



(11) **EP 4 467 899 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
27.11.2024 Bulletin 2024/48

(51) International Patent Classification (IPC):
F25B 13/00 (2006.01)

(21) Application number: **22921862.3**

(52) Cooperative Patent Classification (CPC):
F25B 13/00

(22) Date of filing: **19.01.2022**

(86) International application number:
PCT/JP2022/001826

(87) International publication number:
WO 2023/139703 (27.07.2023 Gazette 2023/30)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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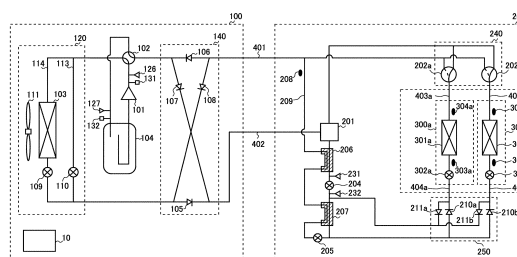
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(54) **AIR CONDITIONING DEVICE**

(57) An air-conditioning apparatus includes a heat source unit including a compressor, a flow switching valve, and a heat-source-side heat exchanger, an indoor unit including a load-side flow control valve and a load-side heat exchanger and configured to perform a cooling operation or a heating operation, a relay unit connected to the heat source unit by a low-pressure pipe and a high-pressure pipe, connected to the indoor unit via a gas branch pipe and a liquid branch pipe, and configured to supply refrigerant supplied from the heat source unit to the indoor unit, and a controller. The relay unit includes a branch portion at which the gas branch pipe and the low-

pressure pipe communicate with each other when the indoor unit performs the cooling operation and the gas branch pipe and the high-pressure pipe communicate with each other when the indoor unit performs the heating operation. The branch portion includes an expansion valve that is connected to the gas branch pipe and the low-pressure pipe and whose opening degree is adjustable. The controller is configured to, when the heat source unit is stopped, control the expansion valve to allow the gas branch pipe and the low-pressure pipe to communicate with each other.

FIG. 1



Description

Technical Field

[0001] The present disclosure relates to an air-conditioning apparatus including a relay unit configured to supply refrigerant supplied from a heat source unit to an indoor unit.

Background Art

[0002] An air-conditioning apparatus that uses a refrigeration cycle includes a refrigerant circuit through which refrigerant flows. In the refrigerant circuit, a heat source unit having a compressor and a heat-source-side heat exchanger is connected by pipes to an indoor unit having an expansion valve and a load-side heat exchanger. The air-conditioning apparatus performs air conditioning while changing the pressure, the temperature, and other factors of the refrigerant flowing through the refrigerant circuit by removing heat from or transferring heat to air in an air-conditioned space, which is a target of heat exchange, when the refrigerant evaporates or condenses in the load-side heat exchanger.

[0003] In addition, an air-conditioning apparatus including a heat source unit, a plurality of indoor units, and a relay unit that distributes refrigerant supplied from the heat source unit to the plurality of indoor units is also known. In such an air-conditioning apparatus, a simultaneous cooling and heating operation is performed in which necessity of a cooling operation or a heating operation is automatically determined for each of the plurality of indoor units depending on a set temperature set by a remote control, an indoor temperature and other temperatures, and a cooling operation or a heating operation is performed in each indoor unit. As an air-conditioning apparatus that performs a simultaneous cooling and heating operation, Patent Literature 1 discloses an air-conditioning apparatus in which a flow of refrigerant for a cooling operation and a flow of refrigerant for a heating operation are switched by two solenoid valves in a relay unit provided between a heat source unit and indoor units.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 6895901

Summary of Invention

Technical Problem

[0005] In the configuration disclosed in Patent Literature 1, the solenoid valves of the relay unit are closed when supply of power to the air-conditioning apparatus is

stopped for vacuum drawing or another reason. Thus, to realize vacuum drawing in a gas branch pipe connecting the relay unit and an indoor unit, it is required to provide, for example, an orifice in a solenoid valve dedicated to cooling operation switching. However, when an orifice is provided in the solenoid valve dedicated to cooling operation switching, part of the refrigerant supplied from the compressor during a heating operation passes through the orifice of the solenoid valve dedicated to cooling operation switching and flows into a low-pressure pipe without passing through the indoor unit, and thus the heating capacity of the indoor unit is reduced. Meanwhile, when the diameter of the orifice is reduced to prevent a decrease in the heating capacity, the flow rate of air flowing through the orifice during vacuum drawing of the whole air-conditioning apparatus is reduced, and thus it takes longer to perform the vacuum drawing. Thus, in the conventional configuration, an improvement in the heating capacity and a reduction in time for vacuum drawing are in a trade-off relationship, and are difficult to be achieved at the same time.

[0006] The present disclosure has been made to solve the above-mentioned problems and provides an air-conditioning apparatus capable of preventing lowering of a heating capacity as well as reducing a time for vacuum drawing.

Solution to Problem

[0007] An air-conditioning apparatus according to an embodiment of the present disclosure includes a heat source unit including a compressor, a flow switching valve, and a heat-source-side heat exchanger, an indoor unit including a load-side flow control valve and a load-side heat exchanger and configured to perform a cooling operation or a heating operation, a relay unit connected to the heat source unit by a low-pressure pipe and a high-pressure pipe, connected to the indoor unit via a gas branch pipe and a liquid branch pipe, and configured to supply refrigerant supplied from the heat source unit to the indoor unit, and a controller. The relay unit includes a branch portion at which the gas branch pipe and the low-pressure pipe communicate with each other when the indoor unit performs the cooling operation and the gas branch pipe and the high-pressure pipe communicate with each other when the indoor unit performs the heating operation. The branch portion includes an expansion valve that is connected to the gas branch pipe and the low-pressure pipe and whose opening degree is adjustable. The controller is configured to, when the heat source unit is stopped, control the expansion valve to allow the gas branch pipe and the low-pressure pipe to communicate with each other.

Advantageous Effects of Invention

[0008] According to the air-conditioning apparatus according to an embodiment of the present disclosure,

because an expansion valve whose opening degree is adjustable is provided in the branch portion of the relay unit, the low-pressure pipe can be closed during the heating operation and can be opened during a stop of the heat source unit by allowing the gas branch pipe and the low-pressure pipe to communicate with each other. As a result, lowering of the heating capacity can be prevented and a time required for vacuum drawing can be reduced.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 1.
[Fig. 2] Fig. 2 is a graph illustrating a relationship between a control amount and an opening degree of a three-way electric expansion valve according to Embodiment 1.

[Fig. 3] Fig. 3 is a refrigerant circuit diagram illustrating a state in a cooling only operation of the air-conditioning apparatus according to Embodiment 1.

[Fig. 4] Fig. 4 is a refrigerant circuit diagram illustrating a state in a heating only operation of the air-conditioning apparatus according to Embodiment 1.

[Fig. 5] Fig. 5 is a refrigerant circuit diagram illustrating a state in a cooling main operation of the air-conditioning apparatus according to Embodiment 1.

[Fig. 6] Fig. 6 is a refrigerant circuit diagram illustrating a state in a heating main operation of the air-conditioning apparatus according to Embodiment 1.

[Fig. 7] Fig. 7 is a flowchart illustrating a control operation of the three-way electric expansion valve according to Embodiment 1.

[Fig. 8] Fig. 8 is a refrigerant circuit diagram of the air-conditioning apparatus according to Embodiment 2.

[Fig. 9] Fig. 9 is a flowchart illustrating control operations of an opening-closing valve for heating and an expansion valve for cooling according to Embodiment 2. Description of Embodiments

[0010] Hereinafter, embodiments will be described with reference to the drawings. Note that, in the drawings, components denoted by the same reference symbols are the same or corresponding components, and this applies throughout this description. In addition, the modes of components described herein are merely illustrative, and the present disclosure is not limited to those described herein. Furthermore, in the drawings, the relationship of sizes of the components may differ from that of actual ones.

Embodiment 1

[0011] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus 1 according to Embodiment 1. As shown in Fig. 1, the air-conditioning apparatus 1 includes

a heat source unit 100, a plurality of indoor units 300a and 300b, a relay unit 200, and a controller 10. Note that, in Embodiment 1, a description will be given of a case where the two indoor units 300a and 300b are connected to the single heat source unit 100, but the number of heat source units 100 may be two or more and the number of relay units 200 may be two or more. Also, the number of indoor units may be one, or three or more.

10 (Configuration of Air-Conditioning Apparatus)

[0012] As shown in Fig. 1, the heat source unit 100, the indoor units 300a and 300b, and the relay unit 200 are connected to form the air-conditioning apparatus 1. The heat source unit 100 has a function of supplying heat to the two indoor units 300a and 300b. The indoor units 300a and 300b are connected in parallel to each other and have the same configuration. The indoor units 300a and 300b each have a function of cooling or heating an air-conditioned space, such as the inside of a room, by using the heat supplied from the heat source unit 100. The relay unit 200 is provided between the heat source unit 100 and the indoor units 300a and 300b and has a function of switching flows of refrigerant supplied from the heat source unit 100 and supplying the refrigerant to the indoor units 300a and 300b in accordance with a request from the indoor units 300a and 300b.

[0013] The heat source unit 100 and the relay unit 200 are connected to each other, on a high-pressure side, by a high-pressure pipe 402 through which refrigerant in a high-pressure state flows and are connected to each other, on a low-pressure side, by a low-pressure pipe 401 through which refrigerant in a low-pressure state flows. In addition, the relay unit 200 and the indoor unit 300a are connected to each other via a gas branch pipe 403a and a liquid branch pipe 404a. The relay unit 200 and the indoor unit 300b are connected to each other via a gas branch pipe 403b and a liquid branch pipe 404b. Refrigerant in a gas state mainly flows through the gas branch pipes 403a and 403b. Refrigerant in a liquid state mainly flows through the liquid branch pipes 404a and 404b.

(Heat Source Unit 100)

[0014] The heat source unit 100 includes a compressor 101, a flow switching valve 102, a heat-source-side heat exchange unit 120, an accumulator 104, and a heat-source-side flow passage control unit 140. The compressor 101 is a fluid machine configured to suck and compress refrigerant in a low-pressure gas state and discharge the refrigerant in a high-pressure gas state. The compressor 101 is, for example, an inverter-driven compressor whose operation frequency is adjustable. The flow switching valve 102 is a four-way valve configured to switch flow passages for the refrigerant discharged from the compressor 101. Note that, the flow switching valve 102 may be formed by combining a two-way valve, a

three-way valve, or other valves.

[0015] The heat-source-side heat exchange unit 120 includes a main pipe 114, a heat-source-side heat exchanger 103, a heat-source-side fan 111, a bypass pipe 113, a heat-source-side flow control valve 109, and a bypass flow control valve 110. The heat-source-side heat exchanger 103 is a heat exchanger configured to exchange heat between the refrigerant flowing therein and air supplied by the heat-source-side fan 111. The heat-source-side heat exchanger 103 is configured to function as an evaporator or a condenser. Note that, the heat-source-side heat exchanger 103 may be a water-cooled type heat exchanger configured to exchange heat between refrigerant and water or brine, for example.

[0016] The heat-source-side fan 111 is a propeller fan, a cross flow fan, or a multi-blade centrifugal fan configured to supply air to the heat-source-side heat exchanger 103. The capacity of heat exchange is controlled by controlling the rotation speed of the heat-source-side fan 111. Note that, when the heat-source-side heat exchanger 103 is a water-cooled type, the heat-source-side fan 111 is omitted and a pump for circulating heat medium is provided instead.

[0017] The main pipe 114 is connected to the flow switching valve 102 at one end, is connected to the high-pressure pipe 402 at the other end, and is provided with the heat-source-side heat exchanger 103 and the heat-source-side flow control valve 109. The bypass pipe 113 is connected to the flow switching valve 102 at one end, is connected to the high-pressure pipe 402 at the other end, and is connected in parallel to the main pipe 114. The refrigerant flowing through the bypass pipe 113 does not pass through the heat-source-side heat exchanger 103 and is not subjected to heat exchange.

