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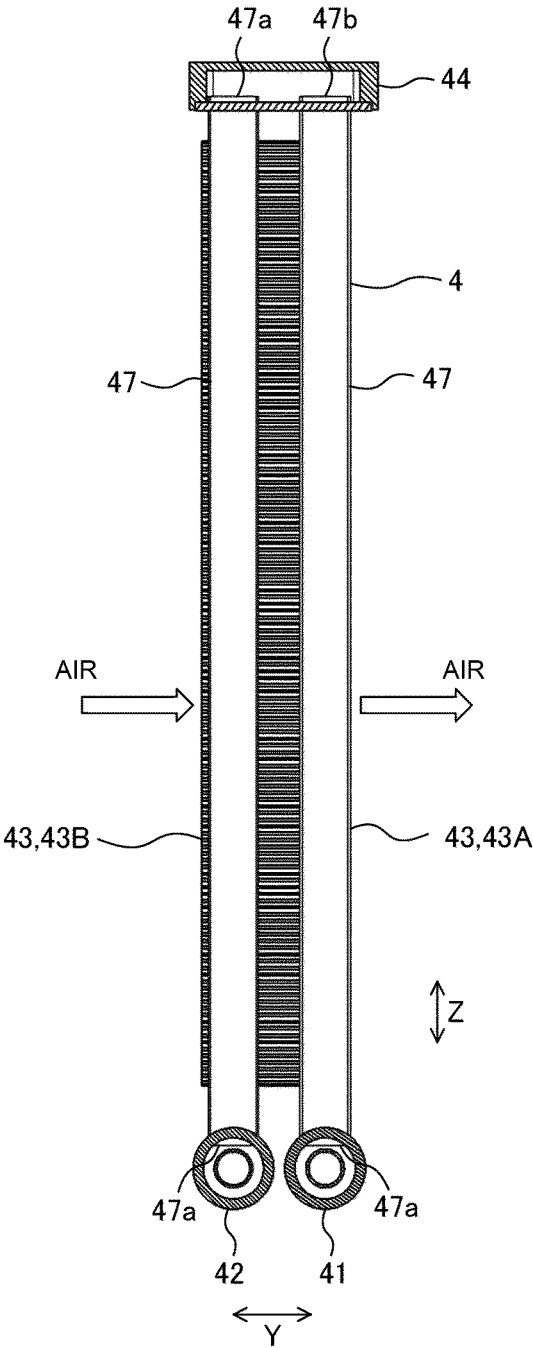
(54) **HEAT EXCHANGER, AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger includes a first heat exchange body that has a plurality of first flat tubes arranged and spaced from each other in a first direction and each of which tube axis extends in a second direction that intersects the first direction; a first refrigerant distributor into which one end portion of each of the plurality of first flat tubes is inserted; and a second refrigerant distributor into which the other end portion of each of the plurality of first flat tubes is inserted. The first refrigerant distributor has a first outer tube that extends in the first direction and into which the one end portion of each of the plurality of first flat tubes is inserted, a first inner tube that extends in the first direction, is located inside the first outer tube, and has a plurality of first refrigerant outflow holes arranged

and spaced from each other in the first direction, and a first partition plate joined to an internal wall of the first outer tube in a state in which the first inner tube passes through a plate thickness. The second refrigerant distributor has a second outer tube that extends in the first direction and into which the other end portion of each of the plurality of first flat tubes is inserted, a second inner tube that extends in the first direction, is located inside the second outer tube, and has a plurality of second refrigerant outflow holes arranged and spaced from each other in the first direction, and a second partition plate joined to an internal wall of the second outer tube in a state in which the second inner tube passes through a plate thickness.

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FIG. 4



Description

Technical Field

[0001] The present disclosure relates to a heat exchanger and a refrigeration cycle apparatus that have a plurality of flat tubes.

Background Art

[0002] Among refrigeration cycle apparatuses that each have a plurality of heat exchangers, some refrigeration cycle apparatus includes a plurality of groups of heat exchangers, with one or more heat exchangers defined as one group. Such a refrigeration cycle apparatus is referable to, for example, Patent Literature 1. The heat exchanger in each of the plurality of groups is an air heat exchanger and has an upper header tube, a lower header tube, heat transfer tubes, and fins.

[0003] In cooling operation, groups are connected in series to each other and a series refrigerant flow passage is thus formed through which refrigerant is caused to flow in series between groups. All the heat exchangers in the series refrigerant flow passage each have heat transfer tubes through which refrigerant is caused to flow from above to below.

[0004] In heating operation, groups are connected in parallel to each other and a parallel refrigerant flow passage is thus formed through which refrigerant is caused to flow in parallel to respective groups. All the heat exchangers in the parallel refrigerant flow passage each have heat transfer tubes through which refrigerant is caused to flow from below to above.

[0005] Also, in some heat exchanger, a refrigerant distributor structured with a double tube provided with an inner tube and an outer tube is used as a lower header, for example. A plurality of outer tubes are provided. Between outer tubes adjacent to each other among the plurality of outer tubes, a gap is defined. A single inner tube is provided and sequentially connected to the plurality of outer tubes. To the outer tubes, a plurality of heat transfer tubes are connected in a tubular-axial direction of the outer tubes. Refrigerant that has flowed between the inner tube and the outer tubes is distributed to the plurality of heat transfer tubes.

Citation List

Patent Literature

[0006] Patent Literature 1: International Publication No. 2019/008664

Summary of Invention

Technical Problem

[0007] Usually, a case in which a heat exchanger

serves as an evaporator, refrigerant in a two-phase gas-liquid state in which gas refrigerant and liquid refrigerant is mixed to each other flows into the heat exchanger. In this case, as a refrigerant distributor located on an inflow side of the heat exchanger, a refrigerant distributor structured with a double tube provided with an inner tube and an outer tube may be used. In the refrigerant distributor structured with a double tube, a large number of refrigerant outflow holes are arranged in parallel to each other in the inner tube. The refrigerant distributor structured with a double tube is formed such that refrigerant is evenly distributed to a plurality of heat transfer tubes included in a heat exchanger and the refrigerant distributor is reduced in capacity.

[0008] On an outflow side of a heat exchanger that serves as an evaporator, a refrigerant distributor structured with a single tube is provided. In a case in which the heat exchanger serves as a condenser, the refrigerant distributor has the function of distributing refrigerant to a plurality of heat transfer tubes included in the heat exchanger.

[0009] However, as in Patent Literature 1 described above, in a case in which a plurality of heat exchangers are mounted on one outdoor unit, connection states between the plurality of heat exchangers are distinguished between a case in which the series refrigerant flow passage is formed and a case in which the parallel refrigerant flow passage is formed. In a case in which, to perform cooling operation, the plurality of heat exchangers mounted on the outdoor unit each serve as a condenser and the plurality of heat exchangers form with each other the series refrigerant flow passage, a heat exchanger located upstream in a flow passage and a heat exchanger located downstream are different in a state of refrigerant that flows in. That is, into the heat exchanger located upstream, gas refrigerant, which is in a single phase, flows. On the other hand, into the heat exchanger located downstream, refrigerant in a two-phase gas-liquid state in which gas refrigerant and liquid refrigerant is mixed to each other flows, because a portion of the gas refrigerant exchanges heat and thus condenses in the heat exchanger located upstream. The refrigerant distributor on an inflow side of the heat exchanger located downstream in this case, however, is a refrigerant distributor structured with a single tube. In the heat exchanger located downstream, refrigerant caused to flow in is thus not evenly distributed to the plurality of flat tubes included in the heat exchanger. In the heat exchanger located downstream, the amounts of the distributed refrigerant vary at different locations of flat tubes. The heat exchange amount is insufficient around the flat tubes into which a large amount of refrigerant is distributed. The heat exchange amount is excessive around the flat tubes into which a small amount of refrigerant is distributed. Such an uneven distribution causes a problem in that efficiency of heat exchange is reduced.

[0010] The present disclosure is made to solve such a problem, and an object of the present disclosure is to

provide a refrigeration cycle apparatus and a heat exchanger that is one heat exchanger among a plurality of heat exchangers that each serve as a condenser in cooling operation and is provided with a refrigerant distributor that evenly distributes refrigerant to a plurality of flat tubes also in a case in which, when the plurality of heat exchangers are connected in series to each other and a series refrigerant flow passage is thus formed, the heat exchanger is located downstream in a direction through refrigerant flows.

Solution to Problem

[0011] A heat exchanger according to one embodiment of the present disclosure includes a first heat exchange body that has a plurality of first flat tubes arranged and spaced from each other in a first direction and each of which tube axis extends in a second direction that intersects the first direction; a first refrigerant distributor into which one end portion of each of the plurality of first flat tubes is inserted; and a second refrigerant distributor into which the other end portion of each of the plurality of first flat tubes is inserted, the first refrigerant distributor having a first outer tube that extends in the first direction and into which the one end portion of each of the plurality of first flat tubes is inserted, a first inner tube that extends in the first direction, is located inside the first outer tube, and has a plurality of first refrigerant outflow holes arranged and spaced from each other in the first direction, and a first partition plate joined to an internal wall of the first outer tube in a state in which the first inner tube passes through a plate thickness, the second refrigerant distributor having a second outer tube that extends in the first direction and into which the other end portion of each of the plurality of first flat tubes is inserted, a second inner tube that extends in the first direction, is located inside the second outer tube, and has a plurality of second refrigerant outflow holes arranged and spaced from each other in the first direction, and a second partition plate joined to an internal wall of the second outer tube in a state in which the second inner tube passes through a plate thickness.

[0012] A refrigeration cycle apparatus according to another embodiment of the present disclosure is provided with an outdoor unit, in which the outdoor unit is provided with the heat exchanger described above, a second heat exchanger, a refrigerant pipe through which the heat exchanger and the second heat exchanger are connected to each other, a housing that is box-shaped and houses the heat exchanger and the second heat exchanger inside, and an air-sending device located at an upper portion of the housing and configured to form a flow of air by being driven to rotate and blow out the air that passes through the heat exchanger and the second heat exchanger upward from an upper face of the housing, and the heat exchanger and the second heat exchanger are located along a part or all of four side faces of the housing.

Advantageous Effects of Invention

[0013] The heat exchanger and the refrigeration cycle apparatus according to an embodiment of the present disclosure have a refrigerant distributor structured with a double tube and a plurality of refrigerant outflow holes arranged in parallel to each other in an inner tube of the refrigerant distributor. Also in a case, for example, in which refrigerant in a two-phase gas-liquid state is caused to flow into the heat exchanger, the refrigerant distributor is thus provided, such an uneven situation is therefore addressed in which refrigerant is unevenly distributed to a plurality of flat tubes. Also, refrigerant is thus evenly distributed to the plurality of flat tubes, which ensures that the required heat exchange amount is uniform across all faces of the heat exchange body and that a reduction in heat exchange efficiency is thus prevented.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 2] Fig. 2 is a perspective view that illustrates a connection state in which an outdoor heat exchanger 3 and an outdoor heat exchanger 4 are connected to each other in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 3] Fig. 3 is a cross-sectional view that illustrates a configuration of the outdoor heat exchanger 3 illustrated in Fig. 2.

[Fig. 4] Fig. 4 is a cross-sectional view that illustrates a configuration of the outdoor heat exchanger 4 illustrated in Fig. 2.

[Fig. 5] Fig. 5 is a cross-sectional view that illustrates a configuration of a refrigerant distributor 31 provided in the outdoor heat exchanger 3 illustrated in Fig. 3.

[Fig. 6] Fig. 6 is a cross-sectional view that illustrates a configuration of a refrigerant distributor 32 provided in the outdoor heat exchanger 3 illustrated in Fig. 3.

[Fig. 7] Fig. 7 is a cross-sectional view that illustrates a configuration of a refrigerant distributor 41 provided in the outdoor heat exchanger 4 illustrated in Fig. 4.

[Fig. 8] Fig. 8 is a cross-sectional view that illustrates a configuration of a refrigerant distributor 42 provided in the outdoor heat exchanger 4 illustrated in Fig. 4.

[Fig. 9] Fig. 9 is a perspective view that illustrates a connection state in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 each in a heating operation state are connected to each other in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 10] Fig. 10 is a diagram that schematically illustrates distribution acts of refrigerant at the refrigerant distributor 31 provided in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 11] Fig. 11 is a diagram that schematically illustrates distribution acts of refrigerant at the refrigerant distributor 32, 41, 42 provided in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 12] Fig. 12 is a diagram that schematically illustrates the state of liquid refrigerant in the refrigerant distributor 31 provided in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 13] Fig. 13 is a diagram that schematically illustrates the state of liquid refrigerant in the refrigerant distributor 32, 41, 42 provided in the refrigeration cycle apparatus 100 according to Embodiment 1.

[Fig. 14] Fig. 14 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Modification 1 of Embodiment 1.

[Fig. 15] Fig. 15 is a refrigerant circuit diagram that illustrates a configuration of the refrigeration cycle apparatus 100 according to Modification 1 of Embodiment 1.

[Fig. 16] Fig. 16 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1.

[Fig. 17] Fig. 17 is a diagram that illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1 is in a cooling operation state.

[Fig. 18] Fig. 18 illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1 is in a heating operation state.

[Fig. 19] Fig. 19 is a perspective view that illustrates a connection state in which an outdoor heat exchanger 3C and an outdoor heat exchanger 4C are connected to each other in a refrigeration cycle apparatus 100 according to Embodiment 2.

[Fig. 20] Fig. 20 is a perspective view that illustrates an external view of an outdoor unit 101 provided in a refrigeration cycle apparatus 100 according to Embodiment 3.

[Fig. 21] Fig. 21 includes plan views that schematically illustrate examples of a configuration of the outdoor unit 101 provided in the refrigeration cycle apparatus 100 according to Embodiment 3.

[Fig. 22] Fig. 22 is a perspective view that illustrates an external view of an outdoor unit 101 provided in a refrigeration cycle apparatus 100 according to Modification of Embodiment 3.

[Fig. 23] Fig. 23 is a plan view that schematically illustrates an example of a configuration of the outdoor unit 101 provided in the refrigeration cycle

apparatus 100 according to Embodiment 3.

