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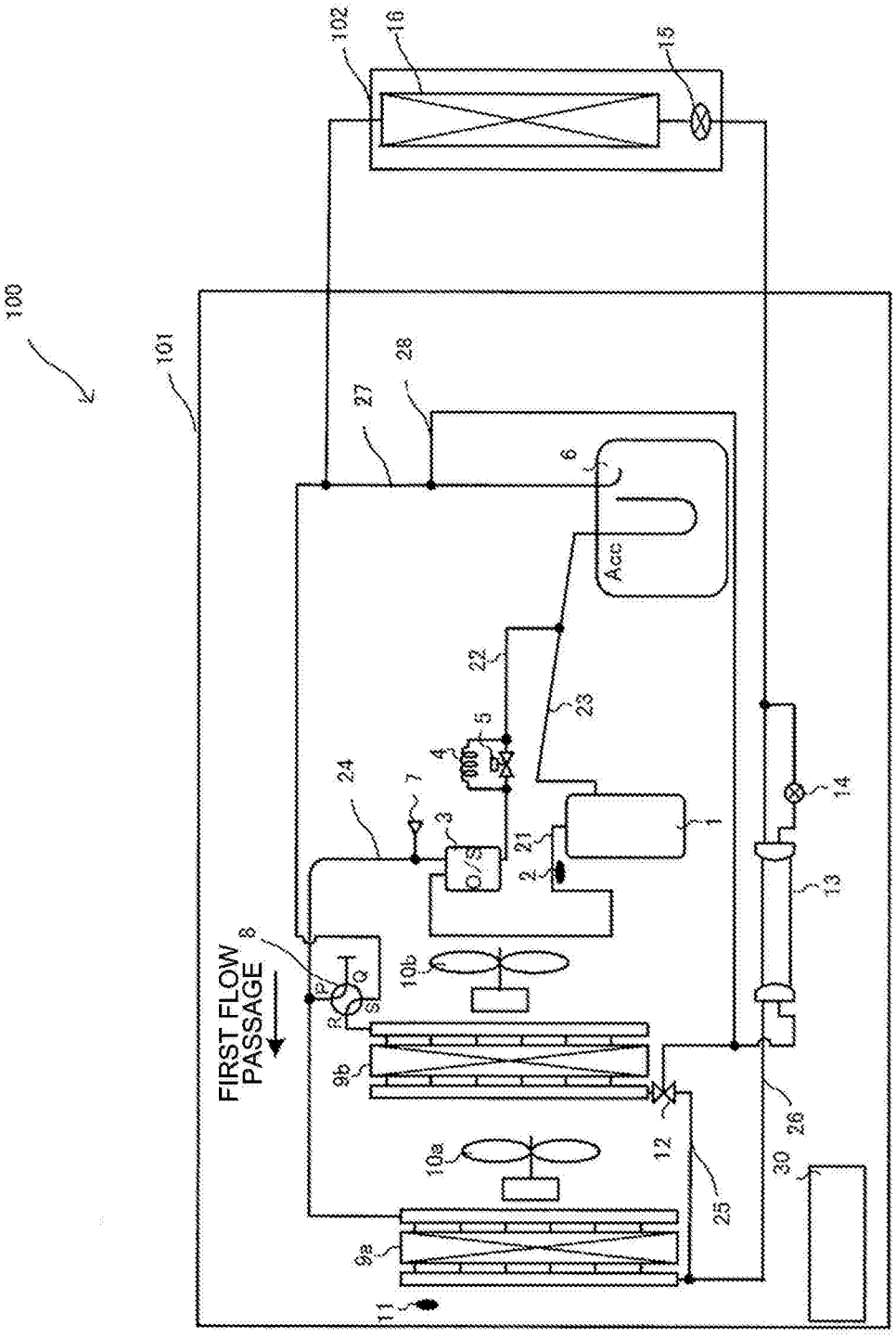

100
101
102
16
15
28
27
6
Acc
22
23
5
4
24
7
3
1
21
2
14
13
8
FIRST FLOW PASSAGE
10b
9b
10a
9a
12
25
26
30
11

FIG. 1

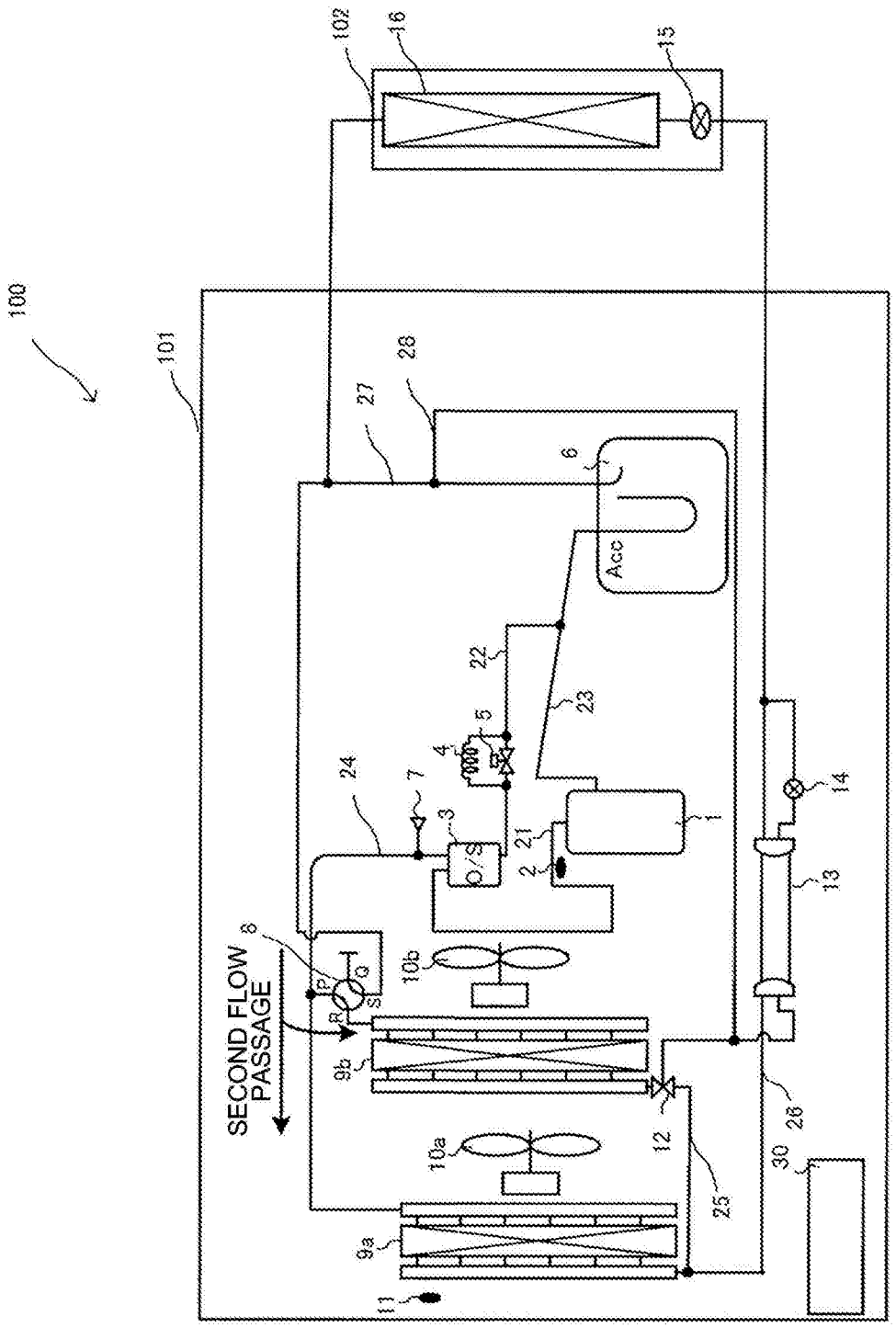

100
101
102
16
15
28
27
6
Acc
22
23
5
4
24
7
3
21
1
14
13
2
O/S
8
P
R
S
10b
SECOND FLOW PASSAGE
9b
12
28
30
10a
25
9a
11