[0018] The heat-source-side flow control valve 109 is connected in series to the heat-source-side heat exchanger 103 in the main pipe 114 and is configured to control the flow rate of the refrigerant flowing through the main pipe 114 to reduce the pressure of the refrigerant. The heat-source-side flow control valve 109 is formed as, for example, a two-way electric expansion valve whose opening degree is adjustable. The bypass flow control valve 110 is provided in the bypass pipe 113 and is configured to control the flow rate of the refrigerant flowing through the bypass pipe 113 to reduce the pressure of the refrigerant. The bypass flow control valve 110 is formed as, for example, an electric expansion valve whose opening degree is adjustable.

[0019] The accumulator 104 is provided between the flow switching valve 102 and a suction port of the compressor 101. The accumulator 104 has a refrigerant storage function of storing excess refrigerant and a gas-liquid separation function of separating the refrigerant in a two-phase gas-liquid state flowing therein, discharging the refrigerant in a gas state to the compressor 101, and storing the refrigerant in a liquid state.

[0020] The heat-source-side flow passage control unit 140 includes a third check valve 105, a fourth check valve

106, a fifth check valve 107, and a sixth check valve 108. The third check valve 105 is provided in a pipe connecting the heat-source-side heat exchange unit 120 and the high-pressure pipe 402, and allows a flow of the refrigerant from the heat-source-side heat exchange unit 120 toward the high-pressure pipe 402. The fourth check valve 106 is provided in a pipe connecting the flow switching valve 102 of the heat source unit 100 and the low-pressure pipe 401, and allows a flow of the refrigerant from the low-pressure pipe 401 toward the flow switching valve 102. The fifth check valve 107 is provided in a pipe connecting the flow switching valve 102 of the heat source unit 100 and the high-pressure pipe 402, and allows a flow of the refrigerant from the flow switching valve 102 toward the high-pressure pipe 402. The sixth check valve 108 is provided in a pipe connecting the heat-source-side heat exchange unit 120 and the low-pressure pipe 401, and allows a flow of the refrigerant from the low-pressure pipe 401 toward the heat-source-side heat exchange unit 120.

[0021] Further, the heat source unit 100 is provided with a discharge pressure sensor 126. The discharge pressure sensor 126 is provided in a pipe connecting the flow switching valve 102 and a discharge side of the compressor 101, and is configured to detect the pressure of the refrigerant discharged from the compressor 101. The discharge pressure sensor 126 is configured to transmit a signal of a detected discharge pressure to the controller 10.

[0022] In addition, the heat source unit 100 is provided with a suction pressure sensor 127. The suction pressure sensor 127 is provided in a pipe connecting the flow switching valve 102 and the accumulator 104, and is configured to detect the pressure of the refrigerant to be sucked into the compressor 101. The suction pressure sensor 127 is configured to transmit a signal of a detected suction pressure to the controller 10.

[0023] Note that, the discharge pressure sensor 126 and the suction pressure sensor 127 each may include a storage device or a similar device. In this case, each of the discharge pressure sensor 126 and the suction pressure sensor 127 is configured to store data of a detected pressure in the storage device for a predetermined period of time, and transmit, at predetermined intervals, a signal including stored pressure data to the controller 10.

[0024] Furthermore, the heat source unit 100 is provided with refrigerant filling units 131 and 132. The refrigerant filling unit 131 is provided on a pipe connecting the flow switching valve 102 and the discharge side of the compressor 101, and enables filling of the refrigerant or vacuum drawing from the discharge side of the compressor 101. The refrigerant filling unit 132 is provided on a pipe connecting the flow switching valve 102 and the accumulator 104, and enables filling of the refrigerant and vacuum drawing from the suction side of the compressor 101. The refrigerant filling units 131 and 132 are formed as, for example, check joints

(Indoor Units 300a and 300b)

[0025] The indoor units 300a and 300b respectively include load-side heat exchangers 301a and 301b functioning as a condenser or evaporator, and load-side flow control valves 302a and 302b configured to control flow rates of the refrigerant flowing in the indoor units 300a and 300b. The load-side heat exchangers 301a and 301b are heat exchangers configured to exchange heat between the refrigerant flowing therein and air supplied by indoor fans (not shown). Note that, the load-side heat exchangers 301a and 301b may be water-cooled type heat exchangers configured to exchange heat between the refrigerant and water or brine, for example.

[0026] The load-side flow control valves 302a and 302b are configured to control the flow rates of the refrigerant flowing into the load-side heat exchangers 301a and 301b or the flow rates of the refrigerant flowing out of the load-side heat exchangers 301a and 301b to reduce the pressures of the refrigerant. The load-side flow control valves 302a and 302b are formed as, for example, two-way electric expansion valves whose opening degrees is adjustable. During a cooling operation, the opening degrees of the load-side flow control valves 302a and 302b are respectively controlled by the controller 10 based on the degrees of superheat on the exit sides of the load-side heat exchangers 301a and 301b. During a heating operation, the opening degrees of the load-side flow control valves 302a and 302b are respectively controlled by the controller 10 based on the degrees of subcooling on the exit sides of the load-side heat exchangers 301a and 301b.

[0027] The indoor unit 300a includes a gas pipe temperature sensor 304a and a liquid pipe temperature sensor 303a. The indoor unit 300b includes a gas pipe temperature sensor 304b and a liquid pipe temperature sensor 303b. The gas pipe temperature sensor 304a is provided between the load-side heat exchanger 301a and the relay unit 200. The gas pipe temperature sensor 304b is provided between the load-side heat exchanger 301b and the relay unit 200. The gas pipe temperature sensor 304a is configured to detect the temperature of the refrigerant flowing in the gas branch pipe 403a connecting the load-side heat exchanger 301a and the relay unit 200. The gas pipe temperature sensor 304b is configured to detect the temperature of the refrigerant flowing in the gas branch pipe 403b connecting the load-side heat exchanger 301b and the relay unit 200. The gas pipe temperature sensors 304a and 304b are, for example, thermistors, and are configured to transmit a signal of a detected temperature to the controller 10.

[0028] The liquid pipe temperature sensor 303a is provided between the load-side heat exchanger 301a and the load-side flow control valve 302a. The liquid pipe temperature sensor 303b is provided between the load-side heat exchanger 301b and the load-side flow control valve 302b. The liquid pipe temperature sensor 303a is configured to detect the temperature of the refrigerant

flowing in the pipe connecting the load-side heat exchanger 301a and the load-side flow control valve 302a. The liquid pipe temperature sensor 303b is configured to detect the temperature of the refrigerant flowing in the pipe connecting the load-side heat exchanger 301b and the load-side flow control valve 302b. The liquid pipe temperature sensors 303a and 303b are, for example, thermistors, and are configured to transmit a signal of a detected temperature to the controller 10.

[0029] The gas pipe temperature sensors 304a and 304b and the liquid pipe temperature sensors 303a and 303b each may include a storage device or a similar device. In this case, each of the sensors is configured to store data of a detected temperature in the storage device for a predetermined period of time, and transmit, at predetermined intervals, a signal including stored temperature data to the controller 10.

(Relay Unit 200)

[0030] The relay unit 200 includes a first branch portion 240, a second branch portion 250, a gas-liquid separator 201, a relay bypass pipe 209, a first flow control valve 204, a second flow control valve 205, a first heat exchange unit 206, and a second heat exchange unit 207.

[0031] The first branch portion 240 is connected to the gas branch pipes 403a and 403b at one end and is connected to the low-pressure pipe 401 and the high-pressure pipe 402 at the other end. In the first branch portion 240, the gas branch pipes 403a and 403b are allowed to connect to the low-pressure pipe 401 or the high-pressure pipe 402 so that a direction in which the refrigerant circulates during a cooling operation is different from a direction in which the refrigerant circulates during a heating operation. The first branch portion 240 includes three-way electric expansion valves 202a and 202b whose opening degrees is adjustable.

[0032] The three-way electric expansion valve 202a is connected to the gas branch pipe 403a, the high-pressure pipe 402, and the low-pressure pipe 401. The three-way electric expansion valve 202b is connected to the gas branch pipe 403b, the high-pressure pipe 402, and the low-pressure pipe 401. The three-way electric expansion valves 202a and 202b each have a function of switching flows of the refrigerant and a function of controlling the flow rate of the refrigerant. More specifically, the three-way electric expansion valve 202a has a first flow passage in which the gas branch pipe 403a and the low-pressure pipe 401 communicate with each other, and a second flow passage in which the gas branch pipe 403a and the high-pressure pipe 402 communicate with each other. Similarly, the three-way electric expansion valve 202b has a first flow passage in which the gas branch pipe 403b and the low-pressure pipe 401 communicate with each other, and a second flow passage in which the gas branch pipe 403b and the high-pressure pipe 402 communicate with each other. By controlling the opening degrees of the three-way electric expansion valves

202a and 202b by the controller 10, opening and closing of the first flow passages and the second flow passages are performed and the flow rates of the refrigerant flowing in the first flow passage and the second flow passage are controlled.

[0033] When the indoor unit 300a performs a cooling operation, the opening degree of the three-way electric expansion valve 202a is controlled to open the first flow passage, in which the gas branch pipe 403a and the low-pressure pipe 401 communicate with each other, and close the second flow passage. In addition, when the indoor unit 300a performs a heating operation, the opening degree of the three-way electric expansion valve 202a is controlled to open the second flow passage, in which the gas branch pipe 403a and the high-pressure pipe 402 communicate with each other, and close the first flow passage. Similarly, when the indoor unit 300b performs a cooling operation, the opening degree of the three-way electric expansion valve 202b is controlled to open the first flow passage, in which the gas branch pipe 403b and the low-pressure pipe 401 communicate with each other, and close the second flow passage. In addition, when the indoor unit 300b performs a heating operation, the opening degree of the three-way electric expansion valve 202b is controlled to open the second flow passage, in which the gas branch pipe 403b and the high-pressure pipe 402 communicate with each other, and close the first flow passage.

[0034] The second branch portion 250 is connected to the liquid branch pipes 404a and 404b at one end and is connected to the low-pressure pipe 401 and the high-pressure pipe 402 at the other end. In the second branch portion 250, the liquid branch pipes 404a and 404b are allowed to connect to the low-pressure pipe 401 or the high-pressure pipe 402 so that a direction in which the refrigerant circulates during a cooling operation is different from a direction in which the refrigerant circulates during a heating operation. The second branch portion 250 includes first check valves 210a and 210b and second check valves 211a and 211b.

[0035] The first check valves 210a and 210b are respectively connected to the liquid branch pipes 404a and 404b at one ends, are connected to the high-pressure pipe 402 at the other ends, and allow the refrigerant to flow from the high-pressure pipe 402 toward the liquid branch pipes 404a and 404b.

[0036] The second check valves 211a and 211b are respectively connected to the liquid branch pipes 404a and 404b at one ends, are connected to the low-pressure pipe 401 at the other ends, and allow the refrigerant to flow from the liquid branch pipes 404a and 404b toward the low-pressure pipe 401.

[0037] The gas-liquid separator 201 is configured to separate the refrigerant in a gas state and the refrigerant in a liquid state. The gas-liquid separator 201 is connected to the high-pressure pipe 402 at an inflow side, is connected to the first branch portion 240 at a gas outflow side, and is connected to the second branch portion 250

at a liquid outflow side. The relay bypass pipe 209 connects the second branch portion 250 with the low-pressure pipe 401. The first flow control valve 204 is connected to the liquid outflow side of the gas-liquid separator 201 and is formed as, for example, a two-way electric expansion valve whose opening degree is adjustable. The first flow control valve 204 is configured to control a flow rate of the refrigerant in a liquid state that flows out of the gas-liquid separator 201.

[0038] The first heat exchange unit 206 is provided between the liquid outflow side of the gas-liquid separator 201 and the first flow control valve 204, and on the relay bypass pipe 209. The first heat exchange unit 206 is configured to exchange heat between the refrigerant in a liquid state flowing out of the gas-liquid separator 201 and the refrigerant flowing in the relay bypass pipe 209. The second heat exchange unit 207 is provided on the downstream side of the first flow control valve 204 and on the relay bypass pipe 209. The second heat exchange unit 207 is configured to exchange heat between the refrigerant flowing out of the first flow control valve 204 and the refrigerant flowing in the relay bypass pipe 209.

