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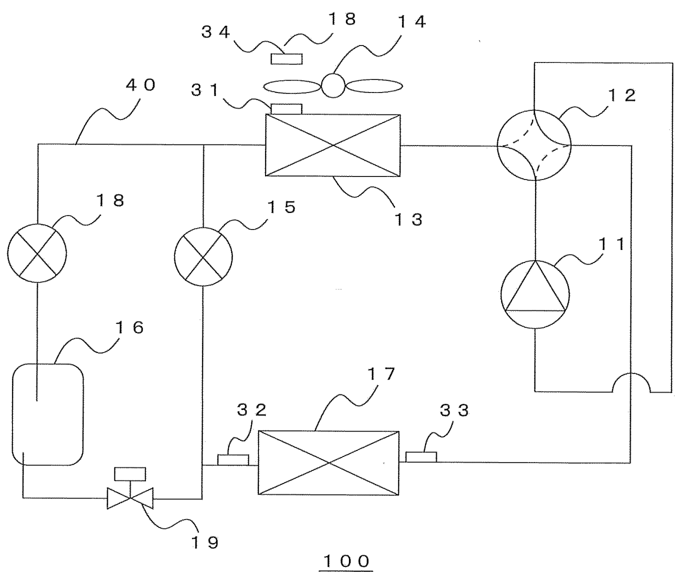
(54) REFRIGERATION CYCLE DEVICE

(57) Provided is a refrigeration cycle apparatus, including: a refrigerant circuit including a compressor, a flow switching device, a heat source-side heat exchanger, a first expansion device, and a use-side heat exchanger; and a liquid backflow suppression circuit connected in parallel to the first expansion device, the liquid backflow suppression circuit including a second expansion device, an on-off valve, and a high-pressure receiver connected between the second expansion device and the on-off valve.

FIG. 1



EP 3 252 397 A1

Description

Technical Field

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

Background Art

[0002] Hitherto, there have been known refrigeration cycle apparatus such as air-cooled heat pump chillers configured to cool and heat water to generate cold water and hot water. In the related-art refrigeration cycle apparatus, when hot water is generated under low outside air temperature, frost may be generated on an air heat exchanger on a heat source side, which functions as an evaporator. When frost is generated on the air heat exchanger, heat exchange between outside air and refrigerant is disturbed, and thus the heating capacity of the refrigeration cycle apparatus is reduced. In view of this, there has been known a defrosting operation that is performed to melt the frost on the air heat exchanger.

[0003] In Patent Literature 1, there is proposed a refrigeration cycle apparatus configured to perform the defrosting operation. In the refrigeration cycle apparatus of Patent Literature 1, when a defrosting operation condition is satisfied, a refrigerant flow passage is reversed to cause the air heat exchanger to function as a condenser, to thereby melt the frost on the air heat exchanger. Further, in the refrigeration cycle apparatus of Patent Literature 1, a bypass including a solenoid valve is connected in parallel to an expansion mechanism (expansion valve) provided between the air heat exchanger and a water heat exchanger. Then, the solenoid valve is opened when the defrosting operation is started to cause the refrigerant to flow to the water heat exchanger side. In this manner, reduction in low-pressure-side pressure due to insufficient supply of refrigerant is suppressed.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-7800

Summary of Invention

Technical Problem

[0005] When the refrigerant flow passage is reversed to perform the defrosting operation in the related-art refrigeration cycle apparatus including a high-pressure receiver configured to store surplus refrigerant, at the time of start of the defrosting operation, liquid refrigerant stored in the high-pressure receiver may pass through the water heat exchanger to flow into a compressor, to thereby cause liquid backflow. In order to suppress such liquid backflow to the compressor, it is conceivable to install an accumulator on a suction side of the compressor to store the liquid refrigerant in the accumulator. However, the accumulator has a large capacity and requires a large installation space in a machine chamber and this may result in increased size and cost of the apparatus.

[0006] The present invention has been made to solve the above-mentioned problems, and has an object to provide a refrigeration cycle apparatus capable of suppressing liquid backflow to a compressor at the time of a defrosting operation or other times. Solution to Problem

[0007] According to one embodiment of the present invention, there is provided a refrigeration cycle apparatus, including: a refrigerant circuit including a compressor, a flow switching device, a heat source-side heat exchanger, a first expansion device, and a use-side heat exchanger; and a liquid backflow suppression circuit connected in parallel to the first expansion device, the liquid backflow suppression circuit including a second expansion device, an on-off valve, and a high-pressure receiver connected between the second expansion device and the on-off valve. Advantageous Effects of Invention

[0008] According to the refrigeration cycle apparatus of one embodiment of the present invention, the liquid backflow to the compressor can be suppressed when the defrosting operation is started or ended, for example.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a diagram for illustrating a refrigerant circuit configuration of a refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a diagram for illustrating a control configuration of the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a flow chart for illustrating a flow of a defrosting operation in the refrigeration cycle apparatus according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a flow chart for illustrating a flow when the defrosting operation is ended in a refrigeration cycle apparatus according to Embodiment 2 of the present invention.

[Fig. 5] Fig. 5 is a diagram for illustrating a refrigerant circuit configuration of a related-art refrigeration cycle apparatus.

Description of Embodiments

[0010] Now, refrigeration cycle apparatus according to Embodiments of the present invention are described with reference to the drawings.