FIG. 2

FIG. 3

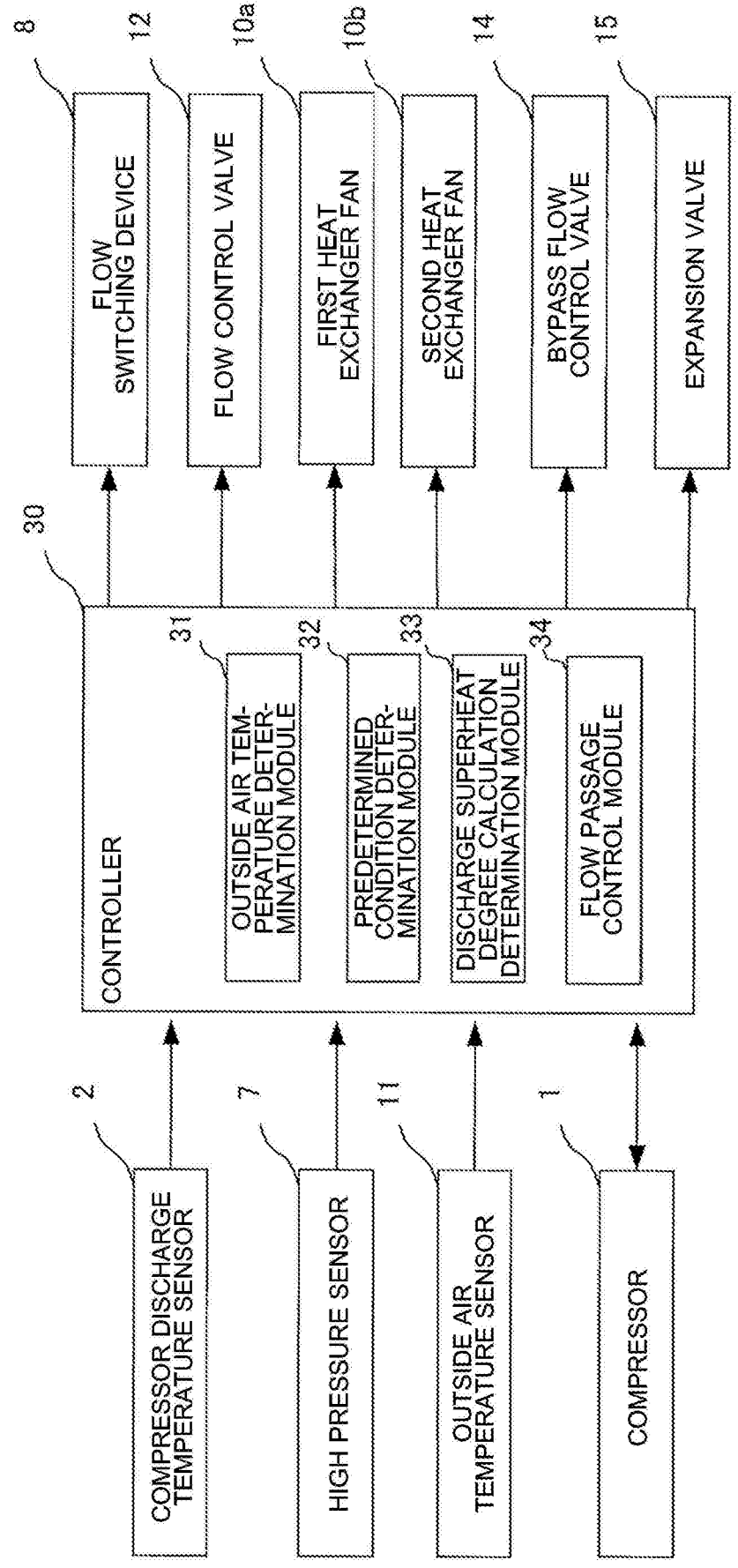

8
FLOW SWITCHING DEVICE
12
FLOW CONTROL VALVE
10a
FIRST HEAT EXCHANGER FAN
10b
SECOND HEAT EXCHANGER FAN
14
BYPASS FLOW CONTROL VALVE
15
EXPANSION VALVE
30
CONTROLLER
31
OUTSIDE AIR TEMPERATURE DETERMINATION MODULE
32
PREDETERMINED CONDITION DETERMINATION MODULE
33
DISCHARGE SUPERHEAT DEGREE CALCULATION DETERMINATION MODULE
34
FLOW PASSAGE CONTROL MODULE
2
COMPRESSOR DISCHARGE TEMPERATURE SENSOR
7
HIGH PRESSURE SENSOR
11
OUTSIDE AIR TEMPERATURE SENSOR
1
COMPRESSOR

FIG. 4

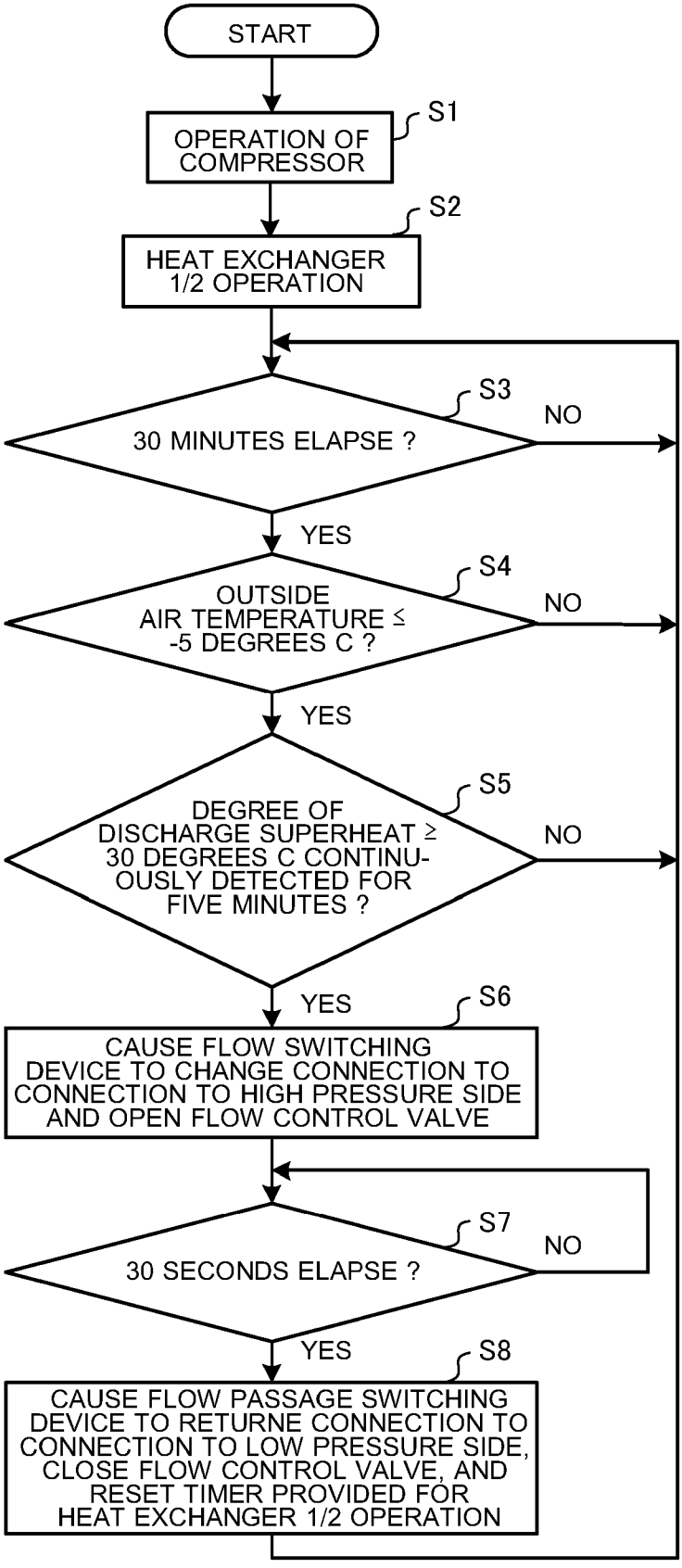

START
OPERATION OF COMPRESSOR
S1
HEAT EXCHANGER 1/2 OPERATION
S2
30 MINUTES ELAPSE ?
S3
NO
YES
OUTSIDE AIR TEMPERATURE ≤ -5 DEGREES C ?
S4
NO
YES
DEGREE OF DISCHARGE SUPERHEAT ≥ 30 DEGREES C CONTINU-OUSLY DETECTED FOR FIVE MINUTES ?
S5
NO
YES
CAUSE FLOW SWITCHING DEVICE TO CHANGE CONNECTION TO CONNECTION TO HIGH PRESSURE SIDE AND OPEN FLOW CONTROL VALVE
S6
30 SECONDS ELAPSE ?
S7
NO
YES
CAUSE FLOW PASSAGE SWITCHING DEVICE TO RETURNE CONNECTION TO CONNECTION TO LOW PRESSURE SIDE, CLOSE FLOW CONTROL VALVE, AND RESET TIMER PROVIDED FOR HEAT EXCHANGER 1/2 OPERATION
S8