[0039] The second flow control valve 205 is provided on the relay bypass pipe 209 on the upstream side of the second heat exchange unit 207 and is formed as, for example, a two-way electric expansion valve whose opening degree is adjustable. The second flow control valve 205 is configured to control a flow rate of the refrigerant that flows out of the second heat exchange unit 207 and enters the relay bypass pipe 209 to reduce the pressure of the refrigerant.

[0040] Here, the upstream sides of the first check valves 210a and 210b are connected to the downstream side of the second heat exchange unit 207 and to the relay bypass pipe 209. Thus, the refrigerant flowed out of the second heat exchange unit 207 branches into a refrigerant stream that flows toward the first check valves 210a and 210b and a refrigerant stream that flows into the relay bypass pipe 209. In addition, the downstream sides of the second check valves 211a and 211b are connected between the first flow control valve 204 and the upstream side of the second heat exchange unit 207. That is, the refrigerant flowed out of the second check valves 211a and 211b flows into the second heat exchange unit 207, is subjected to heat exchange, and then branches into a refrigerant stream that flows toward the first check valves 210a and 210b and a refrigerant stream that flows into the relay bypass pipe 209.

[0041] Furthermore, the relay unit 200 is provided with a first pressure sensor 231, a second pressure sensor 232, and a relay bypass temperature sensor 208. The first pressure sensor 231 is provided between the first heat exchange unit 206 and the upstream side of the first flow control valve 204 and is configured to detect a pressure of the refrigerant on the liquid outflow side of the gas-liquid separator 201. The first pressure sensor 231 is configured to transmit a signal of a detected pressure to the controller 10.

[0042] The second pressure sensor 232 is provided between the downstream side of the first flow control valve 204 and the second heat exchange unit 207 and is configured to detect a pressure of the refrigerant flowed out of the first flow control valve 204. The second pressure sensor 232 is configured to transmit a signal of a detected pressure to the controller 10. The opening degree of the first flow control valve 204 is controlled by the controller 10 so that a difference between a pressure detected by the first pressure sensor 231 and a pressure detected by the second pressure sensor 232 becomes constant.

[0043] The relay bypass temperature sensor 208 is provided in the relay bypass pipe 209 and is configured to detect a temperature of the refrigerant flowing in the relay bypass pipe 209. The relay bypass temperature sensor 208 is formed as, for example, a thermistor, and is configured to transmit a signal of a detected temperature to the control unit 10. The opening degree of the second flow control valve 205 is controlled by the controller 10 based on at least one or more of a pressure detected by the first pressure sensor 231, a pressure detected by the second pressure sensor 232, and a temperature detected by the relay bypass temperature sensor 208.

[0044] Note that, the first pressure sensor 231, the second pressure sensor 232, and the relay bypass temperature sensor 208 may each include a storage device or a similar device. In this case, each of the pressure sensors and the temperature sensor is configured to store data of a detected pressure or temperature in the storage device for a predetermined period of time, and transmit, at predetermined intervals, a signal including stored data of pressure or temperature to the controller 10.

(Refrigerant)

[0045] The refrigerant is filled in the pipes in the air-conditioning apparatus 1. The refrigerant is, for example, a natural refrigerant, such as carbon dioxide (CO₂), hydrocarbon, and helium, a chlorofluorocarbon alternative refrigerant not containing chlorine, such as HFC410A, HFC407C, and HFC404A, or a chlorofluorocarbon-based refrigerant used for existing products, such as R22 and R134a. Note that HFC407C is a zeotropic refrigerant mixture of R32, R125, and R134a of hydrofluorocarbon (HFC) that are mixed at a ratio of 23 wt%, 25 wt%, and 52 wt%, respectively. Alternatively, a heat medium, instead of refrigerant, may be filled in the pipes of the air-conditioning apparatus 1. The heat medium may be, for example, water, brine, or other materials.

(Controller 10)

[0046] The controller 10 is configured to control the entire operation of the air-conditioning apparatus 1. The controller 10 is a computer that includes a memory configured to store data and a program necessary for control

and a central processing unit (CPU) configured to execute the program, dedicated hardware, such as an application specific integrated circuit (ASIC) or a field-programmable gate array (FPGA), or a combination of the computer and the dedicated hardware. The control unit 10 is configured to control the driving frequency of the compressor 101, the rotation speeds of the heat-source-side fan 111 and indoor fans (not shown) provided in the indoor units 300a and 300b, switching of the flow switching valve 102, the opening degrees of the three-way electric expansion valves 202a and 202b, the opening degrees of the heat-source-side flow control valve 109, the bypass flow control valve 110, the load-side flow control valves 302a and 302b, the first flow control valve 204, and the second flow control valve 205, and other operation, based on the detected information received from the gas pipe temperature sensors 304a and 304b, the liquid pipe temperature sensors 303a and 303b, the first pressure sensor 231, the second pressure sensor 232, the relay bypass temperature sensor 208, the discharge pressure sensor 126, and the suction pressure sensor 127, and instructions received from a remote control (not shown).

[0047] In addition, the controller 10 may be configured to calculate a cooling capacity or a heating capacity in a cooling main operation and a heating main operation from a discharge pressure detected by the discharge pressure sensor 126 or a suction pressure detected by the suction pressure sensor 127. Alternatively, the controller 10 may be configured to calculate a cooling capacity or a heating capacity in a cooling main operation and a heating main operation by using an evaporating temperature and a condensing temperature obtained from temperatures detected by the gas pipe temperature sensors 304a and 304b and the liquid pipe temperature sensors 303a and 303b.

[0048] Note that, although, in Fig. 1, the controller 10 is provided in the heat source unit 100, the configuration is not limited thereto. The controller 10 may be provided in any one of the relay unit 200, the indoor unit 300a, and the indoor unit 300b, or may be provided separately from the heat source unit 100, the relay unit 200, the indoor unit 300a, and the indoor unit 300b. Alternatively, the heat source unit 100, the relay unit 200, the indoor unit 300a, and the indoor unit 300b may be provided with respective controllers that are connected via a wireless or wired link to be capable of communicating with each other to transmit and receive various data.

[0049] Next, operations of the three-way electric expansion valves 202a and 202b of the first branch portion 240 will be described. Fig. 2 is a graph illustrating a relationship between a control amount and an opening degree of the three-way electric expansion valve 202a according to Embodiment 1. A relationship between a control amount and an opening degree of the three-way electric expansion valve 202b is the same as the relationship shown in Fig. 2. In Fig. 2, the vertical axis represents the opening degree of the three-way electric expansion

valve 202a and the horizontal axis represents a control amount transmitted to the three-way electric expansion valve 202a from the controller 10. In this case, the "control amount" corresponds to the number of pulses of a pulse signal transmitted to the three-way electric expansion valve 202a from the controller 10.

[0050] Fig. 2 indicates that, when the control amount is less than P1, the three-way electric expansion valve 202a opens the first flow passage in which the gas branch pipe 403a and the low-pressure pipe 401 communicate with each other and closes the second flow passage in which the gas branch pipe 403a and the high-pressure pipe 402 communicate with each other. When the control amount is a minimum control amount Pmin, the opening degree of the first flow passage of the three-way electric expansion valve 202a is set to a maximum opening degree A1, and the opening degree of the first flow passage of the three-way electric expansion valve 202a is reduced as the control amount is increased.

[0051] Next, when the control amount is P1 or greater but less than P2, both the first flow passage and the second flow passage of the three-way electric expansion valve 202a are closed regardless of the control amount. When the control amount is P2 or greater, the second flow passage in which the gas branch pipe 403a and the high-pressure pipe 402 communicate with each other is opened and the first flow passage in which the gas branch pipe 403a and the low-pressure pipe 401 communicate with each other is closed. In addition, when the control amount is a maximum control amount Pmax, the opening degree of the second flow passage of the three-way electric expansion valve 202a is set to a maximum opening degree A1, and the opening degree of the second flow passage of the three-way electric expansion valve 202a is reduced as the control amount is reduced.

(Operation of Air-Conditioning Apparatus)

[0052] Next, operations of the air-conditioning apparatus 1 will be described. The operation modes of the air-conditioning apparatus 1 include a cooling only operation, a heating only operation, a cooling main operation, and a heating main operation. The cooling only operation is a mode in which all the indoor units 300a and 300b perform a cooling operation. The heating only operation is a mode in which all the indoor units 300a and 300b perform a heating operation. The cooling main operation is a mode in which the capacity of a cooling operation is larger than the capacity of a heating operation in a simultaneous cooling and heating operation. The heating main operation is a mode in which the capacity of a heating operation is larger than the capacity of a cooling operation in a simultaneous cooling and heating operation. The controller 10 is configured to perform the cooling only operation, the heating only operation, the cooling main operation, or the heating main operation according to operation requests made to the indoor units 300a and 300b. Each operation mode will be described with refer-

ence to Figs. 3 to 6. Note that, in Figs. 3 to 6, a flow of the refrigerant in a high-pressure state is indicated by a solid-line arrow and a flow of the refrigerant in a low-pressure state is indicated by a broken-line arrow. In addition, in Figs. 3 to 6, among the check valves, check valves in which no refrigerant flows are indicated with black color.

(Cooling Only Operation)

[0053] First, the cooling only operation will be described. Fig. 3 is a refrigerant circuit diagram illustrating a state in the cooling only operation of the air-conditioning apparatus 1 according to Embodiment 1. In the cooling only operation, all the indoor units 300a and 300b perform a cooling operation. As shown in Fig. 3, the refrigerant in a high-temperature, high-pressure gas state discharged from the compressor 101 passes through the flow switching valve 102 and enters the heat-source-side heat exchanger 103. In the heat-source-side heat exchanger 103, the refrigerant is subjected to heat exchange with outdoor air sent by the heat-source-side fan 111 and is condensed and liquefied. Then, the refrigerant being condensed and liquefied enters the gas-liquid separator 201 via the heat-source-side flow control valve 109, the third check valve 105, and the high-pressure pipe 402. Here, the bypass flow control valve 110 is fully closed and thus no refrigerant enters the bypass pipe 113.

[0054] Then, the refrigerant is separated by the gas-liquid separator 201 into the refrigerant in a gas state and the refrigerant in a liquid state. The refrigerant in a liquid state flows out from the liquid outflow side, passes through the first heat exchange unit 206, the first flow control valve 204, and the second heat exchange unit 207 in this order, and branches into refrigerant streams at the second branch portion 250. The refrigerant streams flow into the respective indoor units 300a and 300b via the respective first check valves 210a and 210b and the respective liquid branch pipes 404a and 404b. In the cooling only operation, the pressures in the liquid branch pipes 404a and 404b are lower than that in the high-pressure pipe 402, and thus no refrigerant enters the second check valves 211a and 211b.

[0055] Then, the refrigerant flowed into the indoor unit 300a and the refrigerant flowed into the indoor unit 300b are decompressed to a low pressure respectively by the load-side flow control valves 302a and 302b, which are controlled based on the degrees of superheat on the exit sides of the respective load-side heat exchangers 301a and 301b. The streams of the refrigerant being decompressed flow into the respective load-side heat exchangers 301a and 301b. In the load-side heat exchangers 301a and 301b, the refrigerant is subjected to heat exchange with indoor air, and is evaporated and gasified. At this time, the insides of the rooms where the indoor units 300a and 300b are installed are cooled. Then, the streams of the refrigerant in a gas state pass through the respective gas branch pipes 403a and 403b and flow into the first branch portion 240.

[0056] The controller 10 is configured to, during the cooling only operation, control the opening degrees of the three-way electric expansion valves 202a and 202b so that the first flow passages communicating with the low-pressure pipe 401 are opened and the second flow passages communicating with the high-pressure pipe 402 are closed. Thus, the refrigerant streams flowed into the first branch portion 240 pass through the first flow passages of the respective three-way electric expansion valves 202a and 202b, and then join together and pass through the low-pressure pipe 401.