Description of Embodiments

[0015] Embodiments of a heat exchanger and a refrigeration cycle apparatus according to the present disclosure are described below with reference to drawings. The present disclosure is not limited to embodiments described below and may be variously changed without departing from the spirit of the present disclosure. The present disclosure also includes any combination of combinable configurations among configurations described in the embodiments and their modifications described below. Also, the same or equivalent elements are denoted by the same reference signs in the drawings. Their descriptions are omitted or simplified as long as resultant descriptions are suited. Furthermore, among a plurality of components or elements of the same kind that are, for example, differentiated by suffixes such as upper-case alphabetic characters postfixed to the reference signs, components or elements not required to be distinguished or specified in particular may be described without such suffixes. In addition, relative relationships in dimension between components, shapes of components, and other details of components illustrated in the drawings may differ from those of actual components. Shapes, sizes, locations and other details of components illustrated in the drawings may be changed without departing from the scope of the present disclosure as long as resultant configurations are suited.

[0016] Also, in the drawings, each outdoor heat exchanger has a width direction referred to as an X direction, a height direction referred to as a Z direction, and a front-rear direction referred to as a Y direction. The X direction and the Y direction are, for example, horizontal directions. The Z direction is, for example, an up-down direction and may be a vertical direction in some cases. The X direction is a direction in which a plurality of flat tubes are arranged. The Z direction is an axial direction of the flat tube and a direction through which refrigerant flows. The Y direction is a direction through which air flows. The X direction may be referred to as a first direction or a third direction. The Z direction may be referred to as a second direction.

Embodiment 1

Configuration of Refrigeration Cycle Apparatus 100

[0017] Fig. 1 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1. The refrigeration cycle apparatus 100 has an outdoor unit 101 and an indoor unit 201 and forms a refrigeration cycle such that the outdoor unit 101 and the indoor unit 201 are connected to each other by a refrigerant pipe 310. In addition, the refrigerant pipe 310 includes a plurality of refrigerant pipes 300 to 308. These refrigerant pipes 300 to 308 described herein

may be collectively referred to as the refrigerant pipe 310. The outdoor unit 101 and the indoor unit 201 are connected to each other at connection ports P1 and P2. The connection port P1 and the connection port P2 are each included in the refrigerant pipe 310. The connection port P1 is an inflow connection port through which refrigerant flows into the outdoor unit 101 when the refrigeration cycle apparatus 100 is in a cooling operation state and is also an outflow connection port through which refrigerant flows out from the outdoor unit 101 when the refrigeration cycle apparatus 100 is in a heating operation state. The connection port P2 is an outflow connection port through which refrigerant flows out from the outdoor unit 101 when the refrigeration cycle apparatus 100 is in a cooling operation state and is also an inflow connection port through which refrigerant flows into the outdoor unit 101 when the refrigeration cycle apparatus 100 is in a heating operation state. In addition, Embodiment 1 describes that one outdoor unit 101 and one indoor unit 201 are provided; however, each of the number of the outdoor units 101 and the number of the indoor units 201 is not limited to one and may also be two or more.

[0018] A refrigerant circuit included in the refrigeration cycle apparatus 100 is filled with a refrigerant such as a fluorocarbon refrigerant and an HFO refrigerant.

[0019] Examples of a fluorocarbon refrigerant include an HFC refrigerant, which stands for fluorinated hydrocarbon or hydrofluorocarbon. Examples of an HFC refrigerant include difluoromethane, which is also referred to as HFC-32 and R32, pentafluoroethane, which is also referred to as HFC-125 and R125, 1,1,1-trifluoroethane, which is also referred to as HFC-143a and R143a, 1,1,1,2-tetrafluoroethane, which is also referred to as HFC-134a and R134a. Furthermore, other examples of a fluorocarbon refrigerant also include a refrigerant mixture in which HFC refrigerants described above are mixed with each other. Examples of a refrigerant mixture include a refrigerant mixture R410A in which R32 and R125 are mixed with each other, a refrigerant mixture R407C in which R32, R125, and R134a are mixed with each other, and a refrigerant mixture R404A in which R125, R143a, and R134a are mixed with each other.

[0020] Examples of a HFO refrigerant, which stands for a hydrofluoroolefin refrigerant, include HFO-1234yf, HFO-1234ze(E), and HFO-1234ze(Z).

[0021] A refrigerant with which the refrigerant circuit included in the refrigeration cycle apparatus 100 is filled is not limited to the examples described above and any refrigerants used in a vapor-compression heat pump is also usable. Specific examples of usable refrigerants include a CO₂ refrigerant, an HC refrigerant, such as a propane refrigerant and an isobutane refrigerant, and an ammonia refrigerant. Furthermore, a refrigerant mixture in which a fluorocarbon refrigerant and an HFO refrigerant are mixed with each other, such as a refrigerant mixture in which R32 and HFO-1234yf are mixed with each other, is also usable as a refrigerant.

Outdoor Unit 101

[0022] The outdoor unit 101 has a compressor 1, a four-way valve 2, an outdoor heat exchanger 3, an outdoor heat exchanger 4, an expansion valve 5, an expansion valve 6, a solenoid valve 7, a solenoid valve 8, two outdoor air-sending devices 9, an accumulator 10, and the refrigerant pipes 300 to 306 through which these components are connected to each other.

[0023] The compressor 1 is a fluid machine configured to compress sucked low-pressure refrigerant and discharge the refrigerant as high-pressure refrigerant. The compressor 1 is, for example, a rotary compressor or a scroll compressor. In addition, the compressor 1 may also be, for example, a compressor of which rotational frequency is constant or a compressor of which rotational frequency is controllable with an inverter mounted.

[0024] The four-way valve 2 is a flow switching device provided at a discharge side of the compressor 1 and configured to switch between a circulation direction of refrigerant in the cooling operation state and a circulation direction of refrigerant in the heating operation state. Four connection ports 2a to 2d included in the four-way valve 2 are each connected to its corresponding one of the compressor 1, the outdoor heat exchanger 3, the accumulator 10, and the connection port P1 at which the outdoor unit 101 and the indoor unit 201 are connected to each other. Among the four connection ports 2a to 2d of the four-way valve 2, the connection port 2a located toward the compressor 1 is selected to be connected to either the connection port 2b located toward the outdoor heat exchanger 3 or the connection port 2d located toward the connection port P2 of the outdoor unit 101. Also, between the connection ports 2b and 2d, an unselected connection port is connected to the connection port 2c, which is connected to the accumulator 10. Specifically, in the cooling operation state, the connection port 2a is connected to the connection port 2b and the connection port 2d is connected to the connection port 2c. In the heating operation state, the connection port 2a is connected to the connection port 2d and the connection port 2b is connected to the connection port 2c.

[0025] The outdoor heat exchanger 3 is a heat exchanger that allows refrigerant that flows inside and air to exchange heat with each other. The outdoor heat exchanger 3 serves as a condenser in the cooling operation state and serves as an evaporator in the heating operation state. The outdoor heat exchanger 3 is connected to the four-way valve 2 through the refrigerant pipe 300. The refrigerant pipe 300 is branched from between the outdoor heat exchanger 3 and the four-way valve 2 to the refrigerant pipe 301. The refrigerant pipe 301 is connected to the solenoid valve 8. The outdoor heat exchanger 3 has connection ports 3a and 3b, which are connected to the refrigerant pipes. The connection port 3a is connected to the four-way valve 2. The connection port 3b located across inside from the opposite connection port 3a is connected to the expansion valve 5 through the

refrigerant pipe 302. The refrigerant pipe 302 is branched from between the outdoor heat exchanger 3 and the expansion valve 5 to the refrigerant pipe 303. The refrigerant pipe 303 is connected to the solenoid valve 7. When wind generated by the outdoor air-sending devices 9 passes through the outdoor heat exchanger 3, the outdoor heat exchanger 3 allows air that passes through and refrigerant that flows inside to exchange heat with each other. The outdoor air-sending devices 9 are, for example, centrifugal fans, such as sirocco fans and turbo fans, cross-flow fans, diagonal-flow fans, or propeller fans. In addition, the outdoor heat exchanger 3 corresponds to a second heat exchanger described in Embodiment 1.

[0026] The outdoor heat exchanger 4 is a heat exchanger that allows refrigerant that flows inside and air to exchange heat with each other. The outdoor heat exchanger 4 serves as a condenser in the cooling operation state and serves as an evaporator in the heating operation state. The outdoor heat exchanger 4 is connected to the solenoid valve 8 through the refrigerant pipe 301. The refrigerant pipe 301 is branched from between the outdoor heat exchanger 4 and the solenoid valve 8 to the refrigerant pipe 303 described above. The outdoor heat exchanger 4 has connection ports 4a and 4b, which are connected to the refrigerant pipes. The connection port 4a is connected to the four-way valve 2 through the solenoid valve 8. The connection port 4b located across inside from the opposite connection port 4a is connected to the expansion valve 6 through the refrigerant pipe 304. When wind generated by the outdoor air-sending devices 9 passes through the outdoor heat exchanger 4, the outdoor heat exchanger 4 allows air that passes through and refrigerant that flows inside to exchange heat with each other. In addition, the outdoor heat exchanger 4 corresponds to a heat exchanger described in Embodiment 1. The refrigerant pipe 304 provided with the expansion valve 6 is joined to the refrigerant pipe 302 provided with expansion valve 5. A junction at which the refrigerant pipe 304 and the refrigerant pipe 302 are joined to each other is connected to the connection port P2. The connection port P2 is an outflow connection port through which refrigerant flows out from the outdoor unit 101 in the cooling operation state and is also an inflow connection port through which refrigerant flows into the outdoor unit 101 in the heating operation state.

[0027] The expansion valve 5 and the expansion valve 6 are each configured to serve as a pressure reducing valve or an expansion valve and reduce the pressure of refrigerant and thus expand the refrigerant. The expansion valve 5 and the expansion valve 6 are each, for example, a pressure reducing device such as a linear electronic expansion valve of which opening degree is multi-stepwise or serially adjustable.

[0028] The solenoid valve 7 and the solenoid valve 8 are each configured to open and close a flow passage depending on whether voltage is applied. The solenoid valve 7 and the solenoid valve 8 are configured block and

open respective flows of refrigerant and thus switch flow passages of refrigerant.

[0029] The accumulator 10 is provided such that an outflow side of the accumulator 10 is connected to a suction side of the compressor 1. The accumulator 10 has the function of separating liquid refrigerant and gas refrigerant from each other and storing surplus refrigerant. An inflow side of the accumulator 10 is connected to the connection port 2c of the four-way valve 2 through the refrigerant pipe 306.

[0030] To the outdoor unit 101, a controller 11 is provided. The controller 11 controls acts of the compressor 1, the four-way valve 2, the expansion valve 5, the expansion valve 6, the solenoid valve 7, the solenoid valve 8, and the two outdoor air-sending devices 9.

[0031] A hardware configuration of the controller 11 is described below. The controller 11 is formed by a processor circuit. The processor circuit is formed by dedicated hardware or a processor. Examples of the dedicated hardware include an application specific integrated circuit, which is also referred to as an ASIC, and a field programmable gate array, which is also referred to as an FPGA. The processor executes a program stored in a memory. The controller 11 has unillustrated memory circuitry. The memory circuitry is formed by a memory. The memory is non-volatile or volatile semiconductor memory such as a random access memory, which is also referred to as a RAM, a read only memory, which is also referred to as a ROM, a flash memory, and an erasable programmable ROM, which is also referred to as an EPROM, or a disk such as a magnetic disk, a flexible disk, and an optical disk.

Indoor Unit 201

[0032] The indoor unit 201 is formed by an indoor heat exchanger 21, an indoor air-sending device 22, an expansion valve 23, and the refrigerant pipes 307 and 308 through which these components are connected to each other. The indoor unit 201 forms, together with the outdoor unit 101, a refrigeration cycle. The indoor unit 201 supplies cooling energy or heating energy from the outdoor unit 101 to a cooling load or a heating load. In addition, the refrigerant load and the heating load correspond to, for example, an indoor space in which the indoor unit 201 is located.

[0033] The indoor heat exchanger 21 is a heat exchanger that allows refrigerant that flows inside and air to exchange heat with each other. The indoor heat exchanger 21 serves as an evaporator in the cooling operation state and serves as a condenser in the heating operation state. The indoor heat exchanger 21 has connection ports 21a and 21b, which are connected to the refrigerant pipes. The connection port 21a is connected to the expansion valve 23 through the refrigerant pipe 307. The connection port 21b located across inside from the opposite connection port 21a is connected to the connection port P1 through the refrigerant pipe 308. When wind

generated by the indoor air-sending device 22 passes through the indoor heat exchanger 21, the indoor heat exchanger 21 allows air that passes through and refrigerant that flows inside to exchange heat with each other. The indoor air-sending device 22 is, for example, a centrifugal fan, such as a sirocco fan and a turbo fan, a cross-flow fan, a diagonal-flow fan, or a propeller fan.

[0034] The expansion valve 23 is configured to serve as a pressure reducing valve or an expansion valve and reduce the pressure of refrigerant and thus expand the refrigerant. The expansion valve 23 is, for example, a pressure reducing device such as a linear electronic expansion valve of which opening degree is multi-step-wise or serially adjustable.

Operation of Refrigeration Cycle Apparatus 100

Cooling Operation State under Series Refrigerant Flow Passage

[0035] When the refrigeration cycle apparatus 100 is in a cooling operation state, the controller 11 exercises control such that the expansion valve 5 is in a fully closed state, the solenoid valve 7 is in an open state, the solenoid valve 8 is in a closed state, and the expansion valve 6 is in a fully open state. The compressor 1 sucks in refrigerant from the accumulator 10 and then compresses the refrigerant. The compressed refrigerant turns into gas refrigerant, is then discharged from the compressor 1, and flows into the outdoor heat exchanger 3 through the four-way valve 2. In the outdoor heat exchanger 3, a portion of the gas refrigerant condenses and the gas refrigerant then turns into a two-phase gas-liquid state of gas refrigerant and liquid refrigerant. The refrigerant in a two-phase gas-liquid state passes through the solenoid valve 7 and then flows into the outdoor heat exchanger 4. The refrigerant compressed in the outdoor heat exchanger 4 turns into refrigerant in a liquid state. The refrigerant in a liquid state passes through the expansion valve 6, then flows out from the outdoor unit 101, and flows into the indoor unit 201. In the indoor unit 201, the refrigerant is reduced in pressure in the expansion valve 23, then evaporates in the indoor heat exchanger 21, and supplies cooling energy to air. The refrigerant flows out from the indoor unit 201, then flows into the outdoor unit 101, passes through the refrigerant pipe 305, and flows into the four-way valve 2. Subsequently, the refrigerant flows out from the four-way valve 2, passes through the refrigerant pipe 306, and flows into the accumulator 10. The refrigerant is then sucked from the accumulator 10 into the compressor 1 again and circulates in the refrigerant circuit. This operation establishes a refrigerant circuit that has a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in series to each other.