FIG. 5

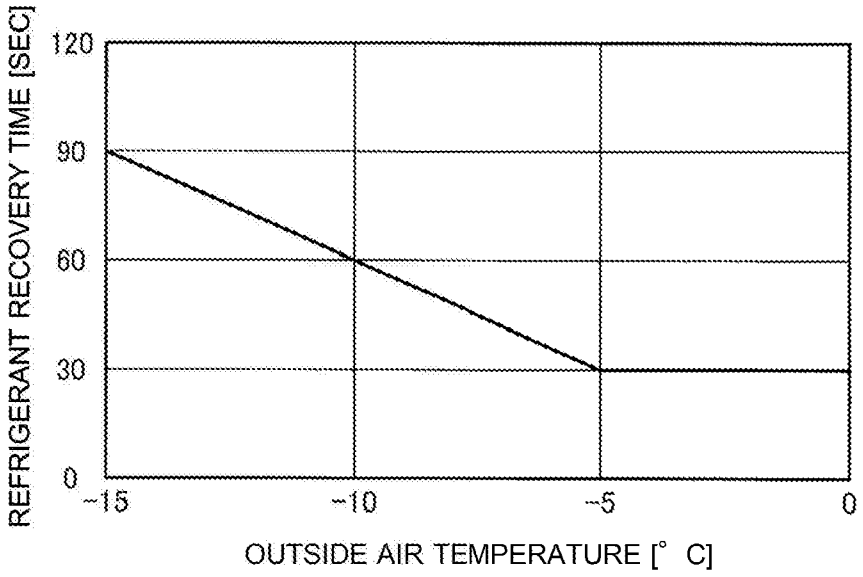
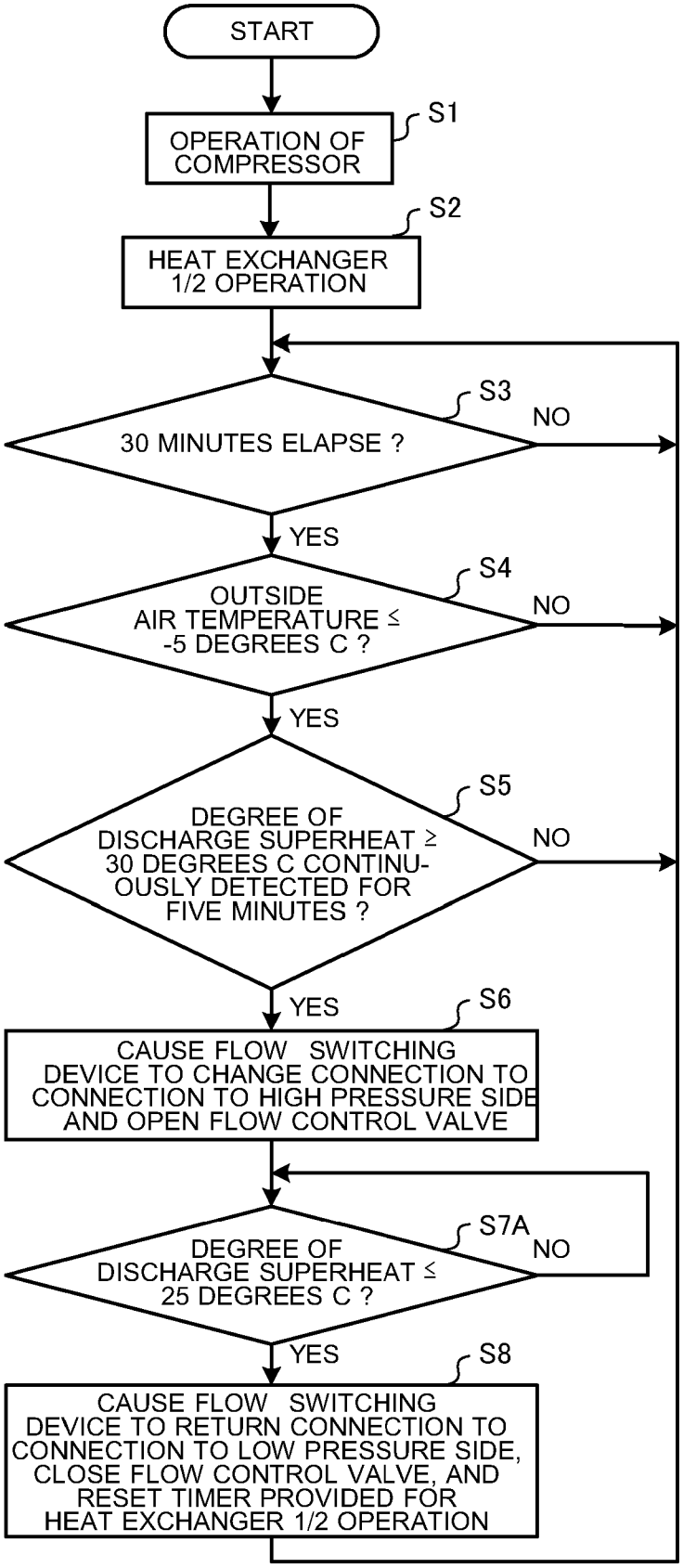

REFRIGERANT RECOVERY TIME [SEC]
120
90
60
30
0
−15
−10
−5
0
OUTSIDE AIR TEMPERATURE [° C]

FIG. 6


START
OPERATION OF COMPRESSOR
S1
HEAT EXCHANGER 1/2 OPERATION
S2
30 MINUTES ELAPSE ?
S3
NO
YES
OUTSIDE AIR TEMPERATURE ≤ -5 DEGREES C ?
S4
NO
YES
DEGREE OF DISCHARGE SUPERHEAT ≥ 30 DEGREES C CONTINUOUSLY DETECTED FOR FIVE MINUTES ?
S5
NO
YES
CAUSE FLOW SWITCHING DEVICE TO CHANGE CONNECTION TO CONNECTION TO HIGH PRESSURE SIDE AND OPEN FLOW CONTROL VALVE
S6
DEGREE OF DISCHARGE SUPERHEAT ≤ 25 DEGREES C ?
S7A
NO
YES
CAUSE FLOW SWITCHING DEVICE TO RETURN CONNECTION TO CONNECTION TO LOW PRESSURE SIDE, CLOSE FLOW CONTROL VALVE, AND RESET TIMER PROVIDED FOR HEAT EXCHANGER 1/2 OPERATION
S8

DESCRIPTION

Title of Invention

AIR-CONDITIONING APPARATUS

Technical Field

[0001]

The present disclosure relates to an air-conditioning apparatus that includes a plurality of heat exchangers.

Background Art

[0002]

When a cooling operation is performed under a condition that the temperature of outside air around an outdoor unit is not high, condensers in the outdoor unit do not require a heat exchange capacity. In such a case, the condensers of the outdoor unit are controlled such that the heat exchange capacity is reduced to maintain an operating range of the compressor for high pressure and low pressure.

[0003]

For example, the heat exchange capacity is controlled to be reduced such that flow passages for refrigerant to all condensers connected in parallel in the outdoor unit are shut except for one or more condensers, thereby reducing the volume of the condensers in the outdoor unit as a whole (see Patent Literature 1, for example).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2014-214951

Summary of Invention

Technical Problem

[0005]

A condenser to which a flow passage for refrigerant is shut (which will hereinafter be referred to as “non-functioning condenser” is connected to a low-pressure side, for the recovery of refrigerant remaining in the non-functioning condenser. However, in a

cooling operation under a condition that the temperature of outdoor air is lower than or equal to the freezing point of water, the saturation pressure of refrigerant in the non-functioning condenser may become lower than the pressure on the suction side of the compressor. As a result, refrigerant remaining in the non-functioning condenser is not recovered to the compressor, that is, the refrigerant remains in the non-functioning condenser.