[0057] Further, part of the refrigerant passed through the second heat exchange unit 207 flows into the relay bypass pipe 209. Then, the refrigerant flowed into the relay bypass pipe 209 is decompressed to a low pressure by the second flow control valve 205. Then, in the second heat exchange unit 207, the refrigerant is subjected to heat exchange with the refrigerant passed through the first flow control valve 204, that is, the refrigerant before being branched to the relay bypass pipe 209, and is evaporated. Furthermore, in the first heat exchange unit 206, the refrigerant is subjected to heat exchange with the refrigerant that will enter the first flow control valve 204 and is evaporated. The refrigerant being evaporated flows into the low-pressure pipe 401 and joins the refrigerant passed through the three-way electric expansion valves 202a and 202b. Then, the merged refrigerant passes through the fourth check valve 106, the flow switching valve 102, and the accumulator 104, and is sucked into the compressor 101.

(Heating Only Operation)

[0058] Next, the heating only operation will be described. Fig. 4 is a refrigerant circuit diagram illustrating a state in the heating only operation of the air-conditioning apparatus 1 according to Embodiment 1. In the heating only operation, all the indoor units 300a and 300b perform a heating operation. As shown in Fig. 4, the refrigerant in a high-temperature, high-pressure gas state discharged from the compressor 101 passes through the flow switching valve 102, the fifth check valve 107, and the high-pressure pipe 402, and enters the gas-liquid separator 201.

[0059] The refrigerant is separated by the gas-liquid separator 201 into the refrigerant in a gas state and the refrigerant in a liquid state. The refrigerant in a gas state flows out from the gas outflow side of the gas-liquid separator 201, and enters the first branch portion 240. The controller 10 is configured to, during the heating only operation, control the opening degrees of the three-way electric expansion valves 202a and 202b so that the second flow passages communicating with the high-pressure pipe 402 are opened and the first flow passages communicating with the low-pressure pipe 401 are closed. Thus, part of the refrigerant flowed into the first branch portion 240 passes through the second flow passage of the three-way electric expansion valve

202a and the gas branch pipe 403a, and flows into the indoor unit 300a. The remaining part of the refrigerant flowed into the first branch portion 240 passes through the second flow passage of the three-way electric expansion valve 202b and the gas branch pipe 403b, and flows into the indoor unit 300b.

[0060] The refrigerant streams flowed into the indoor units 300a and 300b are subjected to heat exchange with indoor air in the respective load-side heat exchangers 301a and 301b and are condensed and liquefied. At this time, the insides of the rooms where the indoor units 300a and 300b are installed are heated. Then, the streams of the refrigerant being condensed and liquefied pass through the respective load-side flow control valves 302a and 302b, which are controlled based on the degrees of subcooling on the exit sides of the respective load-side heat exchangers 301a and 301b, and are decompressed.

[0061] The stream of the refrigerant being decompressed by the load-side flow control valve 302a and the stream of the refrigerant being decompressed by the load-side flow control valve 302b pass through the respective liquid branch pipes 404a and 404b and the respective second check valves 211a and 211b of the second branch portion 250, and then join together. Note that, at this time, no refrigerant enters the first check valves 210a and 210b. The merged refrigerant passes through the second heat exchange unit 207, flows into the relay bypass pipe 209, and is decompressed to a low pressure by the second flow control valve 205. Then, the refrigerant being decompressed flows out of the second branch portion 250, is subjected to heat exchange with the refrigerant before being branched to the relay bypass pipe 209, and is evaporated.

[0062] Then, the refrigerant passes through the first heat exchange unit 206. Note that, during the heating only operation, the first flow control valve 204 is closed. The refrigerant passed through the first heat exchange unit 206 flows into the low-pressure pipe 401, passes through the sixth check valve 108, is decompressed by the heat-source-side flow control valve 109, and is subjected to heat exchange with outdoor air sent by the heat-source-side fan 111 and thus evaporated and gasified in the heat-source-side heat exchanger 103. The refrigerant being gasified is sucked into the compressor 101 via the flow switching valve 102 and the accumulator 104. Note that, because the bypass flow control valve 110 is fully closed, no refrigerant enters the bypass pipe 113.

(Cooling Main Operation)

[0063] Next, the cooling main operation will be described. Fig. 5 is a refrigerant circuit diagram illustrating a state in the cooling main operation of the air-conditioning apparatus 1 according to Embodiment 1. Hereinafter, a case will be described where, when the indoor unit 300a performs a cooling operation and the indoor unit 300b performs a heating operation, the cooling capacity is

larger than the heating capacity. As shown in Fig. 5, the refrigerant in a high-temperature, high-pressure gas state discharged from the compressor 101 passes through the flow switching valve 102 and branches into a refrigerant stream that will enter the main pipe 114 and a refrigerant stream that will enter the bypass pipe 113. In the cooling main operation, the bypass flow control valve 110 is opened.

[0064] The refrigerant flowed into the main pipe 114 is subjected to heat exchange with outdoor air sent by the heat-source-side fan 111 and thus is condensed and liquefied in the heat-source-side heat exchanger 103. The refrigerant being condensed and liquefied is then decompressed by the heat-source-side flow control valve 109. Meanwhile, the refrigerant flowed into the bypass pipe 113 is decompressed by the bypass flow control valve 110. The refrigerant flowed into the heat-source-side heat exchanger 103 and the refrigerant flowed into the bypass pipe 113 join together before reaching the third check valve 105, and the merged refrigerant passes through the third check valve 105 and the high-pressure pipe 402, and reaches the gas-liquid separator 201.

[0065] The refrigerant is separated by the gas-liquid separator 201 into the refrigerant in a gas state and the refrigerant in a liquid state. The refrigerant in a liquid state flowed out from the liquid outflow side of the gas-liquid separator 201 passes through the first heat exchange unit 206, the first flow control valve 204, and the second heat exchange unit 207, and reaches the second branch portion 250. The refrigerant passes through the first check valve 210a of the second branch portion 250 and the liquid branch pipe 404a, and flows into the indoor unit 300a. Because the pressure in the liquid branch pipe 404a is lower than that in the high-pressure pipe 402, no refrigerant enters the second check valve 211a.

[0066] Then, the refrigerant flowed into the indoor unit 300a is decompressed to a low pressure by the load-side flow control valve 302a, which is controlled based on the degree of superheat on the exit side of the load-side heat exchanger 301a. The refrigerant being decompressed flows into the load-side heat exchanger 301a, and is subjected to heat exchange with indoor air and thus evaporated and gasified in the load-side heat exchanger 301a. At this time, the inside of the room where the indoor unit 300a is installed is cooled. Then, the refrigerant in a gas state passes through the gas branch pipe 403a and flows into the first branch portion 240 of the relay unit 200.

[0067] The three-way electric expansion valve 202a, which is connected to the indoor unit 300a that performs the cooling operation in the cooling main operation, is controlled by the controller 10 so that the first flow passage communicating with the low-pressure pipe 401 is opened and the second flow passage communicating with the high-pressure pipe 402 is closed. Thus, the refrigerant flowed into the first branch portion 240 passes through the first flow passage of the three-way electric expansion valve 202a and flows into the low-pressure pipe 401.

[0068] Meanwhile, the refrigerant in a gas state flowed out from the gas outflow side of the gas-liquid separator 201 flows into the first branch portion 240. The three-way electric expansion valve 202b, which is connected to the indoor unit 300b that performs the heating operation in the cooling main operation, is controlled by the controller 10 so that the second flow passage communicating with the high-pressure pipe 402 is opened and the first flow passage communicating with the low-pressure pipe 401 is closed. Thus, the refrigerant flowed into the first branch portion 240 passes through the second flow passage of the three-way electric expansion valve 202b and the gas branch pipe 403b, and flows into the indoor unit 300b.

[0069] The refrigerant flowed into the indoor unit 300b is subjected to heat exchange with indoor air and thus condensed and liquefied in the load-side heat exchanger 301b. At this time, the inside of the room where the indoor unit 300b is installed is heated. The refrigerant being condensed and liquefied passes through the load-side flow control valve 302b, which is controlled based on the degree of subcooling on the exit side of the load-side heat exchanger 301b, and enters a liquid state having a medium pressure between a high pressure and a low pressure. The refrigerant in a medium-pressure liquid state passes through the liquid branch pipe 404b and the second check valve 211b of the second branch portion 250, and flows into the second heat exchange unit 207. Note that, no refrigerant enters the first check valve 210b at this time.

[0070] Then, the refrigerant flows into the relay bypass pipe 209 and is decompressed to a low pressure by the second flow control valve 205. Then, in the second heat exchange unit 207, the refrigerant is subjected to heat exchange with the refrigerant passed through the first flow control valve 204, that is, the refrigerant before being branched to the relay bypass pipe 209, and is evaporated. Furthermore, in the first heat exchange unit 206, the refrigerant is subjected to heat exchange with the refrigerant that will enter the first flow control valve 204 and is evaporated. The refrigerant being evaporated flows into the low-pressure pipe 401 and joins the refrigerant passed through the three-way electric expansion valve 202a. Then, the merged refrigerant passes through the fourth check valve 106, the flow switching valve 102, and the accumulator 104, and is sucked into the compressor 101.

(Heating Main Operation)

[0071] Next, the heating main operation will be described. Fig. 6 is a refrigerant circuit diagram illustrating a state in the heating main operation of the air-conditioning apparatus 1 according to Embodiment 1. Hereinafter, a case will be described where, when the indoor unit 300a performs a cooling operation and the indoor unit 300b performs a heating operation, the heating capacity is larger than the cooling capacity. As shown in Fig. 6, the refrigerant in a high-temperature, high-pressure

gas state discharged from the compressor 101 passes through the flow switching valve 102, the fifth check valve 107, and the high-pressure pipe 402, and reaches the gas-liquid separator 201.

[0072] The refrigerant is separated by the gas-liquid separator 201 into the refrigerant in a gas state and the refrigerant in a liquid state. The refrigerant in a gas state flowed out from the gas outflow side of the gas-liquid separator 201 flows into the first branch portion 240. The three-way electric expansion valve 202b, which is connected to the indoor unit 300b that performs the heating operation in the heating main operation, is controlled by the controller 10 so that the second flow passage communicating with the high-pressure pipe 402 is opened and the first flow passage communicating with the low-pressure pipe 401 is closed. Thus, the refrigerant flowed into the first branch portion 240 passes through the second flow passage of the three-way electric expansion valve 202b and the gas branch pipe 403b, and flows into the indoor unit 300b.

[0073] The refrigerant flowed into the indoor unit 300b is subjected to heat exchange with indoor air and thus condensed and liquefied in the load-side heat exchanger 301b. At this time, the inside of the room where the indoor unit 300b is installed is heated. Then, the refrigerant being condensed and liquefied passes through the load-side flow control valve 302b, which is controlled based on the degree of subcooling on the exit side of the load-side heat exchanger 301b, and enters a liquid state having a medium pressure between a high pressure and a low pressure. The refrigerant in a medium-pressure liquid state passes through the liquid branch pipe 404b and second check valve 211b of the second branch portion 250, and flows into the second heat exchange unit 207. Note that, no refrigerant enters the first check valve 210b at this time. Then, the refrigerant passed through the second check valve 211b flows out from the liquid outflow side of the gas-liquid separator 201, and joins the refrigerant in a liquid state passed through the first heat exchange unit 206 and the first flow control valve 204. The merged refrigerant branches into a refrigerant stream that flows toward the second branch portion 250 and a refrigerant stream that flows toward the relay bypass pipe 209.

[0074] The refrigerant flowed into the second branch portion 250 passes through the first check valve 210a of the second branch portion 250 and the liquid branch pipe 404a, and flows into the indoor unit 300a. Because the pressure in the liquid branch pipe 404a is lower than that in the high-pressure pipe 402, no refrigerant enters the second check valve 211a. Then, the refrigerant flowed into the indoor unit 300a is decompressed to a low pressure by the load-side flow control valve 302a, which is controlled based on the degree of superheat on the exit side of the load-side heat exchanger 301a. The refrigerant being decompressed flows into the load-side heat exchanger 301a and is subjected to heat exchange with indoor air and thus evaporated and gasified in the load-

side heat exchanger 301a. At this time, the inside of the room where the indoor unit 300a is installed is cooled. Then, the refrigerant in a gas state passes through the gas branch pipe 403a and flows into the first branch portion 240 of the relay unit 200.

