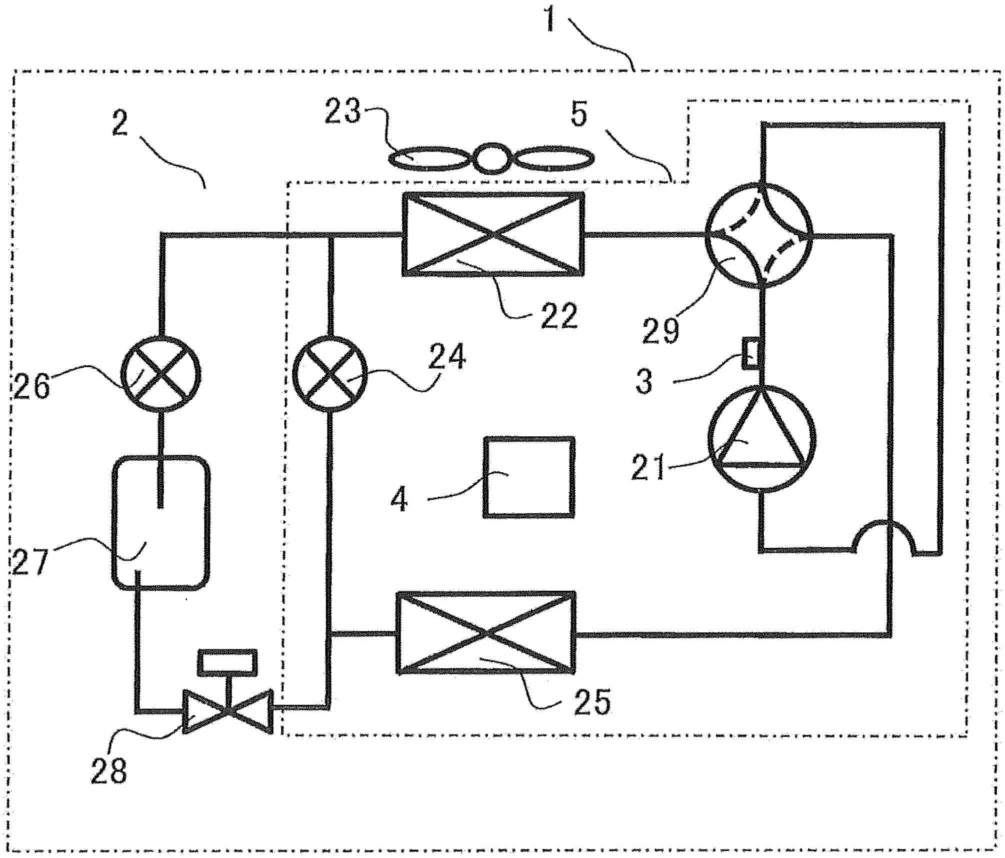


FIG. 2

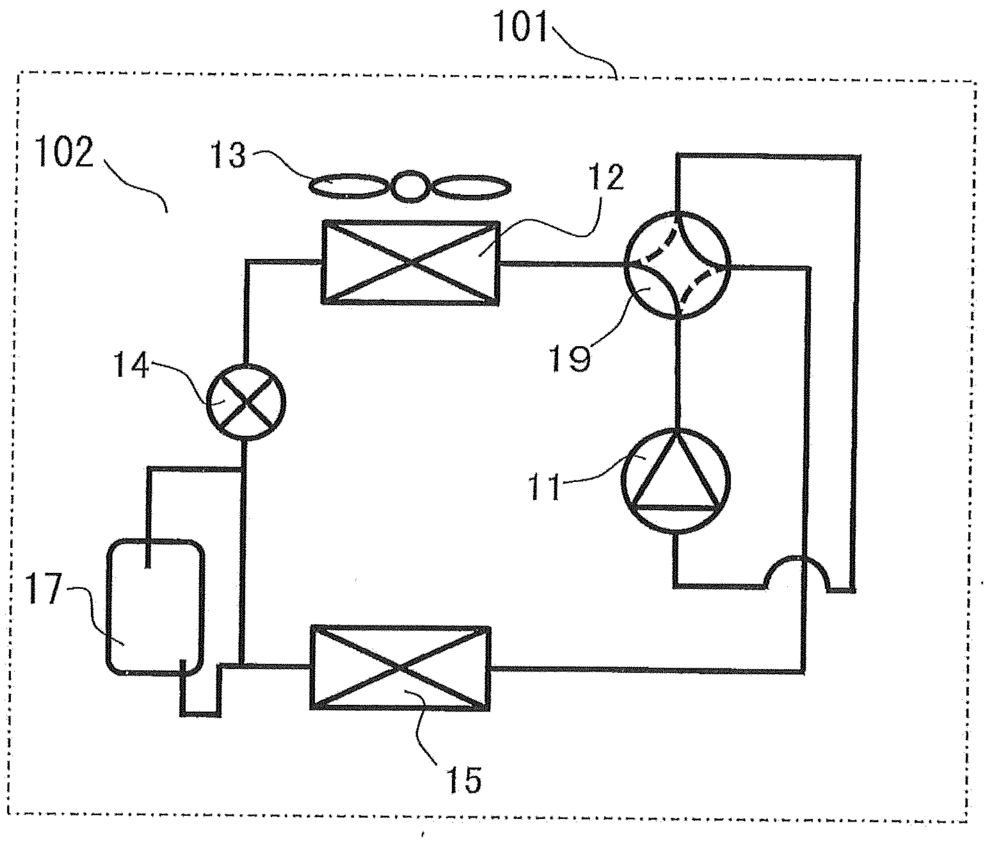


FIG. 3

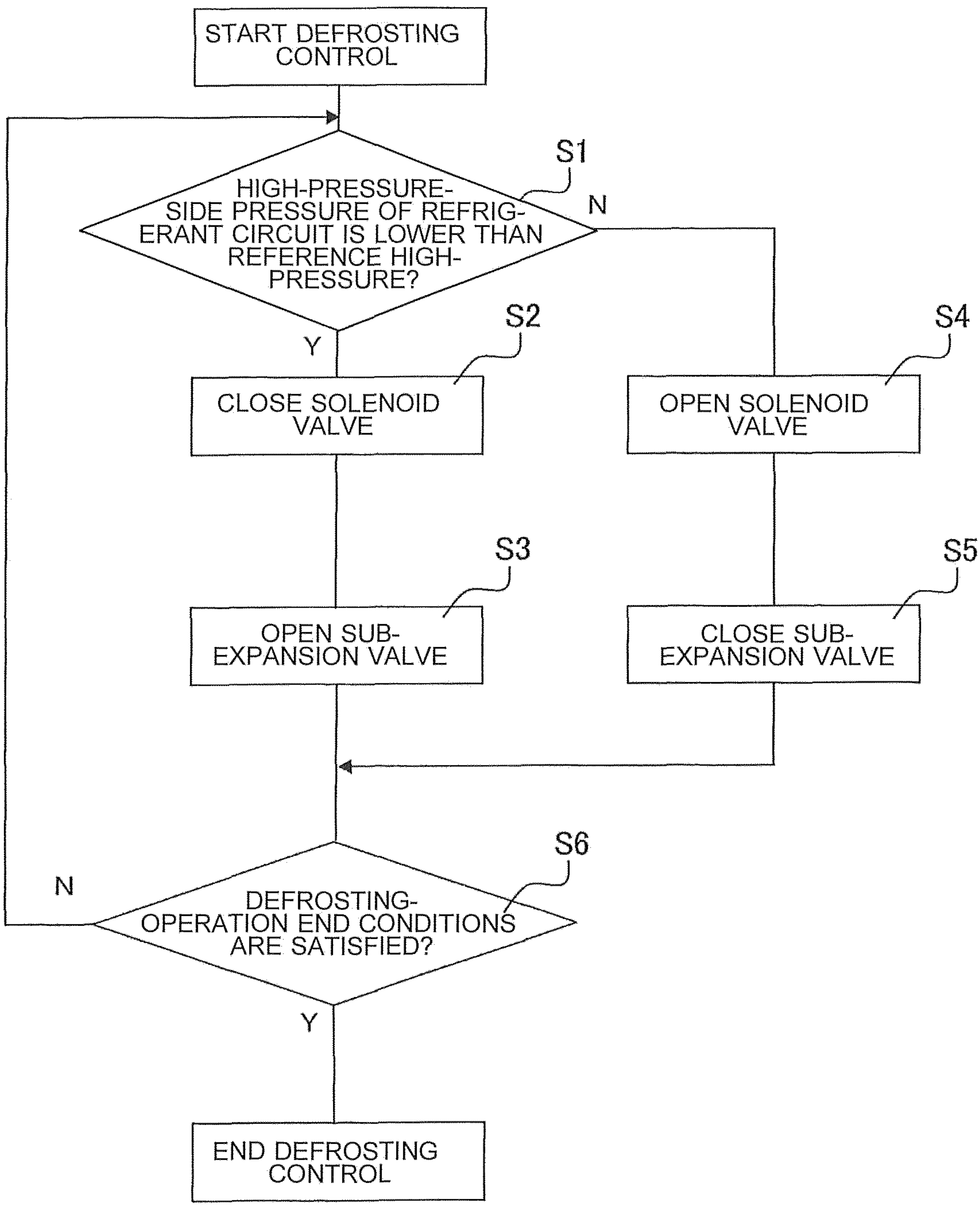

START DEFROSTING CONTROL
S1