[0006]

The present disclosure is applied in view of the above circumstances, and relates to the air-conditioning apparatus. In a cooling operation that is performed under a condition that the temperature of outside air around an outdoor unit including a plurality of heat exchangers is at or below the freezing point of water, in the case where of the plurality of heat exchangers, a heat exchanger does not operate as a condenser because a flow passage for refrigerant is shut, the air-conditioning apparatus can release refrigerant that remains in the heat exchanger not operating as a condenser, from the heat exchanger to a refrigerant circuit.

Solution to Problem

[0007]

An air-conditioning apparatus according to an embodiment of the present disclosure includes: a compressor that compresses refrigerant; a high-pressure-side pipe through which the refrigerant discharged from the compressor flows; a first heat exchanger that is connected to the high-pressure-side pipe, and operates as a condenser; a second heat exchanger that is connected to the high-pressure-side pipe and the first heat exchanger, and operates as a condenser, the second heat exchanger being connected to the first heat exchanger in parallel; a flow switching device that is connected to the high-pressure-side pipe and the second heat exchanger, and switches a flow passage for refrigerant between a first flow passage and a second flow passage, the first flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger via the high-pressure-side pipe and not allowing the refrigerant discharged from the compressor to the second heat exchanger, the second flow passage allowing the refrigerant discharged from the compressor to be supplied to

the first heat exchanger and the second heat exchanger via the high-pressure-side pipe; a flow control valve connected to an outlet of the second heat exchanger for the refrigerant; a refrigerant circuit pipe connected to an outlet of the first heat exchanger for the refrigerant and to the flow control valve; an outside air temperature sensor that measures an outside air temperature; and a controller that controls the flow switching device and the flow control valve. The refrigerant circuit pipe connects the first heat exchanger and the second heat exchanger of a refrigerant circuit to an expansion valve of the refrigerant circuit. The refrigerant circuit is provided as a circuit in which the refrigerant circulates through the compressor, the flow switching device, the first heat exchanger, the second heat exchanger, the flow control valve, the expansion valve, and an evaporator of an indoor unit. The controller determines whether or not, in the case where the flow switching device switches the flow passage for refrigerant to the first flow passage, a predetermined condition is satisfied that the outside air temperature measured by the outside air temperature sensor is lower than or equal to a first temperature that is lower than or equal to the freezing point of water and a degree of discharge superheat of the compressor is higher than or equal to a first degree of discharge superheat. When determining that the predetermined condition is satisfied, the controller performs control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, thereby causing the refrigerant remaining in the second heat exchanger to flow into the refrigerant circuit pipe.

Advantageous Effects of Invention

[0008]

According to the embodiment of the present disclosure, in the case where the flow switching device switches the flow passage for refrigerant to the first flow passage and the flow control valve that is associated with the second heat exchanger is in a closed state, when the predetermined condition is satisfied, the controller determines that refrigerant remains the second heat exchanger. In such a case, the flow switching device is caused to switch the flow passage for refrigerant to the second flow passage and the flow control valve is opened, thereby connecting the second heat exchanger to

the high-pressure-side pipe, and causing the refrigerant remaining in the second heat exchanger to flow into a pipe that is included in the refrigerant circuit. Because of such operations, it is possible to release refrigerant remaining in the second heat exchanger therefrom to the refrigerant circuit.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a diagram illustrating a configuration of a refrigerant circuit of an air-conditioning apparatus according to Embodiment 1.

[Fig. 2] Fig. 2 is a diagram illustrating a case where a flow switching device of the air-conditioning apparatus according to Embodiment 1 switches a flow passage for refrigerant to a second flow passage.

[Fig. 3] Fig. 3 is a block diagram illustrating functions of a controller of the air-conditioning apparatus according to Embodiment 1.

[Fig. 4] Fig. 4 is a flowchart for explanation of an operation of an outdoor unit of the air-conditioning apparatus according to Embodiment 1.

[Fig. 5] Fig. 5 is a graph for explanation of a refrigerant recovery time period in an air-conditioning apparatus according to Embodiment 2.

[Fig. 6] Fig. 6 is a flowchart for explanation of an operation of an outdoor unit of an air-conditioning apparatus according to Embodiment 3.

Description of Embodiments

[0010]

An air-conditioning apparatus according to Embodiment will be described with reference to the drawings. It should be noted that in each of figures, components that are the same as those in a previous figure or previous figures are denoted by the same reference signs, and their descriptions will thus be omitted, except for the case where a description or descriptions need to be made.

[0011]

Embodiment 1

Fig. 1 is a diagram illustrating a configuration of a refrigerant circuit of an air-conditioning apparatus 100 according to Embodiment 1. Fig. 1 also illustrates a

configuration of a flow passage in the case where the temperature of outside air around an outdoor unit 101 of the air-conditioning apparatus 100 is -15 degrees C, for example.

[0012]

A circuit configuration of the air-conditioning apparatus 100 will be described with reference to Fig. 1. The air-conditioning apparatus 100 performs a cooling operation using a refrigeration cycle circuit (heat pump cycle circuit) that circulates refrigerant. In figures including Fig. 1 that will be referred to below, relationships in size between components may differ from those between actual components.

[0013]

As illustrated in Fig. 1, the air-conditioning apparatus 100 includes the outdoor unit 101 and an indoor unit 102. The outdoor unit 101 includes a compressor 1, a compressor discharge temperature sensor 2, an oil separator 3, an oil return bypass capillary 4, an oil return bypass solenoid valve 5, an accumulator 6, a high pressure sensor 7, a flow switching device 8, a first heat exchanger 9a, a second heat exchanger 9b, a first heat exchanger fan 10a, a second heat exchanger fan 10b, an outside air temperature sensor 11, a flow control valve 12, a high-low pressure heat exchanger 13, a bypass flow control valve 14, and a controller 30.

[0014]

The compressor 1 includes an inverter circuit, and the rotation speed of the compressor 1 is controlled by conversion of a power-supply frequency by the inverter circuit, whereby the capacity of the compressor is controlled. The compressor 1 compresses sucked refrigerant to change it to a high-temperature and high-pressure refrigerant. The compressor 1 is connected to the oil separator 3 by a high-pressure-side pipe 21.

[0015]

The compressor discharge temperature sensor 2 is provided at the high-pressure-side pipe 21, and measures the discharge temperature of refrigerant discharged from the compressor 1.

[0016]

The oil separator 3 is provided on the discharge side of the compressor 1, and has a function of separating a refrigerating machine oil component from a refrigerant gas that is discharged from the compressor 1 and mixed with refrigerating machine oil. A pipe 22 is connected to an outlet of the oil separator 3 for refrigerating machine oil separated by the oil separator 3. The pipe 22 is connected to an intermediate portion of a pipe 23. The pipe 23 connects a suction port of the compressor 1 with the accumulator 6. At the pipe 22, the oil return bypass capillary 4 and the oil return bypass solenoid valve 5 are provided.

[0017]

The oil return bypass capillary 4 is provided to connect an upstream side and a downstream side of the oil return bypass solenoid valve 5 and bypass the oil return bypass solenoid valve 5. The oil return bypass capillary 4 adjusts the flow rate of refrigerating machine oil that passes through the pipe 22. The oil return bypass solenoid valve 5 are controlled to be opened or closed, whereby the oil return bypass solenoid valve 5 adjusts along with the oil return bypass capillary 4, the flow rate of refrigerating machine oil.

[0018]

The accumulator 6 is provided on the suction side of the compressor 1, and stores surplus refrigerant that circulates in the refrigerant circuit of the air-conditioning apparatus 100.

[0019]

The high pressure sensor 7 is provided at a high-pressure-side pipe 24. The high-pressure-side pipe 24 connects an outlet of the oil separator 3 for a refrigerant gas separated by the oil separator 3 with an inlet of the flow switching device 8 for refrigerant and an inlet of the first heat exchanger 9a for refrigerant. The high pressure sensor 7 measures the pressure (high pressure) of refrigerant that is discharged from the compressor 1 and flows through the high-pressure-side pipe 24 toward the flow switching device 8 and the first heat exchanger 9a.