[0075] The three-way electric expansion valve 202a, which is connected to the indoor unit 300a that performs the cooling operation in the heating main operation, is controlled by the controller 10 so that the first flow passage communicating with the low-pressure pipe 401 is opened and the second flow passage communicating with the high-pressure pipe 402 is closed. Thus, the refrigerant flowed into the first branch portion 240 passes through the first flow passage of the three-way electric expansion valve 202a and flows into the low-pressure pipe 401.

[0076] Meanwhile, the refrigerant flowed into the relay bypass pipe 209 is decompressed to a low pressure by the second flow control valve 205. Then, in the second heat exchange unit 207, the refrigerant is subjected to heat exchange with the refrigerant flowed out of the second branch portion 250, that is, the refrigerant before being branched to the relay bypass pipe 209, and is evaporated. Furthermore, in the first heat exchange unit 206, the refrigerant is subjected to heat exchange with the refrigerant that will enter the first flow control valve 204 and is evaporated. The refrigerant being evaporated flows into the low-pressure pipe 401 and joins the refrigerant passed through the three-way electric expansion valve 202a. Then, the merged refrigerant passes through the sixth check valve 108 and flows into the main pipe 114 and the bypass pipe 113. The bypass flow control valve 110 is opened in the heating main operation.

[0077] The refrigerant flowed into the main pipe 114 is decompressed by the heat-source-side flow control valve 109 and is subjected to heat exchange with outdoor air sent by the heat-source-side fan 111 and thus evaporated and gasified in the heat-source-side heat exchanger 103. Meanwhile, the refrigerant flowed into the bypass pipe 113 is decompressed by the bypass flow control valve 110, and then joins the refrigerant flowed out of the main pipe 114. The merged refrigerant is sucked into the compressor 101 via the flow switching valve 102 and the accumulator 104.

(Stop State)

[0078] Next, a case where the air-conditioning apparatus 1 is in a stop state will be described. The refrigerant circuit diagram for a case where the air-conditioning apparatus 1 is stopped is the same as the refrigerant circuit diagram for the cooling only operation shown in Fig. 3. When the air-conditioning apparatus 1 is stopped, no operation request is made from the indoor units 300a and 300b, the compressor 101 is stopped, and the flow switching valve 102 is switched so that the discharge pipe of the compressor 101 and the main pipe 114 are made to communicate with each other. In addition, the heat-

source-side flow control valve 109, the bypass flow control valve 110, the first flow control valve 204, and the second flow control valve 205 are opened at predetermined opening degrees. The load-side flow control valves 302a and 302b are closed.

[0079] When the air-conditioning apparatus 1 is stopped, the three-way electric expansion valves 202a and 202b are controlled with the control amount Pmin. That is, when the air-conditioning apparatus 1 is stopped, the three-way electric expansion valves 202a and 202b are controlled so that the first flow passages communicating with the low-pressure pipe 401 are opened and the second flow passages communicating with the high-pressure pipe 402 are closed. When, under this condition, a vacuum pump, for example, is connected to the refrigerant filling units 131 and 132 and is activated, vacuum drawing of the air-conditioning apparatus 1 can be performed.

[0080] Fig. 7 is a flowchart illustrating a control operation of the three-way electric expansion valve 202a according to Embodiment 1. A control operation of the three-way electric expansion valve 202b is the same as that of the three-way electric expansion valve 202a. The controller 10 is configured to determine the control amount for the three-way electric expansion valve 202a according to the operation mode requested for the indoor unit 300a that is connected to the three-way electric expansion valve 202a. First, the controller 10 determines whether the heat source unit 100 is operating or not (S1). In this case, when the compressor 101 is running, the controller 10 determines that the heat source unit 100 is operating. When the heat source unit 100 is operating (YES in S1), the controller 10 determines a state of the indoor unit 300a (S2). In this case, the controller 10 determines which operation, among stop, cooling operation, and heating operation, the indoor unit 300a requests.

[0081] When the indoor unit 300a requests the stop (STOP in S2), the controller 10 transmits a pulse signal of the control amount P1 to the three-way electric expansion valve 202a (S3). Upon receipt of this signal, both the first flow passage and the second flow passage of the three-way electric expansion valve 202a are closed. That is, when the indoor unit 300a is stopped while the heat source unit 100 is operating, the gas branch pipe 403a of the indoor unit 300a is closed.

[0082] When the indoor unit 300a requests the heating operation (HEATING in S2), the controller 10 transmits a pulse signal of the control amount Pmax to the three-way electric expansion valve 202a (S4). Upon receipt of this signal, the second flow passage of the three-way electric expansion valve 202a is opened and the first flow passage is closed. That is, when the indoor unit 300a performs the heating operation while the heat source unit 100 is operating, the gas branch pipe 403a of the indoor unit 300a and the high-pressure pipe 402 are made to communicate with each other.

[0083] When the indoor unit 300a requests the cooling

operation (COOLING in S2) or when the heat source unit 100 is not operating (NO in S1), the controller 10 transmits a pulse signal of the control amount Pmin to the three-way electric expansion valve 202a (S5). Upon receipt of this signal, the first flow passage of the three-way electric expansion valve 202a is opened and the second flow passage is closed. That is, when the indoor unit 300a performs the cooling operation while the heat source unit 100 is operating or when the heat source unit 100 is stopped, the gas branch pipe 403a of the indoor unit 300a and the low-pressure pipe 401 are made to communicate with each other.

[0084] As described above, in Embodiment 1, when the indoor units 300a and 300b request the heating operation, the three-way electric expansion valves 202a and 202b of the relay unit 200 allow the gas branch pipes 403a and 403b to communicate with the high-pressure pipe 402 and stop a flow of the refrigerant toward the low-pressure pipe 401. With this configuration, the refrigerant flowing from the high-pressure pipe 402 is prevented from entering the low-pressure pipe 401 from the three-way electric expansion valves 202a and 202b, and thus lowering of the heating capacity can be prevented compared with the conventional air-conditioning apparatus.

[0085] In addition, when it is determined that the heat source unit 100 is stopped, the three-way electric expansion valves 202a and 202b are opened at the maximum opening degrees to allow the gas branch pipes 403a and 403b and the low-pressure pipe 401 communicate with each other. When vacuum drawing is performed under this condition, more air can flow through the gas branch pipes 403a and 403b and the low-pressure pipe 401 compared with the conventional configuration, and thus a time required for vacuum drawing of the air-conditioning apparatus 1 can be reduced.

[0086] Furthermore, because the flow of the refrigerant is switched for the cooling operation and for the heating operation by using the three-way electric expansion valves 202a and 202b, the number of components in the first branch portion 240 can be reduced and thus the space occupied by the first branch portion 240 can be reduced in the relay unit 200. When the flow of the refrigerant is switched for the cooling operation and for the heating operation by using a plurality of valves for one indoor unit 300a, it is difficult to simultaneously operate the valves in reality and a time lag of a few seconds occurs. On the other hand, because the switching is performed by using a single three-way electric expansion valve 202a for one indoor unit 300a, only one object needs to be controlled and thus there is no need to consider occurrence of a time lag.

Embodiment 2

[0087] Fig. 8 is a refrigerant circuit diagram of an air-conditioning apparatus 1A according to Embodiment 2. As shown in Fig. 8, Embodiment 2 differs from Embodi-

ment 1 in that the air-conditioning apparatus 1A has a different configuration in a first branch portion 240A of a relay unit 200A. The other configurations of the air-conditioning apparatus 1A are the same as those in Embodiment 1.

[0088] As shown in Fig. 8, the first branch portion 240A of the relay unit 200A of Embodiment 2 includes opening-closing valves 213a and 213b for heating and expansion valves 214a and 214b for cooling. The opening-closing valves 213a and 213b for heating are connected to the respective gas branch pipes 403a and 403b at one ends and are connected to the high-pressure pipe 402 at the other ends. The expansion valves 214a and 214b for cooling are connected to the respective gas branch pipes 403a and 403b at one ends and are connected to the low-pressure pipe 401 at the other ends. The opening-closing valves 213a and 213b for heating are, for example, solenoid valves. The expansion valves 214a and 214b for cooling are, for example, two-way electric expansion valves whose opening degrees is adjustable.

[0089] Fig. 9 is a flowchart illustrating control operations of the opening-closing valve 213a for heating and the expansion valve 214a for cooling according to Embodiment 2. Control operations of the opening-closing valve 213b for heating and the expansion valve 214b for cooling are the same as those of the opening-closing valve 213a for heating and the expansion valve 214a for cooling. The controller 10 is configured to determine the opening degree for the opening-closing valve 213a for heating and the opening degree for the expansion valve 214a for cooling according to the operation mode requested for the indoor unit 300a that is connected to the opening-closing valve 213a for heating and the expansion valve 214a for cooling.

[0090] First, the controller 10 determines whether the heat source unit 100 is operating or not (S21). In this case, when the compressor 101 is running, the controller 10 determines that the heat source unit 100 is operating. When the heat source unit 100 is operating (YES in S21), the controller 10 determines a state of the indoor unit 300a (S22). In this case, the controller 10 determines which operation, among stop, cooling operation, and heating operation, the indoor unit 300a requests.

[0091] When the indoor unit 300a requests the stop (STOP in S22), the controller 10 closes both the opening-closing valve 213b for heating and the expansion valve 214b for cooling (S23). That is, when the indoor unit 300a is stopped while the heat source unit 100 is operating, the gas branch pipe 403a of the indoor unit 300a is closed.

[0092] When the indoor unit 300a requests the heating operation (HEATING in S22), the controller 10 opens the opening-closing valve 213a for heating and closes the expansion valve 214a for cooling (S24). Thus, when the indoor unit 300a performs the heating operation while the heat source unit 100 is operating, the gas branch pipe 403a of the indoor unit 300a and the high-pressure pipe 402 are made to communicate with each other.

[0093] When the indoor unit 300a requests the cooling

operation (COOLING in S22) or when the heat source unit 100 is not operating (NO in S21), the controller 10 closes the opening-closing valve 213a for heating and opens the expansion valve 214a for cooling (S25). In this case, the controller 10 fully opens the expansion valve 214a for cooling. Thus, when the indoor unit 300a performs the cooling operation while the heat source unit 100 is operating or when the heat source unit 100 is stopped, the gas branch pipe 403a of the indoor unit 300a and the low-pressure pipe 401 are made to communicate with each other.

[0094] As described above, also in Embodiment 2, when it is determined that the indoor units 300a and 300b request the heating operation, the gas branch pipes 403a and 403b and the high-pressure pipe 402 can communicate with each other and a flow of refrigerant toward the low-pressure pipe 401 can be stopped. With this configuration, the refrigerant flowing from the high-pressure pipe 402 is prevented from entering the low-pressure pipe 401 from the expansion valves 214a and 214b for cooling, and thus lowering of the heating capacity can be prevented compared with the conventional air-conditioning apparatus.

[0095] In addition, when it is determined that the heat source unit 100 is stopped, the gas branch pipes 403a and 403b and the low-pressure pipe 401 can be made to communicate with each other at the maximum opening degrees. When vacuum drawing is performed under this condition, more air can flow through the gas branch pipes 403a and 403b and the low-pressure pipe 401 compared with the conventional configuration, and thus a time required for vacuum drawing of the air-conditioning apparatus 1 can be reduced.

[0096] Although the embodiments are described as above, the present disclosure is not limited thereto, and various modifications and combinations can be made without departing from the scope of the present disclosure. For example, in Embodiment 1, the controller 10 transmits a pulse signal of the control amount P1 to the three-way electric expansion valve 202a when the indoor unit 300a requests the stop (STOP in S2), but the controller 10 may be configured to transmit a pulse signal of any control amount of between P1 and P2, both inclusive.

[0097] Further, although, in Embodiment 1, the controller 10 transmits a pulse signal of the control amount Pmin to the three-way electric expansion valve 202a when the heat source unit 100 is not operating (NO in S1), the controller 10 may be configured to transmit a pulse signal of any control amount of Pmin or more but less than P1. For example, when there is a possibility that the refrigerant flowed from the relay unit 200 and passed the gas branch pipe 403a of the indoor unit 300a stays in the load-side heat exchanger 301a during stop of the heat source unit 100, the control amount may be set to be larger than Pmin. Thus, the opening degree of the three-way electric expansion valve 202a can be reduced and thus the amount of refrigerant stagnation can be reduced.