Heating Operation State in Case of Series Refrigerant Flow Passage

[0036] When the refrigeration cycle apparatus 100 is in a heating operation state, a direction in which refrigerant flows is opposite to a direction in which refrigerant flows in a cooling operation state. Similarly to the states in a cooling operation state, the controller 11 exercises control such that the expansion valve 5 is in a fully closed state, the solenoid valve 7 is in an open state, the solenoid valve 8 is in a closed state, and the expansion valve 6 is in a fully open state. The compressor 1 sucks in refrigerant from the accumulator 10 and then compresses the refrigerant. The compressed refrigerant turns into gas refrigerant, is then discharged from the compressor 1, and flows out through the four-way valve 2 from the outdoor unit 101 into the indoor unit 201. In the indoor unit 201, heat is exchanged at the indoor heat exchanger 21 and the refrigerant thus condenses. The refrigerant flows into the expansion valve 23 and is then reduced in pressure in the expansion valve 23. Subsequently, the refrigerant flows out from the indoor unit 201 and then flows into the outdoor unit 101. In the outdoor unit 101, the refrigerant flows into the outdoor heat exchanger 4 through the expansion valve 6 and then evaporates by heat exchange. Subsequently, the refrigerant passes through the solenoid valve 7 and then flows into the outdoor heat exchanger 3. The refrigerant of which heat is further exchanged at the outdoor heat exchanger 3 turns into refrigerant in a gas state. The refrigerant in a gas state flows into the four-way valve 2. Subsequently, the refrigerant flows out from the four-way valve 2, passes through the refrigerant pipe 306, and flows into the accumulator 10. The refrigerant is then sucked from the accumulator 10 into the compressor 1 again and circulates in the refrigerant circuit. This operation establishes a refrigerant circuit that has a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in series to each other.

Heating Operation State in Case of Parallel Refrigerant Flow Passage

[0037] A case is described in "Heating Operation State in Case of Series Refrigerant Flow Passage" in which a series refrigerant flow passage is formed in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in series to each other. A state of connection, however, is not limited to such a case. That is, a configuration may also be established such that, depending on an operation state of the refrigeration cycle apparatus 100, connection between the outdoor heat exchanger 3 and the outdoor heat exchanger 4 may also be switched to connection by use of a series refrigerant flow passage or connection by use of a parallel refrigerant flow passage. Furthermore, in a heating operation state, a parallel refrigerant flow passage may also be formed in which the outdoor heat exchanger 3 and the outdoor heat

exchanger 4 are connected in parallel to each other. This case is described later with reference to Fig. 14 and Fig. 15.

Outdoor Heat Exchanger 3 and Outdoor Heat Exchanger 4

[0038] Fig. 2 is a perspective view that illustrates a connection state in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected to each other in the refrigeration cycle apparatus 100 according to Embodiment 1. Fig. 2 illustrates a case in which the refrigeration cycle apparatus 100 is in a cooling operation state. Fig. 2 illustrates a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in series to each other, which is expressed by simple connection of refrigerant pipes. Solid arrows illustrated in Fig. 2 each represent a direction in which refrigerant flows and outlined arrows illustrated in Fig. 2 each represent a direction of wind generated by its corresponding one of the outdoor air-sending devices 9, that is, a direction of airflow. Fig. 3 is a cross-sectional view that illustrates a configuration of the outdoor heat exchanger 3 illustrated in Fig. 2. Fig. 4 is a cross-sectional view that illustrates a configuration of the outdoor heat exchanger 4 illustrated in Fig. 2.

Configuration of Outdoor Heat Exchanger 3

[0039] First, the configuration of the outdoor heat exchanger 3 is described below. As illustrated in Fig. 2 and Fig. 3, the outdoor heat exchanger 3 is formed by a refrigerant distributor 31, a refrigerant distributor 32, a plurality of heat exchange bodies 33, and a reverse header 34. As illustrated in Fig. 2, a refrigerant pipe 35 is connected to the refrigerant distributor 31 and a refrigerant pipe 36 is connected to the refrigerant distributor 32.

[0040] The plurality of heat exchange bodies 33 includes, as illustrated in Fig. 3, a heat exchange body 33A and a heat exchange body 33B. The heat exchange body 33A and the heat exchange body 33B are arranged in a direction of airflow and face each other. In other words, the heat exchange body 33A and the heat exchange body 33B are located such that the two heat exchange bodies form layers in a direction along a direction of wind generated by its corresponding one of the outdoor air-sending devices 9. In following description, a heat exchange body 33 located windward is referred to as the heat exchange body 33B and a heat exchange body 33 located leeward is referred to as the heat exchange body 33A. The heat exchange body 33A and the heat exchange body 33B are basically the same in configuration and are thus collectively described below as the heat exchange body 33.

[0041] The heat exchange body 33 is formed by a plurality of flat tubes 37 and a plurality of fins 38. The plurality of flat tubes 37 are spaced from each other and

arranged in a horizontal direction, that is, the X direction. This configuration causes wind generated by its corresponding one of the outdoor air-sending devices 9 to flow between the flat tubes 37, which are adjacent to each other, in a direction represented by its corresponding one of outlined arrows illustrated in Fig. 2. The axial direction of the plurality of flat tubes 37 is the Z direction. Refrigerant flows inside the flat tubes 37 in the Z direction. Refrigerant flows inside the flat tubes 37 and the refrigerant and air thus exchange heat with each other.

[0042] The fins 38 are arranged between the flat tubes 37, which are adjacent to each other in the X direction. The fins 38 are each joined to a side face portion of the flat tube 37 that is adjacent to the fin 38 and each transfer heat to the flat tube 37. In addition, the fin 38, such as a corrugated fin, is used to improve efficiency of heat exchange between air and refrigerant. The fin 38 is, however, not limited to a corrugated fin and may also be, for example, a flat-plate fin. Also, air and refrigerant exchange heat with each other even at a surface of the flat tube 37, and the fins 38 thus do not necessarily have to be provided. In a case in which the plurality of heat exchange bodies 33 have fins 38, the same fins 38 may also be shared among the plurality of heat exchange bodies 33.

[0043] Fig. 5 is a cross-sectional view that illustrates a configuration of the refrigerant distributor 31 provided in the outdoor heat exchanger 3 illustrated in Fig. 3. Fig. 6 is a cross-sectional view that illustrates a configuration of the refrigerant distributor 32 provided in the outdoor heat exchanger 3 illustrated in Fig. 3.

[0044] As illustrated in Fig. 3, the plurality of flat tubes 37 included in the heat exchange body 33A each have tube end portions 37a and 37b at both respective ends in the axial direction. The refrigerant distributor 31 is provided under, between the tube end portions 37a and 37b, the tube end portion 37a, which is lower than the tube end portion 37b. The refrigerant distributor 31 is, as illustrated in Fig. 5, formed by an outer tube 51 and a connection tube 52. The refrigerant distributor 31 has a single-tube structure. The outer tube 51 is a circular tube and its axial direction is the X direction. In an upper face portion of the outer tube 51, a plurality of flat-tube insertion holes 51e are provided. The plurality of flat-tube insertion holes 51e are spaced from each other and arranged in the X direction. The plurality of flat-tube insertion holes 51e are through holes that pass through the upper face portion of the outer tube 51. The tube end portion 37a of each of the flat tubes 37 is directly inserted into a flat-tube insertion hole 51e of the outer tube 51. The outer tube 51 has tube end portions 51a and 51b at both respective ends in the X direction. Between the tube end portions 51a and 51b, at the tube end portion 51a, a closure plate 51c is provided and, at the tube end portion 51b, a closure plate 51d is provided. The tube end portion 51a and the tube end portion 51b are each in a closed state by the closure plate 51c and the closure plate 51d, respectively, and are not open.

[0045] The connection tube 52 is, as illustrated in Fig.

5, connected to the outer tube 51. An axial direction of the connection tube 52 is the Z direction. A lower end portion 52a of the connection tube 52 is inserted into the outer tube 51. An internal space in the connection tube 52 and an internal space in the outer tube 51 communicate with each other. As described above, the refrigerant distributor 31 is, as illustrated in Fig. 2, connected to the refrigerant pipe 35. Specifically, the outer tube 51 of the refrigerant distributor 31 is connected to the refrigerant pipe 35 through the connection tube 52. An inside of the refrigerant distributor 31 is, as illustrated in Fig. 5, one space formed by the internal space in the connection tube 52 and the internal space in the outer tube 51. Refrigerant having flowed from the refrigerant pipe 35 into the space inside the refrigerant distributor 31 is directly distributed to the plurality of flat tubes 37 included in the heat exchange body 33A.

[0046] In addition, the outer tube 51 is herein illustrated as a shape of one circular cylinder with both ends closed by lids, which are the closure plates 51c and 51d; however, a cross-sectional shape of the outer tube 51 does not necessarily have to be circular and may also be rectangular or elliptical. Also, the outer tube 51 does not necessarily have to be formed by one cylindrical part. The outer tube 51 may also be divided into two portions such as an upper half into which the flat tubes 37 are inserted and the other half, that is, a lower half, and may also be formed by joining the upper half and the lower half to each other. The same also applies to an outer tube 53, an outer tube 57, and an outer tube 61, which are described later.

[0047] On top of the tube end portions 37b of the flat tubes 37 in the heat exchange body 33A and on top of the tube end portions 37b of the flat tubes 37 in the heat exchange body 33B, the reverse header 34 is provided. The heat exchange body 33A is thus connected to the heat exchange body 33B through the reverse header 34. The reverse header 34 has the function of reversing an upward flow of refrigerant into a downward flow by causing refrigerant having flowed in from the plurality of flat tubes 37 included in the heat exchange body 33A to flow out into the plurality of flat tubes 37 included in the heat exchange body 33B. Specifically, in the plurality of flat tubes 37 included in the heat exchange body 33A, refrigerant flows from a lower position toward a higher position in the Z direction. On the other hand, in the plurality of flat tubes 37 included in the heat exchange body 33B, refrigerant flows from a higher position toward a lower position in the Z direction. The reverse header 34 thus allows directions in which refrigerant flows to be switched. An example is herein provided in which the flat tubes 37 located leeward and the flat tubes 37 located windward are connected through the reverse header 34; however, the configuration is not limited to such a case. The flat tubes 37 may also not be divided into windward ones and leeward ones and may also be formed by one flat tube. The case in which the flat tube 37 is formed by one flat tube is described later in Embodiment 2 with

reference to Fig. 19.

[0048] As illustrated in Fig. 3, the refrigerant distributor 32 is provided under the tube end portions 37a, which are lower portions of the plurality of flat tubes 37 included in the heat exchange body 33B. The refrigerant distributor 32 is, as illustrated in Fig. 6, formed by the outer tube 53, an inner tube 54, and a connection tube 56. The refrigerant distributor 32 has a double-tube structure. The outer tube 53 is a circular tube and its axial direction is the X direction. In an upper face portion of the outer tube 53, a plurality of flat-tube insertion holes 53e are provided. The plurality of flat-tube insertion holes 53e are spaced from each other and arranged in the X direction. The plurality of flat-tube insertion holes 53e are through holes that pass through the upper face portion of the outer tube 53. The tube end portion 37a of each of the flat tubes 37 is directly inserted into a flat-tube insertion hole 53e of the outer tube 53. Between the tube end portions 53a and 53b of the outer tube 53, at the tube end portion 53a, a closure plate 53c is provided and, at the tube end portion 53b, a closure plate 53d is provided. The tube end portion 53a and the tube end portion 53b are each in a closed state by the closure plate 53c and the closure plate 53d, respectively, and are not open.

[0049] The connection tube 56 is, as illustrated in Fig. 6, connected to the outer tube 53. An axial direction of the connection tube 56 is the Z direction. A lower end portion 56a of the connection tube 56 is inserted into the outer tube 53. An internal space in the connection tube 56 and a first internal space 53g, which is an internal space that faces the tube end portion 53a of the outer tube 53, communicate with each other. A cross-sectional shape of the first internal space 53g is circular. As described above, the refrigerant distributor 32 is, as illustrated in Fig. 2, connected to the refrigerant pipe 36. Specifically, the outer tube 53 of the refrigerant distributor 32 is connected to the refrigerant pipe 36 through the connection tube 56.

[0050] Also, the refrigerant distributor 32 has a double-tube structure such that, inside the outer tube 53, the inner tube 54 is located. Between an internal wall 53f of the outer tube 53 and an external wall 54f of the inner tube 54, a gap is defined as a second internal space 53h in the outer tube 53. A cross-sectional shape of the second internal space 53h is doughnut-shaped, that is, ring-shaped. The inner tube 54 is provided with a plurality of refrigerant outflow holes 54c arranged in parallel to each other in a side face portion of the inner tube 54. The inner tube 54 is joined to the outer tube 53 with a partition plate 55 in between. The partition plate 55 is located between the first internal space 53g and the closure plate 53d of the outer tube 53. The partition plate 55 partitions an area into the first internal space 53g and the second internal space 53h. In the central portion of the partition plate 55, a through hole 55a is formed. Between the tube end portions 54a and 54b of the inner tube 54, the tube end portion 54a is fitted into the through hole 55a. The tube end portion 54a opens toward the first internal space

53g. The first internal space 53g and an internal space in the inner tube 54 thus communicate with each other. Also, the tube end portion 54b of the inner tube 54 is joined to the closure plate 53d and is in a closed state. An outer circumference portion of the partition plate 55 is joined to the internal wall 53f of the outer tube 53. The partition plate 55 is, as described above, joined to the internal wall 53f of the outer tube 53 and the external wall 54f of the inner tube 54. The refrigerant that flows inside the refrigerant distributor 32 is thus allowed to pass through between the first internal space 53g at the tube end portion 53a to which the connection tube 56 is connected and the closure plate 53d at the opposite tube end portion 53b only through the internal space in the inner tube 54.