[0020]

The flow switching device 8 is connected to the high-pressure-side pipe 24, which is located between the oil separator 3 and the first heat exchanger 9a and the second heat exchanger 9b. Specifically, a port P of the flow switching device 8 is connected to the high-pressure-side pipe 24, and a port Q of the flow switching device 8 is sealed. A port R of the flow switching device 8 is connected to the inlet of the second heat exchanger 9b for refrigerant, and a port S of the flow switching device 8 is connected to a pipe 27. The pipe 27 connects the port S of the flow switching device 8 and the accumulator 6. Under a control by the controller 30, the flow switching device 8 switches a flow passage for refrigerant that flows through the high-pressure-side pipe 24 between a first flow passage and a second flow passage. The first flow passage is a flow passage through which refrigerant discharged from the compressor 1 is supplied to the first heat exchanger 9a, but is not supplied to the second heat exchanger 9b. Specifically, as illustrated in Fig. 1, under the control by the controller 30, the port P and the port Q of the flow switching device 8 are connected with each other, and the port R and the port S of the flow switching device 8 are connected with each other. The second flow passage is a flow passage through refrigerant discharged from the compressor 1 is supplied to the first heat exchanger 9a and the second heat exchanger 9b. Fig. 2 is a diagram illustrating the case where the flow switching device 8 of the air-conditioning apparatus 100 according to Embodiment 1 switches the flow passage for the refrigerant to the second flow passage. Specifically, as illustrated in Fig. 2, under the control by the controller 30, the flow switching device 8 connects the port P and the port R of the flow switching device 8, and connects the port Q and the port S of the flow switching device 8.

[0021]

The first heat exchanger 9a and the second heat exchanger 9b are connected in parallel, and operate as condensers. The first heat exchanger 9a and the second heat exchanger 9b cause heat exchange to be performed between outside air and compressed refrigerant that flows in the first heat exchanger 9a and the second heat exchanger 9b, respectively. In the case where the flow switching device 8 switches the flow passage for refrigerant to the first flow passage, refrigerant (high pressure

refrigerant) that flows through the high-pressure-side pipe 24 is supplied to the first heat exchanger 9a, but is not supplied to the second heat exchanger 9b. That is, in the case where the flow passage for refrigerant is switched to the first flow passage, the second heat exchanger 9b does not operate as a condenser.

[0022]

It should be noted that regarding Embodiment 1, the above description is made with respect to the case where the first heat exchanger 9a and the second heat exchanger 9b are connected in parallel. However, three or more heat exchangers that operate as condensers may be connected in parallel. In this case, to the inlet and the outlet of each of the heat exchangers except for one heat exchanger, the flow switching device 8 and the flow control valve 12 are connected, respectively, as in the second heat exchanger 9b.

[0023]

In the case where the flow switching device 8 switches the flow passage for refrigerant to the second flow passage, refrigerant that flows through the high-pressure-side pipe 24 is supplied to the first heat exchanger 9a and the second heat exchanger 9b. To the outlet (high pressure) of the first heat exchanger 9a for refrigerant, a refrigerant circuit pipe 26 is connected. The refrigerant circuit pipe 26 connects the outlet of the first heat exchanger 9a to the pipe 27 via the high-low pressure heat exchanger 13 and an expansion valve 15 and an indoor heat exchanger 16 of the indoor unit 102. The outlet of the second heat exchanger 9b for refrigerant is connected to a refrigerant circuit pipe 25. At the refrigerant circuit pipe 25, the flow control valve 12 is provided. The refrigerant circuit pipe 25 is connected to the refrigerant circuit pipe 26 at a position that is located upstream of the high-low pressure heat exchanger 13, the refrigerant circuit pipe 26 being connected to the outlet of the first heat exchanger 9a.

[0024]

The first heat exchanger fan 10a sends outdoor air to the first heat exchanger 9a under control by the controller 30 to adjust the amount of heat exchange at the first heat exchanger 9a. The second heat exchanger fan 10b sends outdoor air to the second

heat exchanger 9b in response to an instruction from the controller 30 to adjust the amount of heat exchange at the second heat exchanger 9b.

[0025]

The outside air temperature sensor 11 measures the temperature of outside air around the outdoor unit 101.

[0026]

Under control by the controller 30, the flow control valve 12 prevents refrigerant from flowing from the outlet (high pressure) of the second heat exchanger 9b into the refrigerant circuit pipe 25. Specifically, in the case where the flow control valve 12 is in an opened state, refrigerant that flows in the second heat exchanger 9b flows through the refrigerant circuit pipe 25, and joins in the refrigerant circuit pipe 26, refrigerant that flows in the first heat exchanger 9a. In the case where the flow control valve 12 is in a closed state, refrigerant in the second heat exchanger 9b does not flow into the refrigerant circuit pipe 25.

[0027]

A bypass pipe 28 is connected to the pipe 27, which is located upstream of the accumulator 6. At the bypass pipe 28, the high-low pressure heat exchanger 13 and the bypass flow control valve 14 are provided.

[0028]

Refrigerant that flows through the refrigerant circuit pipe 26 branches into refrigerants, and one of the refrigerants flows into the bypass pipe 28. The refrigerant that flowed into the bypass pipe 28 passes through the bypass flow control valve 14 and flows into the high-low pressure heat exchanger 13. The high-low pressure heat exchanger 13 causes heat exchange to be performed between refrigerant that flows through the refrigerant circuit pipe 26 and refrigerant that flows through the bypass pipe 28 toward the accumulator 6. The bypass flow control valve 14 serves as a pressure reducing valve or an expansion valve, and expands refrigerant by reducing the pressure of the refrigerant. The bypass flow control valve 14 may be a valve whose opening degree can be variably controlled, for example, an electronic expansion valve or other valves.

[0029]

The indoor unit 102 includes the expansion valve 15 and the indoor heat exchanger 16.

[0030]

The expansion valve 15 is connected to the refrigerant circuit pipe 26, and serves as an expansion valve for refrigerant that flows through the refrigerant circuit pipe 26.

[0031]

The indoor heat exchanger 16 is connected to the refrigerant circuit pipe 26 at a position that is located downstream of the expansion valve 15. The indoor heat exchanger 16 causes heat exchange to be performed between indoor air and refrigerant that flows through the refrigerant circuit pipe 26. The refrigerant circuit pipe 26 is connected to the pipe 27. The refrigerant that has flowed through the refrigerant circuit pipe 26 and has been subjected to heat exchange at the indoor heat exchanger 16 flows through the pipe 27 and is stored in the accumulator 6.

[0032]

In the refrigerant circuit of the air-conditioning apparatus 100, the compressor 1, the oil separator 3, the flow switching device 8, the first heat exchanger 9a (or the second heat exchanger 9b and the flow control valve 12), the high-low pressure heat exchanger 13, the expansion valve 15, the indoor heat exchanger 16, and the accumulator 6 are connected such that refrigerant flows through the compressor 1, the oil separator 3, the flow switching device 8, the first heat exchanger 9a (or the second heat exchanger 9b and the flow control valve 12), the high-low pressure heat exchanger 13, the expansion valve 15, the indoor heat exchanger 16, and the accumulator 6 in this order. Of refrigerants into which refrigerant flowing through the refrigerant circuit pipe 26 branches, refrigerant that flows into the bypass pipe 28 flows through the bypass flow control valve 14, the high-low pressure heat exchanger 13, and the accumulator 6 in this order.

[0033]

The controller 30 controls the entire air-conditioning apparatus 100. The controller 30 controls the flow switching device 8, the first heat exchanger fan 10a, the

second heat exchanger fan 10b, the flow control valve 12, the bypass flow control valve 14, and the expansion valve 15 based on the outside air temperature measured by the outside air temperature sensor 11, the discharge temperature of refrigerant discharged from the compressor 1, which is measured by the compressor discharge temperature sensor 2, and the pressure of refrigerant discharged from the compressor 1 and flowing to the flow switching device 8, which is measured by the high pressure sensor 7.

[0034]

Fig. 3 is a block diagram illustrating functions of the controller 30 of the air-conditioning apparatus 100 according to Embodiment 1.

[0035]

As illustrated in Fig. 3, the controller 30 includes an outside air temperature determination module 31, a predetermined condition determination module 32, a discharge superheat degree calculation determination module 33, and a flow passage control module 34.

