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(54) REFRIGERATION CYCLE DEVICE

(57) A refrigeration cycle device includes a compressor, an air heat exchanger, a utilization heat exchanger, a first refrigerant passage connecting the utilization heat exchanger to a discharge passage, a second refrigerant passage connecting the air heat exchanger to a suction passage, a receiver to store therein liquid refrigerant, a first expansion valve, a second expansion valve, a third refrigerant passage connecting the utilization heat exchanger to the first expansion valve, a fourth refrigerant passage connecting the first expansion valve to the receiver, a fifth refrigerant passage connecting the receiver to the second expansion valve, a sixth refrigerant passage connecting the second expansion valve to the air heat exchanger, a hot-gas bypass passage connecting the discharge passage to the sixth refrigerant passage, a hot-gas bypass valve, an internal heat exchanger to exchange heat between the liquid refrigerant inside the receiver and the refrigerant passing through the suction passage, or between refrigerant passing through the fourth refrigerant passage and refrigerant passing through the suction passage, a liquid bypass passage including an inlet portion connected to the fourth refrigerant passage, the fifth refrigerant passage, or a lower portion of the receiver, and an outlet portion connected to the suction passage upstream of the internal heat exchanger, and a liquid bypass valve.

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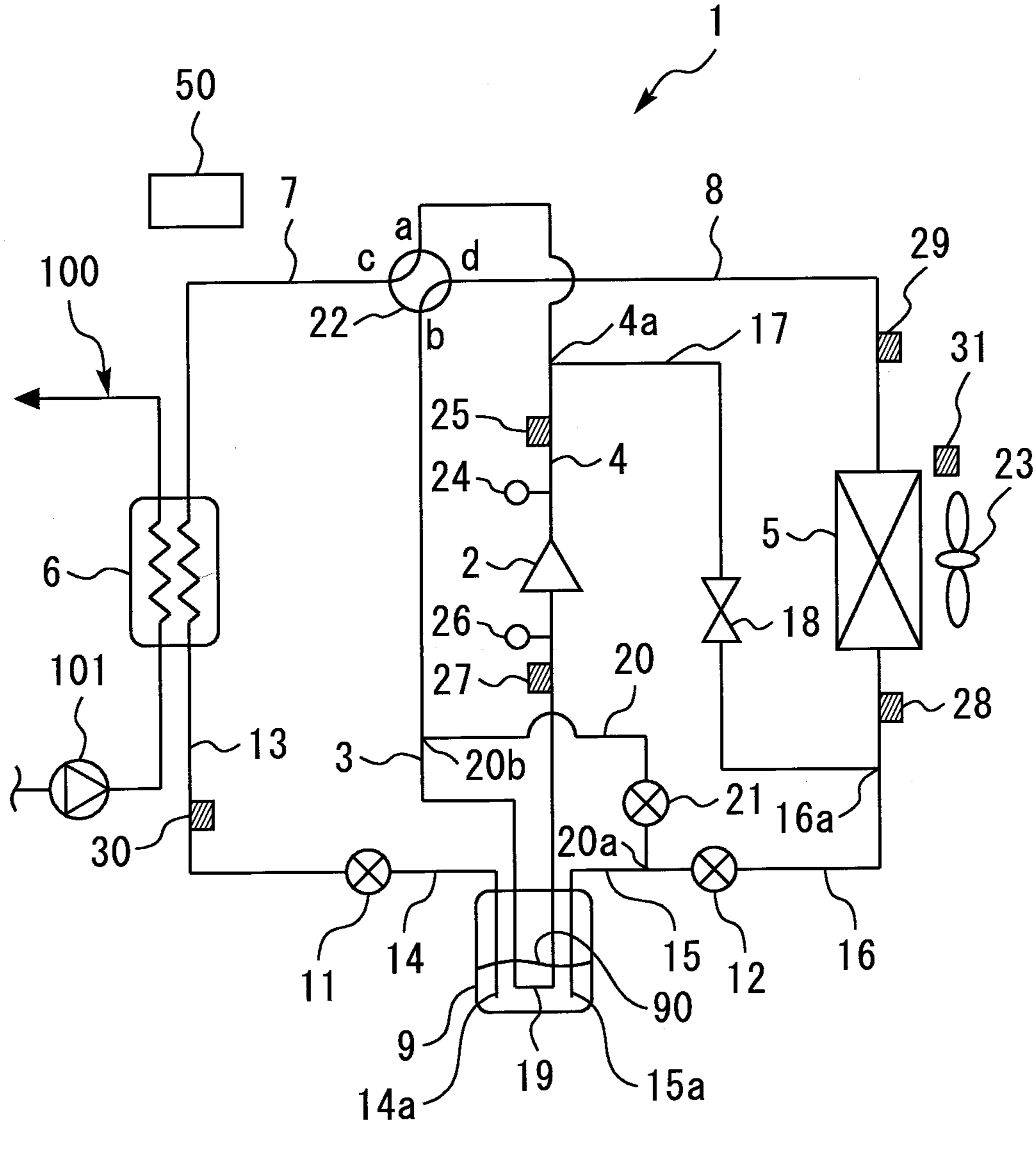
FIG. 1


1
50
7
8
a
c
d
29
100
22
b
4a
17
31
25
4
23
24
5
6
2
18
26
101
27
20
28
13
3
20b
21
16a
30
20a
11
14
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12
16
9
90
19
14a
15a

Description

Field

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

Background

[0002] Patent Literature 1 described below discloses a refrigeration device for container. The refrigeration device includes a condenser positioned outside a refrigerator, an evaporator positioned inside the refrigerator, a hot-gas bypass path connecting a discharge pipe of a compressor and an inlet of the evaporator, a three-way proportional valve provided at a branch point thereof, and an injection bypass path connecting a liquid line and a suction line via an injection solenoid valve. During a defrost operation, this refrigeration device causes a discharge gas refrigerant to flow into the evaporator through the three-way proportional valve and the hot-gas bypass path, and opens the injection solenoid valve to replenish refrigerant from the liquid line to the suction line.

Citation List

Patent Literature

[0003] [PTL 1] JP H6-347143A

Summary

Technical Problem

[0004] Since in the aforementioned conventional refrigeration device, liquid refrigerant flows into the suction line from the liquid line during a defrost operation, there is a likelihood that the liquid refrigerant is sucked into the compressor.

[0005] The present disclosure is made to solve the problem as described above and has an object to provide a refrigeration cycle device that is advantageous in reliably preventing liquid refrigerant from being sucked into a compressor.

Solution to Problem

[0006] A refrigeration cycle device according to the present disclosure includes: a compressor to compress refrigerant; a suction passage connecting to a suction port of the compressor; a discharge passage connecting to a discharge port of the compressor; an air heat exchanger to exchange heat between the refrigerant and air; a utilization heat exchanger to exchange heat between the refrigerant and a heat medium; a first refrigerant passage connecting the utilization heat exchanger to the discharge passage; a second refrigerant passage connecting the air heat exchanger to the suction passage; a receiver to store therein liquid refrigerant that is the refrigerant in liquid phase; a first expansion valve; a second expansion valve; a third refrigerant passage connecting the utilization heat exchanger to the first expansion valve; a fourth refrigerant passage connecting the first expansion valve to the receiver; a fifth refrigerant passage connecting the receiver to the second expansion valve; a sixth refrigerant passage connecting the second expansion valve to the air heat exchanger; a hot-gas bypass passage connecting the discharge passage to the sixth refrigerant passage; a hot-gas bypass valve provided on the hot-gas bypass passage; an internal heat exchanger to exchange heat between the liquid refrigerant inside the receiver and the refrigerant passing through the suction passage, or between the refrigerant passing through the fourth refrigerant passage and the refrigerant passing through the suction passage; a liquid bypass passage including an inlet portion connected to the fourth refrigerant passage, the fifth refrigerant passage, or a lower portion of the receiver, and an outlet portion connected to the suction passage upstream of the internal heat exchanger; and a liquid bypass valve provided on the liquid bypass passage.

Advantageous Effect of Invention

[0007] According to the present disclosure, it becomes possible to provide the refrigeration cycle device that is advantageous in reliably preventing the liquid refrigerant from being sucked into the compressor.

Brief Description of Drawings

[0008]

Fig. 1 is a diagram showing a refrigeration cycle device according to embodiment 1.
Fig. 2 is a diagram showing a flow of refrigerant during a heating operation of the refrigeration cycle device according to embodiment 1.
Fig. 3 is a diagram showing a flow of the refrigerant at a time of a hot-gas defrost operation of the refrigeration cycle device according to embodiment 1.
Fig. 4 is one example of a functional block diagram of the refrigeration cycle device according to embodiment 1.
Fig. 5 is a flowchart showing an example of a process at a time of executing the hot-gas defrost operation.
Fig. 6 is a timing chart showing an operation example of each of actuators from the heating operation until the operation transitions to the hot-gas defrost operation and returns to the heating operation.
Fig. 7 is a diagram showing a refrigeration cycle device according to embodiment 2.
Fig. 8 is one example of a functional block diagram of the refrigeration cycle device according to embodiment 2.
Fig. 9 is a diagram showing a flow of the refrigerant

at a time of a heating operation of the refrigeration cycle device according to embodiment 2.

Fig. 10 is a diagram showing a flow of the refrigerant at a time of a hot-gas defrost operation of the refrigeration cycle device according to embodiment 2.

Fig. 11 is a flowchart showing an example of a process at a time of executing the hot-gas defrost operation according to embodiment 2.

Fig. 12 is a timing chart showing an operation example of each of actuators from the heating operation according to embodiment 2 until the operation transitions to the hot-gas defrost operation and returns to the heating operation.

Description of Embodiments

[0009] Hereinafter, embodiments are described with reference to the drawings. Common or corresponding elements in each of the drawings are assigned with the same reference signs, and explanation thereof is simplified or omitted.

Embodiment 1

[0010] Fig. 1 is a diagram showing a refrigeration cycle device 1 according to embodiment 1. As shown in Fig. 1, the refrigeration cycle device 1 of the present embodiment includes a compressor 2 configured to compress refrigerant. A substance used as the refrigerant is not particularly limited, and may be any one of CO_2, HFC, and HFO, for example. Further, the refrigeration cycle device 1 may use flammable refrigerant. Flammable refrigerant has an advantage of having a small impact on global warming. As the flammable refrigerant, there are cited hydrocarbon refrigerants such as R290 (propane) and R600a (isobutane), for example.

[0011] A suction passage 3 connects to a suction port of the compressor 2. A discharge passage 4 connects to a discharge port of the compressor 2. An air heat exchanger 5 is positioned outdoor. Hereinafter, outdoor air is referred to as "outside air". The air heat exchanger 5 exchanges heat between the refrigerant and outside air. The air heat exchanger 5 has a refrigerant flow path. The air heat exchanger 5 has a structure in which air can pass. When a blower 23 works in the illustrated example, outside air flows through the air heat exchanger 5.

[0012] A utilization heat exchanger 6 exchanges heat between the refrigerant and a heat medium. The heat medium is a medium for conveying heat to a heat demand section (not illustrated) that is equipment or a place that uses heat. The heat medium in the present embodiment is a liquid. The liquid heat medium may be, for example, water, or may be brine, other than water. The utilization heat exchanger 6 in the present embodiment has a refrigerant flow path and a heat medium flow path. In the illustrated example, the heat medium flow path of the utilization heat exchanger 6 is connected to the heat demand section via a heat medium circuit 100. The heat medium circuit 100 has a heat medium pump 101. When the heat medium circulates in the heat medium circuit 100 by an operation of the heat medium pump 101, the heat medium that passes through the utilization heat exchanger 6 is supplied to the heat demand section. The heat medium that passes through the heat demand section returns to the utilization heat exchanger 6. The heat medium circuit 100 may include a valve not illustrated for controlling a flow rate or a circulation route of the heat medium.

[0013] The heat demand section may include indoor heating equipment for heating a room. The indoor heating equipment may include at least one of a floor heating panel that is installed under a floor of a room, a radiator, a panel heater, and a fan convector that are installed in the room, for example. The heat demand section may include a heat storage tank. The heat storage tank may be a hot water storage tank that stores hot water. The heat medium heated by the utilization heat exchanger 6 may be stored in the heat storage tank, or hot water heated by exchanging heat with the heat medium heated by the utilization heat exchanger 6 may be stored in the hot water storage tank. The heat demand section may include indoor cooling equipment for cooling a room. The indoor cooling equipment may include a fan coil, for example. The heat demand section may be used in both the indoor heating equipment and the indoor cooling equipment.

[0014] Note that the heat medium in the present embodiment is not limited to the liquid but may be gas. For example, the heat medium may be indoor air that is air inside the room. In this case, a blower (not illustrated) that generates an air flow may be included so that the indoor air that passes through the utilization heat exchanger 6 is blown into the room.

[0015] A first refrigerant passage 7 connects one end of the refrigerant flow path of the utilization heat exchanger 6 to the discharge passage 4. A second refrigerant passage 8 connects one end of the refrigerant flow path of the air heat exchanger 5 to the suction passage 3.

[0016] In the present disclosure, refrigerant in a liquid phase state is referred to as a "liquid refrigerant", and refrigerant in a gaseous phase state is referred to as a "gas refrigerant". A receiver 9 is provided to store liquid refrigerant. Inside the receiver 9, a liquid level 90 of the liquid refrigerant is formed. An inner space of the receiver 9 above the liquid level 90 is filled with a gas refrigerant.

[0017] The refrigeration cycle device 1 further includes a first expansion valve 11 and a second expansion valve 12. The first expansion valve 11 and the second expansion valve 12 each have a first port and a second port. A third refrigerant passage 13 connects the other end of the refrigerant flow path of the utilization heat exchanger 6 to the first port of the first expansion valve 11. A fourth refrigerant passage 14 connects the second port of the first expansion valve 11 to the receiver 9. A fifth refrigerant passage 15 connects the receiver 9 to the first port of the second expansion valve 12. A sixth refrigerant passage 16 connects the second port of the second expansion valve 12 to the other end of the refrigerant flow path of the air heat exchanger 5.

[0018] In the illustrated example, a tip end opening 14a of the fourth refrigerant passage 14 is located in a lower portion in the receiver 9 and is located under the liquid level 90. A tip end opening 15a of the fifth refrigerant passage 15 is located in the lower portion in the receiver 9 and is under the liquid level 90.

[0019] A hot-gas bypass passage 17 connects the discharge passage 4 to the sixth refrigerant passage 16. One end of the hot-gas bypass passage 17 is connected to a branch portion 4a provided on the discharge passage 4. The other end of the hot-gas bypass passage 17 is connected to a branch portion 16a provided on the sixth refrigerant passage 16. A hot-gas bypass valve 18 is provided on the hot-gas bypass passage 17.

[0020] An internal heat exchanger 19 in the present embodiment exchanges heat between the liquid refrigerant inside the receiver 9 and the refrigerant passing through the suction passage 3. The internal heat exchanger 19 is provided inside the receiver 9. The internal heat exchanger 19 is located under the liquid level 90 of the liquid refrigerant. The refrigerant passing through the suction passage 3 is heated by the liquid refrigerant inside the receiver 9 when passing through the internal heat exchanger 19.

[0021] A liquid bypass passage 20 has an inlet portion 20a connected to the fifth refrigerant passage 15, and an outlet portion 20b connected to the suction passage 3 upstream of the internal heat exchanger 19. The inlet portion 20a is connected to a branch portion provided on the fifth refrigerant passage 15. The outlet portion 20b is connected to a branch portion provided on the suction passage 3. A liquid bypass valve 21 is provided on the liquid bypass passage 20.