Configuration of Outdoor Heat Exchanger 4

[0051] Next, the configuration of the outdoor heat exchanger 4 is described below. As illustrated in Fig. 2 and Fig. 4, the outdoor heat exchanger 4 is formed by a refrigerant distributor 41, a refrigerant distributor 42, a plurality of heat exchange bodies 43, and a reverse header 44. As illustrated in Fig. 2, the refrigerant pipe 36 is connected to the refrigerant distributor 41 and a refrigerant pipe 45 is connected to the refrigerant distributor 42.

[0052] The plurality of heat exchange bodies 43 includes, as illustrated in Fig. 4, a heat exchange body 43A and a heat exchange body 43B. The heat exchange body 43A and the heat exchange body 43B are arranged in a direction of airflow and face each other. In other words, the heat exchange body 43A and the heat exchange body 43B are located such that the two heat exchange bodies form layers in a direction along a direction of wind generated by its corresponding one of the outdoor air-sending devices 9. In following description, a heat exchange body 43 located windward is referred to as the heat exchange body 43B and a heat exchange body 43 located leeward is referred to as the heat exchange body 43A. The heat exchange body 43A and the heat exchange body 43B are basically the same in configuration and are thus collectively described below as the heat exchange body 43.

[0053] The heat exchange body 43 is formed by a plurality of flat tubes 47 and a plurality of fins 48. The plurality of flat tubes 47 are spaced from each other and arranged in a horizontal direction, that is, the X direction. This configuration causes wind generated by its corresponding one of the outdoor air-sending devices 9 to flow between the flat tubes 47, which are adjacent to each other, in a direction represented by its corresponding one of outlined arrows illustrated in Fig. 2. The axial direction of the plurality of flat tubes 47 is the Z direction. Refrigerant flows inside the flat tubes 47 in the Z direction. Refrigerant flows inside the flat tubes 47 and the refrigerant and air thus exchange heat with each other.

[0054] The fins 48 are arranged between the flat tubes

47, which are adjacent to each other in the X direction. The fins 48 are each joined to a side face portion of the flat tube 47 that is adjacent to the fin 48 and each transfer heat to the flat tube 47. In addition, the fin 48, such as a corrugated fin, is used to improve efficiency of heat exchange between air and refrigerant. The fin 48 is, however, not limited to a corrugated fin and may also be, for example, a flat-plate fin. Also, air and refrigerant exchange heat with each other even at a surface of the flat tube 47, and the fins 48 thus do not necessarily have to be provided. In a case in which the plurality of heat exchange bodies 43 have fins 48, the same fins 48 may also be shared among the plurality of heat exchange bodies 43.

[0055] Fig. 7 is a cross-sectional view that illustrates a configuration of the refrigerant distributor 41 provided in the outdoor heat exchanger 4 illustrated in Fig. 4. Fig. 8 is a cross-sectional view that illustrates a configuration of the refrigerant distributor 42 provided in the outdoor heat exchanger 4 illustrated in Fig. 4.

[0056] As illustrated in Fig. 4, the refrigerant distributor 41 is provided under, between the tube end portions 47a and 47b of each of the plurality of flat tubes 47 included in the heat exchange body 43A, the tube end portion 47a, which is lower than the tube end portion 47b. The refrigerant distributor 41 is, as illustrated in Fig. 7, formed by the outer tube 57, an inner tube 58, and a connection tube 60. The refrigerant distributor 41 has a double-tube structure. The outer tube 57 is a circular tube and its axial direction is the X direction. In an upper face portion of the outer tube 57, a plurality of flat-tube insertion holes 57e are provided. The plurality of flat-tube insertion holes 57e are spaced from each other and arranged in the X direction. The plurality of flat-tube insertion holes 57e are through holes that pass through the upper face portion of the outer tube 57. The tube end portion 47a of each of the flat tubes 47 is directly inserted into a flat-tube insertion hole 57e of the outer tube 57. Between the tube end portions 57a and 57b of the outer tube 57, at the tube end portion 57a, a closure plate 57c is provided and, at the tube end portion 57b, a closure plate 57d is provided. The tube end portion 57a and the tube end portion 57b are each in a closed state by the closure plate 57c and the closure plate 57d, respectively, and are not open.

[0057] The connection tube 60 is, as illustrated in Fig. 7, connected to the outer tube 57. An axial direction of the connection tube 60 is the Z direction. A lower end portion 60a of the connection tube 60 is inserted into the outer tube 57. An internal space in the connection tube 60 and a first internal space 57g, which is an internal space that faces the tube end portion 57a of the outer tube 57, communicate with each other. A cross-sectional shape of the first internal space 57g is circular. As described above, the refrigerant distributor 41 is, as illustrated in Fig. 2, connected to the refrigerant pipe 36. Specifically, the outer tube 57 of the refrigerant distributor 41 is connected to the refrigerant pipe 36 through the connection tube 60.

[0058] Also, the refrigerant distributor 41 has a double-

tube structure such that, inside the outer tube 57, the inner tube 58 is located. Between an internal wall 57f of the outer tube 57 and an external wall 58f of the inner tube 58, a gap is defined as a second internal space 57h in the outer tube 57. A cross-sectional shape of the second internal space 57h is doughnut-shaped, that is, ring-shaped. The inner tube 58 is provided with a plurality of refrigerant outflow holes 58c arranged in parallel to each other in a side face portion of the inner tube 58. An inner diameter of the refrigerant outflow hole 58c may also be the same as or different from an inner diameter of the refrigerant outflow hole 54c illustrated in Fig. 6 and the inner diameter of the refrigerant outflow hole 62c illustrated in Fig. 8. The inner tube 58 is joined to the outer tube 57 with a partition plate 59 in between. The partition plate 59 is located between the first internal space 57g and the closure plate 57d of the outer tube 57. The partition plate 59 partitions an area into the first internal space 57g and the second internal space 57h. In the central portion of the partition plate 59, a through hole 59a is formed. Between the tube end portions 58a and 58b of the inner tube 58, the tube end portion 58a is fitted into the through hole 59a. The tube end portion 58a opens toward the first internal space 57g. The first internal space 57g and an internal space in the inner tube 58 thus communicate with each other. Also, the tube end portion 58b of the inner tube 58 is joined to the closure plate 57d and is in a closed state. An outer circumference portion of the partition plate 59 is joined to the internal wall 57f of the outer tube 57. The partition plate 59 is, as described above, joined to the internal wall 57f of the outer tube 57 and the external wall 58f of the inner tube 58. The refrigerant that flows inside the refrigerant distributor 41 is thus allowed to pass through between the first internal space 57g at the tube end portion 57a to which the connection tube 60 is connected and the closure plate 57d at the opposite tube end portion 58b only through the internal space in the inner tube 58.

[0059] On top of the tube end portions 47b that are upper ends of the flat tubes 47 in the heat exchange body 43A and on top of the tube end portions 47b that are upper ends of the flat tubes 47 in the heat exchange body 43B, the reverse header 44 is provided. The heat exchange body 43A is thus connected to the heat exchange body 43B through the reverse header 44. The reverse header 44 has the function of reversing an upward flow of refrigerant into a downward flow by causing refrigerant having flowed in from the plurality of flat tubes 47 included in the heat exchange body 43A to flow out into the plurality of flat tubes 47 included in the heat exchange body 43B. Specifically, in the plurality of flat tubes 47 included in the heat exchange body 43A, refrigerant flows from a lower position toward a higher position in the Z direction. On the other hand, in the plurality of flat tubes 47 included in the heat exchange body 43B, refrigerant flows from a higher position toward a lower position in the Z direction. The reverse header 44 thus allows directions in which refrigerant flows to be switched. An example is herein provided

in which the flat tubes 47 located leeward and the flat tubes 47 located windward are connected through the reverse header 44; however, the configuration is not limited to such a case. The flat tubes 47 may also not be divided into windward ones and leeward ones and may also be formed by one flat tube. The case in which the flat tube 47 is formed by one flat tube is described later in Embodiment 2 with reference to Fig. 19.

[0060] As illustrated in Fig. 4, the refrigerant distributor 42 is provided under, between the tube end portions 47a and 47b of each of the plurality of flat tubes 47 included in the heat exchange body 43B, the tube end portion 47a, which is lower than the tube end portion 47b. The refrigerant distributor 42 is, as illustrated in Fig. 8, formed by the outer tube 61, an inner tube 62, and a connection tube 64. The refrigerant distributor 42 has a double-tube structure. The outer tube 61 is a circular tube and its axial direction is the X direction. In an upper face portion of the outer tube 61, a plurality of flat-tube insertion holes 61e are provided. The plurality of flat-tube insertion holes 61e are spaced from each other and arranged in the X direction. The plurality of flat-tube insertion holes 61e are through holes that pass through the upper face portion of the outer tube 61. The tube end portion 47a of each of the flat tubes 47 is directly inserted into a flat-tube insertion hole 61e of the outer tube 61. Between the tube end portions 61a and 61b of the outer tube 61, at the tube end portion 61a, a closure plate 61c is provided and, at the tube end portion 61b, a closure plate 61d is provided. The tube end portion 61a and the tube end portion 61b are each in a closed state by the closure plate 61c and the closure plate 61d, respectively, and are not open.

[0061] The connection tube 64 is, as illustrated in Fig. 8, connected to the outer tube 61. An axial direction of the connection tube 64 is the Z direction. A lower end portion 64a of the connection tube 64 is inserted into the outer tube 61. An internal space in the connection tube 64 and a first internal space 61g, which is an internal space that faces the tube end portion 61a of the outer tube 61, communicate with each other. A cross-sectional shape of the first internal space 61g is circular. As described above, the refrigerant distributor 42 is, as illustrated in Fig. 2, connected to the refrigerant pipe 45. Specifically, the outer tube 61 of the refrigerant distributor 42 is connected to the refrigerant pipe 45 through the connection tube 64.

[0062] Also, the refrigerant distributor 42 has a double-tube structure such that, inside the outer tube 61, the inner tube 62 is located. Between an internal wall 61f of the outer tube 61 and an external wall 62f of the inner tube 62, a gap is defined as a second internal space 61h in the outer tube 61. A cross-sectional shape of the second internal space 61h is doughnut-shaped, that is, ring-shaped. The inner tube 62 is provided with a plurality of refrigerant outflow holes 62c arranged in parallel to each other in a side face portion of the inner tube 62. The inner tube 62 is joined to the outer tube 61 with a partition plate 63 in between. The partition plate 63 is located

between the first internal space 61g and the closure plate 61d of the outer tube 61. The partition plate 63 partitions an area into the first internal space 61g and the second internal space 61h. In the central portion of the partition plate 63, a through hole 63a is formed. Between the tube end portions 62a and 62b of the inner tube 62, the tube end portion 62a is fitted into the through hole 63a. The tube end portion 62a opens toward the first internal space 61g. The first internal space 61g and an internal space in the inner tube 62 thus communicate with each other. Also, the tube end portion 62b of the inner tube 62 is joined to the closure plate 61d and is in a closed state. An outer circumference portion of the partition plate 63 is joined to the internal wall 61f of the outer tube 61. The partition plate 63 is, as described above, joined to the internal wall 61f of the outer tube 61 and the external wall 62f of the inner tube 62. The refrigerant that flows inside the refrigerant distributor 42 is thus allowed to pass through between the first internal space 61g at the tube end portion 61a to which the connection tube 64 is connected and the closure plate 61d at the opposite tube end portion 61b only through the internal space in the inner tube 62.

[0063] The refrigerant distributor 41 and the refrigerant distributor 42 are thus each the same in configuration as the refrigerant distributor 32 illustrated in Fig. 6 and formed by the outer tubes 57 and 61, the inner tubes 58 and 62, the partition plates 59 and 63, and the connection tubes 60 and 64, respectively. To the refrigerant distributor 41, the refrigerant pipe 36 is connected through the connection tube 60, and, to the refrigerant distributor 42, the refrigerant pipe 45 is connected through the connection tube 64.

[0064] In addition, the outdoor heat exchanger 4 may be referred to as a heat exchanger. The heat exchange body 43 may be referred to as a first heat exchange body. The flat tube 47 may be referred to as a first flat tube. Furthermore, the flat tube 47 connected to the refrigerant distributor 41 may be referred to as a leeward first flat tube and the flat tube 47 connected to the refrigerant distributor 42 may be referred to as a windward first flat tube. The refrigerant distributor 41 may be referred to as a first refrigerant distributor and the refrigerant distributor 42 may be referred to as a second refrigerant distributor. Also, the outer tube 57 may be referred to as a first outer tube, the inner tube 58 as a first inner tube, the refrigerant outflow hole 58c as a first refrigerant outflow hole, and the partition plate 59 as a first partition plate. Also, the outer tube 61 may be referred to as a second outer tube, the inner tube 62 as a second inner tube, the refrigerant outflow hole 62c as a second refrigerant outflow hole, and the partition plate 63 as a second partition plate. Furthermore, the reverse header 44 may be referred to as a first reverse header. Also, the tube end portion 47a of the flat tube 47 that is inserted into the refrigerant distributor 41 may be referred to as one end portion of a first flat tube and the tube end portion 47a of the flat tube 47 that is inserted into the refrigerant distributor 42 may be

referred to as the other end portion of a first flat tube.

[0065] Also, the outdoor heat exchanger 3 may be referred to as a second heat exchanger. The heat exchange body 33 may be referred to as a second heat exchange body. The flat tube 37 may be referred to as a second flat tube. Furthermore, the flat tube 37 connected to the refrigerant distributor 31 may be referred to as a leeward second flat tube and the flat tube 37 connected to the refrigerant distributor 32 may be referred to as a windward second flat tube. The refrigerant distributor 31 may be referred to as a third refrigerant distributor and the refrigerant distributor 32 may be referred to as a fourth refrigerant distributor. Also, the outer tube 51 may be referred to as a third outer tube. The outer tube 53 may be referred to as a fourth outer tube, the inner tube 54 as a fourth inner tube, the refrigerant outflow hole 54c as a fourth refrigerant outflow hole, and the partition plate 55 as a fourth partition plate. Furthermore, the reverse header 34 may be referred to as a second reverse header. Also, the tube end portion 37a of the flat tube 37 that is inserted into the refrigerant distributor 31 may be referred to as one end portion of a second flat tube and the tube end portion 37a of the flat tube 37 that is inserted into the refrigerant distributor 32 may be referred to as the other end portion of a second flat tube.