Embodiment 1

[0011] Fig. 1 is a diagram for illustrating a refrigerant circuit configuration of a refrigeration cycle apparatus 100 according to Embodiment 1 of the present invention. The refrigeration cycle apparatus 100 of Embodiment 1 is used as an air-cooled heat pump chiller configured to cool and heat water to generate cold water and hot water. As illustrated in Fig. 1, the refrigeration cycle apparatus 100 includes a refrigerant circuit including a compressor 11, a flow switching device 12, a heat source-side heat exchanger 13, a fan 14, a first expansion device 15, and a use-side heat exchanger 17. The refrigeration cycle apparatus 100 further includes a liquid backflow suppression circuit 40, which is connected in parallel to the first expansion device 15, and includes a second expansion device 18, a high-pressure receiver 16, and an on-off valve 19. The refrigeration cycle apparatus 100 further includes a controller 20 (Fig. 2) configured to control the refrigerant circuit and the liquid backflow suppression circuit 40.

[0012] The compressor 11 is, for example, a positive displacement compressor to be driven by a motor (not shown) that is controlled by an inverter. The flow switching device 12 is configured to switch the direction in which the refrigerant flows, and is formed of, for example, a four-way valve. The flow switching device 12 is configured to switch the flow passage of the refrigerant as indicated by the solid line of Fig. 1 at the time of a cooling operation, and is configured to switch the flow passage of the refrigerant as indicated by the broken line of Fig. 1 at the time of a heating operation.

[0013] The heat source-side heat exchanger 13 is an air heat exchanger configured to exchange heat with outdoor air, and is formed of, for example, a cross-fin fin-and-tube heat exchanger including heat transfer tubes and a large number of fins. The heat source-side heat exchanger 13 functions as a condenser of the refrigerant at the time of the cooling operation, and functions as an evaporator of the refrigerant at the time of the heating operation. The fan 14 is an air-sending device configured to supply air to the heat source-side heat exchanger 13, and is formed of, for example, a propeller fan to be driven by a fan motor (not shown). The fan 14 has a function of sucking outdoor air and discharging air subjected to heat exchange with the refrigerant by the heat source-side heat exchanger 13 to the outside of the room.

[0014] The first expansion device 15 has a function of decompressing and expanding the refrigerant, and is formed of, for example, an electronic expansion valve. The first expansion device 15 is connected in series between the heat source-side heat exchanger 13 and the use-side heat exchanger 17. The use-side heat exchanger 17 is a water heat exchanger configured to exchange heat with water on the use side, and is formed of, for example, a plate heat exchanger. The use-side heat exchanger 17 functions as the evaporator of the refrigerant at the time of the cooling operation, and functions as the condenser of the refrigerant at the time of the heating operation.

[0015] The high-pressure receiver 16 has a function of storing surplus refrigerant, and is connected in series between the second expansion device 18 and the on-off valve 19. The second expansion device 18 has a function of decompressing and expanding the refrigerant, and is formed of, for example, an electronic expansion valve. The second expansion device 18 is connected in series between the heat source-side heat exchanger 13 and the high-pressure receiver 16. The on-off valve 19 is formed of, for example, a solenoid valve, and is connected in series between the high-pressure receiver 16 and the use-side heat exchanger 17. The second expansion device 18, the high-pressure receiver 16, and the on-off valve 19 are connected in series to construct the liquid backflow suppression circuit 40, and are connected in parallel to the first expansion device 15.

[0016] Examples of the refrigerant usable in the refrigeration cycle apparatus 100 include single-component refrigerant, a near-azeotropic refrigerant mixture, and a zeotropic refrigerant mixture. Examples of the near-azeotropic refrigerant mixture include R410A and R404A, which are types of HFC refrigerant. The near-azeotropic refrigerant mixture has a characteristic similar to that of the zeotropic refrigerant mixture, and also a characteristic of having a working pressure of about 1.6 times as large as that of R22. Examples of the zeotropic refrigerant mixture include R407C, which is a type of hydrofluorocarbon (HFC) refrigerant. The zeotropic refrigerant mixture is a mixture of refrigerants having different boiling points, and thus has such a characteristic that the composition ratio differs between the liquid phase refrigerant and the gas phase refrigerant.

[0017] Further, the refrigeration cycle apparatus 100 includes various sensors. Specifically, the heat source-side heat exchanger 13 includes a heat exchanger temperature sensor 31 configured to detect the temperature of the heat source-side heat exchanger 13. The heat exchanger temperature sensor 31 is configured to detect the temperature of the frost adhering to the heat source-side heat exchanger 13, and is provided to, for example, the heat transfer tube of the heat source-side heat exchanger 13. Further, at an inlet and an outlet of the use-side heat exchanger 17, an inlet temperature sensor 32 and an outlet temperature sensor 33 each configured to detect the temperature of the refrigerant are provided. The controller 20 controls the first expansion device 15 and the second expansion device 18 based on the refrigerant temperature detected by the inlet temperature sensor 32 and the outlet temperature sensor 33. Further, in a part of the refrigeration cycle apparatus 100 that is arranged outdoors, an outside air temperature sensor 34 configured to detect the outside air temperature is provided. Although not shown in Fig. 1, the refrigeration cycle apparatus 100 may include a sensor configured to detect a suction pressure of the refrigerant, a sensor configured to detect a discharge temperature of the refrigerant, sensors configured to detect the temperature of the refrigerant at an inlet and an outlet of the heat source-side heat exchanger 13, and other sensors.