[0036]

The outside air temperature determination module 31 determines whether or not the outside air temperature measured by the outside air temperature sensor 11 is a predetermined temperature. For example, the outside air temperature determination module 31 determines whether or not the outside air temperature is a first temperature (for example, -5 degrees C).

[0037]

The predetermined condition determination module 32 determines whether or not a predetermined condition is satisfied based on the outside air temperature measured by the outside air temperature sensor 11 and the discharge pressure measured by the compressor discharge temperature sensor 2. It should be noted that the "predetermined condition" is a condition that it is continuously detected for five minutes that the degree of discharge superheat of the compressor 1 is higher than or equal to a set degree of discharge superheat (for example, 30 degrees C), and that the outside air temperature measured by the outside air temperature sensor 11 is lower than or equal to the first temperature (for example, -5 degrees C).

[0038]

The discharge superheat degree calculation determination module 33 calculates the degree of discharge superheat of the compressor 1 based on the discharge temperature of the compressor 1 that is measured by the compressor discharge temperature sensor 2 and a saturation temperature of refrigerant that is calculated using a pressure measured by the high pressure sensor 7. The discharge superheat degree calculation determination module 33 detects that it is continuously detected for five minutes that the calculated degree of discharge superheat is higher than or equal to a predetermined degree of discharge superheat (for example, 30 degrees C).

[0039]

The flow passage control module 34 controls the flow switching device 8, the flow control valve 12, the first heat exchanger fan 10a, and the second heat exchanger fan 10b based on the result of the determination by the outside air temperature determination module 31 and the result of the determination by the predetermined condition determination module 32.

[0040]

The controller 30 is dedicated hardware or a central processing unit (also referred to as a CPU, a processing unit, an arithmetic unit, a microprocessor, a microcomputer, or a processor) that executes a program stored in a memory.

[0041]

In the case where the controller 30 is dedicated hardware, for example, the controller 30 corresponds to a single circuit, a composite circuit, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), or a combination of these circuits. Each of function modules of the controller 30 may be individual hardware, or the function modules may be single hardware.

[0042]

In the case where the controller 30 is a CPU, functions to be fulfilled by the controller 30 are fulfilled by software, firmware, or a combination of the software and the firmware. The software and the firmware are each described as a program, and are stored in the memory. The CPU reads and executes each of the programs stored in

the memory to fulfill an associated one of the functions of the controller 30. The memory may be, for example, a nonvolatile or volatile semiconductor memory, such as a RAM, a ROM, a flash memory, an EPROM, or an EEPROM.

[0043]

The controller 30 may be configured such that some of the functions of the controller 30 are fulfilled by dedicated hardware, and some of the functions of the controller 30 are fulfilled by software or firmware.

[0044]

Fig. 4 is a flowchart for explanation of an operation of the outdoor unit 101 of the air-conditioning apparatus 100 according to Embodiment 1.

[0045]

When a cooling operation is started, the compressor 1 starts to operate (S1). At that time, the controller 30 performs control of causing the flow switching device 8 to switch the flow passage for refrigerant to the second flow passage, and control of opening the flow control valve 12. Refrigerant discharged from the compressor 1 circulates in such a manner as to flow through the oil separator 3, the first heat exchanger 9a, the second heat exchanger 9b, the high-low pressure heat exchanger 13, the expansion valve 15, the indoor heat exchanger 16, and the accumulator 6 and then returns to the compressor 1. Thereafter, the refrigerant discharged from the compressor 1 passes through the oil separator 3, the flow switching device 8, the second heat exchanger 9b, the flow control valve 12, and the refrigerant circuit pipe 25, and then joins refrigerant that passes through the first heat exchanger 9a and flows through the refrigerant circuit pipe 26.

[0046]

The controller 30 performs a heat-exchanger 1/2 operation in which only the first heat exchanger 9a is used and the second heat exchanger 9b is not used (S2).

[0047]

In the heat exchanger 1/2 operation in step S2, the controller 30 performs control of causing the flow switching device 8 to switch the flow passage for refrigerant to the first flow passage, and control of closing the flow control valve 12. Refrigerant

discharged from the compressor 1 circulates in such a manner as to flow through the oil separator 3, the first heat exchanger 9a, the high-low pressure heat exchanger 13, the expansion valve 15, the indoor heat exchanger 16, and the accumulator 6, and then returns to the compressor 1. The refrigerant discharged from the compressor 1 is not supplied to the second heat exchanger 9b, since the flow passage for refrigerant is switched to the first flow passage by the flow switching device 8. Furthermore, refrigerant does not flow out from the second heat exchanger 9b, since the flow control valve 12 is controlled to be in the closed state. That is, the flow control valve 12 closes the flow passage of the second heat exchanger 9b for refrigerant. In the heat exchanger 1/2 operation as illustrated in Fig. 1, refrigerant remains in the second heat exchanger 9b that does not operate as a condenser. In the case where refrigerant remains in the second heat exchanger 9b, the circulation amount of refrigerant is reduced, and the degree of discharge superheat of the compressor 1 is reduced to be low. At this time, the controller 30 operates the first heat exchanger fan 10a, but does not operate the second heat exchanger fan 10b.

[0048]

The controller 30 determines whether or not in the heat exchanger 1/2 operation not using the second heat exchanger 9b, 30 minutes elapse from the time at which the operation of the compressor 1 is started (S3). When determining in step S3 that 30 minutes do not elapse (NO in S3), the controller 30 continues to make determination in step S3. In contrast, when it is determined in step S3 that 30 minutes elapse (YES in S3), the process by the controller 30 proceeds the process of step S4. The time period to be set as a reference for the determination is 30 minutes for the following reason. In the outdoor unit 101 of the air-conditioning apparatus 100 of Embodiment 1, in 30 minutes, refrigerant remains in the second heat exchanger 9b and the circulation amount of refrigerant is reduced. In addition, if time shorter than 30 minutes is set as the reference, controls in the steps from step S4 onward may be frequently performed. In this case, each time the process proceeds to the controls from step S4 onward, the amount of heat exchange at the second heat exchanger 9b is increased and the

pressure is reduced, whereby the operation of the compressor 1 will be out of the operating range of the compressor 1.

[0049]

Next, the controller 30 determines whether or not the outside air temperature measured by the outside air temperature sensor 11 is lower than or equal to the first temperature (for example, -5 degrees C) (S4). When it is determined in step S4 that the outside air temperature measured by the outside air temperature sensor 11 is not lower than or equal to the first temperature (NO in S4), the process by the controller 30 returns to the process of step S3. By contrast, when it is determined in step S4 that the outside air temperature measured by the outside air temperature sensor 11 is lower than or equal to the first temperature (YES in S4), the process by the controller 30 proceeds to the process of step S5. The outside air temperature to be set as a reference for the determination is -5 degrees C for the following reason. In the outdoor unit 101 of the air-conditioning apparatus 100 of Embodiment 1, when the second heat exchanger 9b is cooled by outside air having a temperature of -5 degrees C or less, a pressure in the second heat exchanger 9b becomes lower than a pressure during the operation of the compressor 1. For this reason, an outside air temperature of -5 degrees C or less is set as a condition that refrigerant remains in the second heat exchanger 9b.

[0050]

In step S5, the controller 30 calculates the degree of discharge superheat of the compressor 1 based on the discharge temperature of the compressor 1 that is measured by the compressor discharge temperature sensor 2, and the saturation temperature of refrigerant that is calculated based the pressure measured by the high pressure sensor 7. Then, the controller 30 determines whether or not it is continuously detected for five minutes that the calculated degree of discharge superheat is higher than or equal to a predetermined degree of discharge superheat (for example, 30 degrees C). In step S5, when it is not continuously detected for five minutes that the degree of discharge superheat is higher than or equal to the predetermined degree of discharge superheat (NO in S5), the process by the controller 30 returns to the process

of step S3. By contrast, in step S5, when it is continuously detected for five minutes that the degree of discharge superheat is higher than or equal to the predetermined degree of discharge superheat (YES in S5), it is determined that refrigerant remains in the second heat exchanger 9b, and the process by the controller 30 proceeds to step S6. The condition that the above state is continuously detected for five minutes is set as a condition for making the above determination, for the following reason. In the case where it is transitionally detected that the degree of discharge superheat is 30 degrees C, this detection may be erroneous. Therefore, in order to prevent such erroneous detection, the above condition is set as the condition for making the above determination.