[0022] The refrigeration cycle device 1 can perform a heating operation. The heating operation is an operation that heats the heat medium by causing the refrigerant discharged from the compressor 2 to flow into the utilization heat exchanger 6. For example, in a system in which the heat demand section includes the indoor heating equipment, an indoor-heating can be performed by supplying the heat medium heated by the utilization heat exchanger 6 by a heating operation to the indoor heating equipment. Alternatively, in a system in which the heat demand section includes a heat storage tank such as a hot water storage tank, a heat accumulating operation that accumulates the heat medium or hot water heated by the heating operation into the heat storage tank can be performed.

[0023] Fig. 2 is a diagram showing a flow of the refrigerant during the heating operation of the refrigeration cycle device 1 according to embodiment 1. As shown in Fig. 2, the flow of the refrigerant during the heating operation is as follows. The hot-gas bypass valve 18 and the liquid bypass valve 21 are closed, and the refrigerant does not flow into the hot-gas bypass passage 17 and the liquid bypass passage 20. A high-temperature and high-pressure refrigerant discharged from the compressor 2 flows into the utilization heat exchanger 6 through the discharge passage 4 and the first refrigerant passage 7. The high-pressure refrigerant cooled by the heat medium in the utilization heat exchanger 6 flows into the first expansion valve 11 through the third refrigerant passage 13. The high-pressure refrigerant is decompressed and expanded by the first expansion valve 11 to become a medium-pressure refrigerant. The medium-pressure refrigerant flows into the receiver 9 from the first expansion valve 11 through the fourth refrigerant passage 14. The low-pressure refrigerant flowing through the suction passage 3 to pass through the internal heat exchanger 19 cools the liquid refrigerant in the receiver 9. The medium-pressure liquid refrigerant in the receiver 9 flows into the second expansion valve 12 through the fifth refrigerant passage 15. The medium-pressure liquid refrigerant is decompressed and expanded by the second expansion valve 12 to become a gas-liquid two-phase low-temperature and low-pressure refrigerant. The low-temperature and low-pressure refrigerant flows into the air heat exchanger 5 through the sixth refrigerant passage 16. The low-temperature and low-pressure refrigerant evaporates by absorbing heat of outside air in the air heat exchanger 5. The low-pressure refrigerant flows into the suction passage 3 through the second refrigerant passage 8 from the air heat exchanger 5. The low-pressure refrigerant flowing in the suction passage 3 is heated by the medium-pressure refrigerant inside the receiver 9 when passing through the internal heat exchanger 19 on the way, and thereafter sucked by the compressor 2.

[0024] If the heating operation is performed under a condition that the temperature of the outside air is low, moisture contained in the outside air may become frost and adhere to the air heat exchanger 5. The refrigeration cycle device 1 can execute a hot-gas defrost operation for removing the frost adhering to the air heat exchanger 5. Fig. 3 is a diagram showing a flow of the refrigerant at a time of a hot-gas defrost operation of the refrigeration cycle device 1 according to embodiment 1. At the time of the hot-gas defrost operation, the hot-gas bypass valve 18 is opened, the second expansion valve 12 is closed, the first expansion valve 11 is continuously or intermittently opened, and the liquid bypass valve 21 is continuously or intermittently opened.

[0025] As shown in Fig. 3, the flow of the refrigerant at the time of the hot-gas defrost operation is as follows. Most of the high-temperature and high-pressure refrigerant discharged to the discharge passage 4 from the compressor 2 passes through the branch portion 4a, the hot-gas bypass passage 17, the hot-gas bypass valve 18, the branch portion 16a, and the sixth refrigerant passage 16, and flows into the air heat exchanger 5. Frost is melted and removed by the heat of the refrigerant, that is, hot gas flowing into the air heat exchanger 5. The refrigerant passing through the air heat exchanger 5 is sucked by the compressor 2 after passing through the second refrigerant passage 8, the suction passage 3, and the internal heat exchanger 19. The rest of the high-temperature and high-pressure refrigerant discharged to the discharge passage 4 from the compressor 2 flows into the utilization heat exchanger 6 through the first refrigerant passage 7. The refrigerant flowing into the utilization heat exchanger 6 is cooled by the heat medium and condenses. The condensed liquid refrigerant stays inside the utilization heat exchanger 6. The liquid refrigerant inside the utilization heat exchanger 6 passes through the third refrigerant passage 13 and the first expansion valve 11 and flows into the receiver 9. The liquid refrigerant inside the receiver 9 flows to the fifth refrigerant passage 15 from the tip end opening 15a. The liquid refrigerant passes through the inlet portion 20a, the liquid bypass passage 20, and the outlet portion 20b, and joins the refrigerant flowing through the suction passage 3.

[0026] If the liquid refrigerant accumulates inside the utilization heat exchanger 6 at the time of the hot-gas defrost operation, the flow rate of the refrigerant circulating from the compressor 2 to the air heat exchanger 5 will become insufficient, as a result of which, a defrosting ability will be reduced. In contrast to this, the present embodiment provides the following effect at the time of the hot-gas defrost operation. The liquid refrigerant accumulated inside the utilization heat exchanger 6 can be supplied to the suction passage 3 through the first expansion valve 11 and the liquid bypass passage 20. Therefore, shortage of the flow rate of the refrigerant circulating from the compressor 2 to the air heat exchanger 5 can be reliably prevented, so that a high defrosting ability can be maintained. The liquid refrigerant flowing into the suction passage 3 from the outlet portion 20b of the liquid bypass passage 20 is heated by the internal heat exchanger 19 and evaporated. Therefore, the liquid refrigerant can be reliably prevented from being sucked by the compressor 2. Therefore, according to the present embodiment, there is provided an advantage that an accumulator for preventing the liquid refrigerant from being sucked by the compressor 2 does not have to be provided on a suction side of the compressor 2. Accordingly, as illustrated, an accumulator is not provided on the suction passage 3. In other words, the refrigerant passing through the internal heat exchanger 19 is sucked by the compressor 2 without passing through an accumulator.

[0027] The refrigeration cycle device 1 may further include controlling circuitry 50 configured to execute the heating operation and the hot-gas defrost operation. By adding the controlling circuitry 50, there is provided an advantage that the operation of the heating operation and the operation of the hot-gas defrost operation can be automated. At the time of the heating operation, the controlling circuitry 50 closes the hot-gas bypass valve 18 and the liquid bypass valve 21. At the time of the hot-gas defrost operation, the controlling circuitry 50 opens the hot-gas bypass valve 18 and closes the second expansion valve 12. Further, at the time of the hot-gas defrost operation, the controlling circuitry 50 continuously or intermittently opens the liquid bypass valve 21. The controlling circuitry 50 may perform control so that an opening degree of the first expansion valve 11 at the time of the hot-gas defrost operation becomes smaller than an opening degree of the first expansion valve 11 at the time of the heating operation. During execution of the hot-gas defrost operation, the controlling circuitry 50 may keep the first expansion valve 11 open or may control the first expansion valve 11 so that it repeatedly opens and closes. During execution of the hot-gas defrost operation, the controlling circuitry 50 may keep the liquid bypass valve 21 open, or may control the liquid bypass valve 21 so that it repeatedly opens and closes.

[0028] The refrigeration cycle device 1 may further include a refrigerant circuit switching valve 22 that switches between a forward cycle circuit and a reverse cycle circuit. The forward cycle circuit shown in Fig. 2 is a circuit in which the refrigerant discharged from the compressor 2 flows into the utilization heat exchanger 6 through the first refrigerant passage 7. Though not illustrated, the reverse cycle circuit is a circuit in which the refrigerant discharged from the compressor 2 flows into the air heat exchanger 5 through the second refrigerant passage 8. By adding the refrigerant circuit switching valve 22, it becomes possible to perform a cooling operation using the reverse cycle circuit. A cooling operation is an operation that cools the heat medium in the utilization heat exchanger 6. For example, in the system in which the heat demand section includes the indoor cooling equipment, an indoor-cooling can be performed by supplying the heat medium cooled by the cooling operation to the indoor cooling equipment from the utilization heat exchanger 6.

[0029] In the illustrated example, the refrigerant circuit switching valve 22 includes an a-port, a b-port, a c-port and a d-port. The a-port of the refrigerant circuit switching valve 22 is connected to the discharge port of the compressor 2 by the discharge passage 4. The b-port of the refrigerant circuit switching valve 22 is connected to the suction port of the compressor 2 by the suction passage 3. The c-port of the refrigerant circuit switching valve 22 is connected to the utilization heat exchanger 6 by the first refrigerant passage 7. The d-port of the refrigerant circuit switching valve 22 is connected to the air heat exchanger 5 by the second refrigerant passage 8.

[0030] The refrigerant circuit switching valve 22 switches the refrigerant flow path by moving a valve body, for example. At the time of the heating operation in Fig. 2, the refrigerant circuit switching valve 22 causes the a-port to communicate with the c-port, and causes the b-port to communicate with the d-port, whereby the forward cycle circuit is formed. Thereby, the discharge passage 4 is connected to the first refrigerant passage 7, and the suction passage 3 is connected to the second refrigerant passage 8. A state of the refrigerant circuit switching valve 22 at the time of the hot-gas defrost operation in Fig. 3 is also the same as described above.

[0031] At a time of the cooling operation, the refrigerant circuit switching valve 22 causes the a-port to communicate with the d-port, and causes the b-port to communicate with the c-port, whereby the reverse cycle circuit is formed. Thereby, the discharge passage 4 is connected to the second refrigerant passage 8, and the suction passage 3 is connected to the first refrigerant passage 7. A flow of the refrigerant at the time of an operation by the reverse cycle circuit is as follows. The high-temperature and high-pressure refrigerant discharged from the compressor 2 flows into the air heat exchanger 5 through the discharge passage 4 and the second refrigerant passage 8. The high-pressure refrigerant is cooled by outside air in the air heat exchanger 5. The cooled high-pressure refrigerant flows into the second expansion valve 12 through the sixth refrigerant passage 16 from the air heat exchanger 5. The high-pressure refrigerant is decompressed and expanded by the second expansion valve 12 and becomes a medium-pressure refrigerant. The medium-pressure refrigerant flows into the receiver 9 through the fifth refrigerant passage 15 from the second expansion valve 12. The medium-pressure liquid refrigerant flows into the first expansion valve 11 through the fourth refrigerant passage 14 from the receiver 9. The medium-pressure liquid refrigerant is decompressed and expanded by the first expansion valve 11 and becomes a gas-liquid two-phase low-pressure refrigerant. The low-pressure refrigerant flows into the utilization heat exchanger 6 through the third refrigerant passage 13. The low-pressure refrigerant evaporates in the utilization heat exchanger 6, and thereby the heat medium is cooled. The low-pressure refrigerant passing through the utilization heat exchanger 6 flows into the suction passage 3 from the first refrigerant passage 7. The low-pressure refrigerant flowing through the suction passage 3 is heated by the medium-pressure refrigerant in the receiver 9 when passing through the internal heat exchanger 19 on the way, and thereafter is sucked by the compressor 2. The liquid refrigerant in the receiver 9 is cooled by the low-pressure refrigerant flowing through the suction passage 3 and passing through the internal heat exchanger 19.

[0032] The refrigeration cycle device 1 of the present disclosure may not include the refrigerant circuit switching valve 22 and may not be able to execute the reverse cycle operation. When the refrigerant circuit switching valve 22 is not included, the discharge passage 4 can be configured to directly connect to the first refrigerant passage 7 and the suction passage 3 can be configured to directly connect to the second refrigerant passage 8.

[0033] As shown in Fig. 1, the refrigeration cycle device 1 may further include at least one of a discharge pressure sensor 24, a discharge temperature sensor 25, a suction pressure sensor 26, a suction temperature sensor 27, a first temperature sensor 28, a second temperature sensor 29, a third temperature sensor 30, and an outside air temperature sensor 31. The discharge pressure sensor 24 installed on the discharge passage 4 detects a compressor discharge pressure that is a pressure of the refrigerant discharged from the compressor 2. The discharge temperature sensor 25 installed on the discharge passage 4 detects a compressor discharge temperature that is a temperature of the refrigerant discharged from the compressor 2. The suction pressure sensor 26 installed on the suction passage 3 detects a compressor suction pressure that is a pressure of the refrigerant to be sucked by the compressor 2. The suction temperature sensor 27 installed on the suction passage 3 downstream of the internal heat exchanger 19 detects a compressor suction temperature that is a temperature of the refrigerant to be sucked by the compressor 2. The first temperature sensor 28 installed on the sixth refrigerant passage 16 between the branch portion 16a and the air heat exchanger 5 detects a temperature of the refrigerant between the air heat exchanger 5 and the second expansion valve 12. The second temperature sensor 29 installed on the second refrigerant passage 8 detects a temperature of the refrigerant between the refrigerant circuit switching valve 22 and the air heat exchanger 5. The third temperature sensor 30 installed on the fourth refrigerant passage 14 detects a temperature of the liquid refrigerant between the utilization heat exchanger 6 and the first expansion valve 11. The outside air temperature sensor 31 detects a temperature of outside air before flowing into the air heat exchanger 5.

[0034] Fig. 4 is one example of a functional block diagram of the refrigeration cycle device 1 according to embodiment 1. As shown in Fig. 4, each of the compressor 2, the first expansion valve 11, the second expansion valve 12, the hot-gas bypass valve 18, the liquid bypass valve 21, the refrigerant circuit switching valve 22, the blower 23, the discharge pressure sensor 24, the discharge temperature sensor 25, the suction pressure sensor 26, the suction temperature sensor 27, the first temperature sensor 28, the second temperature sensor 29, the third temperature sensor 30, and the outside air temperature sensor 31 may be electrically connected to the controlling circuitry 50. Each of functions of the controlling circuitry 50 may be realized by processing circuitry. The processing circuitry of the controlling circuitry 50 may include at least one processor 51 and at least one memory 52. At least the one processor 51 may realize each of the functions of the controlling circuitry 50 by reading and executing a program stored in at least the one memory 52. The processing circuitry of the controlling circuitry 50 may include at least one dedicated piece of hardware. The controlling circuitry 50 may perform control so that a rotation speed of the compressor 2 becomes variable by inverter control, for example. The controlling circuitry 50 may perform control so that a rotation speed of the blower 23 becomes variable by the inverter control, for example.

[0035] The hot-gas bypass valve 18 is preferably configured by a solenoid valve that is switchable only between opening (full open) and closing (full close), and has a small pressure loss, for example.

[0036] The liquid bypass valve 21 preferably has a function as an expansion valve capable of adjusting a flow rate by adjusting an opening degree thereof, for example.

[0037] An operation of the heat medium pump 101 of the heat medium circuit 100 may be controlled by a controller except for the controlling circuitry 50. For example, a controller included by an air-conditioning device or a hot-water supply device that uses a heat medium may control the operation of the heat medium pump 101.

[0038] In the present embodiment, the refrigeration cycle device 1 may be configured to execute the hot-gas defrost operation without stopping the flow of the heat medium in the utilization heat exchanger 6. According to the present embodiment, it is not necessary to stop the heat medium pump 101 when executing the hot-gas defrost operation, so that a control operation becomes simple. When the heat medium continues to flow into the utilization heat exchanger 6 during the hot-gas defrost operation, the high-temperature and high-pressure refrigerant from the compressor 2 is cooled and condensed by the heat medium, and therefore, liquid refrigerant is easily generated in the utilization heat exchanger 6. According to the present embodiment, the liquid refrigerant in the utilization heat exchanger 6 can be supplied to the suction passage 3 through the first expansion valve 11 and the liquid bypass passage 20. Therefore, the liquid refrigerant can be prevented from accumulating in the utilization heat exchanger 6, so that shortage of the flow rate of the refrigerant circulating from the compressor 2 to the air heat exchanger 5 can be reliably prevented, and a high defrosting ability can be maintained.