[0018] Fig. 2 is a diagram for illustrating a control configuration of the refrigeration cycle apparatus 100. The controller 20 is configured to control each unit of the refrigeration cycle apparatus 100, and is formed of, for example, a microcomputer or a digital signal processor (DSP). The controller 20 is configured to control a rotation frequency of the compressor 11, switching of the flow switching device 12, an air-sending amount of the fan 14, an opening degree of each of the first expansion device 15 and the second expansion device 18, and opening or closing of the on-off valve 19 based on the detection results obtained by the various sensors including the heat exchanger temperature sensor 31, the inlet temperature sensor 32, the outlet temperature sensor 33, and the outside air temperature sensor 34.

[0019] Next, the operation of the refrigeration cycle apparatus 100 is described. First, the operation at the time of the cooling operation in the refrigeration cycle apparatus 100 is described. At the time of the cooling operation, the flow switching device 12 switches the flow passage of the refrigerant as indicated by the solid line of Fig. 1. Further, the on-off valve 19 is fixed in an opened state, and the controller 20 controls the opening degrees of the first expansion device 15 and the second expansion device 18 based on a degree of superheat. Specifically, the controller 20 determines the opening degrees of the first expansion device 15 and the second expansion device 18 so that the degree of superheat (suction superheat degree of the compressor 11) obtained based on the temperature detected by the inlet temperature sensor 32 and the outlet temperature sensor 33 reaches a target value (for example, from 3 degrees C to 5 degrees C).

[0020] The high-temperature high-pressure gas refrigerant compressed and discharged by the compressor 11 passes through the flow switching device 12 to flow into the heat source-side heat exchanger 13. The high-temperature high-pressure refrigerant flowing into the heat source-side heat exchanger 13 rejects heat to, for example, outdoor air, and is thus condensed to transition to high-pressure liquid refrigerant. The high-pressure liquid refrigerant flowing out from the heat source-side heat exchanger 13 flows into the first expansion device 15 to be expanded and decompressed, to thereby transition to low-temperature low-pressure two-phase gas-liquid refrigerant. The two-phase gas-liquid refrigerant flowing out from the first expansion device 15 flows into the use-side heat exchanger 17. Further, at this time, the surplus refrigerant passes through the second expansion device 18 to be stored in the high-pressure receiver 16. The two-phase gas-liquid refrigerant flowing into the use-side heat exchanger 17 exchanges heat with water to be evaporated, to thereby transition to low-temperature low-pressure gas refrigerant. The gas refrigerant flowing out from the use-side heat exchanger 17 is sucked into the compressor 11 to be compressed again.

[0021] Next, the operation at the time of the heating operation is described. At the time of the heating operation, the flow switching device 12 switches the flow passage of the refrigerant as indicated by the broken line of Fig. 1. Further, the on-off valve 19 is fixed in an opened state, and the controller 20 controls the opening degrees of the first expansion device 15 and the second expansion device 18 based on a degree of subcooling. Specifically, the controller 20 determines the opening degrees of the first expansion device 15 and the second expansion device 18 so that the degree of subcooling at the outlet of the use-side heat exchanger 17, which is obtained based on the temperature detected by the inlet temperature sensor 32 and the outlet temperature sensor 33, reaches a target value (for example, from 3 degrees C to 5 degrees C).

[0022] The high-temperature high-pressure gas refrigerant compressed and discharged by the compressor 11 passes through the flow switching device 12 to flow into the use-side heat exchanger 17. The high-temperature high-pressure refrigerant flowing into the use-side heat exchanger 17 rejects heat to water, and is thus condensed to transition to high-pressure liquid refrigerant. The high-pressure liquid refrigerant flowing out from the use-side heat exchanger 17 flows into the first expansion device 15 to be expanded and decompressed, to thereby transition to low-temperature low-pressure two-phase gas-liquid refrigerant. The two-phase gas-liquid refrigerant flowing out from the first expansion device 15 flows into the heat source-side heat exchanger 13. Further, at this time, the surplus refrigerant is stored in the high-pressure receiver 16. The two-phase gas-liquid refrigerant flowing into the heat source-side heat exchanger 13 exchanges heat with outdoor air to be evaporated, to thereby transition to low-temperature low-pressure gas refrigerant. The gas refrigerant flowing out from the heat source-side heat exchanger 13 is sucked into the compressor 11 to be compressed again.

[0023] Further, when frost is generated on the heat source-side heat exchanger 13 at the time of the above-mentioned heating operation, the refrigeration cycle apparatus 100 performs the defrosting operation for melting the frost on the heat source-side heat exchanger 13. Specifically, when the controller 20 determines that a defrosting operation start condition for the heat source-side heat exchanger 13 is satisfied during the heating operation, the controller 20 performs the cooling operation of switching the flow switching device 12 to cause the heat source-side heat exchanger 13 to function as the condenser. Further, at this time, the controller 20 controls the second expansion device 18 and the on-off valve 19 so as to suppress occurrence of liquid backflow due to the liquid refrigerant stored in the high-pressure receiver 16 passing through the use-side heat exchanger 17 to flow into the compressor 11.