[0051]

In step S6, as illustrated in Fig. 2, the controller 30 causes the flow switching device 8 to switch the flow passage for refrigerant to the second flow passage to connect the second heat exchanger 9b to the high-pressure-side pipe 24 for high pressure. Furthermore, the controller 30 opens the flow control valve 12. Because of these controls, refrigerant that remains in the second heat exchanger 9b is released therefrom to the refrigerant circuit pipe 26 via the refrigerant circuit pipe 25. In addition, the controller 30 turns off the first heat exchanger fan 10a and the second heat exchanger fan 10b. It is therefore possible to reduce the electricity consumption of the first heat exchanger fan 10a and the second heat exchanger fan 10b.

[0052]

In step S7, the controller 30 determines whether or not a predetermined time period (for example, 30 seconds) elapses from the time at which the flow passage is changed by the flow switching device 8 and the flow control valve 12 under the control thereof in step S6 (S7). When it is determined in step S7 that 30 seconds do not elapse (NO in S7), the controller 30 continues to make determination in step S7. In contrast, when it is determined in step S7 that 30 seconds elapses (YES in S7), the process by the controller 30 proceeds to the process of step S8. The time period of 30 seconds is set as a reference for the determination for the following reason. In the outdoor unit 101 of the air-conditioning apparatus 100 of Embodiment 1, when the

second heat exchanger 9b is connected to the high-pressure side for more than 30 seconds, the amount of heat exchange at the second heat exchanger 9b that operates as a condenser increases, and the pressure on the high-pressure side drops.

[0053]

In step S8, as illustrated in Fig. 1, the controller 30 causes the flow switching device 8 to switch the flow passage for refrigerant to the first flow passage to connect the second heat exchanger 9b to the pipe 27 on the low-pressure side. Furthermore, the controller 30 closes the flow control valve 12. At that time, the first heat exchanger fan 10a and the second heat exchanger fan 10b are kept in the off state. In addition, the controller 30 resets a timer that measures time for which the 1/2 operation is performed (S8), and the process by the controller 30 returns to the process of step S3.

[0054]

In the outdoor unit 101 of the air-conditioning apparatus 100 according to Embodiment 1, the controller 30 determines whether or not the predetermined condition is satisfied based on the outside air temperature measured by the outside air temperature sensor 11, the pressure measured by the compressor discharge temperature sensor 2, and the pressure measured by the high pressure sensor 7. When determining that the predetermined condition is satisfied, the controller 30 determines that refrigerant remains in the second heat exchanger 9b, and causes the flow switching device 8 to switch the flow passage for refrigerant to the second flow passage and opens the flow control valve 12. Because of these controls, the high-pressure-side pipe 24 is connected to the second heat exchanger 9b, and refrigerant remaining in the second heat exchanger 9b is released therefrom to the refrigerant circuit through the refrigerant circuit pipe 25.

[0055]

Embodiment 2

Regarding Embodiment 1, the above description is made with respect to the case where after the elapse of 30 seconds in which refrigerant remaining in the second heat exchanger 9b is recovered, the operation to be performed is returned to the original

heat exchanger 1/2 operation. However, as the outside air temperature decreases, the amount of refrigerant remaining in the second heat exchanger 9b increases.

[0056]

In Embodiment 2, a refrigerant recovery time period in which refrigerant remaining in the second heat exchanger 9b is recovered is changed depending on the outside air temperature at the time of starting the control of the heat exchanger 1/2 operation.

[0057]

The refrigerant recovery time period is set to a time period in which a sufficient amount of refrigerant can be recovered. If a recovery time period in which remaining refrigerant is recovered to the refrigerant circuit is too long, the condensing capacity of the first heat exchanger 9a and the second heat exchanger 9b increases, and the pressure on the high-pressure side of the compressor 1 drops, as a result of which the operation of the compressor 1 will be out of the operating range of the compressor 1. The refrigerant recovery time period is determined in consideration of the above points.

[0058]

Fig. 5 is a diagram for explanation of the refrigerant recovery time period in the air-conditioning apparatus 100 according to Embodiment 2.

[0059]

As indicated in Fig. 5, the refrigerant recovery time period is set in proportion to the outside air temperature. In Fig. 5, for example, in the case where the outside air temperature at the time of starting the control of the heat exchanger 1/2 operation is -15 degrees C, the refrigerant recovery time period is set to 90 seconds. In the case where the outside air temperature is -10 degrees C, the refrigerant recovery time period is set to 60 seconds. In the case where the outside air temperature is -5 degrees C, the refrigerant recovery time period is set to 30 seconds.

[0060]

Therefore, in the outdoor unit 101 of the air-conditioning apparatus 100 according to Embodiment 2, it is possible to more appropriately recover refrigerant remaining in the second heat exchanger 9b than in Embodiment 1.

[0061]

Embodiment 3

Regarding Embodiment 2, the above description is made with respect to the case where the refrigerant recovery time period is set depending on the outside air temperature. This will be described in more detail regarding Embodiment 3. In Embodiment 3, the controller 30 may determine a refrigerant recovery time period based on the degree of discharge superheat of the compressor 1.

[0062]

Fig. 6 is a flowchart for explanation of the operation of the outdoor unit 101 of the air-conditioning apparatus 100 according to Embodiment 3.

[0063]

Operations in steps S1 to S6 and S8 as indicated in Fig. 6 are substantially the same as those in Fig. 4, and their descriptions will thus be omitted. Thus, regarding Embodiment 3, only the operation in step S7A that is different from that in Fig. 4 will be described.

[0064]

In step S7A, the controller 30 determines whether or not the degree of discharge superheat of the compressor 1 is lower than or equal to a predetermined degree of discharge superheat (for example, 25 degrees C) after the flow passage is changed by the flow switching device 8 and the flow control valve 12 under the controls thereof in step S6. When it is determined in step S7A that the degree of discharge superheat is not lower than or equal to 25 degrees C (NO in S7A), the controller 30 continues to make determination in step S7A. In contrast, when it is determined in step S7A that the degree of discharge superheat is lower than or equal to 25 degrees C (YES in S7A), the process by the controller 30 proceeds to the process of step S8.

[0065]

The embodiments are merely described as example, and the descriptions of the embodiments do not limit the scope of the embodiments. The embodiments can be variously modified in configuration, and various omissions, replacements, and changes may be made to the embodiments without departing from the gist thereof. The

embodiments to which omissions, replacements or changes are made, and such modifications of the embodiments fall within the scope and the gist of the embodiments.

Reference Signs List

[0066]

1: compressor, 2: compressor discharge temperature sensor, 3: oil separator, 4: oil return bypass capillary, 5: oil return bypass solenoid valve, 6: accumulator, 7: high pressure sensor, 8: flow switching device, 9: condenser, 9a: first heat exchanger, 9b: second heat exchanger, 10a: first heat exchanger fan, 10b: second heat exchanger fan, 11: outside air temperature sensor, 12: flow control valve, 13: high-low pressure heat exchanger, 14: bypass flow control valve, 15: expansion valve, 16: indoor heat exchanger, 21, 24: high-pressure-side pipe, 22, 23: pipe, 25, 26: refrigerant circuit pipe, 27, 28: pipe, 30: controller, 31: outside air temperature determination module, 32: predetermined condition determination module, 33: discharge superheat degree calculation determination module, 34: flow passage control module, 100: air-conditioning apparatus, 101: outdoor unit, 102: indoor unit.