HIGH-PRESSURE-SIDE PRESSURE OF REFRIGERANT CIRCUIT IS LOWER THAN REFERENCE HIGH-PRESSURE?
N
Y
S2
CLOSE SOLENOID VALVE
S4
OPEN SOLENOID VALVE
S3
OPEN SUB-EXPANSION VALVE
S5
CLOSE SUB-EXPANSION VALVE
S6
DEFROSTING-OPERATION END CONDITIONS ARE SATISFIED?
N
Y
END DEFROSTING CONTROL

FIG. 4

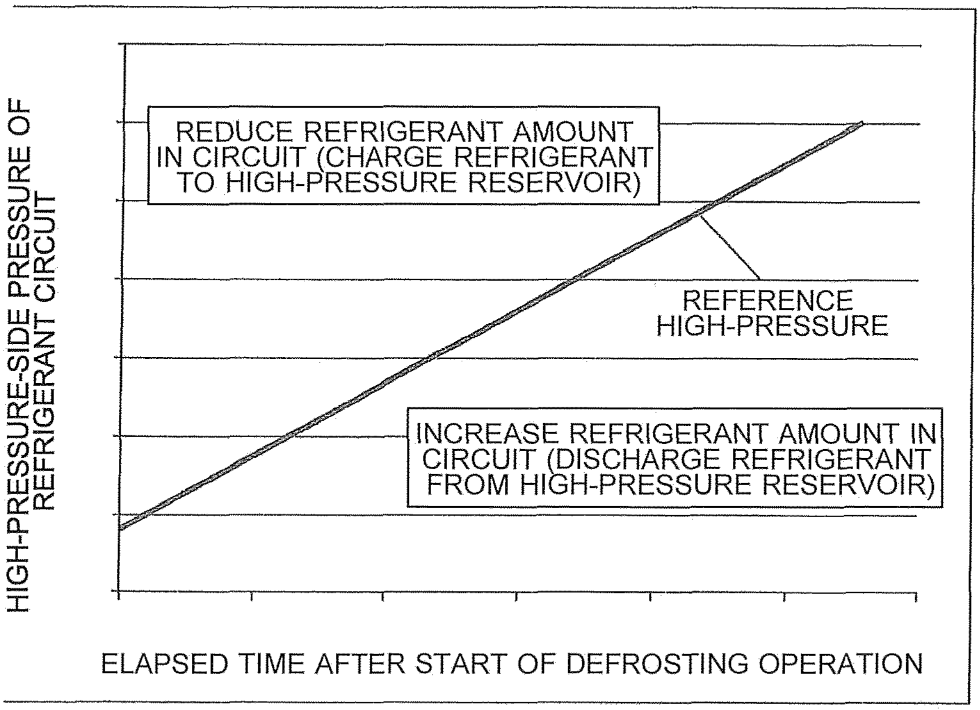
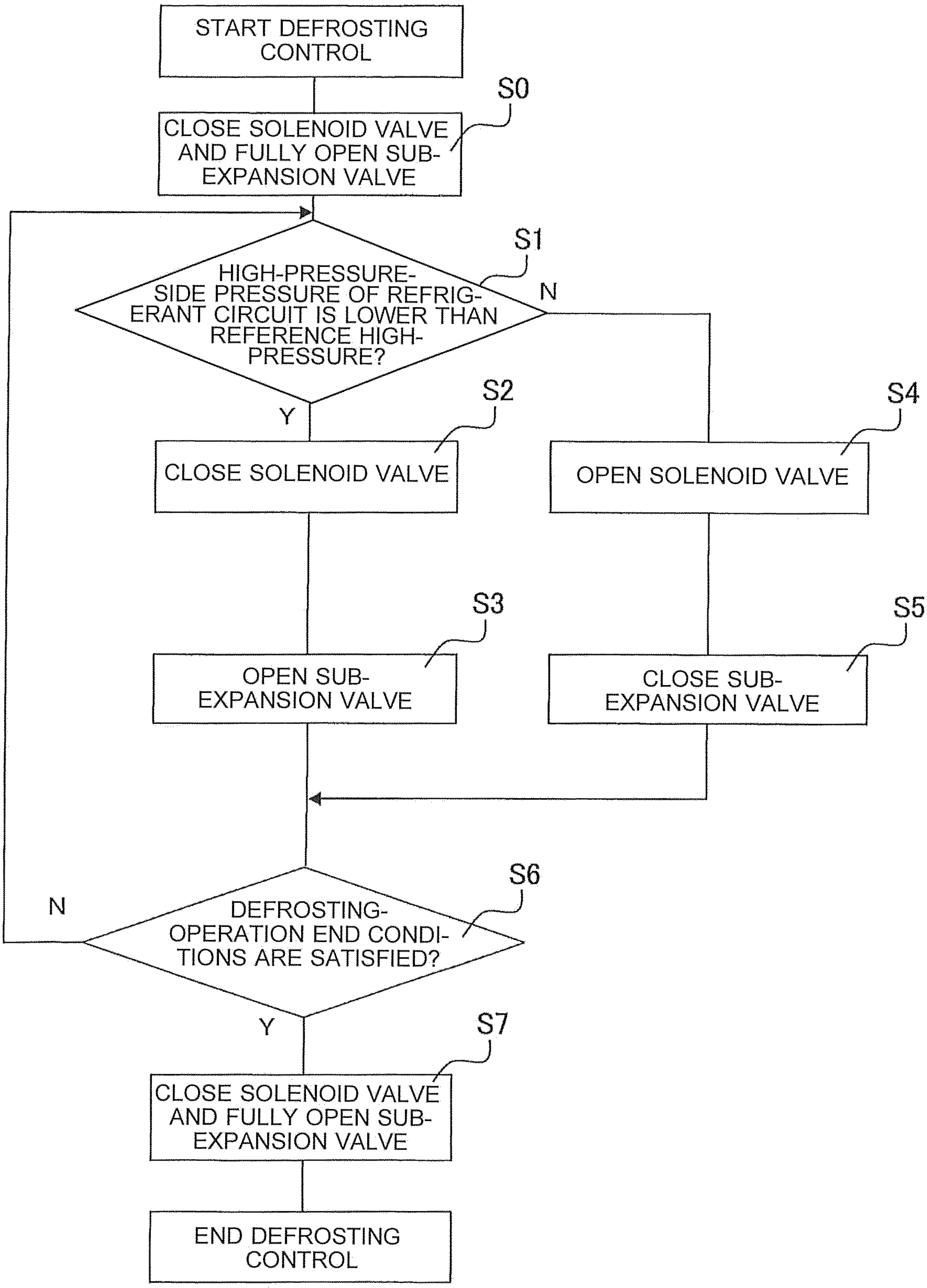