[0024] Fig. 3 is a flow chart for illustrating the flow of the defrosting operation in the refrigeration cycle apparatus 100 according to Embodiment 1. As illustrated in Fig. 3, first, the controller 20 determines whether or not the defrosting operation start condition is satisfied during the heating operation (S1). In this case, the controller 20 determines that frost is generated on the heat source-side heat exchanger 13 and the defrosting operation start condition is satisfied when the heat exchanger temperature, which is detected by the heat exchanger temperature sensor 31 provided to the heat source-side heat exchanger 13, or the outside air temperature, which is detected by the outside air temperature sensor 34, is lower than a predetermined temperature (for example, 0 degrees C). Then, when the defrosting operation start condition is satisfied (S1: YES), the second expansion device 18 is fully closed (S2), and the on-off valve 19 is also closed (S3). With this, the pressure in the high-pressure receiver 16 is maintained in a high-pressure state, and the liquid refrigerant is stored in the high-pressure receiver 16. Then, under this state, the flow switching device 12 is switched, and thus the defrosting operation is started (S4).

[0025] When the defrosting operation is started, the flow switching device 12 switches the flow passage of the refrigerant as indicated by the solid line of Fig. 1, and thus the heat source-side heat exchanger 13 functions as the condenser similarly to the case of the cooling operation. Then, the opening degree of the first expansion device 15 is controlled based on the suction superheat degree (S5). Next, it is determined whether or not the suction superheat degree of the compressor 11 is larger than a threshold value B (S6). In this case, the suction superheat degree of the compressor 11 is obtained as a difference between the outlet refrigerant temperature of the use-side heat exchanger 17, which is detected by the outlet temperature sensor 33, and the inlet refrigerant temperature of the use-side heat exchanger 17, which is detected by the inlet temperature sensor 32. Further, the threshold value B is a value for determining that a sufficient suction superheat degree is obtained for the compressor 11, and is set to, for example, 5 degrees C.

[0026] Then, when the suction superheat degree of the compressor 11 is larger than the threshold value B (S6: YES), the second expansion device 18 is opened (S7), and the on-off valve 19 is also opened (S8). After that, the opening degrees of the first expansion device 15 and the second expansion device 18 are controlled based on the suction superheat degree (S9), and the defrosting operation is continued. Then, it is determined whether or not a defrosting operation end condition is satisfied (S10). When the defrosting operation end condition is not satisfied (S10: NO), the defrosting operation is continued. In this case, the controller 20 determines that the frost on the heat source-side heat exchanger 13 is melted and the defrosting operation end condition is satisfied when the temperature detected by the heat exchanger temperature sensor 31 provided to the heat source-side heat exchanger 13 or the temperature detected by the outside air temperature sensor 34 is higher than a predetermined temperature (for example, 10 degrees C). On the other hand, when the defrosting operation end condition is satisfied (S10: YES), the flow switching device 12 is switched (S11). With this, the defrosting operation is ended, and the heating operation is restarted.

[0027] As described above, in Embodiment 1, the second expansion device 18 and the on-off valve 19 are closed after the defrosting operation start condition is satisfied (S1: YES) and before the defrosting operation (S4) is started. In this manner, the liquid backflow of the liquid refrigerant stored in the high-pressure receiver 16 to the compressor 11 can be suppressed. Further, when the suction superheat degree of the compressor 11 is equal to or larger than a threshold value (that is, when a state in which liquid backflow does not occur is achieved), the second expansion device 18 and the on-off valve 19 are opened to be normally controlled. Thus, the defrosting operation can be performed.

[0028] Fig. 5 is a diagram for illustrating a refrigerant circuit configuration of a related-art refrigeration cycle apparatus 200. As illustrated in Fig. 5, the related-art refrigeration cycle apparatus 200 includes a compressor 1, a four-way valve 2, an air heat exchanger 3, a fan 4, an expansion valve 5, a high-pressure receiver 6, and a water heat exchanger 7. The expansion valve 5 is connected in series between the air heat exchanger 3 and the water heat exchanger 7, and is configured to perform decompression and flow rate control of the refrigerant flowing through the refrigerant circuit. Further, the high-pressure receiver 6 is arranged between the expansion valve 5 and the water heat exchanger 7, and is configured to store surplus refrigerant. In the case of the related-art refrigeration cycle apparatus 200 illustrated in Fig. 5, when the refrigerant flow passage is reversed to perform the defrosting operation, at the time of start of the defrosting operation, the liquid refrigerant stored in the high-pressure receiver 6 passes through the water heat exchanger 7 to flow into the compressor 1, to thereby cause liquid backflow. In contrast, in Embodiment 1, the liquid backflow suppression circuit 40 is provided as described above, and the controller 20 controls the second expansion device 18 and the on-off valve 19, to thereby suppress the liquid backflow.

Embodiment 2

[0029] Subsequently, Embodiment 2 of the present invention is described. In Embodiment 1, the second expansion device 18 and the on-off valve 19 are controlled in order to suppress occurrence of the liquid backflow when the defrosting operation is started. Note that, the liquid refrigerant stored in the heat source-side heat exchanger 13 may return to the compressor 1 to cause liquid backflow not only when the defrosting operation is started, but also when the defrosting operation is ended. Embodiment 2 differs from Embodiment 1 in that, when the defrosting operation is ended, the second expansion device 18 and the on-off valve 19 are controlled to suppress occurrence of the liquid backflow. The refrigerant circuit configuration and the control configuration of the refrigeration cycle apparatus 100 of Embodiment 2 are similar to those of Embodiment 1 illustrated in Fig. 1 and Fig. 2.