CLAIMS

[Claim 1]

An air-conditioning apparatus comprising:

a compressor configured to compress refrigerant;

a high-pressure-side pipe through which the refrigerant discharged from the compressor flows;

a first heat exchanger connected to the high-pressure-side pipe, and configured to operate as a condenser;

a second heat exchanger connected to the high-pressure-side pipe and the first heat exchanger, and configured to operate as a condenser, the second heat exchanger being connected to the first heat exchanger in parallel;

a flow switching device connected to the high-pressure-side pipe and the second heat exchanger, and configured to switch a flow passage for refrigerant between a first flow passage and a second flow passage, the first flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger via the high-pressure-side pipe and not allowing the refrigerant discharged from the compressor to the second heat exchanger, the second flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger and the second heat exchanger via the high-pressure-side pipe;

a flow control valve connected to an outlet of the second heat exchanger for the refrigerant;

a refrigerant circuit pipe connected to an outlet of the first heat exchanger for the refrigerant and to the flow control valve;

an outside air temperature sensor configured to measure an outside air temperature; and

a controller configured to control the flow switching device and the flow control valve,

wherein

the refrigerant circuit pipe is a pipe that connects the first heat exchanger and the second heat exchanger of a refrigerant circuit to an expansion valve of the refrigerant

circuit, the refrigerant circuit being provided as a circuit in which the refrigerant circulates through the compressor, the flow switching device, the first heat exchanger, the second heat exchanger, the flow control valve, the expansion valve, and an evaporator of an indoor unit,

the controller is configured to determine whether or not, in a case where the flow switching device switches the flow passage for refrigerant to the first flow passage, a predetermined condition is satisfied that the outside air temperature measured by the outside air temperature sensor is lower than or equal to a first temperature that is lower than or equal to the freezing point of water and a degree of discharge superheat of the compressor is higher than or equal to a first degree of discharge superheat, and

the controller is configured to perform, when determining that the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, thereby causing the refrigerant remaining in the second heat exchanger to flow into the refrigerant circuit pipe.

[Claim 2]

The air-conditioning apparatus of claim 1, further comprising:

a compressor discharge temperature sensor configured to measure a discharge temperature of the refrigerant discharged from the compressor; and

a high pressure sensor configured to measure a pressure of the refrigerant discharged from the compressor and flowing toward the flow switching device,

wherein the degree of discharge superheat of the compressor is obtained based on the discharge temperature measured by the compressor discharge temperature sensor and the pressure measured by the high pressure sensor.

[Claim 3]

The air-conditioning apparatus of claim 1 or 2, wherein the controller is configured to perform, after the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, and then perform, after a predetermined time

period elapses, control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage and of closing the flow control valve.

[Claim 4]

The air-conditioning apparatus of claim 3, wherein the predetermined time period is set depending on the outside air temperature that is measured by the outside air temperature sensor when the predetermined condition is satisfied.

[Claim 5]

The air-conditioning apparatus of claim 1, wherein the controller is configured to perform, after the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, and then perform, in a case where the degree of discharge superheat of the compressor is lower than or equal to a second degree of discharge superheat, control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage and of closing the flow control valve.

[Claim 6]

The air-conditioning apparatus of any one of claims 1 to 5, further comprising:

a first heat exchanger fan configured to supply outdoor air to the first heat exchanger to adjust an amount of heat exchange thereat; and

a second heat exchanger fan configured to supply outdoor air to the second heat exchanger to adjust an amount of heat exchange thereat,

wherein the controller is configured to stop the first heat exchanger fan and the second heat exchanger fan in a case where the controller performs control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage.

ABSTRACT

An air-conditioning apparatus includes: a compressor that compresses refrigerant; a high-pressure-side pipe through which the refrigerant discharged from the compressor flows; a first heat exchanger that is connected to the high-pressure-side pipe, and operates as a condenser; a second heat exchanger that is connected to the high-pressure-side pipe and the first heat exchanger, and operates as a condenser, the second heat exchanger being connected to the first heat exchanger in parallel; a flow switching device that is connected to the high-pressure-side pipe and the second heat exchanger, and switches a flow passage for refrigerant between a first flow passage and a second flow passage, the first flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger via the high-pressure-side pipe and not allowing the refrigerant discharged from the compressor to the second heat exchanger, the second flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger and the second heat exchanger via the high-pressure-side pipe; a flow control valve connected to an outlet of the second heat exchanger for the refrigerant; a refrigerant circuit pipe connected to an outlet of the first heat exchanger for the refrigerant and to the flow control valve; an outside air temperature sensor that measures an outside air temperature; and a controller that controls the flow switching device and the flow control valve. The refrigerant circuit pipe connects the first heat exchanger and the second heat exchanger of a refrigerant circuit to an expansion valve of the refrigerant circuit. The refrigerant circuit is provided as a circuit in which the refrigerant circulates through the compressor, the flow switching device, the first heat exchanger, the second heat exchanger, the flow control valve, the expansion valve, and an evaporator of an indoor unit. The controller determines whether or not, in the case where the flow switching device switches the flow passage for refrigerant to the first flow passage, a predetermined condition is satisfied that the outside air temperature measured by the outside air temperature sensor is lower than or equal to a first temperature that is lower than or equal to the freezing point of water and a degree of discharge superheat of the compressor is higher than or equal to a first degree of discharge superheat. When determining that the

predetermined condition is satisfied, the controller performs control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, thereby causing the refrigerant remaining in the second heat exchanger to flow into the refrigerant circuit pipe.

CLAIMS

[Claim 1]

An air-conditioning apparatus comprising:

a compressor configured to compress refrigerant;

a high-pressure-side pipe through which the refrigerant discharged from the compressor flows;

a first heat exchanger connected to the high-pressure-side pipe, and configured to operate as a condenser;

a second heat exchanger connected to the high-pressure-side pipe and the first heat exchanger, and configured to operate as a condenser, the second heat exchanger being connected to the first heat exchanger in parallel;

a flow switching device connected to the high-pressure-side pipe and the second heat exchanger, and configured to switch a flow passage for refrigerant between a first flow passage and a second flow passage, the first flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger via the high-pressure-side pipe and not allowing the refrigerant discharged from the compressor to the second heat exchanger, the second flow passage allowing the refrigerant discharged from the compressor to be supplied to the first heat exchanger and the second heat exchanger via the high-pressure-side pipe;

a flow control valve connected to an outlet of the second heat exchanger for the refrigerant;

a refrigerant circuit pipe connected to an outlet of the first heat exchanger for the refrigerant and to the flow control valve;

an outside air temperature sensor configured to measure an outside air temperature;

a controller configured to control the flow switching device and the flow control valve,

a first heat exchanger fan configured to supply outdoor air to the first heat exchanger to adjust an amount of heat exchange thereat; and

a second heat exchanger fan configured to supply outdoor air to the second heat exchanger to adjust an amount of heat exchange thereat,

wherein

the refrigerant circuit pipe is a pipe that connects the first heat exchanger and the second heat exchanger of a refrigerant circuit to an expansion valve of the refrigerant circuit, the refrigerant circuit being provided as a circuit in which the refrigerant circulates through the compressor, the flow switching device, the first heat exchanger, the second heat exchanger, the flow control valve, the expansion valve, and an evaporator of an indoor unit,

the controller is configured to determine whether or not, in a case where the flow switching device switches the flow passage for refrigerant to the first flow passage, a predetermined condition is satisfied that the outside air temperature measured by the outside air temperature sensor is lower than or equal to a first temperature that is lower than or equal to the freezing point of water and a degree of discharge superheat of the compressor is higher than or equal to a first degree of discharge superheat,

the controller is configured to perform, when determining that the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, thereby causing the refrigerant remaining in the second heat exchanger to flow into the refrigerant circuit pipe, and

the controller is configured to stop the first heat exchanger fan and the second heat exchanger fan in a case where the controller performs control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage.

[Claim 2]

The air-conditioning apparatus of claim 1, further comprising:

a compressor discharge temperature sensor configured to measure a discharge temperature of the refrigerant discharged from the compressor; and

a high pressure sensor configured to measure a pressure of the refrigerant discharged from the compressor and flowing toward the flow switching device,

wherein the degree of discharge superheat of the compressor is obtained based on the discharge temperature measured by the compressor discharge temperature sensor and the pressure measured by the high pressure sensor.

[Claim 3]

The air-conditioning apparatus of claim 1 or 2, wherein the controller is configured to perform, after the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, and then perform, after a predetermined time period elapses, control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage and of closing the flow control valve.

[Claim 4]

The air-conditioning apparatus of claim 3, wherein the predetermined time period is set depending on the outside air temperature that is measured by the outside air temperature sensor when the predetermined condition is satisfied.

[Claim 5]

The air-conditioning apparatus of claim 1, wherein the controller is configured to perform, after the predetermined condition is satisfied, control of causing the flow switching device to switch the flow passage for refrigerant to the second flow passage and of opening the flow control valve, and then perform, in a case where the degree of discharge superheat of the compressor is lower than or equal to a second degree of discharge superheat, control of causing the flow switching device to switch the flow passage for refrigerant to the first flow passage and of closing the flow control valve.