[0039] A heating power [W] is an amount of heat that is given to the heat medium in the utilization heat exchanger 6 per unit time at the time of the heating operation. At the time of the heating operation, the controlling circuitry 50 may adjust the rotation speed of the compressor 2 so as to obtain a predetermined heating power corresponding to a load on the heat medium circuit 100.

[0040] A superheat degree of the refrigerant to be sucked by the compressor 2 is referred to as a "suction superheat degree" below. A superheat degree of the refrigerant discharged from the compressor 2 is referred to as a "discharge superheat degree" below. A saturation temperature corresponding to a compressor suction pressure is referred to as a "suction saturation temperature" below. A saturation temperature corresponding to a compressor discharge pressure is referred to as a "discharge saturation temperature" below. The controlling circuitry 50 can calculate the suction saturation temperature by using a detected pressure of the suction pressure sensor 26. The controlling circuitry 50 can calculate the discharge saturation temperature by using a detected pressure of the discharge pressure sensor 24. The controlling circuitry 50 can calculate the suction superheat degree from a difference between a detected temperature of the suction temperature sensor 27 and the suction saturation temperature. In the present embodiment, the suction pressure sensor 26 and the suction temperature sensor 27 correspond to detectors that detect the suction superheat degree. The controlling circuitry 50 can calculate the discharge superheat degree from a difference between the detected temperature of the discharge temperature sensor 25 and the discharge saturation temperature. In the present embodiment, the discharge pressure sensor 24 and the discharge temperature sensor 25 correspond detectors that detect the discharge superheat degree.

[0041] At the time of the heating operation, the controlling circuitry 50 may control an opening degree of the first expansion valve 11 so that a supercooling degree of the refrigerant flowing out from the utilization heat exchanger 6 becomes close to a target. The controlling circuitry 50 may calculate the supercooling degree from a difference between the discharge saturation temperature and a detected temperature of the third temperature sensor 30. For example, when the controlling circuitry 50 increases the opening degree of the first expansion valve 11, a flow rate of the refrigerant passing through the utilization heat exchanger 6 increases, and the supercooling degree decreases.

[0042] At the time of the heating operation, the controlling circuitry 50 may control an opening degree of the second expansion valve 12 so that the suction superheat degree or the discharge superheat degree becomes close to a target. The controlling circuitry 50 may control the second expansion valve 12 by using either the suction superheat degree or the discharge superheat degree.

[0043] In the following explanation, a temperature of the refrigerant flowing out from the air heat exchanger 5 is referred to as a "refrigerant outlet temperature of the air heat exchanger 5", and a temperature of the refrigerant flowing into the air heat exchanger 5 is referred to as a "refrigerant inlet temperature of the air heat exchanger 5". At the time of the heating operation, the controlling circuitry 50 may control the opening degree of the second expansion valve 12 so that an evaporation superheat degree becomes close to a target. The evaporation superheat degree corresponds to a difference between the refrigerant outlet temperature of the air heat exchanger 5 detected by the second temperature sensor 29 and the refrigerant inlet temperature of the air heat exchanger 5 detected by the first temperature sensor 28.

[0044] When the controlling circuitry 50 increases the opening degree of the second expansion valve 12 at the time of the heating operation, the flow rate of the refrigerant passing through the air heat exchanger 5 increases, and each of the suction superheat degree, discharge superheat degree and evaporation superheat degree decreases. At the time of the heating operation, the controlling circuitry 50 may operate the blower 23 at a predetermined rotation speed.

[0045] Fig. 5 is a flowchart showing an example of a process at a time of executing the hot-gas defrost operation. Fig. 6 is a timing chart showing an operation example of each of actuators from the heating operation until the operation transitions to the hot-gas defrost operation and returns to the heating operation. Hereinafter, the examples shown in Fig. 5 and Fig. 6 are described.

[0046] When a surface temperature of the air heat exchanger 5 goes down to below freezing due to a low outside air temperature during execution of the heating operation, frost is formed on the surface of the air heat exchanger 5, and as a result, heat transfer performance of the air heat exchanger 5 is deteriorated. As the amount of frost formation increases, the evaporation temperature with respect to the outside air temperature is lowered. The evaporation temperature mentioned here refers to a saturation temperature of the refrigerant that evaporates in a pipe of the air heat exchanger 5. When a difference between the outside air temperature and the temperature of the liquid refrigerant in the air heat exchanger 5 becomes larger than a reference value, the controlling circuitry 50 may perform control to transition from the heating operation to the hot-gas defrost operation. The reference value may be approximately 10 K, for example.

[0047] When transitioning from the heating operation to the hot-gas defrost operation, the controlling circuitry 50 first controls the operation so that the rotation speed of the compressor 2 becomes equal to a minimum rotation speed Fcmin, as step S101 in Fig. 5. Next, the controlling circuitry 50 stops the blower 23, as step S102. Next, the controlling circuitry 50 opens the hot-gas bypass valve 18, as step S103. Next, the controlling circuitry 50 controls the operation so that an opening degree of the liquid bypass valve 21 becomes slight opening (P3-1), as step S104. The slight opening (P3-1) preferably corresponds to a minimum opening degree at which the refrigerant flows through the liquid bypass valve 21. Next, the controlling circuitry 50 controls the operation so that the opening degree of the first expansion valve 11 becomes slight opening (P1-2), as step S105. The slight opening (P1-2) preferably corresponds to a minimum opening degree at which the refrigerant flows through the first expansion valve 11. Next, the controlling circuitry 50 controls the operation so that the opening degree of the second expansion valve 12 becomes fully closed, as step S106. This prevents the refrigerant from flowing into the second expansion valve 12. The process from step S101 to step S106 described above corresponds to a defrost preparation process in Fig. 6.

[0048] After step S106, the controlling circuitry 50 controls the operation so that the rotation speed of the compressor 2 becomes equal to a target rotation speed Fc2, as step S107. The target rotation speed Fc2 may be a fixed value. The controlling circuitry 50 may adjust a value of the target rotation speed Fc2 so that the compressor discharge pressure becomes constant, for example. Next, the controlling circuitry 50 controls the operation so that the opening degree of the liquid bypass valve 21 becomes equal to a target opening degree (P3-2), as step S108. At this time, the controlling circuitry 50 may adjust a value of the target opening degree (P3-2) so that the suction superheat degree or the discharge superheat degree becomes close to a target. By a process of step S107 and step S108 described above, the hot-gas defrost operation starts.

[0049] Since the opening degree of the first expansion valve 11 is the slight opening (P1-2) at the time of the hot-gas defrost operation, only a small amount of the high-temperature and high-pressure refrigerant discharged to the discharge passage 4 from the compressor 2 flows into the utilization heat exchanger 6, and most of the refrigerant flows into the hot-gas bypass passage 17. The high-temperature and high-pressure refrigerant flowing into the hot-gas bypass passage 17 is decompressed to be the low-pressure gas refrigerant when passing through the hot-gas bypass valve 18, and thereafter flows into the air heat exchanger 5. Since the second expansion valve 12 is fully closed at this time, the low-pressure gas refrigerant flows into a pipe that forms the refrigerant flow path of the air heat exchanger 5, and exchanges heat with frost adhering to a surface of fins joined to the pipe. The frost receives heat of the refrigerant and melts. The refrigerant is cooled by the frost. The refrigerant leaving the air heat exchanger 5 passes through the second refrigerant passage 8 and the refrigerant circuit switching valve 22, and flows into the suction passage 3. The refrigerant flowing into the suction passage 3 joins the refrigerant from the liquid bypass passage 20. The joining refrigerant is heated by exchanging heat with the refrigerant in the receiver 9 in the internal heat exchanger 19, and thereafter is sucked by the compressor 2 again. In this way, a hot-gas defrost circuit that circulates the refrigerant to the compressor 2, the hot-gas bypass valve 18, the air heat exchanger 5, the refrigerant circuit switching valve 22 and the internal heat exchanger 19 in this order is formed.

[0050] Since the opening degree of the first expansion valve 11 is the slight opening (P1-2) at the time of the hot-gas defrost operation, a small amount of high-pressure refrigerant flows into the utilization heat exchanger 6 through the first refrigerant passage 7 from the discharge passage 4. Heat is exchanged between the heat medium continuing to flow into the utilization heat exchanger 6 and the high-pressure refrigerant, and thereby the high-pressure refrigerant is cooled and liquefied. The liquefied refrigerant passes through the first expansion valve 11 and flows into the receiver 9. Since the liquid bypass valve 21 opens, the liquid refrigerant from the receiver 9 passes through the liquid bypass passage 20 and flows into the suction passage 3.

[0051] During execution of the hot-gas defrost operation, the controlling circuitry 50 determines whether the refrigerant outlet temperature of the air heat exchanger 5 detected by the second temperature sensor 29 is higher than the reference temperature, as step S109. The reference temperature is a temperature for determining an end of the hot-gas defrost operation, and may be 0°C at which frost melts, or a temperature higher than 0°C. When the refrigerant outlet temperature of the air heat exchanger 5 is the reference temperature or less, it can be determined that frost cannot be removed yet, and therefore the controlling circuitry 50 returns to a process in step S107 and continues the hot-gas defrost operation. In contrast to this, when the refrigerant outlet temperature of the air heat exchanger 5 is higher than the reference temperature, it can be determined that frost has been removed. In this case, the controlling circuitry 50 proceeds to a process in step S110 to end the hot-gas defrost operation and restart the heating operation.

[0052] As step S110, the controlling circuitry 50 controls the operation so that the rotation speed of the compressor 2 becomes equal to the minimum rotation speed Fcmin. Next, as step S111, the controlling circuitry 50 controls the operation so that the opening degree of the first expansion valve 11 becomes an initial opening degree (P1-3) of the heating operation. Next, as step S112, the controlling circuitry 50 controls the operation so that the opening degree of the second expansion valve 12 becomes an initial opening degree (P2-3) of the heating operation. Next, the controlling circuitry 50 closes the hot-gas bypass valve 18, as step S113. Next, the controlling circuitry 50 fully closes the liquid bypass valve 21, as step S114. A process from step S110 to step S114 described above corresponds to a return process in Fig. 6. The heating operation restarts by the return process. After the restart of the heating operation, the controlling circuitry 50 operates the blower 23 at a predetermined rotation speed again and controls the operation of each of the compressor 2, the first expansion valve 11, and the second expansion valve 12 as in the explanation of the heating operation described above.

[0053] The refrigeration cycle device 1 of the present embodiment may be configured to be able to further execute a reverse cycle defrost operation. The reverse cycle defrost operation is an operation that removes frost from the air heat exchanger 5 by circulating the refrigerant into the reverse cycle circuit similarly to the aforementioned cooling operation. In the reverse cycle defrost operation, the air heat exchanger 5 is used as a condenser, and the utilization heat exchanger 6 is used as an evaporator.

[0054] When the reverse cycle defrost operation is executed in the system using a heat medium that can freeze like water, for example, the heat medium in the utilization heat exchanger 6 is cooled by heat of evaporation of the refrigerant to a temperature below the freezing point and may freeze. If the heat medium in the utilization heat exchanger 6 is frozen and expands in volume, there arises a likelihood that the utilization heat exchanger 6 is broken. If the utilization heat exchanger 6 is broken, there is a likelihood that a wall that partitions the heat medium flow path and a refrigerant flow path is broken to leak the refrigerant into the heat medium circuit 100, or leak the refrigerant into the atmosphere. In order to reliably prevent such an event from occurring, a temperature sensor (not illustrated) that detects the temperature of the heat medium may be provided, and the controlling circuitry 50 may be configured to execute the hot-gas defrost operation when the temperature of the heat medium is lower as compared with a reference, and execute the reverse cycle defrost operation when the temperature of the heat medium is higher as compared with the reference, when melting the frost adhering to the air heat exchanger 5. Thereby, the hot-gas defrost operation is executed when the heat medium in the utilization heat exchanger 6 is likely to freeze, and the reverse cycle defrost operation is executed when the heat medium in the utilization heat exchanger 6 is unlikely to freeze, so that both can be more properly used.

[0055] In the refrigeration cycle device 1 using flammable refrigerant, it is particularly important to reliably prevent leakage of the refrigerant into the heat medium circuit 100 or leakage of the refrigerant into the atmosphere. According to the present embodiment, the hot-gas defrost operation is executable, and therefore, the heat medium in the utilization heat exchanger 6 can be reliably prevented from freezing. Therefore, leakage of the refrigerant into the heat medium circuit 100 or leakage of the refrigerant into the atmosphere can be reliably prevented, so that it is suitable to use of flammable refrigerant.

[0056] The opening degree of the first expansion valve 11 at the time of the hot-gas defrost operation can be an opening degree at which the liquid refrigerant staying in the utilization heat exchanger 6 can be moved to the receiver 9 side through the fourth refrigerant passage 14. In the present embodiment, the opening degree of the first expansion valve 11 at the time of the hot-gas defrost operation is smaller than the opening degree of the first expansion valve 11 at the time of the heating operation. This can reliably prevent the flow rate of the refrigerant from the compressor 2 to the utilization heat exchanger 6 from becoming larger than necessary at the time of the hot-gas defrost operation. Therefore, reduction in the flow rate of the refrigerant in the hot-gas bypass circuit can be reliably prevented, so that a high defrost ability is obtained.

[0057] The following problem will arise if the amount of the refrigerant in the hot-gas defrost circuit becomes insufficient as a result that the condensed liquid refrigerant accumulates in the utilization heat exchanger 6 during the hot-gas defrost operation. A density of the refrigerant to be sucked by the compressor 2 is reduced, and the flow rate of the refrigerant is reduced. Further, since the discharge pressure of the compressor is reduced and the discharge temperature is lowered, the defrost ability is reduced. As a result, a time required for defrosting becomes longer. In contrast to this, according to the present embodiment, the refrigerant can be supplied to the hot-gas defrost circuit from the receiver 9 through the liquid bypass valve 21, so that the amount of the refrigerant in the hot-gas defrost circuit can reliably prevented from becoming insufficient.

[0058] It is assumed that the refrigerant is supplied to the hot-gas defrost circuit from the receiver 9 by opening the second expansion valve 12 and causing the liquid refrigerant to flow into the air heat exchanger 5 through the sixth refrigerant passage 16 from the receiver 9 during the hot-gas defrost operation. In this case, the gas refrigerant from the hot-gas bypass passage 17 and the liquid refrigerant from the receiver 9 mix, and thereby, the temperature of the refrigerant flowing into the air heat exchanger 5 is lowered. As a result, an amount of heat used for defrosting of the air heat exchanger 5 decreases. In contrast to this, according to the present embodiment, the liquid refrigerant is caused to flow into the suction passage 3 of the compressor 2, so that the amount of the refrigerant of the hot-gas frost circuit can be adjusted without decreasing the amount of heat used for defrosting of the air heat exchanger 5.

[0059] At the time of the hot-gas defrost operation, the controlling circuitry 50 may control the operation or the opening degree of the liquid bypass valve 21 so that the suction superheat degree becomes close to a target. In doing so, it is possible to more reliably prevent the amount of the liquid refrigerant flowing into the suction passage 3 from the liquid bypass passage 20 from becoming too large, and therefore, it is possible to more reliably prevent the compressor 2 from sucking the liquid refrigerant.