[0030] Fig. 4 is a flow chart for illustrating the flow when the defrosting operation is ended in the refrigeration cycle apparatus 100 according to Embodiment 2. As illustrated in Fig. 4, it is determined whether or not the defrosting operation end condition is satisfied (S21). When the defrosting operation end condition is not satisfied (S21: NO), the defrosting operation is continued until the defrosting operation end condition is satisfied. On the other hand, when the defrosting operation end condition is satisfied (S21: YES), the on-off valve 19 is closed (S22), and the second expansion device 18 is fully opened (S23). With this, the pressure in the high-pressure receiver 16 is set to a high-pressure state. Then, under this state, the refrigeration cycle apparatus 100 waits until a predetermined time period elapses (S24). At this time, the rotation frequency of the compressor 11 is maintained, and thus the liquid refrigerant of the heat source-side heat exchanger 13 is stored in the high-pressure receiver 16. Then, after the predetermined time period has elapsed (S24: YES), the flow switching device 12 is switched, and thus the defrosting operation is ended (S25). After that, the on-off valve 19 is opened (S26), and the heating operation is restarted.

[0031] As described above, in Embodiment 2, the second expansion device 18 and the on-off valve 19 are opened when the condition for ending the defrosting operation is satisfied (S21: YES) and before the defrosting operation is ended (S25). Thus, the liquid refrigerant stored in the heat source-side heat exchanger 13 is stored in the high-pressure receiver 16. With this, when the defrosting operation is ended, the liquid backflow of the liquid refrigerant stored in the heat source-side heat exchanger 13 to the compressor 11 is suppressed.

[0032] Embodiments of the present invention have been described above, but the present invention is not limited to the configurations of Embodiments, and various modifications and combinations may be made thereto within the scope of the technical idea of the present invention. For example, in Embodiments, description is made of a case where, as illustrated in Fig. 1, the refrigeration cycle apparatus 100 includes one compressor 11, one heat source-side heat exchanger 13, and one use-side heat exchanger 17, but the number of those members is not particularly limited. For example, the refrigeration cycle apparatus 100 may include two or more compressors 11, two or more heat source-side heat exchangers 13, and two or more use-side heat exchangers 17. Further, in Embodiments, description is made of an example of a case where the refrigeration cycle apparatus 100 is an air-cooled heat pump chiller configured to cool and heat water to generate cold water and hot water, but the present invention is not limited thereto. The present invention may be applied to an air-conditioning apparatus to be used for cooling and heating indoor air.

[0033] Further, in the embodiments, the suction superheat degree and the degree of subcooling are controlled based on the refrigerant temperature detected by the inlet temperature sensor 32 and the outlet temperature sensor 33, but the present invention is not limited thereto. The suction superheat degree and the degree of subcooling may be controlled based on other temperature sensors or pressure sensors. Further, a discharge superheat degree and other matters may be controlled in addition to the suction superheat degree and the degree of subcooling. Further, the defrosting operation start condition and the defrosting operation end condition are also not limited to the conditions described in Embodiments, and other conditions may be used.

[0034] Further, only one of the controls for suppressing the liquid backflow described in Embodiment 1 and Embodiment 2 may be performed, or both of the controls may be performed when the defrosting operation is started and when the defrosting operation is ended. Further, with the liquid backflow suppression circuit 40 of the present invention, it is possible to suppress liquid backflow that may occur at the time of the next activation under a state in which the liquid refrigerant is stored in the heat source-side heat exchanger 13, for example, when the heating (air heating) operation is ended under low outside air temperature, other than the time of the defrosting operation. In this case, similarly to the case where the defrosting operation is ended in Embodiment 2, the second expansion device 18 and the on-off valve 19 are opened before the heating operation is ended so that the liquid refrigerant stored in the heat source-side heat exchanger 13 is stored in the high-pressure receiver 16. With this, at the time of the next activation, the liquid backflow of the liquid refrigerant stored in the heat source-side heat exchanger 13 to the compressor 11 is suppressed.

Reference Signs List

[0035] 1, 11 compressor2 four-way valve 3 air heat exchanger 4, 14 fan 5 expansion valve 6, 16 high-pressure receiver 7 water heat exchanger 12 flow switching device 13 heat source-side heat exchanger 14 fan 15 first expansion device 17 use-side heat exchanger 18 second expansion device 19 on-off valve 20 controller 31 heat exchanger temperature sensor 32 inlet temperature sensor 33 outlet temperature sensor 34 outside air temperature sensor 40 liquid backflow suppression circuit 100, 200 refrigeration cycle apparatus

Claims

1. A refrigeration cycle apparatus, comprising:

a refrigerant circuit including a compressor, a flow switching device, a heat source-side heat exchanger, a first expansion device, and a use-

side heat exchanger; and
a liquid backflow suppression circuit connected in parallel to the first expansion device,
the liquid backflow suppression circuit including a second expansion device, an on-off valve, and a high-pressure receiver connected between the second expansion device and the on-off valve.

2. The refrigeration cycle apparatus of claim 1, further comprising a controller configured to control the second expansion device and the on-off valve,
wherein, when a defrosting operation is started or when the defrosting operation is ended, the controller controls the second expansion device and the on-off valve.

3. The refrigeration cycle apparatus of claim 2, wherein, when a defrosting operation start condition is satisfied, the controller closes the second expansion device and the on-off valve, and then switches the flow switching device to start the defrosting operation.

4. The refrigeration cycle apparatus of claim 3, wherein, when a suction superheat degree of the compressor reaches a value that is larger than a predetermined value after the defrosting operation is started, the controller is configured to open the second expansion device and the on-off valve.