[0098] Furthermore, in Embodiment 2, expansion

valves for heating, which are formed as two-way electric expansion valves and whose opening degrees is adjustable, may be used in place of the opening-closing valves 213a and 213b for heating. In this case, the controller 10 is configured to, when the indoor unit 300a requests the stop (STOP in S22), close both the expansion valve for heating and the expansion valve 214a for cooling. In addition, the controller 10 is configured to, when the indoor unit 300a requests the heating operation (HEATING in S22), fully open the expansion valve for heating and close the expansion valve 214a for cooling. Moreover, the controller 10 is configured to, when the indoor unit 300a requests the cooling operation (COOLING in S22) or when the heat source unit 100 is not operating (NO in S21), close the expansion valve for heating and open the expansion valve 214a for cooling. In this case also, similar effects to those of Embodiment 2 can be obtained.

Reference Signs List

[0099] 1, 1A: air-conditioning apparatus, 10: controller, 100: heat source unit, 101: compressor, 102: flow switching valve, 103: heat-source-side heat exchanger, 104: accumulator, 105: third check valve, 106: fourth check valve, 107: fifth check valve, 108: sixth check valve, 109: heat-source-side flow control valve, 110: bypass flow control valve, 111: heat-source-side fan, 113: bypass pipe, 114: main pipe, 120: heat-source-side heat exchange unit, 126: discharge pressure sensor, 127: suction pressure sensor, 131, 132: refrigerant filling unit, 140: heat-source-side flow passage control unit, 200, 200A: relay unit, 201: gas-liquid separator, 202a, 202b: three-way electric expansion valve, 204: first flow control valve, 205: second flow control valve, 206: first heat exchange unit, 207: second heat exchange unit, 208: relay bypass temperature sensor, 209: relay bypass pipe, 210a, 210b: first check valve, 211a, 211b: second check valve, 213a, 213b: opening-closing valve for heating, 214a, 214b: expansion valve for cooling, 231: first pressure sensor, 232: second pressure sensor, 240, 240A: first branch portion, 250: second branch portion, 300a, 300b: indoor unit, 301a, 301b: load-side heat exchanger, 302a, 302b: load-side flow control valve, 303a, 303b: liquid pipe temperature sensor, 304a, 304b: gas pipe temperature sensor, 401: low-pressure pipe, 402: high-pressure pipe, 403a, 403b: gas branch pipe, 404a, 404b: liquid branch pipe

Claims

1. An air-conditioning apparatus comprising:

a heat source unit including a compressor, a flow switching valve, and a heat-source-side heat exchanger;
an indoor unit including a load-side flow control

valve and a load-side heat exchanger and configured to perform a cooling operation or a heating operation;

a relay unit connected to the heat source unit by a low-pressure pipe and a high-pressure pipe, connected to the indoor unit via a gas branch pipe and a liquid branch pipe, and configured to supply refrigerant supplied from the heat source unit to the indoor unit; and

a controller, wherein the relay unit includes a branch portion at which the gas branch pipe and the low-pressure pipe communicate with each other when the indoor unit performs the cooling operation, and at which the gas branch pipe and the high-pressure pipe communicate with each other when the indoor unit performs the heating operation,

the branch portion includes an expansion valve that is connected to the gas branch pipe and the low-pressure pipe and whose opening degree is adjustable, and

the controller is configured to, when the heat source unit is stopped, control the expansion valve to allow the gas branch pipe and the low-pressure pipe to communicate with each other.

2. The air-conditioning apparatus of claim 1, wherein the expansion valve is a three-way electric expansion valve including a first flow passage in which the gas branch pipe and the low-pressure pipe communicate with each other and a second flow passage in which the gas branch pipe and the high-pressure pipe communicate with each other.

3. The air-conditioning apparatus of claim 2, wherein the controller is configured to, when the heat source unit is stopped, control the three-way electric expansion valve to open the first flow passage and close the second flow passage.

4. The air-conditioning apparatus of claim 3, wherein the controller is configured to, when the heat source unit is operating and the indoor unit is stopped, control the three-way electric expansion valve to close the first flow passage and the second flow passage.

5. The air-conditioning apparatus of claim 3 or 4, wherein the controller is configured to, when the heat source unit is operating and the indoor unit performs the cooling operation, control the three-way electric expansion valve to open the first flow passage and close the second flow passage.

6. The air-conditioning apparatus of any one of claims 3 to 5, wherein

the controller is configured to, when the heat source unit is operating and the indoor unit performs the heating operation, control the three-way electric expansion valve to open the second flow passage and close the first flow passage.

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7. The air-conditioning apparatus of claim 1, wherein

the expansion valve is an expansion valve for cooling, comprising a two-way electric expansion valve, and

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the branch portion further includes an opening-closing valve for heating, connected between the gas branch pipe and the high-pressure pipe.

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8. The air-conditioning apparatus of claim 7, wherein the controller is configured to, when the heat source unit is stopped, control the expansion valve for cooling to allow the gas branch pipe and the low-pressure pipe to communicate with each other and control the opening-closing valve for heating to close the gas branch pipe and the high-pressure pipe.