Refrigerant Flows in Outdoor Heat Exchanger 3 and Outdoor Heat Exchanger 4

[0066] Next, refrigerant flows in the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are described below.

Refrigerant Flows in Cooling Operation State

[0067] First, refrigerant flows in a cooling operation state are described below. As described above, Fig. 2 is a perspective view that illustrates a connection state in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 each in a cooling operation state are connected to each other and flows of refrigerant. As illustrated in Fig. 2, among four connection tubes included in the outdoor heat exchanger 3 and the outdoor heat exchanger 4, that is, the connection tube 52, the connection tube 56, the connection tube 60, and the connection tube 64, the connection tube 56 and the connection tube 60 are connected through the refrigerant pipe 36. Refrigerant flows from the refrigerant pipe 35 connected to the connection tube 52 into the outdoor heat exchanger 3, in which a portion of the refrigerant then condenses and the refrigerant thus transitions into a two-phase gas-liquid state, and flows out into the refrigerant pipe 36. Subsequently, the refrigerant, which remains in a two-phase gas-liquid state, flows into the outdoor heat exchanger 4. The refrigerant having flowed into the outdoor heat exchanger 4 is first caused to flow into the refrigerant distributor 41. The refrigerant distributor 41 has a double-tube structure such that, in its inner tube 58,

a large number of the refrigerant outflow holes 58c are arranged in parallel to each other. Refrigerant having flowed into the refrigerant distributor 41 flows, when the refrigerant passes through inside the inner tube 58, out through the refrigerant outflow holes 58c into the second internal space 57h. Subsequently, the refrigerant is distributed from the second internal space 57h into the respective flat tubes 47. The inner tube 58 is thus provided with the refrigerant outflow holes 58c, which enables refrigerant to be evenly distributed to the respective flat tubes 47 in the heat exchange body 43A. Refrigerant having condensed inside the heat exchange body 43A and the heat exchange body 43B passes through the refrigerant distributor 42 and flows out into the refrigerant pipe 45.

[0068] As described above, the refrigerant distributor 41, which is located on an inflow side of the outdoor heat exchanger 4 located downstream between the plurality of outdoor heat exchanger 3 and outdoor heat exchanger 4 that form a series refrigerant flow passage in cooling operation, has a double-tube structure. The inner tube 58 in the refrigerant distributor 41 has a large number of refrigerant outflow holes 58c arranged in parallel to each other. This configuration improves the uniformity of distribution of refrigerant in a two-phase gas-liquid state into the heat exchange body 43A in the outdoor heat exchanger 4 located downstream.

[0069] Specifically, at the refrigerant distributor 41, refrigerant flows into the first internal space 57g in the outer tube 57 through the connection tube 60. Subsequently, the refrigerant enters the inner tube 58 from the first internal space 57g once and then flows out through a large number of refrigerant outflow holes 58c arranged in parallel to each other included in the inner tube 58 into the second internal space 57h in the outer tube 57. At this time, in the outer tube 57, the second internal space 57h is separated from the first internal space 57g by the partition plate 59. This configuration causes the refrigerant having flowed into the second internal space 57h in the outer tube 57 does not flow toward the first internal space 57g and flows out through the flat-tube insertion holes 57e into the plurality of flat tubes 47 connected to the outer tube 57.

[0070] Distribution acts of refrigerant in a single-tube structure and a double-tube structure are described herein. Fig. 10 is a diagram that schematically illustrates distribution acts of refrigerant at the refrigerant distributor 31 provided in the refrigeration cycle apparatus 100 according to Embodiment 1. Fig. 11 is a diagram that schematically illustrates distribution acts of refrigerant at the refrigerant distributor 32, 41, 42 provided in the refrigeration cycle apparatus 100 according to Embodiment 1. In addition, Fig. 10 and Fig. 11 illustrate a case for clarity in which the refrigerant outflow holes 54c, 58c, 62c open directly downward.

[0071] As illustrated in Fig. 10, in a case of a single-tube structure, refrigerant flows in through one location, that is, the connection tube 52, and flows out through a plurality

of locations, that is, the flat-tube insertion holes 51e. This configuration tends to cause more refrigerant to flow through the flat-tube insertion hole 51e located closer to the connection tube 52 than through the other flat-tube insertion holes 51e.

[0072] On the other hand, as illustrated in Fig. 11, in a case of a double-tube structure, refrigerant flows into the outer tube 53, 57, 61 through a plurality of locations, that is, the refrigerant outflow holes 54c, 58c, 62c in the inner tube 54, 58, 62, and flows out through a plurality of locations, that is, the flat-tube insertion holes 53e, 57e, 61e. This configuration improves the uniformity of distribution of refrigerant, even when outflows through the inner tube 54, 58, 62 are uneven, compared to a case in which no inner tube 54, 58, 62 is provided.

[0073] Fig. 12 is a diagram that schematically illustrates the state of liquid refrigerant in the refrigerant distributor 31 provided in the refrigeration cycle apparatus 100 according to Embodiment 1. Fig. 13 is a diagram that schematically illustrates the state of liquid refrigerant in the refrigerant distributor 32, 41, 42 provided in the refrigeration cycle apparatus 100 according to Embodiment 1. In addition, Fig. 12 and Fig. 13 illustrate a case for clarity in which the refrigerant outflow holes 54c, 58c, 62c open directly downward.

[0074] Fig. 12 and Fig. 13 illustrate a case in which two-phase gas-liquid refrigerant flows into the refrigerant distributor 31 and a case in which two-phase gas-liquid refrigerant flows into the refrigerant distributor 32, 41, 42. In a case of a single-tube structure, as illustrated in Fig. 12, refrigerant contains liquid refrigerant that accumulates at a lower portion of the outer tube 51 and the amount of refrigerant that circulates in the refrigerant circuit may decrease. On the other hand, in a case of a double-tube structure, as illustrated in Fig. 13, refrigerant spouts out through a plurality of refrigerant outflow holes 54c, 58c, 62c provided in the inner tube 54, 58, 62. This configuration disturbs liquid refrigerant that accumulates inside the outer tube 53, 57, 61 and thus prevents liquid refrigerant from accumulating at a lower portion of the outer tube 51. As a result, the amount of liquid refrigerant that accumulates in the outer tube 51 decreases and refrigerant is thus caused to effectively circulate in the refrigerant circuit.

[0075] In addition, an example illustrated in Fig. 12 and Fig. 13 is provided as a case of separated flows, of which gas refrigerant and liquid refrigerant flow separately; however, flows of refrigerant are not limited to the example illustrated in Fig. 12 and Fig. 13. Other examples of flows of refrigerant that flows inside the refrigerant distributors 31, 32, 41, and 42 include a case of an annular flow. In a case in which refrigerant flows as an annular flow, liquid refrigerant forms an annular shape and the annular flow of the liquid refrigerant surrounds gas refrigerant.

[0076] There are two cases for refrigerant that flows out through the refrigerant outflow holes 54c, 58c, and 62c provided in the inner tubes 54, 58, and 62: one case in

which the refrigerant is mainly gas refrigerant and the other case in which the refrigerant is mainly liquid refrigerant. Whether gas refrigerant or liquid refrigerant mainly flows out through the refrigerant outflow holes 54c, 58c, 62c varies depending on the state of the refrigerant that flows inside the inner tube 54, 58, 62, as well as the arrangement and the positions of the refrigerant outflow holes 54c, 58c, 62c. For example, in a case in which refrigerant flows as an annular flow, liquid refrigerant covers the refrigerant outflow holes 54c, 58c, 62c and the liquid refrigerant thus mainly flows out through the refrigerant outflow holes 54c, 58c, 62c. On the other hand, in a case in which refrigerant flows as separated flows, whether gas refrigerant or liquid refrigerant mainly flows out is determined depending on whether the refrigerant outflow holes 54c, 58c, 62c open upward or downward. That is, in a case of separated flows, when the refrigerant outflow holes 54c, 58c, 62c open upward, gas refrigerant mainly flows out through the refrigerant outflow holes 54c, 58c, 62c. In a case of separated flows, when the refrigerant outflow holes 54c, 58c, 62c open downward, liquid refrigerant mainly flows out through the refrigerant outflow holes 54c, 58c, 62c. Also, depending on whether each of the refrigerant outflow holes 54c, 58c, 62c is located at the inlet of the inner tube 54, 58, 62 or farther away, the refrigerant that flows out through the refrigerant outflow holes 54c, 58c, 62c turns into either gas refrigerant or liquid refrigerant. Also in a case of an annular flow, the closer the refrigerant outflow hole is located to the inner tube 54, 58, 62, the more predominantly liquid refrigerant flows out. As long as more liquid refrigerant flows out, the quality of refrigerant changes. Thus, the farther into the inner tube 54, 58, 62 the refrigerant proceeds, the more predominantly gas refrigerant flows. Subsequently, when the liquid refrigerant decreases to a level at which the refrigerant no longer maintains an annular flow, gas refrigerant begins mainly flowing out through the refrigerant outflow holes 54c, 58c, 62c.

Refrigerant Flows in Heating Operation State

[0077] Next, refrigerant flows in a heating operation state are described below. Fig. 9 is a perspective view that illustrates a connection state in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 each in a heating operation state are connected to each other in the refrigeration cycle apparatus 100 according to Embodiment 1. Fig. 9 illustrates a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected to each other, which is expressed by simple connection of refrigerant pipes. Solid arrows illustrated in Fig. 9 each represent a direction in which refrigerant flows and outlined arrows illustrated in Fig. 9 each represent a direction of wind generated by its corresponding one of the outdoor air-sending devices 9.

[0078] As seen in comparison of Fig. 2 and Fig. 9, the

direction in which refrigerant flows in a heating operation state is opposite the direction in cooling operation. In a heating operation state, refrigerant flows into the outdoor heat exchanger 3 and the outdoor heat exchanger 4 through the refrigerant distributor 32 and the refrigerant distributor 42. Both the refrigerant distributor 32 and the refrigerant distributor 42 are each a refrigerant distributor provided with a double-tube structure.

[0079] At the refrigerant distributor 32, refrigerant flows into the first internal space 53g in the outer tube 53 through the connection tube 56. Subsequently, the refrigerant enters the inner tube 54 from the first internal space 53g once and then flows out through a large number of refrigerant outflow holes 54c arranged in parallel to each other included in the inner tube 54 into the second internal space 53h in the outer tube 53. At this time, in the outer tube 53, the second internal space 53h is separated from the first internal space 53g by the partition plate 55. This configuration causes the refrigerant having flowed into the second internal space 53h in the outer tube 53 does not flow toward the first internal space 53g and flows out through the flat-tube insertion holes 53e into the plurality of flat tubes 37 connected to the outer tube 53.

[0080] At the refrigerant distributor 42, refrigerant flows into the first internal space 61g in the outer tube 61 through the connection tube 64. Subsequently, the refrigerant enters the inner tube 62 from the first internal space 61g once and then flows out through a large number of refrigerant outflow holes 62c arranged in parallel to each other included in the inner tube 62 into the second internal space 61h in the outer tube 61. At this time, in the outer tube 61, the second internal space 61h is separated from the first internal space 61g by the partition plate 63. This configuration causes the refrigerant having flowed into the second internal space 61h in the outer tube 61 does not flow toward the first internal space 61g and flows out through the flat-tube insertion holes 53e into the plurality of flat tubes 47 connected to the outer tube 61.

[0081] In a heating operation state, refrigerant flows out from the outdoor heat exchanger 3 and the outdoor heat exchanger 4 through the refrigerant distributor 31 and the refrigerant distributor 41. The refrigerant distributor 31 is a single-tube structured refrigerant distributor, whereas the refrigerant distributor 41 is a double-tube structured refrigerant distributor. Refrigerant having flowed from the flat tubes 37 into the refrigerant distributor 31 passes through inside the outer tube 51 and flows out through the connection tube 52. On the other hand, refrigerant having flowed from the flat tubes 47 into the refrigerant distributor 41 first flows into the second internal space 61h in the outer tube 57 and then subsequently flows into the inner tube 58 through the refrigerant outflow holes 58c. Subsequently, the refrigerant passes through inside the inner tube 58 and flows out from the inner tube 58 into the first internal space 57g, which is separated by the partition plate 59. The refrigerant flows out from the

first internal space 57g through the connection tube 60 to the outside of the refrigerant distributor 41.

[0082] In heating operation, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 each serve as an evaporator. As described above, the refrigerant distributor 41, which is provided on an outflow side of the outdoor heat exchanger 4, is a refrigerant distributor structured by a double pipe such that, in its inner tube 58, a large number of the refrigerant outflow holes 58c are arranged in parallel to each other. The double-tube structured refrigerant distributor 41 thus increases pressure loss in a refrigerant flow passage and decreases pressure on a suction side of the compressor 1, compared to a case in which a single-tube structured refrigerant distributor is in use as the refrigerant distributor 41. Problems thus arise in that the required amount of work of the compressor 1 is increased and the performance of the refrigeration cycle apparatus is decreased.

[0083] To address the problems described above, the specifications of the refrigerant distributor 41 and the refrigerant distributor 42 included in the outdoor heat exchanger 4 should preferably be defined with consideration given to the balance between the uniformity of distribution of refrigerant in a cooling operation state and the pressure loss caused in the outdoor heat exchanger 4 in a heating operation state. That is, a part or all of the specifications of the refrigerant distributor 41 may also be designed differently from a part or all of the specifications of the refrigerant distributor 42 such as the uniformity of refrigerant in a cooling operation state is ensured and pressure loss in a heating operation state is controllable.

[0084] Here, the following items are listed as modifiable specifications for the refrigerant distributor 41 and the refrigerant distributor 42.

- Diameters of the refrigerant outflow holes 58c and 62c, that is, hole diameters
- Spacings of the refrigerant outflow holes 58c and 62c
- Locations of the refrigerant outflow holes 58c and 62c
- Numbers of the refrigerant outflow holes 58c and 62c
- Diameters of the inner tubes 58 and 62, which are inner diameters and outer diameters
- Diameters of the outer tubes 57 and 61, which are inner diameters and outer diameters

[0085] When the specifications of the refrigerant distributor 41 and the refrigerant distributor 42 are to be modified, the specifications should preferably be defined to be suited according to data such as results from simulations or experiments with prototypes. Specifically, by increasing the diameters and the numbers of the refrigerant outflow holes 58c and the refrigerant outflow holes 62c, increase in pressure loss is reduced and the distribution characteristics of refrigerant are modified. According to the modified characteristics, the spacings or the locations of the refrigerant outflow holes 58c and

the refrigerant outflow holes 62c are modified such that reduction in the uniformity of distribution in cooling operation is prevented. Also, increase in the diameters of the inner tube 58 and the inner tube 62, as well as the diameters of the outer tube 57 and the outer tube 61, helps prevent pressure loss. The specifications of the refrigerant distributor 41 and the refrigerant distributor 42 thus should preferably be adjusted to achieve the balance between the uniformity of distribution of refrigerant in a cooling operation state and the pressure loss in a heating operation state, with consideration given to this balance.