5. The refrigeration cycle apparatus of any one of claims 2 to 4, wherein, when a defrosting operation end condition is satisfied, the controller is configured to open the second expansion device and the on-off valve, and then switch the flow switching device to end the defrosting operation.

FIG. 1

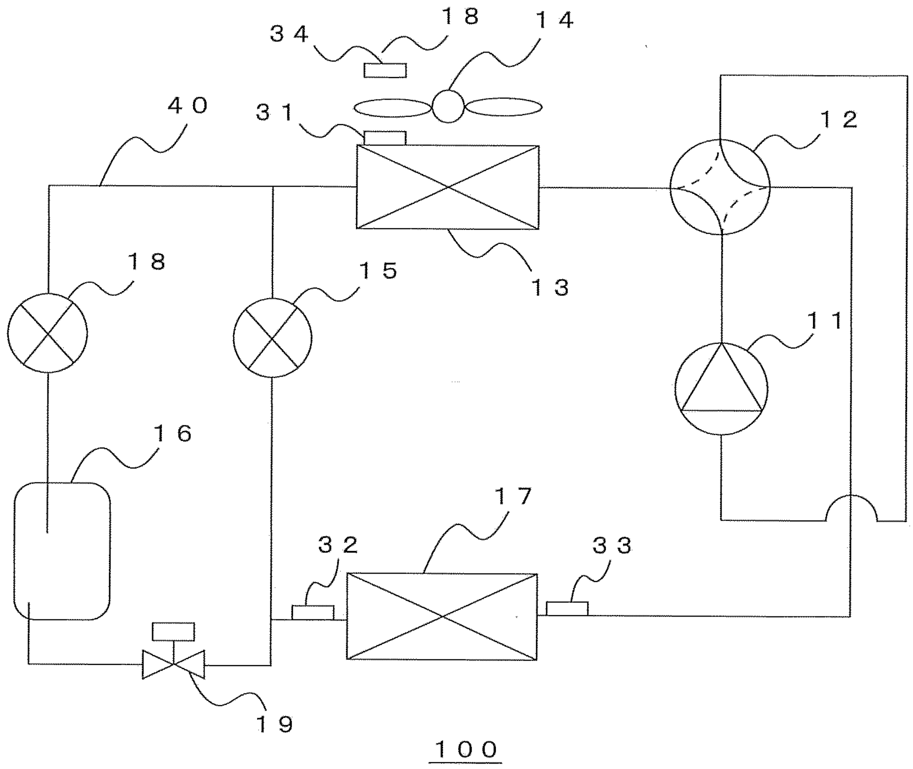

34
18
14
40
31
12
18
15
13
11
16
17
32
33
19
100

FIG. 2

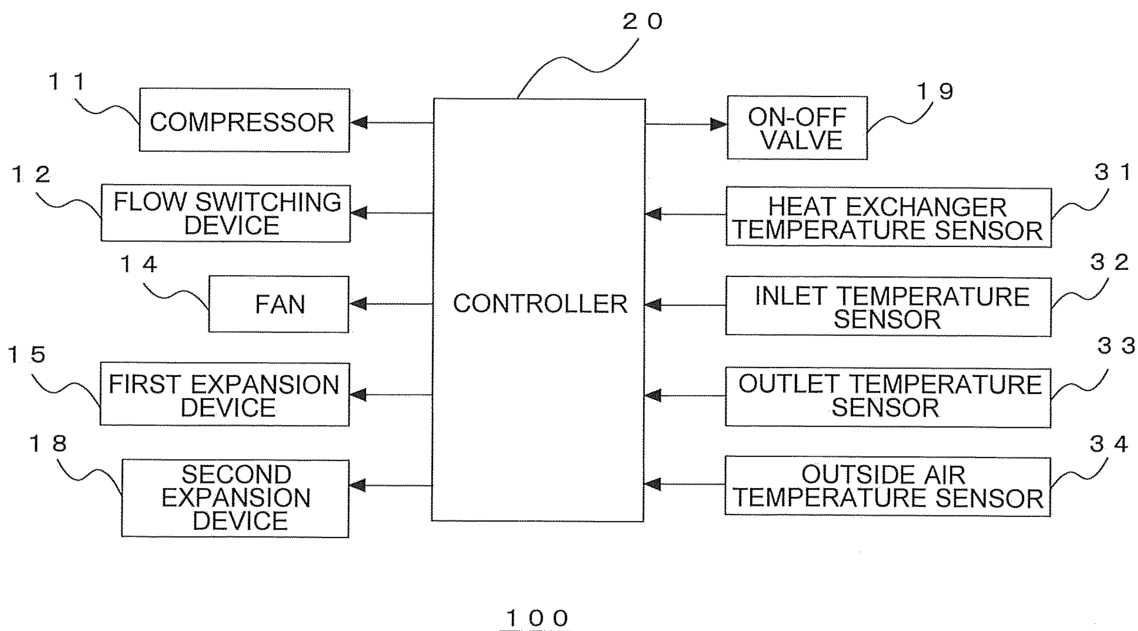

20
11
COMPRESSOR
ON-OFF VALVE
19
12
FLOW SWITCHING DEVICE
HEAT EXCHANGER TEMPERATURE SENSOR
31
14
FAN
CONTROLLER
INLET TEMPERATURE SENSOR
32
15
FIRST EXPANSION DEVICE
OUTLET TEMPERATURE SENSOR
33
18
SECOND EXPANSION DEVICE
OUTSIDE AIR TEMPERATURE SENSOR
34
100