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FIG. 1

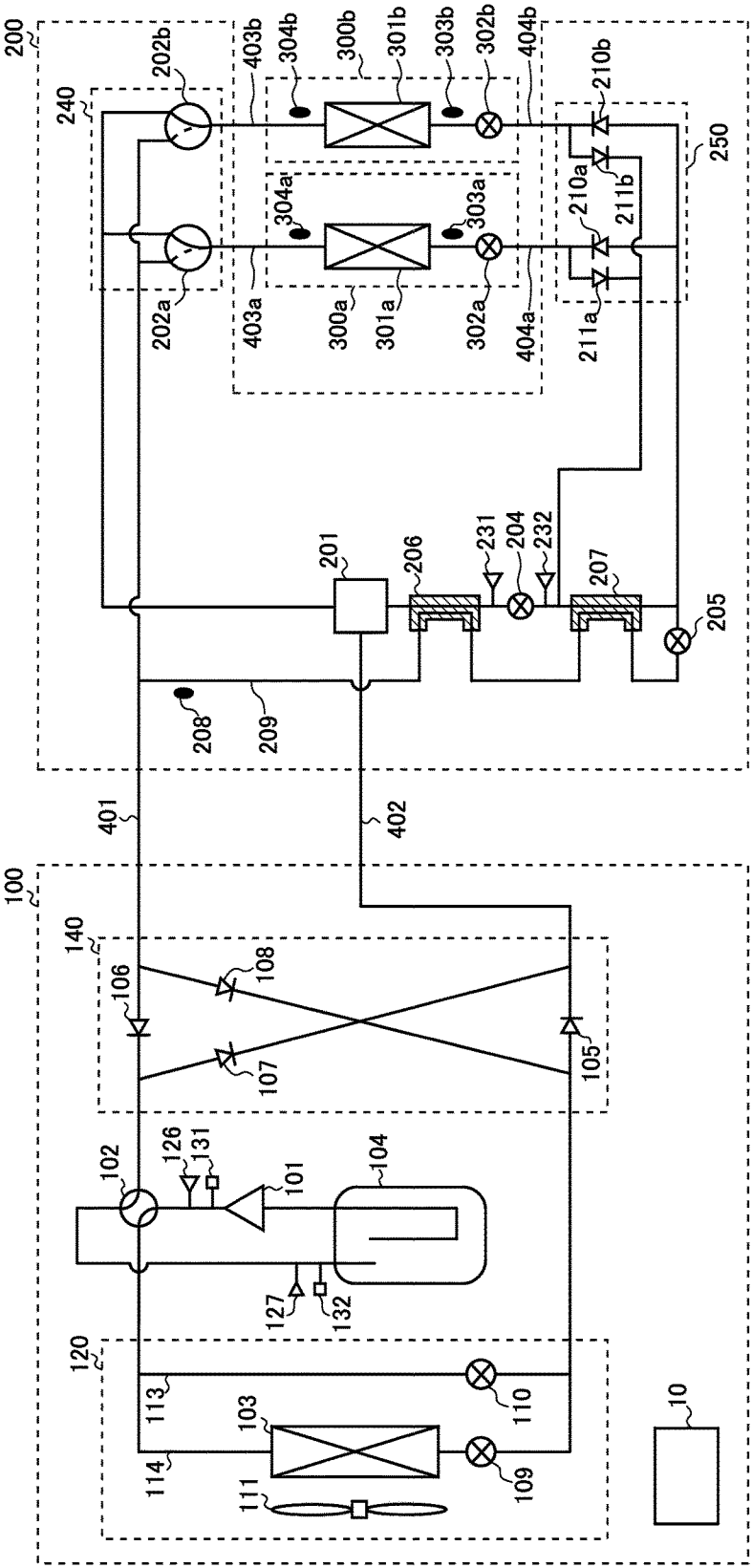


FIG. 2

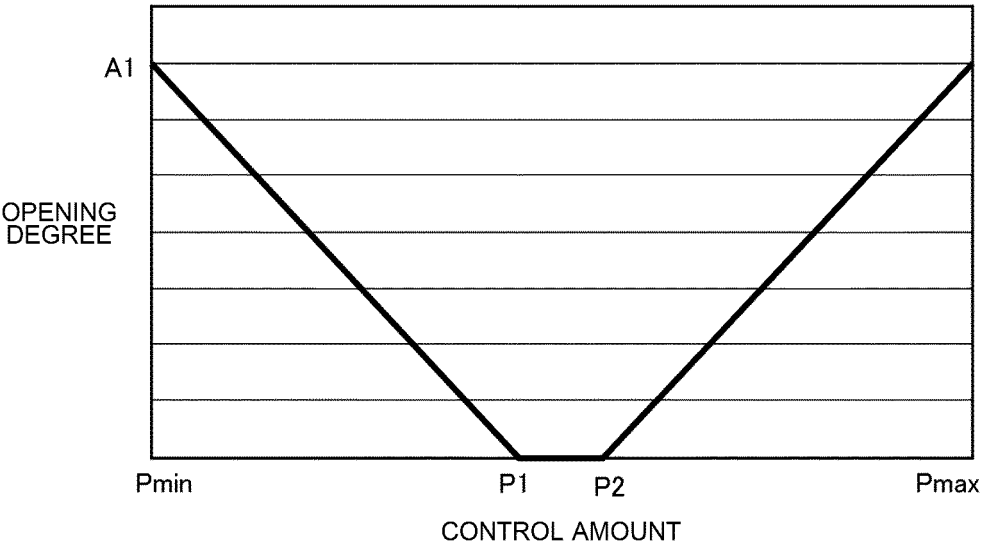


FIG. 3

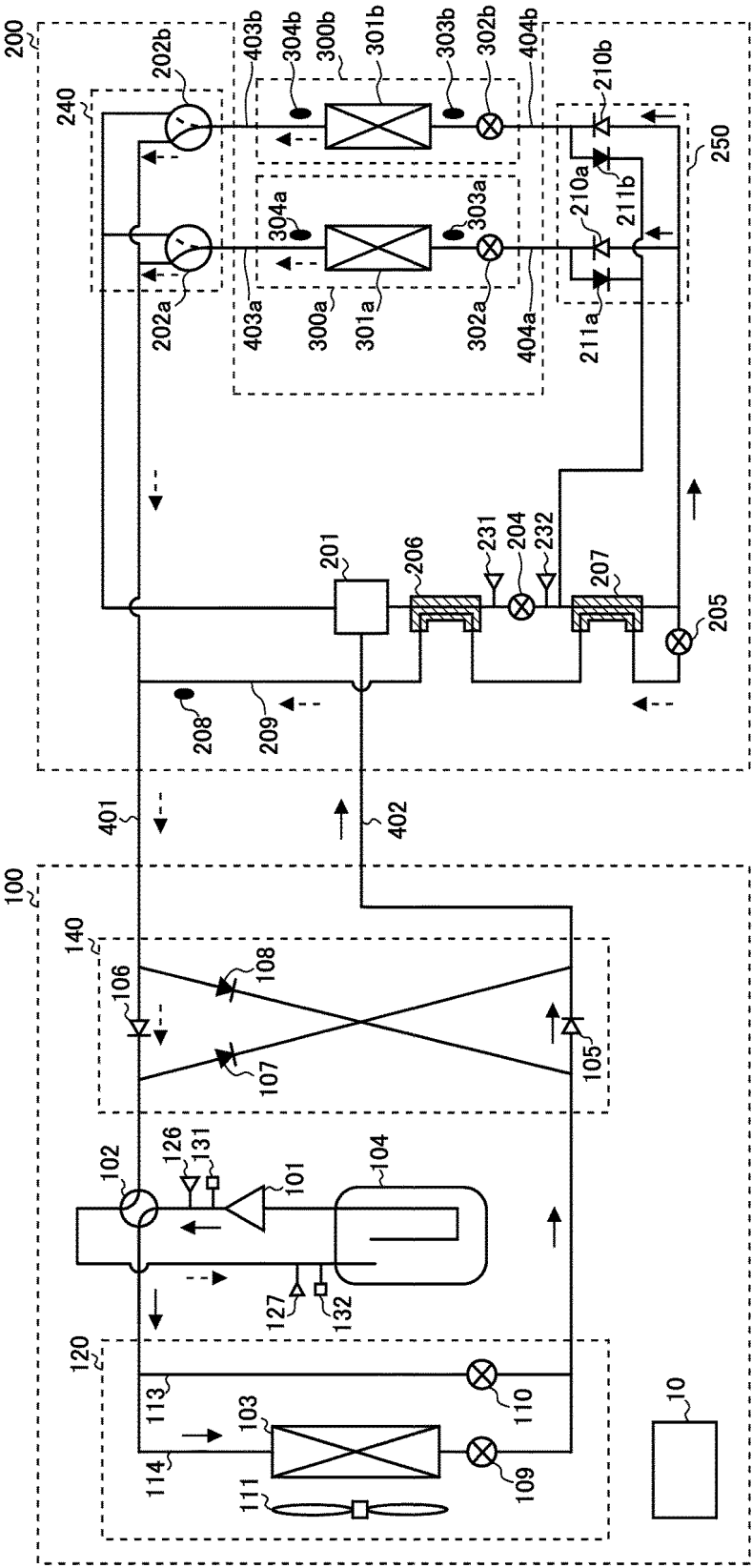
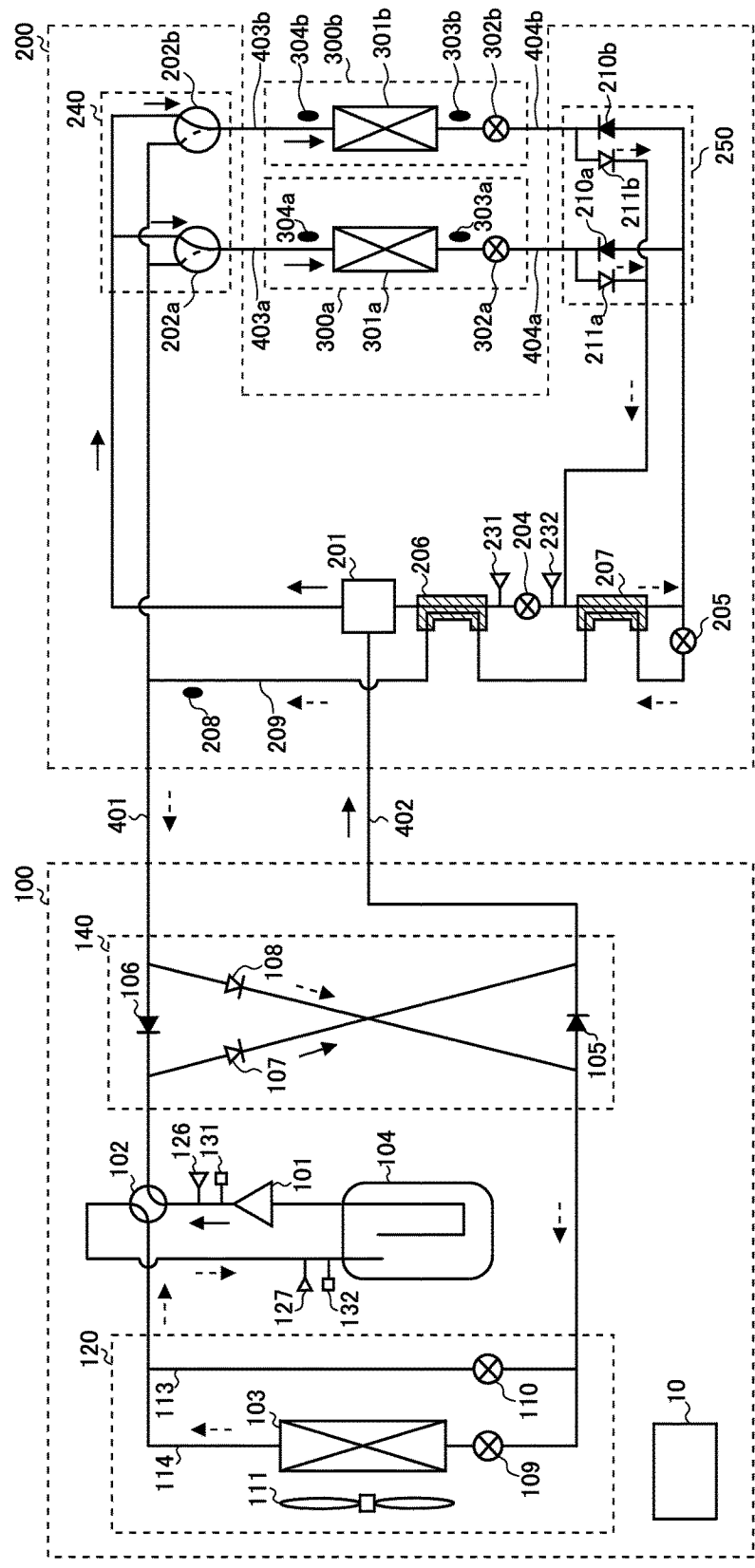