[0086] The specifications of the refrigerant distributor 41 and the specifications of the refrigerant distributor 42 are thus defined according to the uniformity state of distribution of refrigerant when the outdoor heat exchangers 3 and 4 serve as condensers and the pressure loss caused when the outdoor heat exchangers 3 and 4 serve as evaporators.

[0087] Furthermore, a part or all of the specifications of the refrigerant distributor 41 and the refrigerant distributor 42 may also be designed differently from a part or all of the specifications of the refrigerant distributor 32 included in the outdoor heat exchanger 3. In this case, for example, the specifications described above of the refrigerant distributor 41 and the refrigerant distributor 42 may also be modified such that total pressure loss of the refrigerant distributor 41 and the refrigerant distributor 42 is smaller than pressure loss of the refrigerant distributor 32 included in the outdoor heat exchanger 3.

[0088] By thus adjusting the specifications of the refrigerant distributor 41 and the refrigerant distributor 42, increase in pressure loss in heating operation described in the previous paragraph is prevented, without a significant compromise in the aforementioned effect of improving the uniformity of distribution of refrigerant to the heat exchange bodies 43A and 43B in cooling operation.

[0089] As described above, the plurality of outdoor heat exchanger 3 and outdoor heat exchanger 4 that form a series refrigerant flow passage in heating operation each serve as an evaporator. The refrigerant distributor 42, which is located on an inflow side of the outdoor heat exchanger 4 located upstream, and the refrigerant distributor 32, which is located on an inflow side of the outdoor heat exchanger 3 located downstream, thus each have a double-tube structure. The inner tube 62 in the refrigerant distributor 42 and the inner tube 54 in the refrigerant distributor 32 respectively have a large number of refrigerant outflow holes 62c arranged in parallel to each other and a large number of refrigerant outflow holes 54c arranged in parallel to each other. This configuration improves the uniformity of distribution of refrigerant in the outdoor heat exchanger 4 located upstream and the outdoor heat exchanger 3 located downstream, in which refrigerant in a two-phase gas-liquid state is evenly distributed to the heat exchange body 43B and the heat exchange body 33B.

Modification 1

[0090] Cases are described above in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 form a series refrigerant flow passage in both cooling operation and heating operation. The configuration is, however, not limited to such cases. A circuit may also be formed such that the two outdoor heat exchangers 3 and 4 are configured to switch between a series refrigerant flow passage and a parallel refrigerant flow passage: forming a series refrigerant flow passage in cooling operation and forming a parallel refrigerant flow passage in heating operation.

[0091] Fig. 14 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Modification 1 of Embodiment 1. Fig. 14 illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 1 is in a cooling operation state. Fig. 15 is a refrigerant circuit diagram that illustrates a configuration of the refrigeration cycle apparatus 100 according to Modification 1 of Embodiment 1. Fig. 15 illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 1 is in a heating operation state.

Cooling Operation State in Case of Series Refrigerant Flow Passage

[0092] In Modification 1, when the refrigeration cycle apparatus 100 is in a cooling operation state, as illustrated in Fig. 14, the flows of refrigerant are the same as the flows of refrigerant in a cooling operation state described above with reference to Fig. 1. Their descriptions are thus omitted here. As described above, in Modification 1, in a cooling operation state, similarly to Embodiment 1, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 form a series refrigerant flow passage.

Heating Operation State in Case of Parallel Refrigerant Flow Passage

[0093] In Modification 1, when the refrigeration cycle apparatus 100 is in a heating operation state, as illustrated in Fig. 15, a parallel refrigerant flow passage is formed in which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in parallel to each other. In this case, the controller 11 exercises control such that the expansion valve 5 and the expansion valve 6 are each in an open state, the solenoid valve 7 is in a closed state, and the solenoid valve 8 is in an open state. The compressor 1 sucks in refrigerant from the accumulator 10 and then compresses the refrigerant. The compressed refrigerant turns into gas refrigerant, is then discharged from the compressor 1, flows through the four-way valve 2 and the refrigerant pipe 305 out from the outdoor unit 101, and flows into the indoor unit 201. In the indoor unit 201, the refrigerant condenses in the

indoor heat exchanger 21 and supplies heating energy to air. The refrigerant then flows out from the indoor unit 201 and then flows into the outdoor unit 101. In the outdoor unit 101, the refrigerant branches off into the refrigerant pipe 302 and the refrigerant pipe 304 and the respective branches of the refrigerant flow into the expansion valve 5 and the expansion valve 6. Each refrigerant reduced in pressure and expanded by the expansion valve 5 and the expansion valve 6 flows into and evaporates in its corresponding one of the outdoor heat exchanger 3 and the outdoor heat exchanger 4. The refrigerant having flowed out from the outdoor heat exchanger 4 passes through the solenoid valve 8 and then merges with refrigerant having flowed out from the outdoor heat exchanger 3. Subsequently, the refrigerant having merged flows through the four-way valve 2 and the refrigerant pipe 306 into the accumulator 10. The refrigerant is sucked from the accumulator 10 into the compressor 1 again and circulates in the refrigerant circuit. This operation establishes a refrigerant circuit that has a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in parallel to each other.

[0094] In a case of Modification 1, in heating operation, the two outdoor heat exchangers 3 and 4 are connected in parallel to each other. Thus, even when an outdoor heat exchanger with the same specifications as the two outdoor heat exchangers 3 and 4 is in use, the difference in pressure loss caused by the difference between the refrigerant distributors 32 and 42 may result in refrigerant being unevenly distributed to the two outdoor heat exchangers 3 and 4. In this case, by adjusting the opening degrees of the expansion valve 5 and the expansion valve 6 by use of the controller 11, the uniformity of distribution to the outdoor heat exchangers 3 and 4 is enhanced. Specifically, between the expansion valve 5 and the expansion valve 6, the opening degree of one of the expansion valve 5 and the expansion valve 6 through which more refrigerant easily flows is reduced, while the opening degree of the other of the expansion valve 5 and the expansion valve 6 through which refrigerant less easily flows is increased.

Modification 2

[0095] Incidentally, a case is described in Embodiment 1 in which the number of outdoor heat exchangers is two. However, even when the number of outdoor heat exchangers is three or more, the configuration of Embodiment 1 may also be applied. Specifically, in a case in which the number of n outdoor heat exchangers are configured to form a series refrigerant flow passage in accordance with control by the refrigerant circuit and serve as condensers, the same configuration of the outdoor heat exchanger 3 is used for an outdoor heat exchanger located upstream while the same configuration of the outdoor heat exchanger 4 is used for an outdoor heat exchanger located downstream. This configuration

naturally results in an advantageous effect similar to that of Embodiment 1. Here, n is a natural number greater than or equal to three. Also, a case of $n = 2$ is described in Embodiment 1. Therefore, according to Embodiment 1 and its modifications, n is a natural number greater than or equal to two.

[0096] Fig. 16 is a refrigerant circuit diagram that illustrates a configuration of a refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1. Fig. 17 is a diagram that illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1 is in a cooling operation state. Fig. 18 illustrates flows of refrigerant in a case in which the refrigeration cycle apparatus 100 according to Modification 2 of Embodiment 1 is in a heating operation state.

[0097] The configuration illustrated in Fig. 16 and the configuration illustrated in Fig. 1 differ from each other in that, instead of the outdoor heat exchanger 3 illustrated in Fig. 1, two outdoor heat exchangers 3A and 3B are provided in Fig. 16. The two outdoor heat exchangers 3A and 3B are connected in parallel to each other. The outdoor heat exchangers 3A and 3B each have the same configuration of the outdoor heat exchanger 3 illustrated in Fig. 1. The other configurations are the same as those illustrated in Fig. 1 and their descriptions are thus omitted here.

Refrigerant Flows in Outdoor Heat Exchanger 3 and Outdoor Heat Exchanger 4

[0098] Next, refrigerant flows in the outdoor heat exchanger 3 and the outdoor heat exchanger 4 in Modification 2 are described below.

Refrigerant Flows in Cooling Operation State

[0099] First, refrigerant flows in a cooling operation state are described below. In Modification 2, the outdoor heat exchangers 3A and 3B serve as outdoor heat exchangers located upstream and the outdoor heat exchanger 4 serve as an outdoor heat exchanger located downstream. As illustrated in Fig. 3, the refrigerant distributors 31 of the outdoor heat exchangers 3A and 3B each have a single-tube structure and the refrigerant distributors 32 of the outdoor heat exchangers 3A and 3B each have a double-tube structure.

[0100] In Modification 2, when the refrigeration cycle apparatus 100 is in a cooling operation state, as illustrated in Fig. 17, a series refrigerant flow passage is formed in which the outdoor heat exchangers 3A and 3B and the outdoor heat exchanger 4 are connected in series to each other. However, the outdoor heat exchanger 3A and the outdoor heat exchanger 3B are connected in parallel to each other. In this case, the controller 11 exercises control such that the expansion valve 5 is in a fully closed state, the solenoid valve 7 is in an open state, the solenoid valve 8 is in a closed state, and the

expansion valve 6 is in a fully open state.

[0101] Subsequently, as illustrated in Fig. 17, gas refrigerant discharged from the compressor 1 flows into the refrigerant distributors 31 of the outdoor heat exchangers 3A and 3B. The gas refrigerant exchanges heat with air at the outdoor heat exchangers 3A and 3B, a portion of the gas refrigerant condenses, and the gas refrigerant thus transitions into a two-phase gas-liquid state. The two-phase gas-liquid refrigerant having flowed out from the outdoor heat exchanger 3A and the two-phase gas-liquid refrigerant having flowed out from the outdoor heat exchanger 3B merges with each other on an upstream side of the solenoid valve 7. Subsequently, the refrigerant having merged is caused to flow through the solenoid valve 7 into the refrigerant distributor 41 of the outdoor heat exchanger 4. As described with reference to Fig. 7, the refrigerant distributor 41 has a double-tube structure such that, in its inner tube 58, a large number of the refrigerant outflow holes 58c are arranged in parallel to each other. Refrigerant having flowed into the refrigerant distributor 41 flows, when the refrigerant passes through inside the inner tube 58, out through the refrigerant outflow holes 58c into the second internal space 57h. The inner tube 58 is thus provided with the refrigerant outflow holes 58c, which enables refrigerant to be evenly distributed to the respective flat tubes 47 in the heat exchange body 43A. Refrigerant having condensed inside the heat exchange body 43A and the heat exchange body 43B passes through the refrigerant distributor 42 and flows out into the refrigerant pipe 45. The refrigerant having flowed out from the outdoor heat exchanger 4 flows into the indoor heat exchanger 21. At the indoor heat exchanger 21, the refrigerant exchanges heat with air and thus evaporates. Subsequently, the refrigerant flows out from the indoor unit 201 and then flows into the outdoor unit 101. In the outdoor unit 101, the refrigerant flows through the four-way valve 2 and the refrigerant pipe 306 into the accumulator 10. The refrigerant is sucked from the accumulator 10 into the compressor 1 again and circulates in the refrigerant circuit.

[0102] As described above, also in Modification 2, the refrigerant distributor 41, which is located on an inflow side of the outdoor heat exchanger 4 located downstream between the plurality of outdoor heat exchangers 3A and 3B and the outdoor heat exchanger 4 that form a series refrigerant flow passage in refrigerant operation, has a double-tube structure. The inner tube 58 in the refrigerant distributor 41 has a large number of refrigerant outflow holes 58c arranged in parallel to each other. This configuration improves the uniformity of distribution of refrigerant in a two-phase gas-liquid state into the heat exchange body 43A in the outdoor heat exchanger 4 located downstream.

Heating Operation State in Case of Parallel Refrigerant Flow Passage

[0103] In Modification 2, when the refrigeration cycle

apparatus 100 is in a heating operation state, as illustrated in Fig. 18, a parallel refrigerant flow passage is formed in which the outdoor heat exchangers 3A and 3B and the outdoor heat exchanger 4 are connected in parallel to each other. In this case, the controller 11 exercises control such that the expansion valve 5 and the expansion valve 6 are each in an open state, the solenoid valve 7 is in a closed state, and the solenoid valve 8 is in an open state. The compressor 1 sucks in refrigerant from the accumulator 10 and then compresses the refrigerant. The compressed refrigerant turns into gas refrigerant, is then discharged from the compressor 1, flows through the four-way valve 2 and the refrigerant pipe 305 out from the outdoor unit 101, and flows into the indoor unit 201. In the indoor unit 201, the refrigerant condenses in the indoor heat exchanger 21 and supplies heating energy to air. The refrigerant then flows out from the indoor unit 201 and then flows into the outdoor unit 101. In the outdoor unit 101, the refrigerant branches off into the refrigerant pipe 302 and the refrigerant pipe 304 and the respective branches of the refrigerant flow into the expansion valve 5 and the expansion valve 6. Each refrigerant reduced in pressure and expanded by the expansion valve 5 and the expansion valve 6 flows into and evaporates in its corresponding one of the outdoor heat exchangers 3A and 3B and the outdoor heat exchanger 4. The refrigerant having flowed out from the outdoor heat exchanger 4 passes through the solenoid valve 8 and then merges with refrigerant having flowed out from the outdoor heat exchangers 3A and 3B. Subsequently, the refrigerant having merged flows through the four-way valve 2 and the refrigerant pipe 306 into the accumulator 10. The refrigerant is sucked from the accumulator 10 into the compressor 1 again and circulates in the refrigerant circuit. This operation establishes a refrigerant circuit that has a refrigerant flow passage through which the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are connected in parallel to each other.

Heating Operation State in Case of Series Refrigerant Flow Passage

[0104] In Modification 2, when the refrigeration cycle apparatus 100 is in a heating operation state, a series refrigerant flow passage may also be formed in which the outdoor heat exchangers 3A and 3B and the outdoor heat exchanger 4 are connected in series to each other. The flows of refrigerant in this case are opposite to the flows of refrigerant in a cooling operation state described above with reference to Fig. 17. Their descriptions are thus omitted here.