FIG. 3

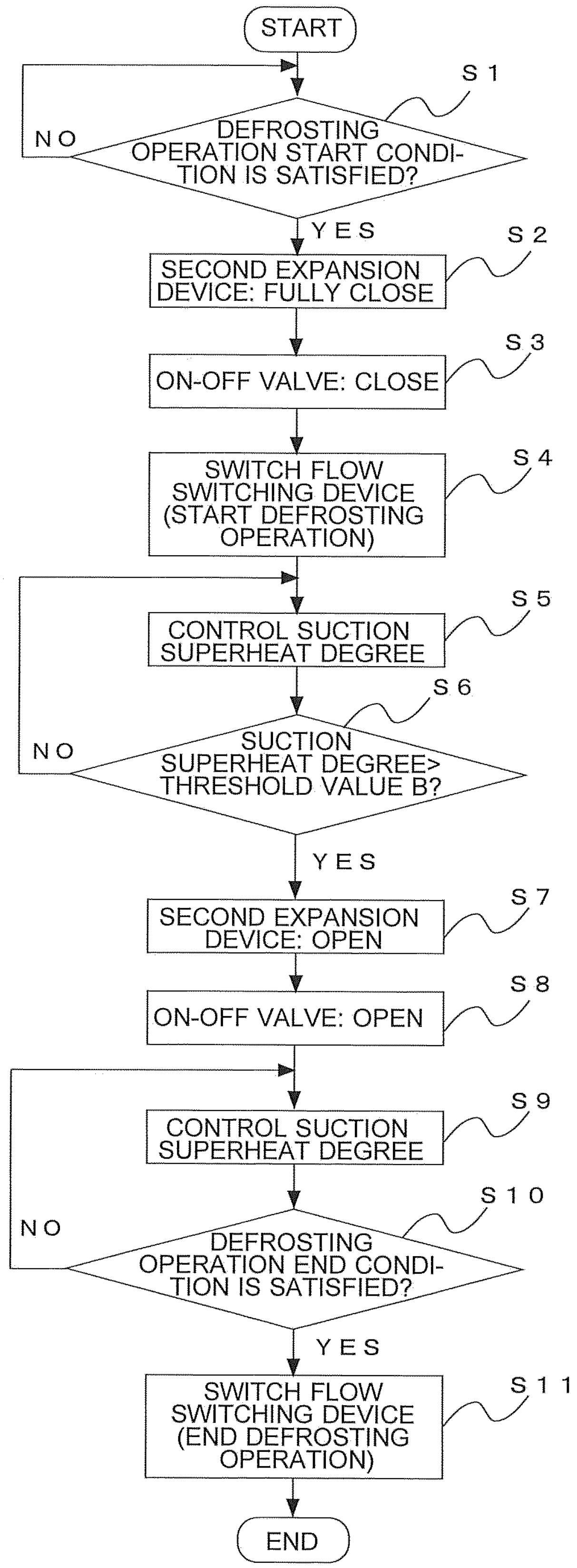

START
S1
DEFROSTING OPERATION START CONDITION IS SATISFIED?
NO
YES
S2
SECOND EXPANSION DEVICE: FULLY CLOSE
S3
ON-OFF VALVE: CLOSE
S4
SWITCH FLOW SWITCHING DEVICE (START DEFROSTING OPERATION)
S5
CONTROL SUCTION SUPERHEAT DEGREE
S6
SUCTION SUPERHEAT DEGREE> THRESHOLD VALUE B?
NO
YES
S7
SECOND EXPANSION DEVICE: OPEN
S8
ON-OFF VALVE: OPEN
S9
CONTROL SUCTION SUPERHEAT DEGREE
S10
DEFROSTING OPERATION END CONDITION IS SATISFIED?
NO
YES
S11
SWITCH FLOW SWITCHING DEVICE (END DEFROSTING OPERATION)
END