FIG. 4



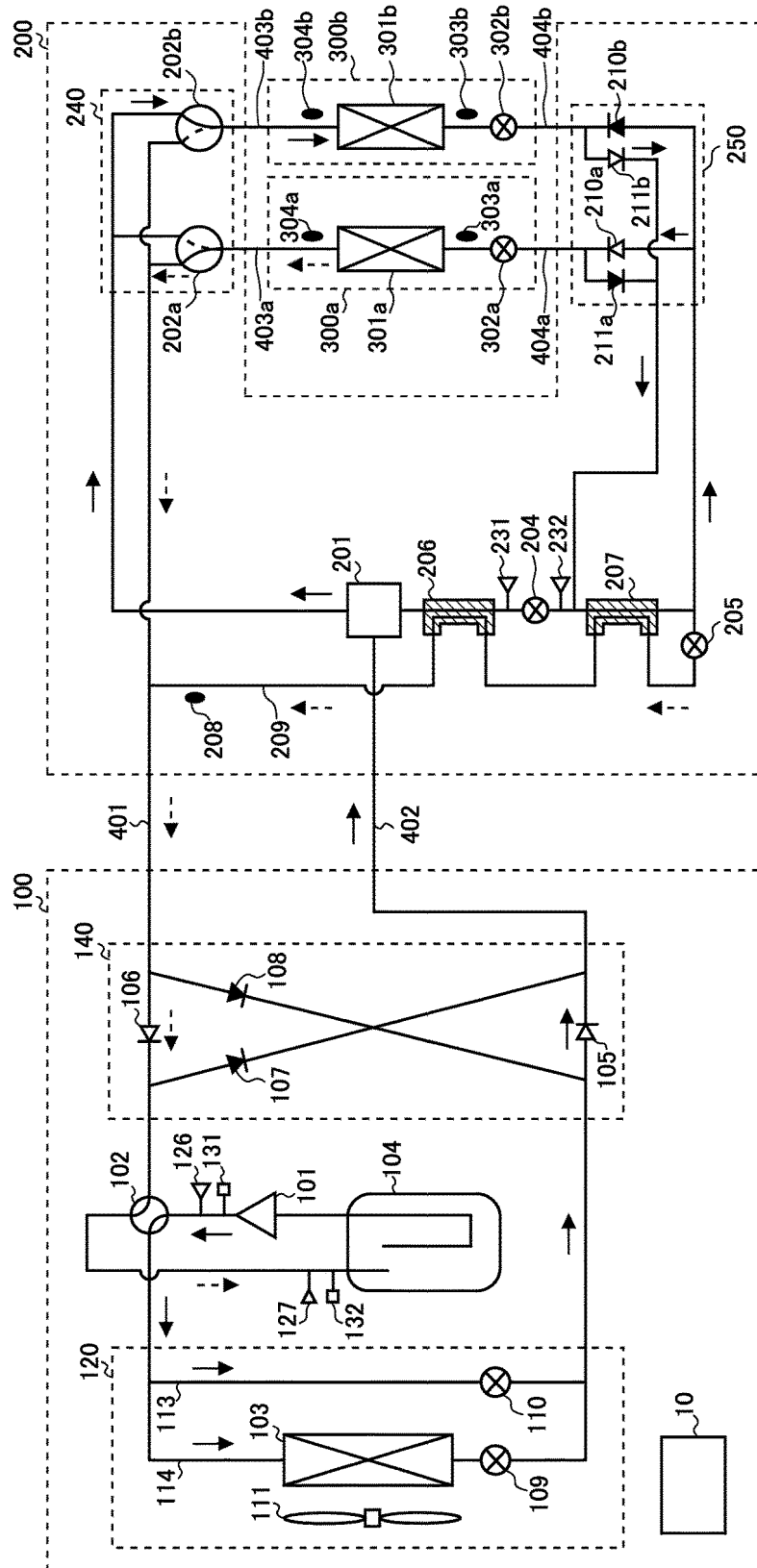


FIG. 5

FIG. 6

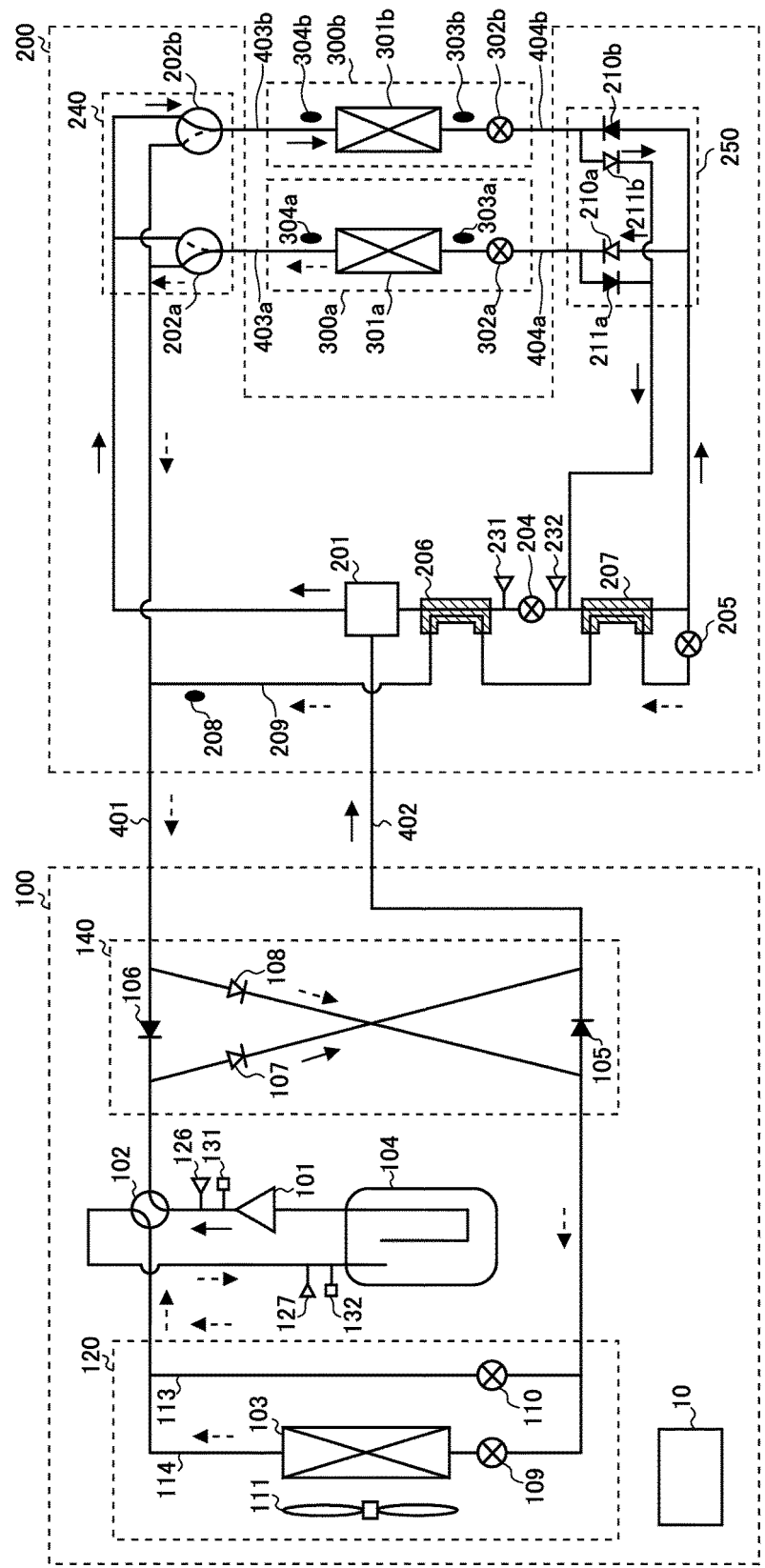


FIG. 7

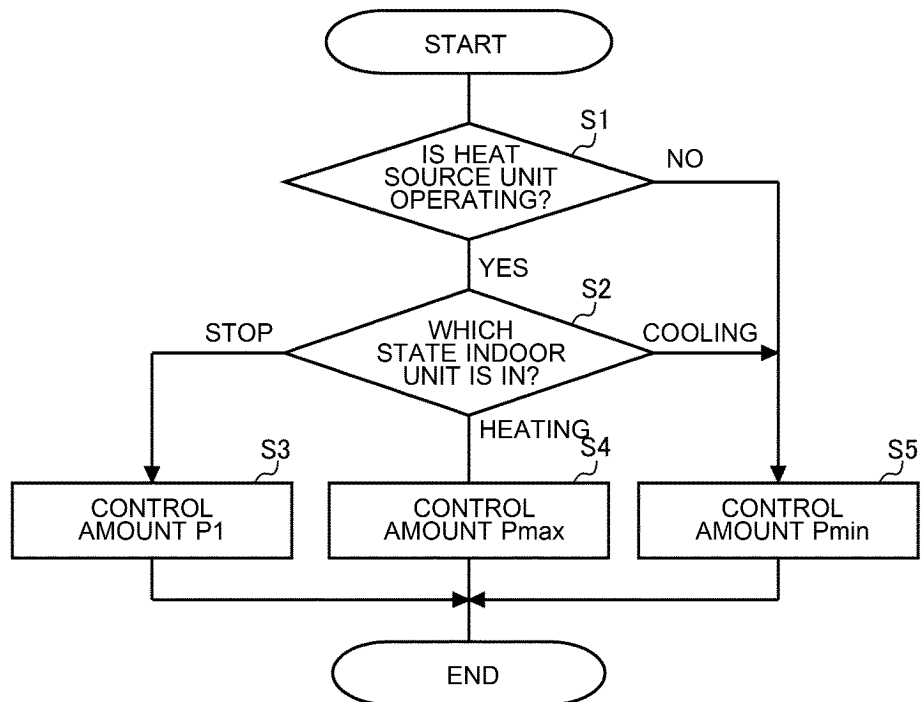
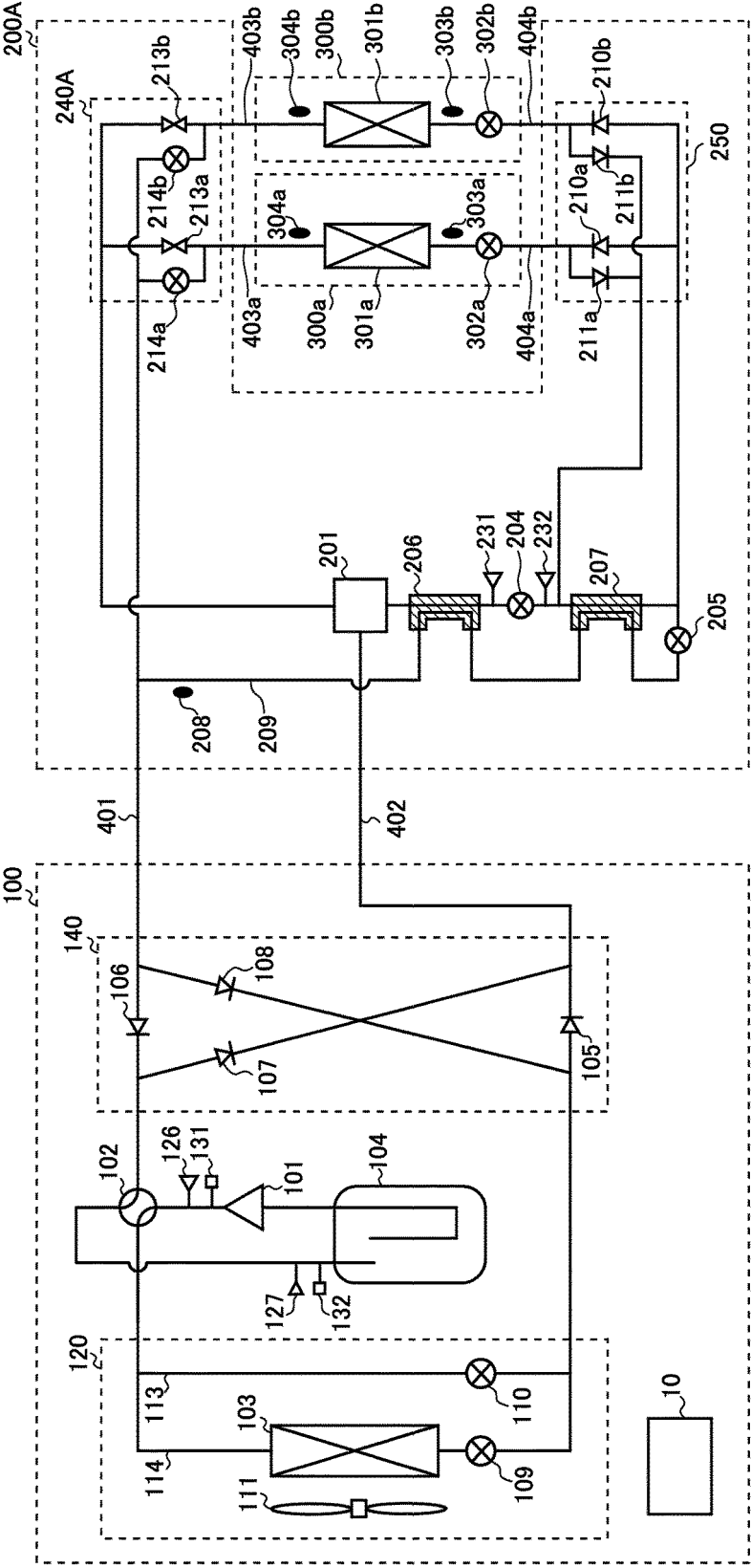
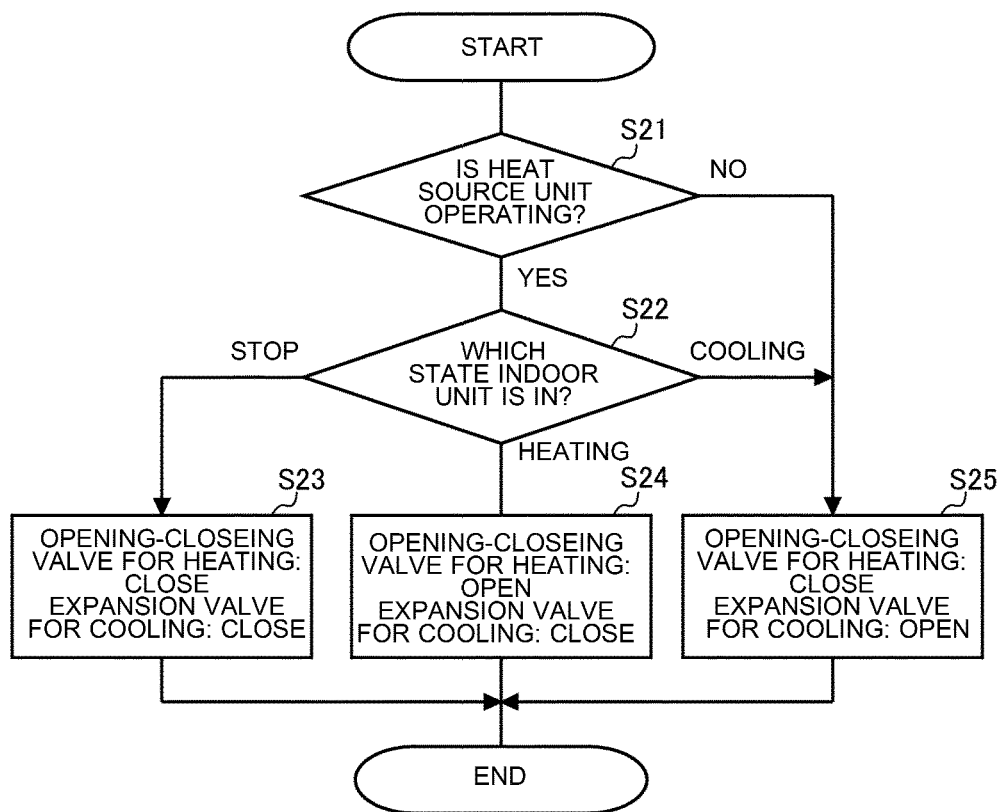


FIG. 8



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FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/001826

A. CLASSIFICATION OF SUBJECT MATTER F25B 13/00 (2006.01)i FI: F25B13/00 104 According to International Patent Classification (IPC) or to both national classification and IPC															
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F25B13/00 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 1971-2022 Registered utility model specifications of Japan 1996-2022 Published registered utility model applications of Japan 1994-2022 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)															
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>JP 6895901 B2 (MITSUBISHI ELECTRIC CORP) 30 June 2021 (2021-06-30) paragraphs [0007]-[0029], fig. 1-10</td> <td>1</td> </tr> <tr> <td>Y</td> <td></td> <td>2-8</td> </tr> <tr> <td>Y</td> <td>JP 60-89643 A (MATSUSHITA SEIKO KK) 20 May 1985 (1985-05-20) p. 2, upper right column, line 4 to lower left column, line 3</td> <td>2-6</td> </tr> <tr> <td>Y</td> <td>JP 63-169451 A (MITSUBISHI ELECTRIC CORP) 13 July 1988 (1988-07-13) p. 1, right column, line 11 to p. 2, lower right column, line 8</td> <td>7-8</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	JP 6895901 B2 (MITSUBISHI ELECTRIC CORP) 30 June 2021 (2021-06-30) paragraphs [0007]-[0029], fig. 1-10	1	Y		2-8	Y	JP 60-89643 A (MATSUSHITA SEIKO KK) 20 May 1985 (1985-05-20) p. 2, upper right column, line 4 to lower left column, line 3	2-6	Y	JP 63-169451 A (MITSUBISHI ELECTRIC CORP) 13 July 1988 (1988-07-13) p. 1, right column, line 11 to p. 2, lower right column, line 8	7-8
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Y		2-8													
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Date of the actual completion of the international search 04 February 2022	Date of mailing of the international search report 08 March 2022														
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.														

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No. PCT/JP2022/001826

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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JP	60-89643	A	20 May 1985	(Family: none)	
JP	63-169451	A	13 July 1988	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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