[0060] At the time of the hot-gas defrost operation, the controlling circuitry 50 may control the operation or the opening degree of the liquid bypass valve 21 so that the discharge superheat degree becomes close to a target. In doing so, it is possible to more reliably prevent the amount of the liquid refrigerant flowing into the suction passage 3 from the liquid bypass passage 20 from being too large, and therefore, it is possible to more reliably prevent the compressor 2 from sucking the liquid refrigerant.

[0061] As described above, according to the present embodiment, the amount of the refrigerant in the hot-gas defrost circuit can be adjusted by one actuator (the liquid bypass valve 21) and one control target (the suction superheat degree or discharge superheat degree). Therefore, it is possible to more simplify the control, and it is possible to make the hot-gas defrost operation more stable.

[0062] In the present disclosure, instead of the illustrated example, the inlet portion 20a of the liquid bypass passage 20 may be directly connected to the lower portion of the receiver 9. In this case, at the time of the hot-gas defrost operation, the liquid refrigerant flowing out to the liquid bypass passage 20 from the lower portion of the receiver 9 can be caused to flow into the suction passage 3.

[0063] In the present disclosure, instead of the illustrated example, the inlet portion 20a of the liquid bypass passage 20 may be connected to the fourth refrigerant passage 14. In this case, at the time of the hot-gas defrost operation, the liquid refrigerant in the fourth refrigerant passage 14 can be caused to flow into the suction passage 3 through the liquid bypass passage 20. Directly connecting a pipe to a vessel like the receiver 9 tends to be more costly than connecting the pipe to a pipe. When the inlet portion 20a of the liquid bypass passage 20 is connected to the fourth refrigerant passage 14, or when the inlet portion 20a of the liquid bypass passage 20 is connected to the fifth refrigerant passage 15 as in the illustrated example, it is not necessary to directly connect the pipe forming the liquid bypass passage 20 to the receiver 9, which is advantageous in cost reduction.

[0064] As a modified example, the refrigeration cycle device 1 may include an internal heat exchanger that exchanges heat between the refrigerant passing through the fourth refrigerant passage 14 and the refrigerant passing through the suction passage 3, in place of the illustrated internal heat exchanger 19. In other words, the internal heat exchanger may be outside the receiver 9. By the modified example, a similar effect to that of the illustrated embodiment is also obtained.

[0065] At the time of the hot-gas defrost operation, the controlling circuitry 50 may control the operation or the opening degree of the liquid bypass valve 21 according to the refrigerant outlet temperature of the air heat exchanger 5. The gas refrigerant is cooled in the air heat exchanger 5 at the time of the hot-gas defrost operation, and therefore, when the amount of the refrigerant in the hot-gas defrost circuit is large, there is a possibility that the refrigerant condenses on a downstream side of the air heat exchanger 5. When the refrigerant condenses on the downstream side of the air heat exchanger 5, there is a possibility that the internal heat exchanger 19 cannot sufficiently evaporate the liquid refrigerant in the suction passage 3. In the light of this, at the time of the hot-gas defrost operation, the controlling circuitry 50 may adjust the amount of the refrigerant in the hot-gas defrost circuit by controlling the operation or the opening degree of the liquid bypass valve 21 so that the refrigerant flowing out from the air heat exchanger 5 is brought into a state of superheated gas. This can more reliably prevent the liquid refrigerant from being sucked by the compressor 2. A difference between the refrigerant outlet temperature of the air heat exchanger 5 detected by the second temperature sensor 29 and the suction saturation temperature corresponds to the superheat degree of the refrigerant flowing out from the air heat exchanger 5. The controlling circuitry 50 may control the operation or the opening degree of the liquid bypass valve 21 so that the superheat degree of the refrigerant flowing out from the air heat exchanger 5 becomes close to the target. For example, when the controlling circuitry 50 increases the opening degree of the liquid bypass valve 21, the amount of the refrigerant in the hot-gas defrost circuit increases, so that the superheat degree of the refrigerant flowing out from the air heat exchanger 5 is reduced. When the controlling circuitry 50 reduces the opening degree of the liquid bypass valve 21 on the contrary to this, the superheat degree of the refrigerant flowing out from the air heat exchanger 5 increases.

[0066] At the time of the hot-gas defrost operation, the controlling circuitry 50 may control the operation or the opening degree of the liquid bypass valve 21 according to a temperature difference between the refrigerant inlet temperature of the air heat exchanger 5 detected by the first temperature sensor 28, and the refrigerant outlet temperature of the air heat exchanger 5 detected by the second temperature sensor 29. When the controlling circuitry 50 increases the opening degree of the liquid bypass valve 21, the temperature difference increases, and when the controlling circuitry 50 reduces the opening degree of the liquid bypass valve 21, the temperature difference reduces.

[0067] At the time of the hot-gas defrost operation, the controlling circuitry 50 may temporarily increase the opening degree of the first expansion valve 11 according to the temperature of the liquid refrigerant flowing out from the utilization heat exchanger 6. When the high-pressure gas refrigerant is cooled by the heat medium flowing in the utilization heat exchanger 6, the temperature of the refrigerant is lowered to a lower temperature than the discharge saturation temperature. The lower the refrigerant temperature, the more refrigerant is condensed in the utilization heat exchanger 6. In the light of this, the controlling circuitry 50 preferably moves the liquid refrigerant staying in the utilization heat exchanger 6 to the receiver 9 by temporarily increasing the opening degree of the first expansion valve 11 when the supercooling degree of the liquid refrigerant flowing out from the utilization heat exchanger 6 becomes larger than the reference. This can always store the liquid refrigerant in the receiver 9, and therefore adjustment of the amount of the refrigerant in the hot-gas defrost circuit becomes easier.

[0068] Further, a temperature sensor that detects the temperature of the heat medium flowing into the utilization heat exchanger 6 or the temperature of the heat medium flowing out from the utilization heat exchanger 6 may be installed. At the time of the hot-gas defrost operation, the controlling circuitry 50 determines that the condensation amount of the refrigerant in the utilization heat exchanger 6 becomes large when a difference between the heat medium temperature detected by the temperature sensor, and the temperature of the liquid refrigerant flowing out from the utilization heat exchanger 6 becomes smaller than the reference and may temporarily increase the opening degree of the first expansion valve 11.

Embodiment 2

[0069] Next, embodiment 2 is described with reference to Fig. 7 to Fig. 12, a difference from embodiment 1 described above is mainly described, and common explanation is simplified or omitted. Further, elements that are common to or correspond to the elements described above are assigned with the same reference signs.

[0070] Fig. 7 is a diagram showing a refrigeration cycle device 32 according to embodiment 2. As shown in Fig. 7, the refrigeration cycle device 32 according to present embodiment 2 further includes a bypass heating heat exchanger 33 as compared with the refrigeration cycle device 1 according to embodiment 1. The bypass heating heat exchanger 33 heats liquid refrigerant passing through a liquid bypass passage 20 by a heat medium. The bypass heating heat exchanger 33 includes a heat medium passage 33a and a refrigerant passage 33b. Heat is exchanged between the heat medium passing through the heat medium passage 33a and the refrigerant passing through the refrigerant passage 33b. In the illustrated example, the heat medium passing through the utilization heat exchanger 6 flows into the heat medium passage 33a of the bypass heating heat exchanger 33. As a modified example, the heat medium passing through the heat medium passage 33a of the bypass heating heat exchanger 33 may be configured to flow into the utilization heat exchanger 6.

[0071] The liquid bypass passage 20 has a first passage 20c that connects an inlet portion 20a to an inlet of the refrigerant passage 33b of the bypass heating heat exchanger 33, and a second passage 20d that connects an outlet of the refrigerant passage 33b of the bypass heating heat exchanger 33 to an outlet portion 20b.

[0072] The refrigeration cycle device 32 includes a liquid bypass expansion valve 34. The liquid bypass expansion valve 34 corresponds to the liquid bypass valve 21 in embodiment 1. The liquid bypass expansion valve 34 is configured by an expansion valve capable of adjusting a flow rate. The liquid bypass expansion valve 34 is positioned on the second passage 20d. An operation and a function of the liquid bypass expansion valve 34 are the same as or similar to the operation and the function of the liquid bypass valve 21 in embodiment 1. The liquid bypass expansion valve 34 is configured to decompress the refrigerant from the bypass heating heat exchanger 33 at a time of a hot-gas defrost operation.

[0073] The refrigeration cycle device 32 further includes a liquid bypass solenoid valve 35. The liquid bypass solenoid valve 35 is positioned on the first passage 20c. The liquid bypass solenoid valve 35 is preferably a valve that can be switched only between being open and closed. The liquid bypass solenoid valve 35 is configured to decompress the liquid refrigerant passing through the first passage 20c at the time of the hot-gas defrost operation.

[0074] The refrigeration cycle device 32 further includes a liquid bypass temperature sensor 36. The liquid bypass temperature sensor 36 is positioned in the second passage 20d between the liquid bypass expansion valve 34 and the outlet portion 20b.

[0075] Fig. 8 is one example of a functional block diagram of the refrigeration cycle device 32 according to embodiment 2. As shown in Fig. 8, each of the liquid bypass expansion valve 34, the liquid bypass solenoid valve 35, and the liquid bypass temperature sensor 36 is electrically connected to a controlling circuitry 50.

[0076] Fig. 9 is a diagram showing a flow of the refrigerant at a time of a heating operation of the refrigeration cycle device 32 according to embodiment 2. As shown in Fig. 9, at the time of the heating operation, the liquid bypass expansion valve 34 and the liquid bypass solenoid valve 35 are closed, and the refrigerant does not flow into the liquid bypass passage 20. The flow of the refrigerant at the time of the heating operation is the same as that of embodiment 1.

[0077] Fig. 10 is a diagram showing a flow of the refrigerant at a time of a hot-gas defrost operation of the refrigeration cycle device 32 according to embodiment 2. As shown in Fig. 10, at the time of the hot-gas defrost operation, the refrigeration cycle device 32 operates as follows. The liquid bypass expansion valve 34 and the liquid bypass solenoid valve 35 are opened. A liquid refrigerant in a receiver 9 flows into the liquid bypass passage 20 from the inlet portion 20a after flowing into a fifth refrigerant passage 15 from a tip end opening 15a. The liquid refrigerant passing through the liquid bypass passage 20 is heated by receiving heat of a heat medium of a heat medium circuit 100 when passing through the bypass heating heat exchanger 33. At least a part of the liquid refrigerant may evaporate while passing through the bypass heating heat exchanger 33. According to the present embodiment, at the time of the hot-gas defrost operation, the liquid refrigerant in the liquid bypass passage 20 can be caused to flow into a suction passage 3 after being heated by the bypass heating heat exchanger 33. Therefore, together with heating by an internal heat exchanger 19, the liquid refrigerant can be evaporated more reliably before being sucked by the compressor 2. As a result, the liquid refrigerant can be prevented from being sucked by the compressor 2 more reliably without providing an accumulator on the suction passage 3.

[0078] The refrigerant from the inlet portion 20a of the liquid bypass passage 20 flows into the bypass heating heat exchanger 33 after being decompressed to a medium pressure by the liquid bypass solenoid valve 35. The refrigerant passing through the bypass heating heat exchanger 33 flows into the suction passage 3 after being further decompressed to a low pressure by the liquid bypass expansion valve 34.

[0079] The liquid bypass expansion valve 34 can adjust a flow rate of the refrigerant by adjustment of an opening degree thereof. In general, an expansion valve may not be able to completely shut off a flow of refrigerant even if a valve body is set to a minimum opening degree. In the present embodiment, the liquid bypass solenoid valve 35 is further installed, so that when the liquid bypass solenoid valve 35 is closed, the flow of the refrigerant can reliably be shut off. Therefore, it is possible to more reliably prevent the liquid refrigerant from bypassing from the liquid bypass passage 20 to the suction passage 3 at the time of the heating operation, for example.

[0080] According to the present embodiment, the liquid bypass solenoid valve 35 is installed between the inlet portion 20a of the liquid bypass passage 20 and the bypass heating heat exchanger 33, and therefore, closing the liquid bypass solenoid valve 35 ensures that the refrigerant does not build up in the bypass heating heat exchanger 33.

[0081] The liquid bypass solenoid valve 35 preferably has a bore diameter thereof selected so that it can decompress the refrigerant. The liquid bypass solenoid valve 35 decompresses the refrigerant, and thereby can make a temperature of the refrigerant flowing into the bypass heating heat exchanger 33 lower than a temperature of the heat medium flowing in the heat medium circuit 100. As a result, it is possible to evaporate the refrigerant more reliably in the bypass heating heat exchanger 33.

[0082] A first expansion valve 11 has a bore diameter thereof selected so that it can control the flow of the refrigerant at the time of the heating operation. Accordingly, when the first expansion valve 11 is slightly opened at the time of the hot-gas defrost operation, there is a possibility that the first expansion valve 11 cannot decompress the refrigerant. If the first expansion valve 11 cannot decompress the refrigerant, and the liquid bypass solenoid valve 35 does not exist, there is a possibility that the refrigerant cannot evaporate in the bypass heating heat exchanger 33. In contrast to this, according to the present embodiment, the liquid bypass solenoid valve 35 decompresses the refrigerant before entering the bypass heating heat exchanger 33, and thereby the temperature of the refrigerant reliably becomes lower than the temperature of the heat medium flowing in the heat medium circuit 100. Therefore, the refrigerant can be reliably evaporated in the bypass heating heat exchanger 33.

[0083] According to the present embodiment, the liquid bypass expansion valve 34 installed downstream of the bypass heating heat exchanger 33 decompresses the refrigerant, and thereby the temperature of the refrigerant of the bypass heating heat exchanger 33 can be made higher than a suction saturation temperature. Therefore, it is possible to more reliably prevent the refrigerant temperature of the bypass heating heat exchanger 33 from becoming too low, and therefore, it is possible to more reliably prevent the heat medium like water from being frozen in the bypass heating heat exchanger 33.

[0084] In this way, according to the present embodiment, the bypass heating heat exchanger 33 is installed between the liquid bypass solenoid valve 35 and the liquid bypass expansion valve 34, in the refrigerant flow in the liquid bypass passage 20, and thereby the bypassing refrigerant can be evaporated at a more appropriate temperature.

[0085] Note that the liquid bypass solenoid valve 35 can be omitted. For example, if the first expansion valve 11 can decompress the refrigerant at the time of the hot-gas defrost operation, the liquid bypass solenoid valve 35 may not be provided.

[0086] The bypass heating heat exchanger 33 heats the refrigerant by a heat medium on a utilization side flowing in the heat medium circuit 100. The heat medium on the utilization side is heated at the time of the heating operation directly before the hot-gas defrost operation, and therefore, has a high temperature to some extent. Therefore, the heat medium on the utilization side has a sufficient amount of heat required to evaporate the refrigerant in the bypass heating heat exchanger 33.

[0087] Fig. 11 is a flowchart showing an example of a process at a time of executing the hot-gas defrost operation according to embodiment 2. Fig. 12 is a timing chart showing an operation example of each of actuators from the heating operation according to embodiment 2 until the operation transitions to the hot-gas defrost operation and returns to the heating operation. Concerning an example shown in Fig. 11 and Fig. 12, a difference from the example shown in Fig. 5 and Fig. 6 of embodiment 1 is described hereinafter.

[0088] Step S201 to step S203 in Fig. 11 are the same as step S101 to step S103 in Fig. 5. After opening a hot-gas bypass valve 18 as step S203, the controlling circuitry 50 opens the liquid bypass solenoid valve 35 as step S204. Next, the controlling circuitry 50 controls the operation so that the opening degree of the liquid bypass expansion valve 34 becomes slightly opening (P3-1), as step S205. Step S206 to step S208 in Fig. 11 are similar to step S105 to step S107 in Fig. 5. A process from step S201 to step S207 corresponds to a defrost preparation process in Fig. 12.