FIG. 4

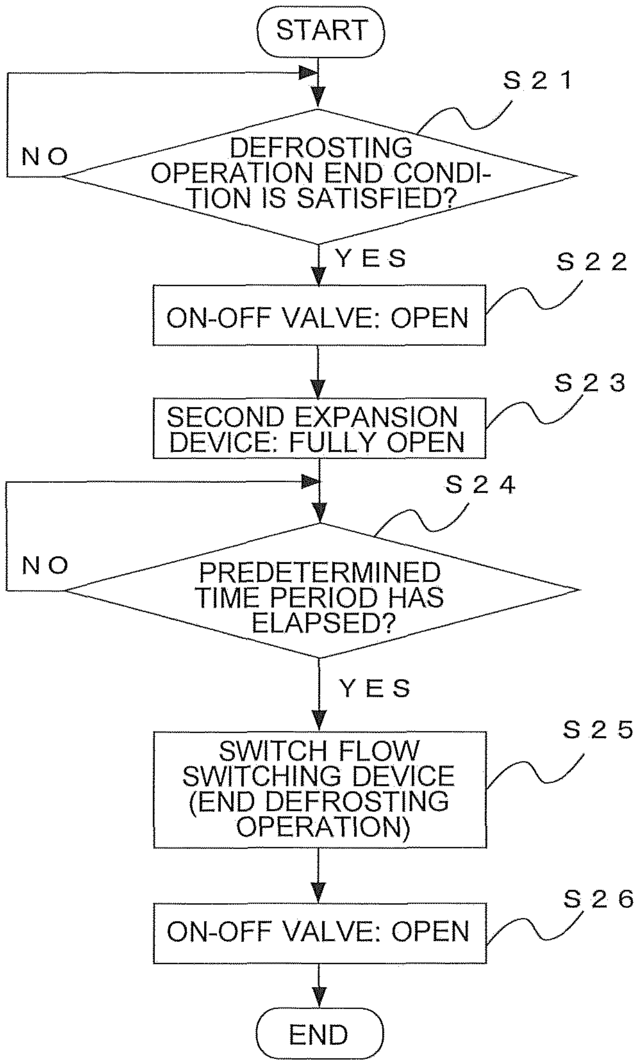
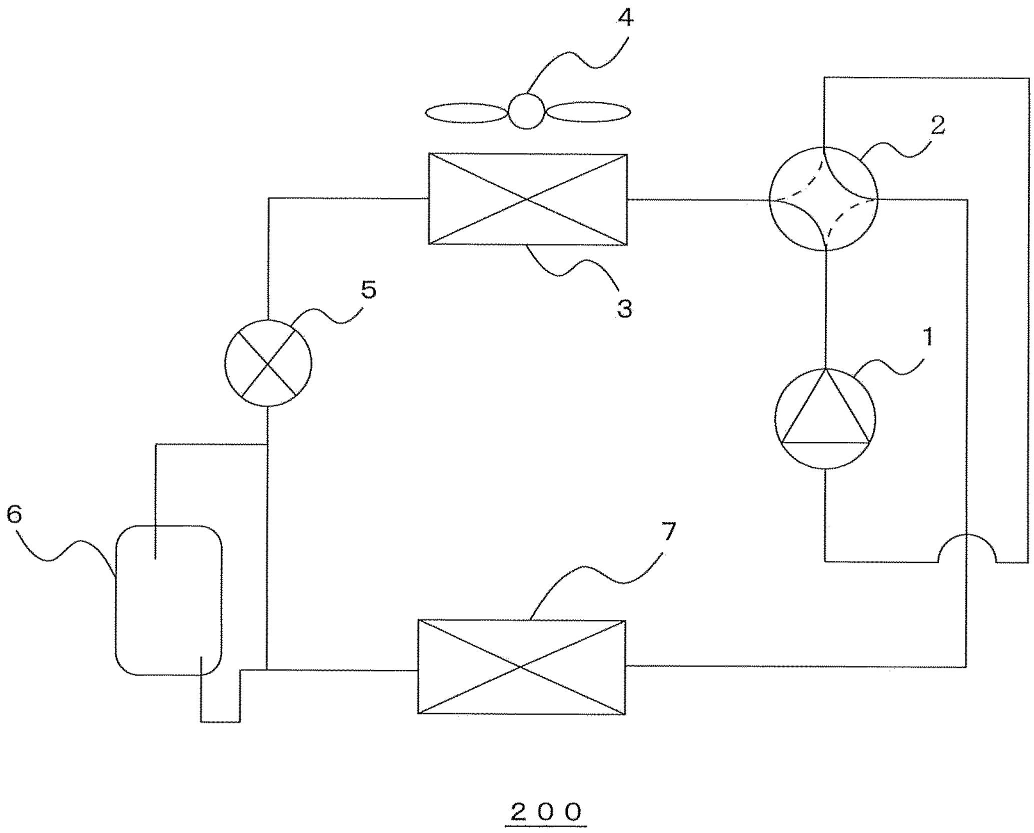

START
S21
NO
DEFROSTING OPERATION END CONDITION IS SATISFIED?
YES
S22
ON-OFF VALVE: OPEN
S23
SECOND EXPANSION DEVICE: FULLY OPEN
S24
NO
PREDETERMINED TIME PERIOD HAS ELAPSED?
YES
S25
SWITCH FLOW SWITCHING DEVICE (END DEFROSTING OPERATION)
S26
ON-OFF VALVE: OPEN
END

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/052577

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F25B43/00*(2006.01)i, *F25B47/02*(2006.01)i

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)
F25B1/00, F25B43/00, F25B47/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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.
Y	JP 2014-119145 A (Sharp Corp.), 30 June 2014 (30.06.2014), paragraphs [0018] to [0054]; fig. 2, 3 (Family: none)	1-3,5
Y	JP 5-332644 A (Daikin Industries, Ltd.), 14 December 1993 (14.12.1993), paragraph [0028]; fig. 1, 7 & US 5524449 A & WO 1993/024795 A1 & EP 643275 A1 & CN 1082698 A	1-3
Y	WO 2011/010473 A1 (Mitsubishi Electric Corp.), 27 January 2011 (27.01.2011), paragraph [0040]; fig. 11, 14 & US 2012/0111042 A1 & WO 2011/010473 A1 & EP 2458305 A1 & CN 102472540 A	1-2,5

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 April 2015 (24.04.15)	12 May 2015 (12.05.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/052577

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-119152 A (Sharp Corp.), 30 June 2014 (30.06.2014), fig. 1 (Family: none)	1-5
A	JP 2012-7800 A (Mitsubishi Heavy Industries, Ltd.), 12 January 2012 (12.01.2012), fig. 1 & EP 2420767 A2	1-5
A	US 2006/0107671 A1 (HOSHIZAKI DENKI KABUSHIKI KAISHA), 25 May 2006 (25.05.2006), fig. 1, 2 (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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