[0105] As described above, the configurations in Embodiment 1 and its modifications result in the following advantageous effects.

[0106] In a cooling operation state, when the plurality of outdoor heat exchangers are connected in series to each other and caused to serve as condensers, refrigerant in a

two-phase gas-liquid state in which gas refrigerant and liquid refrigerant is mixed to each other may flow into an outdoor heat exchanger located downstream. In Embodiment 1, the refrigeration cycle apparatus 100 is configured to form a refrigerant flow passage such that, in cooling operation, the outdoor heat exchanger 4 is located downstream and the outdoor heat exchanger 3 is located upstream. The refrigerant distributor 41 of the outdoor heat exchanger 4 located downstream has a double-tube structure such that, in its inner tube 58, the plurality of refrigerant outflow holes 58c are formed. In a case in which refrigerant in a two-phase gas-liquid state flows into the outdoor heat exchanger 4, the function of the refrigerant distributor 41 thus structured prevents a situation in which refrigerant is unevenly distributed to the plurality of flat tubes 47 in the outdoor heat exchanger 4. Refrigerant is thus evenly distributed to the plurality of flat tubes 47, which ensures that the required heat exchange amount is uniform across all faces of the heat exchange body 43 included in the outdoor heat exchanger 4 and that a reduction in heat exchange efficiency is thus prevented.

[0107] Specifically, the outdoor heat exchanger 4 has the refrigerant distributor 41 and the refrigerant distributor 42. The refrigerant distributors 41 and 42 each have a double-tube structure formed by an outer tube and an inner tube. Also, in the inner tubes 58 and 62, the respective refrigerant outflow holes 58c and 62c are formed, through which refrigerant flows from the inner tubes out into the inside of the outer tubes. Into the outer tubes 57 and 61, the flat tubes 47 are inserted. Also in a case in which two-phase gas-liquid refrigerant is caused to flow into the refrigerant distributor 41 or 42, the refrigerant is thus evenly distributed to all the flat tubes 47.

[0108] Also in a case in which the plurality of outdoor heat exchangers 3 and 4, which serve as condensers, are connected and thus form a series refrigerant flow passage, two-phase gas-liquid refrigerant that flows into the outdoor heat exchanger 4 located downstream is evenly distributed.

[0109] The refrigerant distributor 31 provided in the outdoor heat exchanger 3 is a single-tube structured and is thus designed to reduce pressure loss in cooling operation and heating operation.

Embodiment 2

[0110] Fig. 19 is a perspective view that illustrates a connection state in which an outdoor heat exchanger 3C and an outdoor heat exchanger 4C are connected to each other in a refrigeration cycle apparatus 100 according to Embodiment 2. The configuration of the refrigeration cycle apparatus 100 according to Embodiment 2 is basically the same as the configuration of the refrigeration cycle apparatus 100 according to Embodiment 1. Embodiment 2 differs from Embodiment 1 in that, instead of the outdoor heat exchangers 3 and 4 in Embodiment 1, the respective outdoor heat exchangers 3C and 4C are

provided in Embodiment 2. The other configurations are the same as those in Embodiment 1 and their descriptions are thus omitted here.

[0111] In Embodiment 1 described above, as illustrated in Fig. 3 and Fig. 4, the heat exchange bodies 33 included in the outdoor heat exchanger 3 and the heat exchange bodies 43 included in the outdoor heat exchanger 4 are each located as two layers in a direction along a direction of wind generated by their corresponding one of the outdoor air-sending devices 9. On the other hand, in Embodiment 2, as illustrated in Fig. 19, a heat exchange body 33 included in the outdoor heat exchanger 3 and a heat exchange body 43 included in the outdoor heat exchanger 4 are each located as a single layer in a direction along a direction of wind generated by its corresponding one of the outdoor air-sending devices 9.

[0112] Fig. 19 illustrates a refrigerant flow passage through which the outdoor heat exchanger 3C and the outdoor heat exchanger 4C are connected in series to each other, which is expressed by simple connection of refrigerant pipes. Outlined arrows each represent a direction of wind generated by its corresponding one of the outdoor air-sending devices 9. Also, arrows illustrated around a refrigerant pipe 35A, a refrigerant pipe 36A, and a refrigerant pipe 45A represent flows of refrigerant. Solid arrows represent flows of refrigerant in cooling operation and dashed arrows represent flows of refrigerant in heating operation.

Configuration of Outdoor Heat Exchanger 3C

[0113] First, the configuration of the outdoor heat exchanger 3C is described below. As illustrated in Fig. 19, the outdoor heat exchanger 3C is formed by a refrigerant distributor 31, a refrigerant distributor 32, and the heat exchange body 33. The heat exchange body 33 is formed by a plurality of flat tubes 37 and a plurality of fins 38. The configuration of the heat exchange body 33 is as described in Embodiment 1 and its description is thus omitted here. In Embodiment 2, the refrigerant distributor 31, which is single-tube structured, is provided on top of the heat exchange body 33 and the refrigerant distributor 32, which is double-tube structured, is provided under the heat exchange body 33. The configurations of the refrigerant distributor 31 and the refrigerant distributor 32 are as described in Embodiment 1 and their description is thus omitted here. As illustrated in Fig. 19, the refrigerant pipe 35A is connected to the refrigerant distributor 31 through a connection tube 52 and the refrigerant pipe 36A is connected to the refrigerant distributor 32 through a connection tube 56.

Configuration of Outdoor Heat Exchanger 4C

[0114] Next, the configuration of the outdoor heat exchanger 4C is described below. As illustrated in Fig. 19, the outdoor heat exchanger 4C is formed by a refrigerant

distributor 41, a refrigerant distributor 42, and the heat exchange body 43. The heat exchange body 43 is formed by a plurality of flat tubes 47 and a plurality of fins 48.

[0115] The configuration of the heat exchange body 43 is as described in Embodiment 1 and its description is thus omitted here. In Embodiment 2, the refrigerant distributor 41, which is double-tube structured, is provided on top of the heat exchange body 43 and the refrigerant distributor 42, which is double-tube structured, is provided under the heat exchange body 43. The configurations of the refrigerant distributor 41 and the refrigerant distributor 42 are as described in Embodiment 1 and their description is thus omitted here. As illustrated in Fig. 19, the refrigerant pipe 36A is connected to the refrigerant distributor 41 through a connection tube 60 and the refrigerant pipe 45A is connected to the refrigerant distributor 42 through a connection tube 64.

[0116] In addition, the outdoor heat exchanger 4C may be referred to as a heat exchanger. The heat exchange body 43 may be referred to as a first heat exchange body. The flat tube 47 may be referred to as a first flat tube. The refrigerant distributor 41 may be referred to as a first refrigerant distributor and the refrigerant distributor 42 may be referred to as a second refrigerant distributor. Also, an outer tube 57 may be referred to as a first outer tube, an inner tube 58 as a first inner tube, and a partition plate 59 as a first partition plate. Also, an outer tube 61 may be referred to as a second outer tube, an inner tube 62 as a second inner tube, and a partition plate 63 as a second partition plate. Also, a tube end portion 47c of the flat tube 47, which is inserted into the refrigerant distributor 41, may be referred to as one end portion of a first flat tube and a tube end portion 47d of the flat tube 47, which is inserted into the refrigerant distributor 42, may be referred to as the other end portion of a first flat tube.

[0117] Also, the outdoor heat exchanger 3C may be referred to as a second heat exchanger. The heat exchange body 33 may be referred to as a second heat exchange body. The flat tube 37 may be referred to as a second flat tube. The refrigerant distributor 31 may be referred to as a third refrigerant distributor and the refrigerant distributor 32 may be referred to as a fourth refrigerant distributor. Also, an outer tube 51 may be referred to as a third outer tube. An outer tube 53 may be referred to as a fourth outer tube, an inner tube 54 as a fourth inner tube, and a partition plate 55 as a fourth partition plate. Also, a tube end portion 37c of the flat tube 37, which is inserted into the refrigerant distributor 31, may be referred to as one end portion of a second flat tube and a tube end portion 37d of the flat tube 37, which is inserted into the refrigerant distributor 32, may be referred to as the other end portion of a second flat tube.

Refrigerant Flows in Cooling Operation State

[0118] First, refrigerant flows in a cooling operation state are described below. As illustrated in Fig. 19, gas refrigerant discharged from the compressor 1, which is

referable to Fig. 1, flows from the refrigerant pipe 35A through the connection tube 52 into the refrigerant distributor 31. A portion of the refrigerant having flowed in condenses in the outdoor heat exchanger 3 and the refrigerant thus transitions into a two-phase gas-liquid state and flows out through the refrigerant distributor 32 into the refrigerant pipe 36A. Subsequently, the refrigerant, which remains in a two-phase gas-liquid state, flows into the outdoor heat exchanger 4. The refrigerant having flowed into the outdoor heat exchanger 4 is first caused to flow through the connection tube 60 into the refrigerant distributor 41. The refrigerant distributor 41 has a double-tube structure such that, in its inner tube 58, a large number of the refrigerant outflow holes 58c are arranged in parallel to each other. Refrigerant having flowed into the refrigerant distributor 41 flows, when the refrigerant passes through inside the inner tube 58, out through the refrigerant outflow holes 58c into the second internal space 57h in the outer tube 57. The inner tube 58 is thus provided with the refrigerant outflow holes 58c, which enables refrigerant to be evenly distributed to the respective flat tubes 47 in the heat exchange body 43A. Refrigerant having condensed inside the heat exchange body 43 flows out from the refrigerant distributor 42 through the connection tube 64 into the refrigerant pipe 45A.

[0119] As described above, the refrigerant distributor 41, which is located on an inflow side of the outdoor heat exchanger 4C located downstream between the plurality of outdoor heat exchanger 3C and outdoor heat exchanger 4C that form a series refrigerant flow passage in refrigerant operation, has a double-tube structure. The inner tube 58 in the refrigerant distributor 41 has a large number of refrigerant outflow holes 58c arranged in parallel to each other. This configuration improves the uniformity of distribution of refrigerant in a two-phase gas-liquid state into the heat exchange body 43 in the outdoor heat exchanger 4C located downstream.

Refrigerant Flows in Heating Operation State

[0120] Next, refrigerant flows in a heating operation state are described below. As seen in comparison of the solid arrows and the dashed arrows illustrated in Fig. 19, the direction in which refrigerant flows in a heating operation state is opposite the direction in a cooling operation state. In a heating operation state, refrigerant flows into the outdoor heat exchanger 3C and the outdoor heat exchanger 4C through the refrigerant distributor 32 and the refrigerant distributor 42. Both the refrigerant distributor 32 and the refrigerant distributor 42 are each a refrigerant distributor provided with a double-tube structure.

[0121] As described above, the plurality of outdoor heat exchanger 3C and outdoor heat exchanger 4C that form a series refrigerant flow passage in a heating operation state each serve as an evaporator. The refrigerant distributor 42, which is located on an inflow side of the

outdoor heat exchanger 4C located upstream, and the refrigerant distributor 32, which is located on an inflow side of the outdoor heat exchanger 3C located downstream, thus each have a double-tube structure. The inner tube 62 in the refrigerant distributor 42 and the inner tube 54 in the refrigerant distributor 32 respectively have a large number of refrigerant outflow holes 62c arranged in parallel to each other and a large number of refrigerant outflow holes 54c arranged in parallel to each other. This configuration improves the uniformity of distribution of refrigerant in the outdoor heat exchanger 4C located upstream and the outdoor heat exchanger 3C located downstream, in which refrigerant in a two-phase gas-liquid state is evenly distributed to the heat exchange body 43 and the heat exchange body 33.

[0122] As described above, also in Embodiment 2, the refrigerant distributor 41 of the outdoor heat exchanger 4C, which is located downstream in a cooling operation state, is double-tube structured, the same advantageous effects are obtained as in Embodiment 1 described above.

Embodiment 3

[0123] Fig. 20 is a perspective view that illustrates an external view of an outdoor unit 101 provided in a refrigeration cycle apparatus 100 according to Embodiment 3. Fig. 21 includes plan views that schematically illustrate examples of a configuration of the outdoor unit 101 provided in the refrigeration cycle apparatus 100 according to Embodiment 3.

[0124] As illustrated in Fig. 20 and Fig. 21, the outdoor unit 101 has outdoor heat exchangers 3 and 4, refrigerant pipes 35, 36, and 45, which are referable to Fig. 2 and through which the outdoor heat exchangers 3 and 4 are connected to each other, a housing 101a, and an outdoor air-sending device 9.

[0125] The housing 101a has, as illustrated in Fig. 20, a box shape. Inside the housing 101a, as illustrated in Fig. 21, the outdoor heat exchangers 3 and 4 are housed. In addition, illustration is omitted in Fig. 21; inside the housing 101a, other components are further housed such as the compressor 1, the four-way valve 2, the expansion valves 5 and 6, the solenoid valves 7 and 8, which are illustrated in Fig. 1, and an unillustrated control box, which houses a control board that forms the controller 11. Also, in an upper portion 101b of the housing 101a, the outdoor air-sending device 9 is located. The outdoor air-sending device 9 is driven to rotate and flows of air are thus generated as represented by the outlined arrows illustrated in Fig. 20. The air is sucked from at least two side faces among four side faces of the housing 101a into the housing 101a. Also, the air passes through the outdoor heat exchangers 3 and 4 and is then discharged upward from an air outlet provided to the upper portion 101b of the housing 101a.

[0126] In an example illustrated in Fig. 21(a), the outdoor heat exchanger 3 and the outdoor heat exchanger 4

each have a rectangular shape in plan view. In the example illustrated in Fig. 21(a), the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located such that they face each other. Also, in the example illustrated in Fig. 21(a), the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are each located along a part of side faces of the housing 101a. That is, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located along respective two side faces among the four side faces of the housing 101a.

[0127] In an example illustrated in Fig. 21(b), the outdoor heat exchanger 3 and the outdoor heat exchanger 4 each have an L-shape in plan view. In the example illustrated in Fig. 21(b), the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located in positions that are point-symmetric with each other. Also, in the example illustrated in Fig. 21(b), the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located along all the side faces of the housing 101a. That is, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located along the four side faces of the housing 101a.