[0089] Next, the controlling circuitry 50 controls the operation so that the opening degree of the liquid bypass expansion valve 34 becomes equal to a target opening degree (P3-2), as step S209. At this time, the controlling circuitry 50 may adjust a value of the target opening degree (P3-2) so that the suction superheat degree or discharge superheat degree becomes close to a target. By a process of step S208 and step S209, the hot-gas defrost operation starts.

[0090] Step S210 to step S214 in Fig. 11 are similar to step S109 to step S113 in Fig. 5. Next, the controlling circuitry 50 closes the liquid bypass solenoid valve 35 as step S215. Next, the controlling circuitry 50 fully closes the liquid bypass expansion valve 34 as step S216. A process from step S211 to step S216 corresponds to a return process in Fig. 12.

Reference Signs List

[0091]

1	refrigeration cycle device
2	compressor
3	suction passage
4	discharge passage
4a	branch portion
5	air heat exchanger
6	utilization heat exchanger
7	first refrigerant passage
8	second refrigerant passage
9	receiver
11	first expansion valve
12	second expansion valve
13	third refrigerant passage
14	fourth refrigerant passage
14a	tip end opening
15	fifth refrigerant passage
15a	tip end opening
16	sixth refrigerant passage
16a	branch portion
17	hot-gas bypass passage
18	hot-gas bypass valve
19	internal heat exchanger
20	liquid bypass passage
20a	inlet portion
20b	outlet portion
20c	first passage
20d	second passage
21	liquid bypass valve
22	refrigerant circuit switching valve
23	blower
24	discharge pressure sensor
25	discharge temperature sensor
26	suction pressure sensor
27	suction temperature sensor
28	first temperature sensor
29	second temperature sensor
30	third temperature sensor
31	outside air temperature sensor
32	refrigeration cycle device
33	bypass heating heat exchanger
34	liquid bypass expansion valve
35	liquid bypass solenoid valve
36	liquid bypass temperature sensor
50	controlling circuitry
51	processor
52	memory
90	liquid level
100	heat medium circuit
101	heat medium pump

Claims

1. A refrigeration cycle device comprising:

a compressor to compress refrigerant;
a suction passage connecting to a suction port of the compressor;
a discharge passage connecting to a discharge port of the compressor;
an air heat exchanger to exchange heat between the refrigerant and air;
a utilization heat exchanger to exchange heat between the refrigerant and a heat medium;
a first refrigerant passage connecting the utilization heat exchanger to the discharge passage;
a second refrigerant passage connecting the air heat exchanger to the suction passage;
a receiver to store therein liquid refrigerant that is the refrigerant in liquid phase;
a first expansion valve;
a second expansion valve;

a third refrigerant passage connecting the utilization heat exchanger to the first expansion valve;
a fourth refrigerant passage connecting the first expansion valve to the receiver;
a fifth refrigerant passage connecting the receiver to the second expansion valve;
a sixth refrigerant passage connecting the second expansion valve to the air heat exchanger;
a hot-gas bypass passage connecting the discharge passage to the sixth refrigerant passage;
a hot-gas bypass valve provided on the hot-gas bypass passage;
an internal heat exchanger to exchange heat between the liquid refrigerant inside the receiver and the refrigerant passing through the suction passage, or between the refrigerant passing through the fourth refrigerant passage and the refrigerant passing through the suction passage;
a liquid bypass passage including an inlet portion connected to the fourth refrigerant passage, the fifth refrigerant passage, or a lower portion of the receiver, and an outlet portion connected to the suction passage upstream of the internal heat exchanger; and
a liquid bypass valve provided on the liquid bypass passage.

2. The refrigeration cycle device according to claim 1, further comprising

controlling circuitry to execute a heating operation that causes the refrigerant discharged from the compressor to flow into the utilization heat exchanger, and a hot-gas defrost operation that melts frost adhering to the air heat exchanger,
wherein at a time of the heating operation, the controlling circuitry is configured to cause the refrigerant discharged from the compressor to flow into the utilization heat exchanger by closing the hot-gas bypass valve and the liquid bypass valve,
at a time of the hot-gas defrost operation, the controlling circuitry is configured to cause the refrigerant discharged from the compressor to pass through the hot-gas bypass passage and flow into the air heat exchanger by opening the hot-gas bypass valve and closing the second expansion valve, and
at the time of the hot-gas defrost operation, the controlling circuitry is configured to cause the liquid refrigerant to flow into the suction passage from the liquid bypass passage by opening the liquid bypass valve continuously or intermittently.

3. The refrigeration cycle device according to claim 2, further comprising

a detector to detect a suction superheat degree that is a superheat degree of the refrigerant to be sucked by the compressor,
wherein at the time of the hot-gas defrost operation, the controlling circuitry is configured to control an operation of the liquid bypass valve so that the suction superheat degree becomes close to a target.

4. The refrigeration cycle device according to claim 2, further comprising

a detector to detect a discharge superheat degree that is a superheat degree of the refrigerant discharged from the compressor,
wherein at the time of the hot-gas defrost operation, the controlling circuitry is configured to control an operation of the liquid bypass valve so that the discharge superheat degree becomes close to a target.

5. The refrigeration cycle device according to any one of claim 2 to claim 4,
wherein the refrigeration cycle device is configured to be able to execute the hot-gas defrost operation without stopping a flow of the heat medium in the utilization heat exchanger.

6. The refrigeration cycle device according to any one of claim 2 to claim 5, further comprising:

a refrigerant circuit switching valve to switch between a forward cycle circuit in which the refrigerant discharged from the compressor flows into the utilization heat exchanger through the first refrigerant passage, and a reverse cycle circuit in which the refrigerant discharged from the compressor flows into the air heat exchanger through the second refrigerant passage; and
a temperature sensor to detect a temperature of the heat medium,
wherein when melting frost adhering to the air heat exchanger, the controlling circuitry is configured to execute the hot-gas defrost operation when the temperature of the heat medium is lower as compared with a reference, and is configured to execute a reverse cycle defrost operation that circulates the refrigerant into the reverse cycle circuit when the temperature of the heat medium is higher as compared with the reference.

7. The refrigeration cycle device according to any one of claim 2 to claim 6,
wherein at the time of the hot-gas defrost operation, the controlling circuitry is configured to cause the

liquid refrigerant inside the utilization heat exchanger to flow into the fourth refrigerant passage by opening the first expansion valve continuously or intermittently.

8. The refrigeration cycle device according to any one of claim 2 to claim 7,
wherein at the time of the hot-gas defrost operation, the controlling circuitry is configured to control an operation of the liquid bypass valve so that the refrigerant of superheated gas flows out from the air heat exchanger.

9. The refrigeration cycle device according to any one of claim 1 to claim 8, wherein the refrigerant is flammable refrigerant.

10. The refrigeration cycle device according to any one of claim 1 to claim 9, wherein an accumulator is not provided on the suction passage.

11. The refrigeration cycle device according to any one of claim 1 to claim 10, further comprising

a bypass heating heat exchanger to heat the liquid refrigerant passing through the liquid bypass passage by the heat medium,
wherein the liquid bypass passage includes a first passage connecting the inlet portion to the bypass heating heat exchanger, and a second passage connecting the bypass heating heat exchanger to the outlet portion.

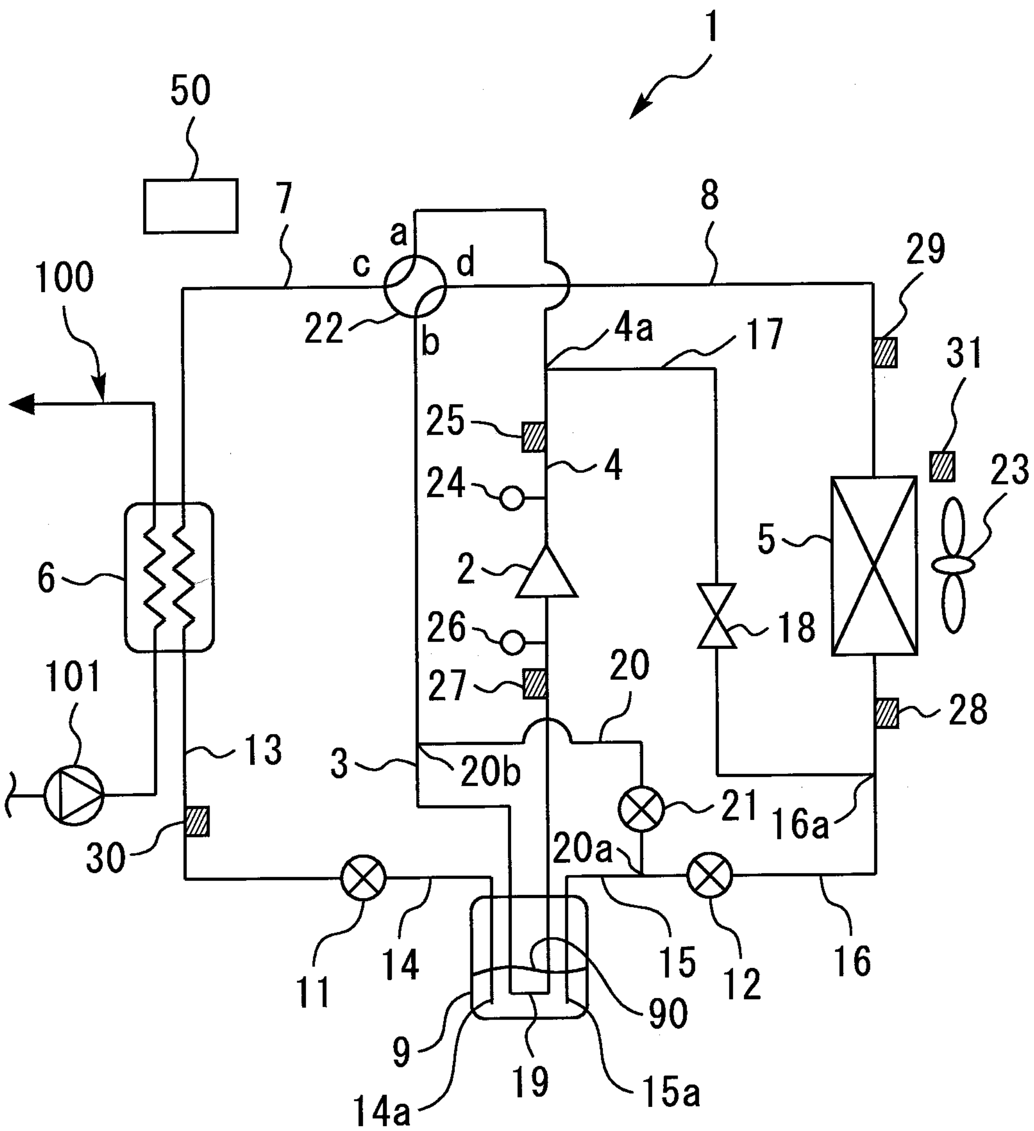
12. The refrigeration cycle device according to claim 11, comprising

a liquid bypass expansion valve that is the liquid bypass valve configured by an expansion valve capable of adjusting a flow rate,
wherein the liquid bypass expansion valve is positioned on the second passage.

13. The refrigeration cycle device according to claim 12, further comprising

a liquid bypass solenoid valve positioned on the first passage,
wherein the liquid bypass solenoid valve is configured to decompress the liquid refrigerant passing through the first passage.

FIG. 1



1
50
7
8
a
c
d
100
22
b
4a
17
29
31
25
4
24
23
5
2
6
18
26
20
27
28
101
13
3
20b
21
16a
30
20a
11
14
15
12
16
90
9
19
14a
15a

FIG. 2

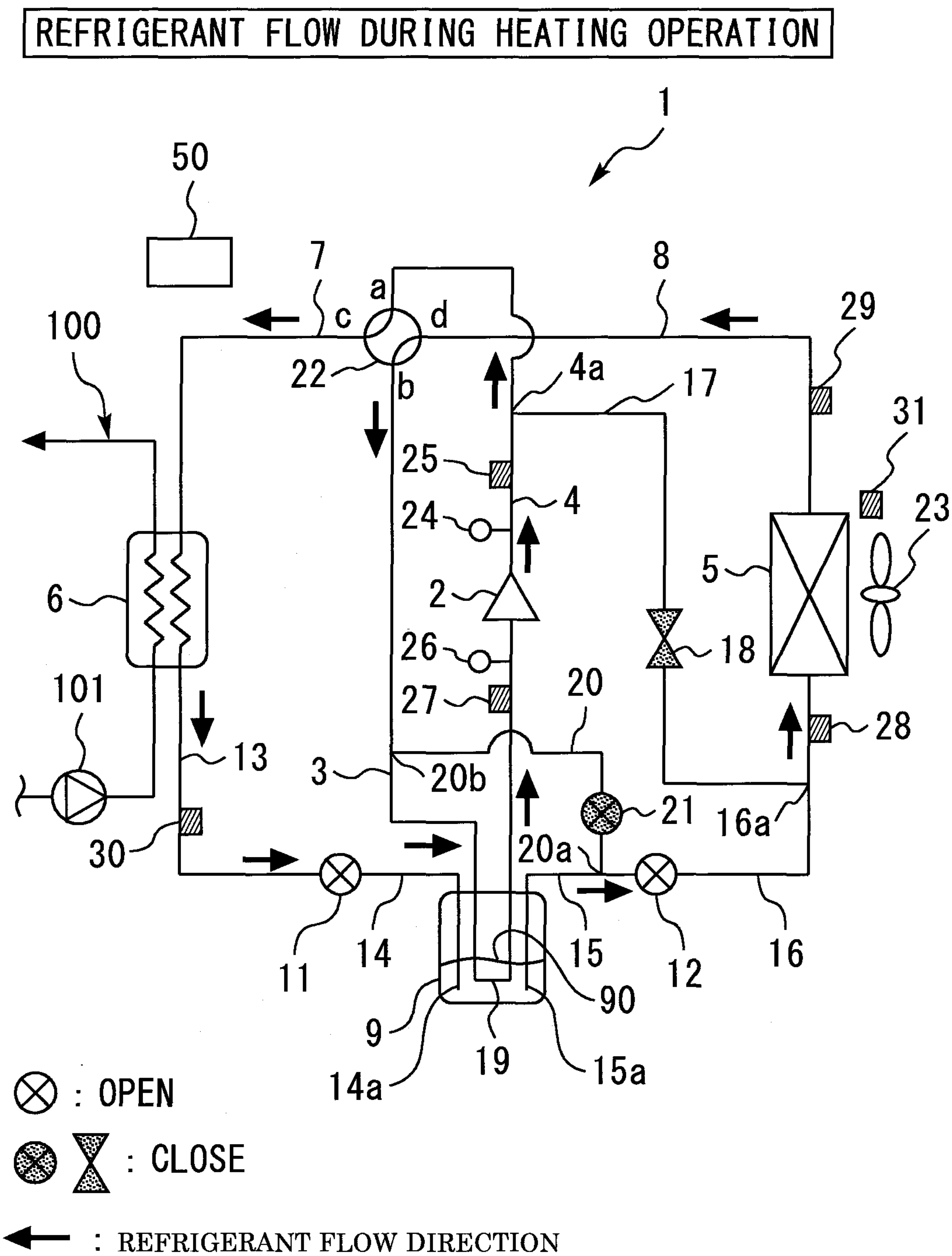

REFRIGERANT FLOW DURING HEATING OPERATION
1
50
7
8
a
c
d
100
22
b
4a
17
29
31
25
4
24
23
5
6
2
18
26
20
27
101
28
13
3
20b
21
16a
30
20a
11
14
15
12
16
90
9
19
14a
15a
: OPEN
: CLOSE
: REFRIGERANT FLOW DIRECTION