HIGH-PRESSURE-SIDE PRESSURE OF REFRIGERANT CIRCUIT
REDUCE REFRIGERANT AMOUNT IN CIRCUIT (CHARGE REFRIGERANT TO HIGH-PRESSURE RESERVOIR)
REFERENCE HIGH-PRESSURE
INCREASE REFRIGERANT AMOUNT IN CIRCUIT (DISCHARGE REFRIGERANT FROM HIGH-PRESSURE RESERVOIR)
ELAPSED TIME AFTER START OF DEFROSTING OPERATION

FIG. 5


START DEFROSTING CONTROL
S0
CLOSE SOLENOID VALVE AND FULLY OPEN SUB-EXPANSION VALVE
S1
HIGH-PRESSURE-SIDE PRESSURE OF REFRIG-ERANT CIRCUIT IS LOWER THAN REFERENCE HIGH-PRESSURE?
N
Y
S2
CLOSE SOLENOID VALVE
S4
OPEN SOLENOID VALVE
S3
OPEN SUB-EXPANSION VALVE
S5
CLOSE SUB-EXPANSION VALVE
S6
N
DEFROSTING-OPERATION END CONDI-TIONS ARE SATISFIED?
Y
S7
CLOSE SOLENOID VALVE AND FULLY OPEN SUB-EXPANSION VALVE
END DEFROSTING CONTROL

REFERENCES CITED IN THE DESCRIPTION

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- JP HEI752052 B **[0009]**
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