FIG. 3

REFRIGERANT FLOW DURING HOT-GAS DEFROST OPERATION

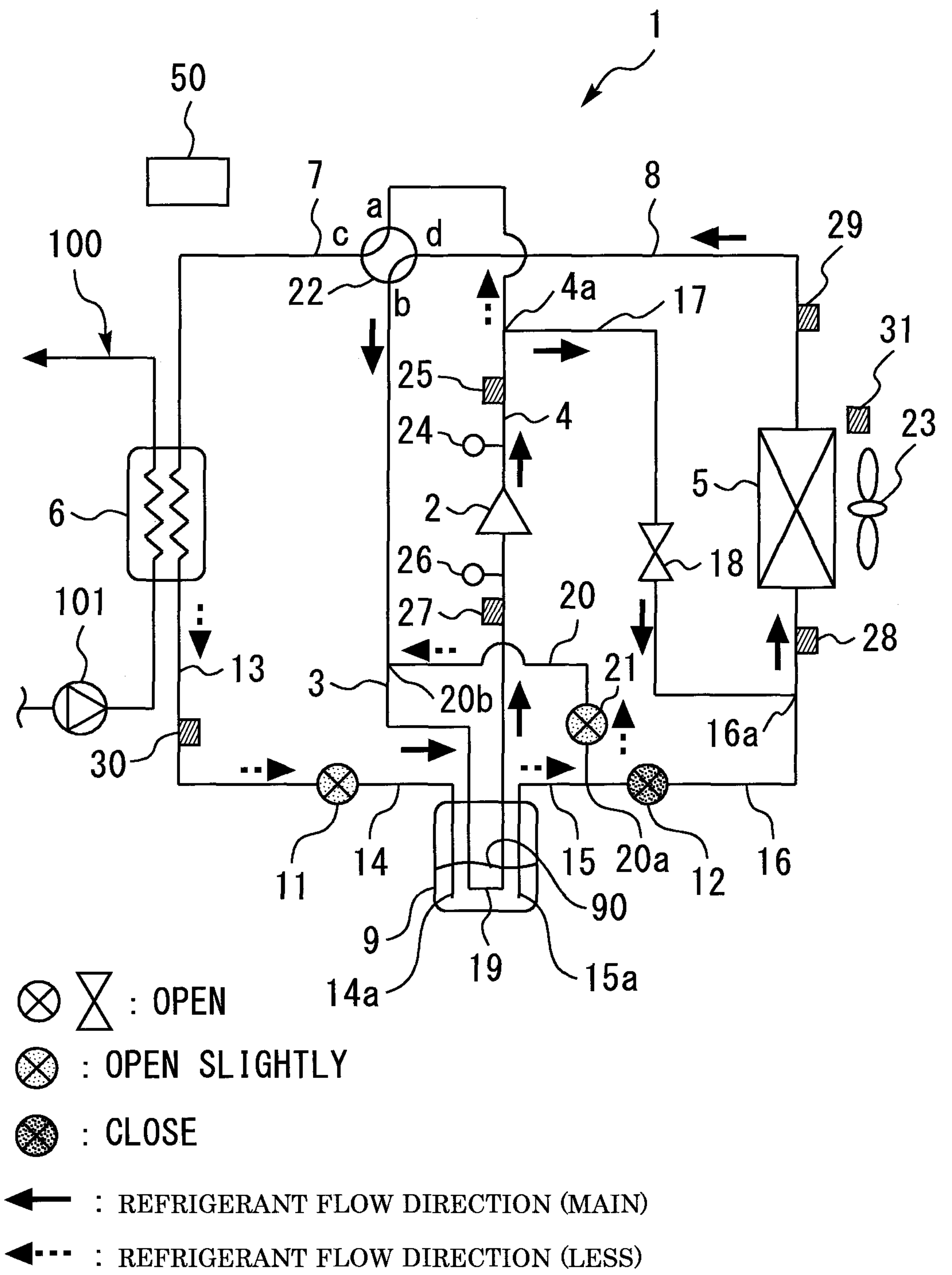


FIG. 4

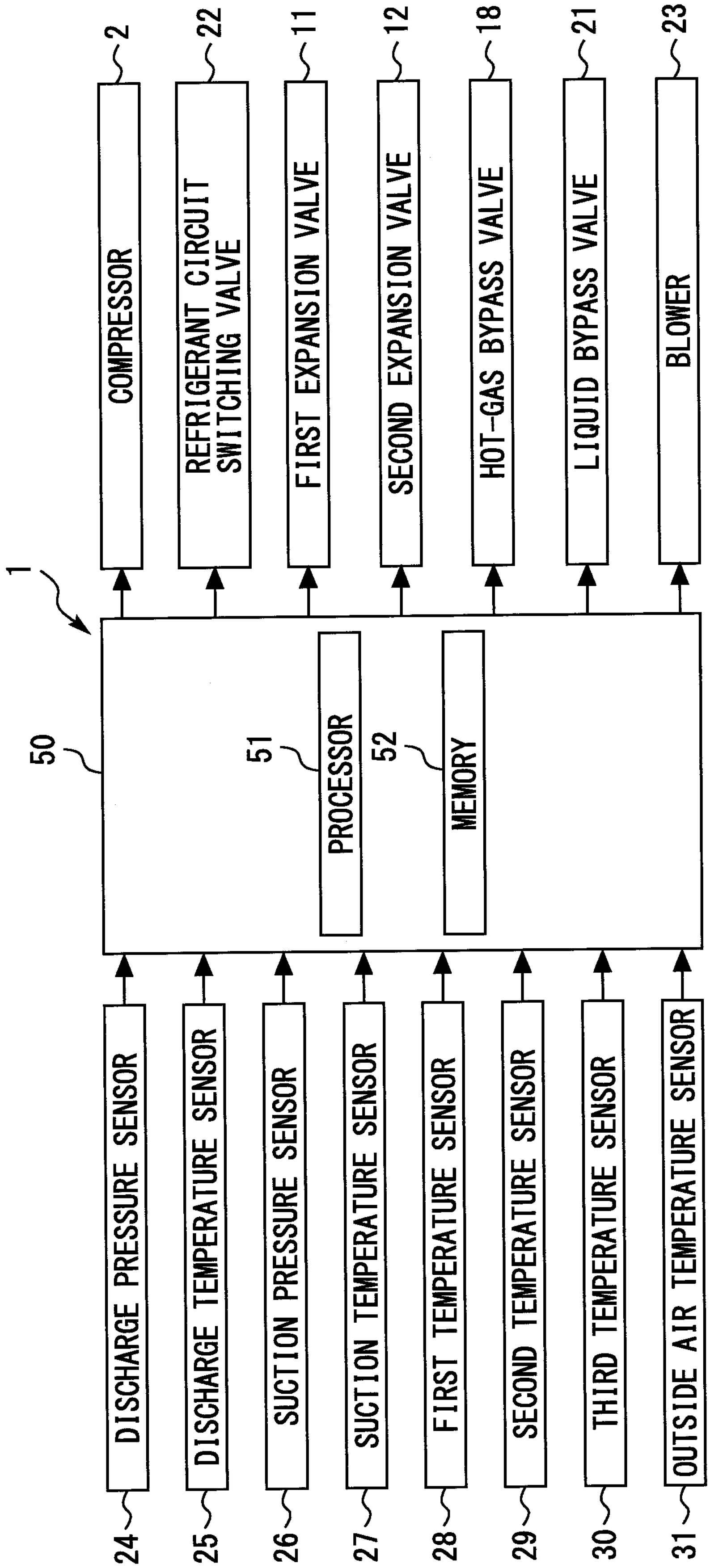

1
50
51
PROCESSOR
52
MEMORY
COMPRESSOR
2
REFRIGERANT CIRCUIT SWITCHING VALVE
22
FIRST EXPANSION VALVE
11
SECOND EXPANSION VALVE
12
HOT-GAS BYPASS VALVE
18
LIQUID BYPASS VALVE
21
BLOWER
23
DISCHARGE PRESSURE SENSOR
24
DISCHARGE TEMPERATURE SENSOR
25
SUCTION PRESSURE SENSOR
26
SUCTION TEMPERATURE SENSOR
27
FIRST TEMPERATURE SENSOR
28
SECOND TEMPERATURE SENSOR
29
THIRD TEMPERATURE SENSOR
30
OUTSIDE AIR TEMPERATURE SENSOR
31

FIG. 5

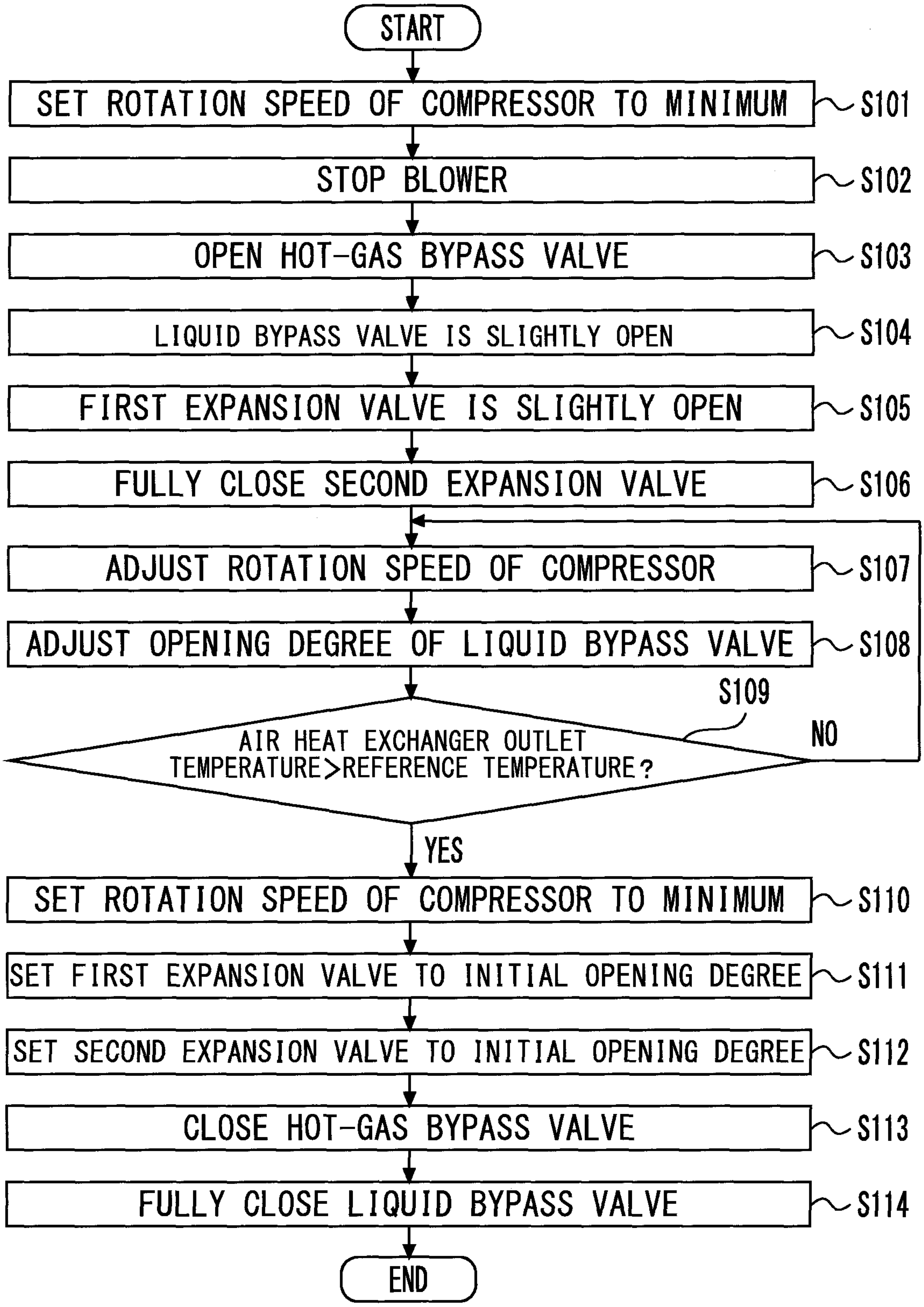

START
SET ROTATION SPEED OF COMPRESSOR TO MINIMUM
S101
STOP BLOWER
S102
OPEN HOT-GAS BYPASS VALVE
S103
LIQUID BYPASS VALVE IS SLIGHTLY OPEN
S104
FIRST EXPANSION VALVE IS SLIGHTLY OPEN
S105
FULLY CLOSE SECOND EXPANSION VALVE
S106
ADJUST ROTATION SPEED OF COMPRESSOR
S107
ADJUST OPENING DEGREE OF LIQUID BYPASS VALVE
S108
S109
AIR HEAT EXCHANGER OUTLET TEMPERATURE>REFERENCE TEMPERATURE?
NO
YES
SET ROTATION SPEED OF COMPRESSOR TO MINIMUM
S110
SET FIRST EXPANSION VALVE TO INITIAL OPENING DEGREE
S111
SET SECOND EXPANSION VALVE TO INITIAL OPENING DEGREE
S112
CLOSE HOT-GAS BYPASS VALVE
S113
FULLY CLOSE LIQUID BYPASS VALVE
S114
END

FIG. 6

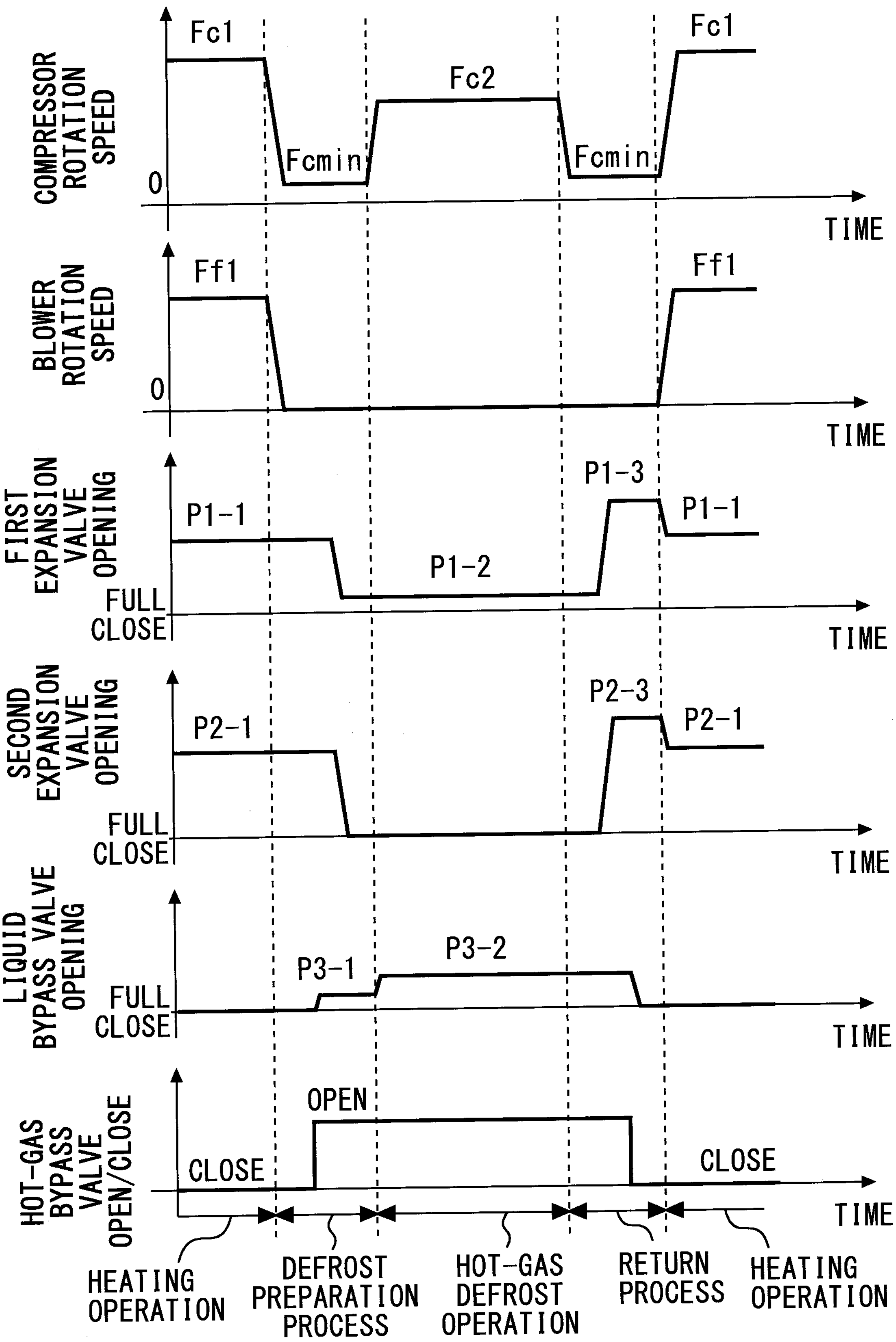
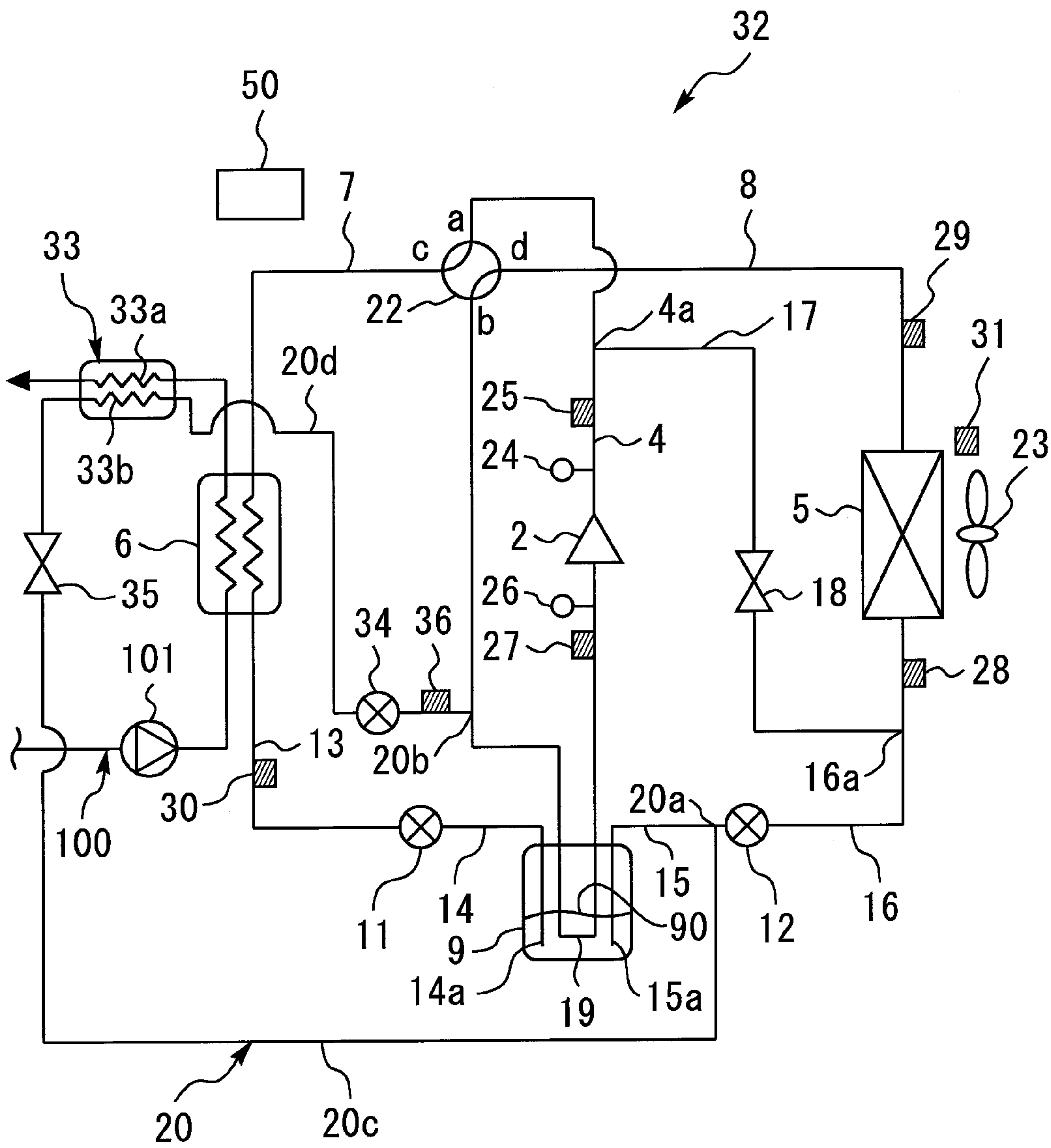

COMPRESSOR ROTATION SPEED
Fc1
Fcmin
Fc2
Fcmin
Fc1
0
TIME
BLOWER ROTATION SPEED
Ff1
Ff1
0
TIME
FIRST EXPANSION VALVE OPENING
P1-1
P1-2
P1-3
P1-1
FULL CLOSE
TIME
SECOND EXPANSION VALVE OPENING
P2-1
P2-3
P2-1
FULL CLOSE
TIME
LIQUID BYPASS VALVE OPENING
P3-1
P3-2
FULL CLOSE
TIME
HOT-GAS BYPASS VALVE OPEN/CLOSE
CLOSE
OPEN
CLOSE
TIME
HEATING OPERATION
DEFROST PREPARATION PROCESS
HOT-GAS DEFROST OPERATION
RETURN PROCESS
HEATING OPERATION

FIG. 7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7
8
a
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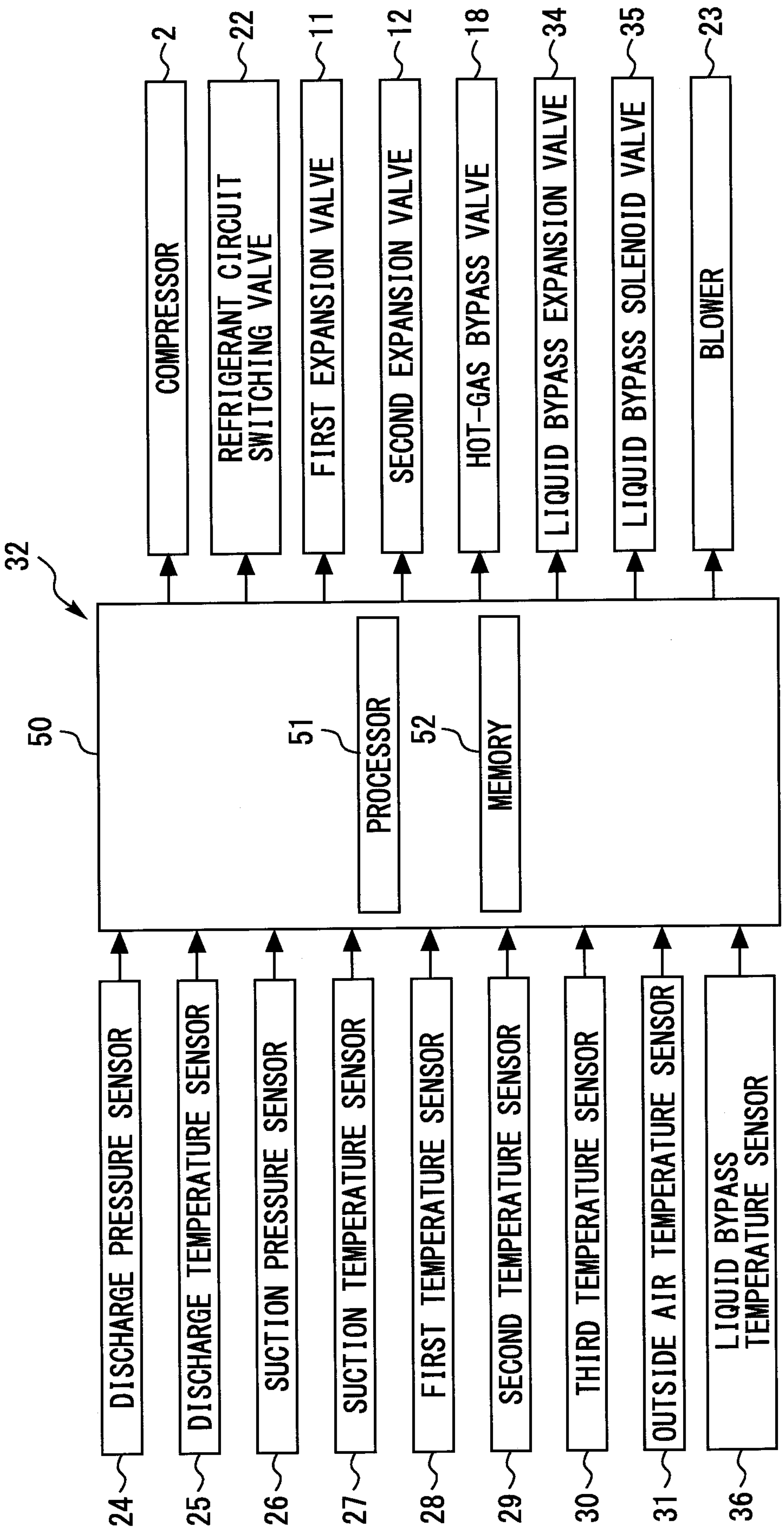
d
29
33
33a
22
b
4a
17
20d
31
25
4
33b
24
23
5
6
2
35
18
26
34
36
27
101
28
13
20b
16a
30
20a
100
11
14
15
12
16
9
90
14a
19
15a
20
20c

FIG. 8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50
51
PROCESSOR
52
MEMORY
2
COMPRESSOR
22
REFRIGERANT CIRCUIT SWITCHING VALVE
11
FIRST EXPANSION VALVE
12
SECOND EXPANSION VALVE
18
HOT-GAS BYPASS VALVE
34
LIQUID BYPASS EXPANSION VALVE
35
LIQUID BYPASS SOLENOID VALVE
23
BLOWER
24
DISCHARGE PRESSURE SENSOR
25
DISCHARGE TEMPERATURE SENSOR
26
SUCTION PRESSURE SENSOR
27
SUCTION TEMPERATURE SENSOR
28
FIRST TEMPERATURE SENSOR
29
SECOND TEMPERATURE SENSOR
30
THIRD TEMPERATURE SENSOR
31
OUTSIDE AIR TEMPERATURE SENSOR
36
LIQUID BYPASS TEMPERATURE SENSOR

FIG. 9

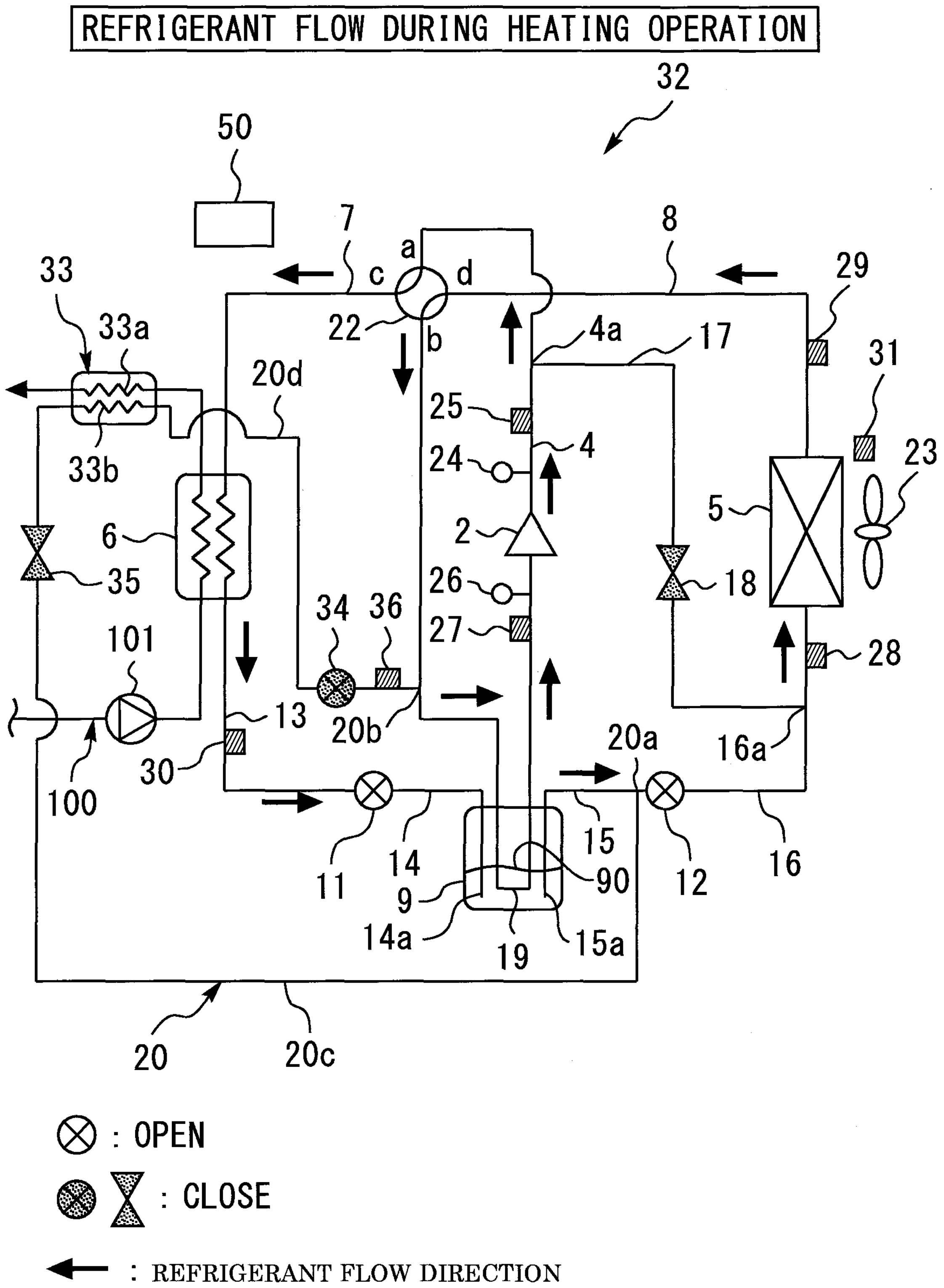

REFRIGERANT FLOW DURING HEATING OPERATION
32
50
7
8
a
c
d
b
33
33a
33b
22
4a
17
29
20d
25
4
31
23
24
6
5
35
2
18
26
34
36
27
101
28
13
20b
30
20a
16a
100
11
14
15
12
16
9
90
14a
19
15a
20
20c
: OPEN
: CLOSE
: REFRIGERANT FLOW DIRECTION

FIG. 10

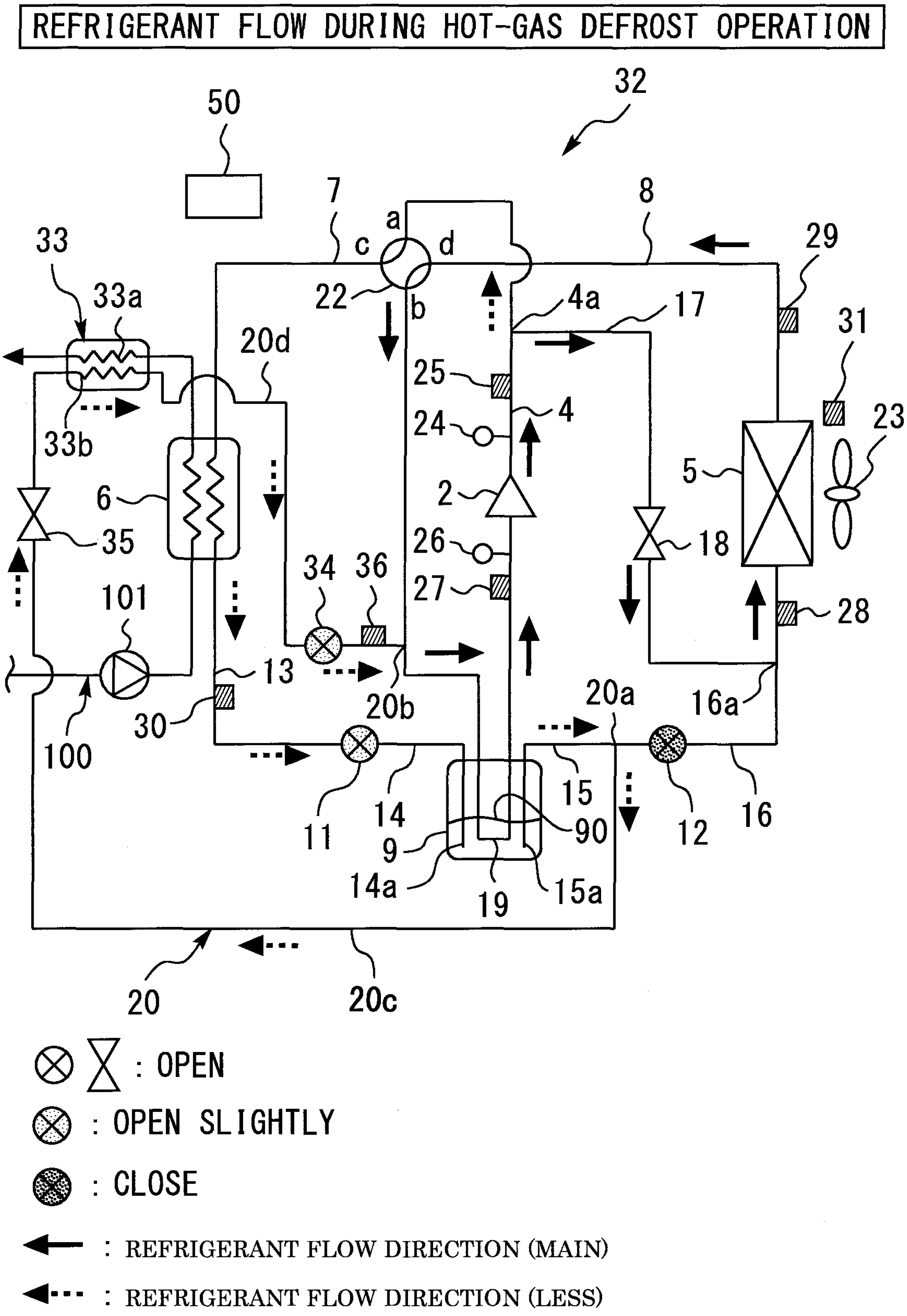

REFRIGERANT FLOW DURING HOT-GAS DEFROST OPERATION
32
50
7
8
a
c
d
b
33
33a
33b
22
4a
17
29
31
23
20d
25
24
4
5
2
6
35
18
26
27
34
36
101
28
13
20b
20a
16a
30
100
11
14
9
14a
19
15
90
15a
12
16
20
20c
: OPEN
: OPEN SLIGHTLY
: CLOSE
: REFRIGERANT FLOW DIRECTION (MAIN)
: REFRIGERANT FLOW DIRECTION (LESS)

FIG. 11

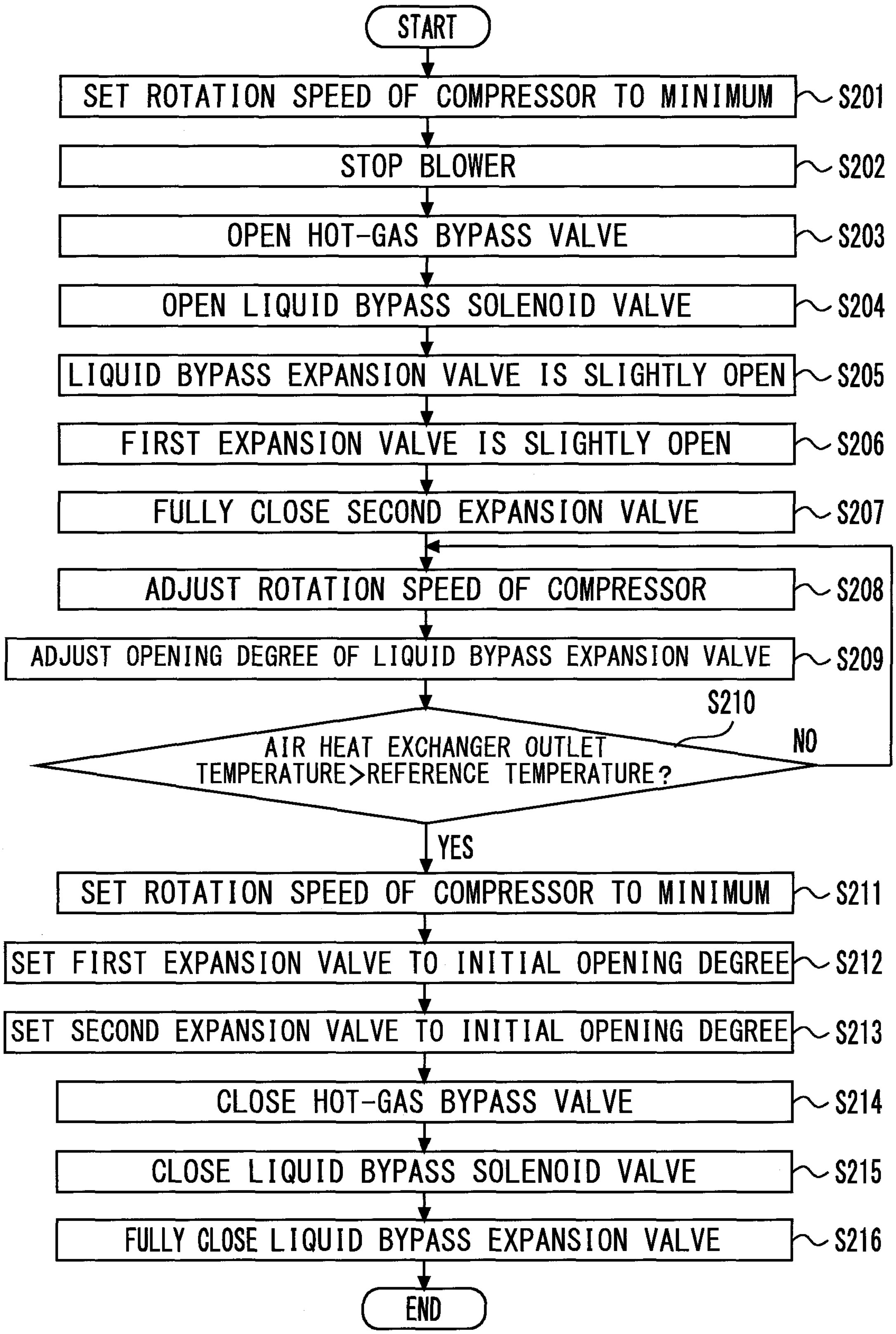
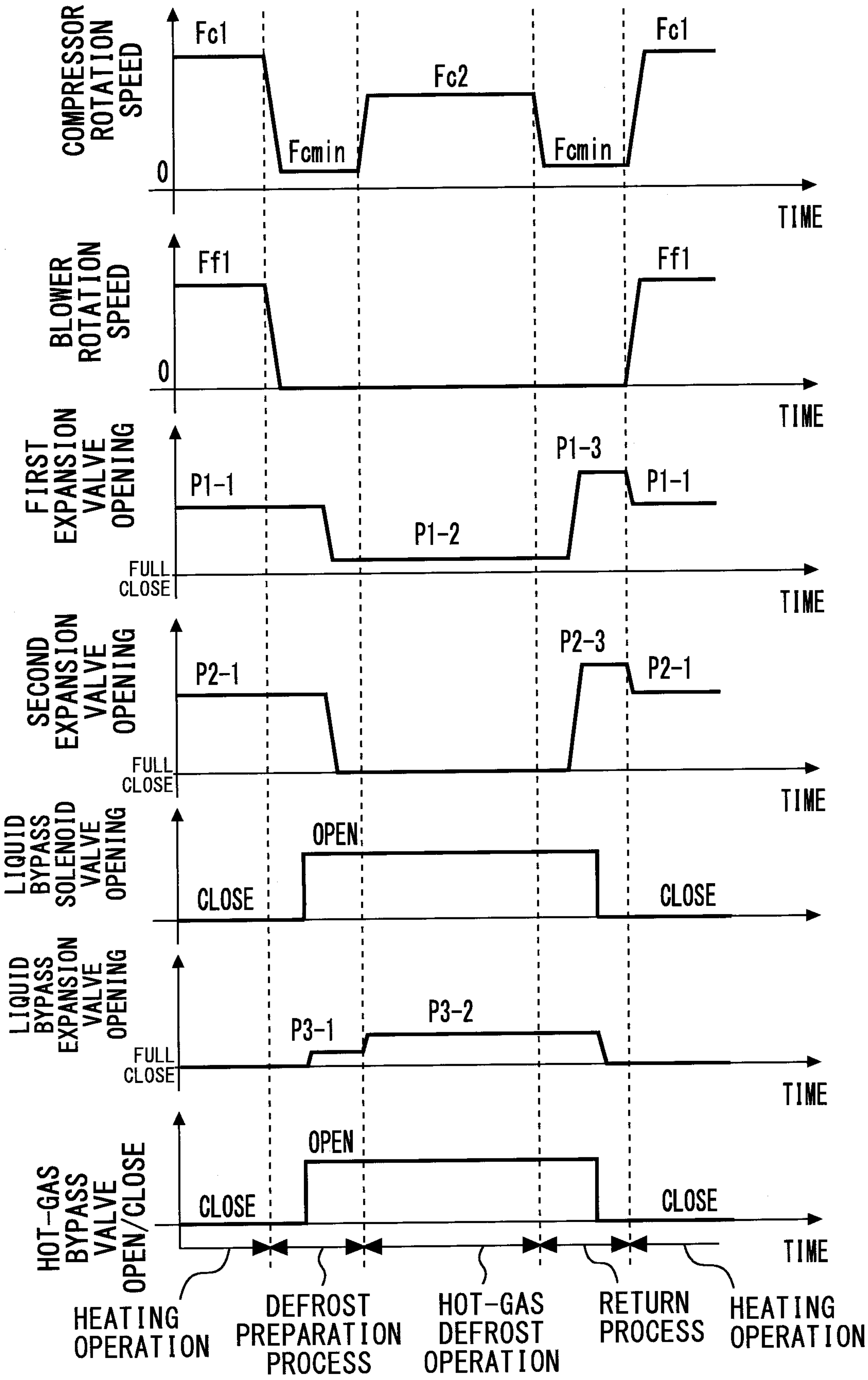

START
SET ROTATION SPEED OF COMPRESSOR TO MINIMUM
S201
STOP BLOWER
S202
OPEN HOT-GAS BYPASS VALVE
S203
OPEN LIQUID BYPASS SOLENOID VALVE
S204
LIQUID BYPASS EXPANSION VALVE IS SLIGHTLY OPEN
S205
FIRST EXPANSION VALVE IS SLIGHTLY OPEN
S206
FULLY CLOSE SECOND EXPANSION VALVE
S207
ADJUST ROTATION SPEED OF COMPRESSOR
S208
ADJUST OPENING DEGREE OF LIQUID BYPASS EXPANSION VALVE
S209
S210
AIR HEAT EXCHANGER OUTLET TEMPERATURE>REFERENCE TEMPERATURE?
NO
YES
SET ROTATION SPEED OF COMPRESSOR TO MINIMUM
S211
SET FIRST EXPANSION VALVE TO INITIAL OPENING DEGREE
S212
SET SECOND EXPANSION VALVE TO INITIAL OPENING DEGREE
S213
CLOSE HOT-GAS BYPASS VALVE
S214
CLOSE LIQUID BYPASS SOLENOID VALVE
S215
FULLY CLOSE LIQUID BYPASS EXPANSION VALVE
S216
END

FIG. 12


COMPRESSOR ROTATION SPEED
Fc1
Fcmin
Fc2
Fcmin
Fc1
0
TIME
BLOWER ROTATION SPEED
Ff1
Ff1
0
TIME
FIRST EXPANSION VALVE OPENING
P1-1
P1-2
P1-3
P1-1
FULL CLOSE
TIME
SECOND EXPANSION VALVE OPENING
P2-1
P2-3
P2-1
FULL CLOSE
TIME
LIQUID BYPASS SOLENOID VALVE OPENING
CLOSE
OPEN
CLOSE
LIQUID BYPASS EXPANSION VALVE OPENING
P3-1
P3-2
FULL CLOSE
TIME
HOT-GAS BYPASS VALVE OPEN/CLOSE
CLOSE
OPEN
CLOSE
TIME
HEATING OPERATION
DEFROST PREPARATION PROCESS
HOT-GAS DEFROST OPERATION
RETURN PROCESS
HEATING OPERATION

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/038476

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B1/00(2006.01)i, F25B47/02(2006.01)i
FI: F25B1/00 101J, F25B47/02 530D

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)
Int. Cl. F25B1/00, F25B47/02

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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 2002-98451 A (DENSO CORP.) 05 April 2002, paragraphs [0011]-[0034], fig. 1, 2	1-13
Y	JP 2010-164257 A (MITSUBISHI ELECTRIC CORP.) 29 July 2010, paragraphs [0014]-[0062], fig. 1-8	1-13
Y	WO 2017/085812 A1 (MITSUBISHI ELECTRIC CORP.) 26 May 2017, paragraphs [0062]-[0083], fig. 10	11-13
Y	WO 2009/001535 A1 (PANASONIC CORP.) 31 December 2008, paragraphs [0009]-[0024], fig. 1	11-13
Y	JP 2018-87676 A (DAIKIN INDUSTRIES, LTD.) 07 June 2018, fig. 1	12-13

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

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Date of the actual completion of the international search	Date of mailing of the international search report
24.11.2020	08.12.2020

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

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2020/038476

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2019-15434 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 31 January 2019, fig. 3	12-13

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/038476

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2002-98451 A	05.04.2002	(Family: none)	
JP 2010-164257 A	29.07.2010	(Family: none)	
WO 2017/085812 A1	26.05.2017	GB 2559496 A paragraphs [0062]-[0083], fig. 10	
WO 2009/001535 A1	31.12.2008	US 2010/0229583 A1 paragraphs [0016]-[0031], fig. 1 US 2014/0000308 A1 EP 2096378 A1 CN 101542218 A	
JP 2018-87676 A	07.06.2018	(Family: none)	
JP 2019-15434 A	31.01.2019	EP 3425309 A1 fig. 3	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP H6347143 A **[0003]**