[0128] In an example illustrated in Fig. 21(c), a case is illustrated in which three outdoor heat exchangers are provided, as in Modification 2 of Embodiment 1 illustrated in Fig. 16 to Fig. 18. In the example illustrated in Fig. 21(c), the outdoor heat exchangers 3A, 3B, and 4 are located in a U-shape in plan view. In the example illustrated in Fig. 21(c), the outdoor heat exchangers 3A, 3B, and 4 are located along a part of the side faces of the housing 101a. That is, the outdoor heat exchangers 3A, 3B, and 4 are located along three side faces of the housing 101a.

Modification

[0129] Fig. 22 is a perspective view that illustrates an external view of an outdoor unit 101 provided in a refrigeration cycle apparatus 100 according to Modification of Embodiment 3. Fig. 23 is a plan view that schematically illustrates an example of a configuration of the outdoor unit 101 provided in the refrigeration cycle apparatus 100 according to Embodiment 3.

[0130] In the example illustrated in Fig. 21, one outdoor air-sending device 9 is located in the upper portion 101b of the housing 101a. This number is, however, not limited to such a case. The number of outdoor air-sending devices 9 may also be one as illustrated in Fig. 21 or two as illustrated in Fig. 1, which is referred to in Embodiment 1. Fig. 22 illustrates a case in which two outdoor air-sending devices 9 are provided in an upper portion 101b of a housing 101a.

[0131] In an example illustrated in Fig. 23, an outdoor heat exchanger 3 and an outdoor heat exchanger 4 each have an L-shape in plan view. In the example illustrated in Fig. 23, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located in positions that are line-symmetric with each other. Also, in the example illus-

trated in Fig. 23, the outdoor heat exchanger 3 and the outdoor heat exchanger 4 are located along three side faces among four side faces of the housing 101a.

Reference Signs List

[0132] 1: compressor, 2: four-way valve, 2a: connection port, 2b: connection port, 2c: connection port, 2d: connection port, 3: outdoor heat exchanger, 3A: outdoor heat exchanger, 3B: outdoor heat exchanger, 3C: outdoor heat exchanger, 3a: connection port, 3b: connection port, 4: outdoor heat exchanger, 4C: outdoor heat exchanger, 4a: connection port, 4b: connection port, 5: expansion valve, 6: expansion valve, 7: solenoid valve, 8: solenoid valve, 9: outdoor air-sending device, 10: accumulator, 11: controller, 21: indoor heat exchanger, 21a: connection port, 21b: connection port, 22: indoor air-sending device, 23: expansion valve, 31: refrigerant distributor, 32: refrigerant distributor, 33: heat exchange body, 33A: heat exchange body, 33B: heat exchange body, 34: reverse header, 35: refrigerant pipe, 35A: refrigerant pipe, 36: refrigerant pipe, 36A: refrigerant pipe, 37: flat tube, 37a: tube end portion, 37b: tube end portion, 37c: tube end portion, 37d: tube end portion, 38: fin, 41: refrigerant distributor, 42: refrigerant distributor, 43: heat exchange body, 43A: heat exchange body, 43B: heat exchange body, 44: reverse header, 45: refrigerant pipe, 45A: refrigerant pipe, 47: flat tube, 47a: tube end portion, 47b: tube end portion, 47c: tube end portion, 47d: tube end portion, 48: fin, 51: outer tube, 51a: tube end portion, 51b: tube end portion, 51c: closure plate, 51d: closure plate, 51e: flat-tube insertion hole, 52: connection tube, 52a: lower end portion, 53: outer tube, 53a: tube end portion, 53b: tube end portion, 53c: closure plate, 53d: closure plate, 53e: flat-tube insertion hole, 53f: internal wall, 53g: first internal space, 53h: second internal space, 54: inner tube, 54a: tube end portion, 54b: tube end portion, 54c: refrigerant outflow hole, 54f: external wall, 55: partition plate, 55a: through hole, 56: connection tube, 56a: lower end portion, 57: outer tube, 57a: tube end portion, 57b: tube end portion, 57c: closure plate, 57d: closure plate, 57e: flat-tube insertion hole, 57f: internal wall, 57g: first internal space, 57h: second internal space, 58: inner tube, 58a: tube end portion, 58b: tube end portion, 58c: refrigerant outflow hole, 58f: external wall, 59: partition plate, 59a: through hole, 60: connection tube, 60a: lower end portion, 61: outer tube, 61a: tube end portion, 61b: tube end portion, 61c: closure plate, 61d: closure plate, 61e: flat-tube insertion hole, 61f: internal wall, 61g: first internal space, 61h: second internal space, 62: inner tube, 62a: tube end portion, 62b: tube end portion, 62c: refrigerant outflow hole, 62f: external wall, 63: partition plate, 63a: through hole, 64: connection tube, 100: refrigeration cycle apparatus, 101: outdoor unit, 101a: housing, 101b: upper portion, 201: indoor unit, 300: refrigerant pipe, 301: refrigerant pipe, 302: refrigerant pipe, 303: refrigerant pipe, 304: refrigerant pipe, 305: refrigerant pipe, 306: refrigerant pipe, 307:

refrigerant pipe, 308: refrigerant pipe, 310: refrigerant pipe, P1: connection port, P2: connection port

Claims

1. A heat exchanger comprising:

a first heat exchange body that has a plurality of first flat tubes arranged and spaced from each other in a first direction and each of which tube axis extends in a second direction that intersects the first direction;
 a first refrigerant distributor into which one end portion of each of the plurality of first flat tubes is inserted; and
 a second refrigerant distributor into which an other end portion of each of the plurality of first flat tubes is inserted,
 the first refrigerant distributor having
 a first outer tube that extends in the first direction and into which the one end portion of each of the plurality of first flat tubes is inserted,
 a first inner tube that extends in the first direction, is located inside the first outer tube, and has a plurality of first refrigerant outflow holes arranged and spaced from each other in the first direction, and
 a first partition plate joined to an internal wall of the first outer tube in a state in which the first inner tube passes through a plate thickness,
 the second refrigerant distributor having
 a second outer tube that extends in the first direction and into which the other end portion of each of the plurality of first flat tubes is inserted,
 a second inner tube that extends in the first direction, is located inside the second outer tube, and has a plurality of second refrigerant outflow holes arranged and spaced from each other in the first direction, and
 a second partition plate joined to an internal wall of the second outer tube in a state in which the second inner tube passes through a plate thickness.

2. The heat exchanger of claim 1, wherein when the heat exchanger serves as a condenser, refrigerant flows from the first refrigerant distributor into the one end portion of each of the plurality of first flat tubes, flows through inside the plurality of first flat tubes, and flows out from the other end portion of each of the plurality of first flat tubes into the second refrigerant distributor.

3. The heat exchanger of claim 2, wherein the refrigerant that flows from the first refrigerant distributor into the one end portion of each of the plurality of first

flat tubes is in a two-phase gas-liquid state.

4. The heat exchanger of any one of claims 1 to 3, wherein

a part or all of specifications of the first refrigerant distributor differ from a part or all of specifications of the second refrigerant distributor, and the specifications of the first refrigerant distributor and the specifications of the second refrigerant distributor are defined according to an uniformity state of distribution of the refrigerant in the first refrigerant distributor and the second refrigerant distributor when the heat exchanger serves as a condenser and pressure loss caused in the first refrigerant distributor and the second refrigerant distributor when the heat exchanger serves as an evaporator.

5. The heat exchanger of any one of claims 1 to 4, wherein

the plurality of first flat tubes has
 a leeward first flat tube that is located leeward in a direction in which air flows and has the one end portion of each of the plurality of first flat tubes, and
 a windward first flat tube that is located windward in the direction in which air flows and has the other end portion of each of the plurality of first flat tubes, and
 an end portion of the leeward first flat tube that is opposite the one end portion and an end portion of the windward first flat tube that is opposite the other end portion are connected to each other through a first reverse header.

6. The heat exchanger of any one of claims 1 to 5, wherein

when the heat exchanger serves as a condenser, the heat exchanger is connected in series to a second heat exchanger, which serves as a condenser, and
 the second heat exchanger is located upstream of the heat exchanger in a direction in which the refrigerant flows.

7. The heat exchanger of claim 6, wherein

the second heat exchanger includes
 a second heat exchange body that has a plurality of second flat tubes arranged and spaced from each other in a third direction and each of which tube axis extends in the second direction, which intersects the third direction,
 a third refrigerant distributor into which one end portion of each of the plurality of second flat

tubes is inserted, and
 a fourth refrigerant distributor into which an other
 end portion of each of the plurality of second flat
 tubes is inserted,
 the third refrigerant distributor has a third outer 5
 tube that extends in the third direction and into
 which the one end portion of each of the plurality
 of second flat tubes is inserted, and
 the fourth refrigerant distributor has
 a fourth outer tube that extends in the third 10
 direction and into which the other end portion
 of each of the plurality of second flat tubes is
 inserted,
 a fourth inner tube that extends in the third
 direction, is located inside the fourth outer tube, 15
 and has a plurality of fourth refrigerant outflow
 holes arranged and spaced from each other in
 the third direction, and
 a fourth partition plate joined to an internal wall of
 the fourth outer tube in a state in which the fourth 20
 inner tube passes through a plate thickness.

8. The heat exchanger of claim 7, wherein when the
 second heat exchanger serves as a condenser, re- 25
 frigerant flows from the third refrigerant distributor
 into the one end portion of each of the plurality of
 second flat tubes, flows through inside the plurality of
 second flat tubes, and flows out from the other end
 portion of each of the plurality of second flat tubes
 into the fourth refrigerant distributor. 30

9. The heat exchanger of claim 8, wherein the refrigerant
 that flows from the third refrigerant distributor
 into the one end portion of each of the plurality of
 second flat tubes is in a gas state. 35

10. The heat exchanger of any one of claims 7 to 9,
 wherein

the plurality of second flat tubes has 40
 a leeward second flat tube that is located leeward
 in a direction in which air flows and has the
 one end portion of each of the plurality of second
 flat tubes, and
 a windward second flat tube that is located wind- 45
 ward in the direction in which air flows and has
 the other end portion of each of the plurality of
 second flat tubes, and
 an end portion of the leeward second flat tube
 that is opposite the one end portion and an end 50
 portion of the windward second flat tube that is
 opposite the other end portion are connected to
 each other through a second reverse header.

11. A refrigeration cycle apparatus comprising an outdoor
 unit, wherein 55

the outdoor unit is provided with

the heat exchanger of any one of claims 1 to 5,
 the second heat exchanger of any one of claims
 6 to 10,
 a refrigerant pipe through which the heat ex-
 changer and the second heat exchanger are
 connected to each other,
 a housing that is box-shaped and houses the
 heat exchanger and the second heat exchanger
 inside, and
 an air-sending device located at a upper portion
 of the housing and configured to form a flow of air
 by being driven to rotate and blow out the air that
 passes through the heat exchanger and the
 second heat exchanger upward from an upper
 face of the housing, and
 the heat exchanger and the second heat ex-
 changer are located along a part or all of four
 side faces of the housing.

FIG. 1

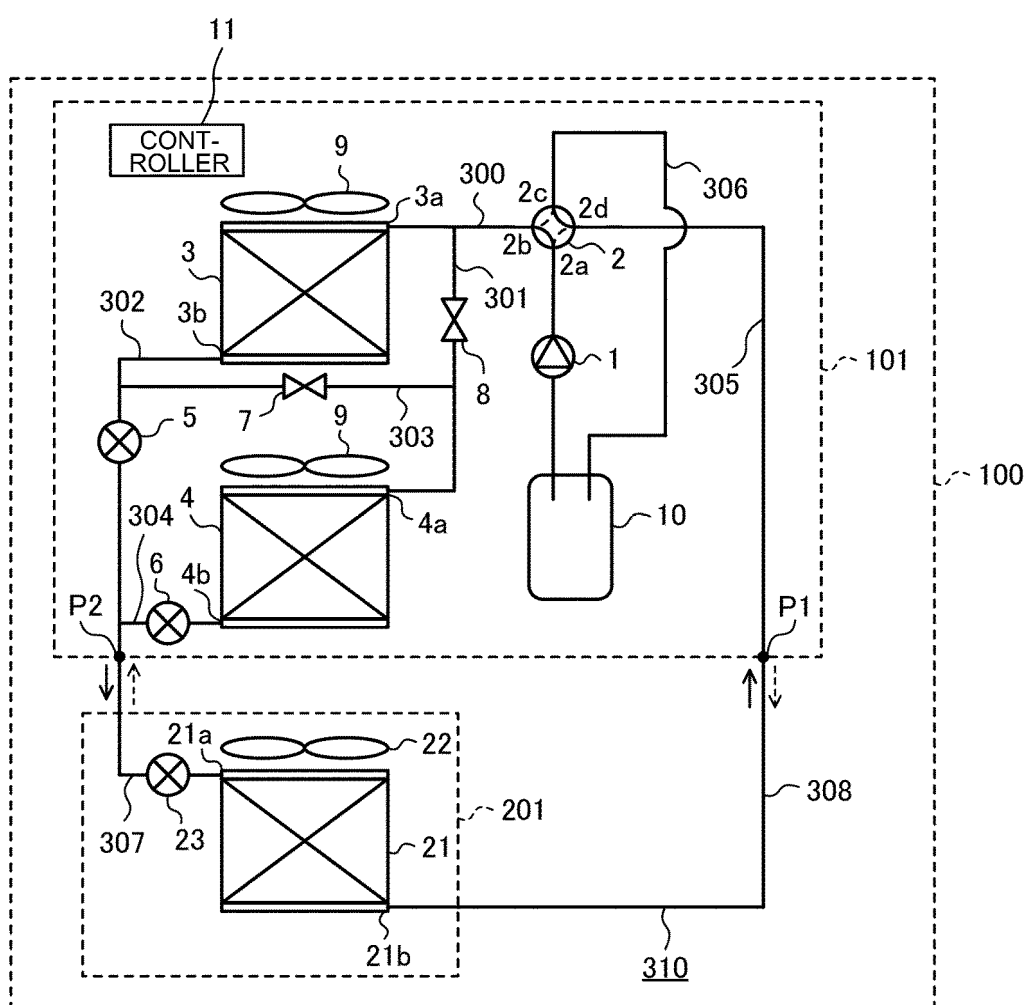


FIG. 2

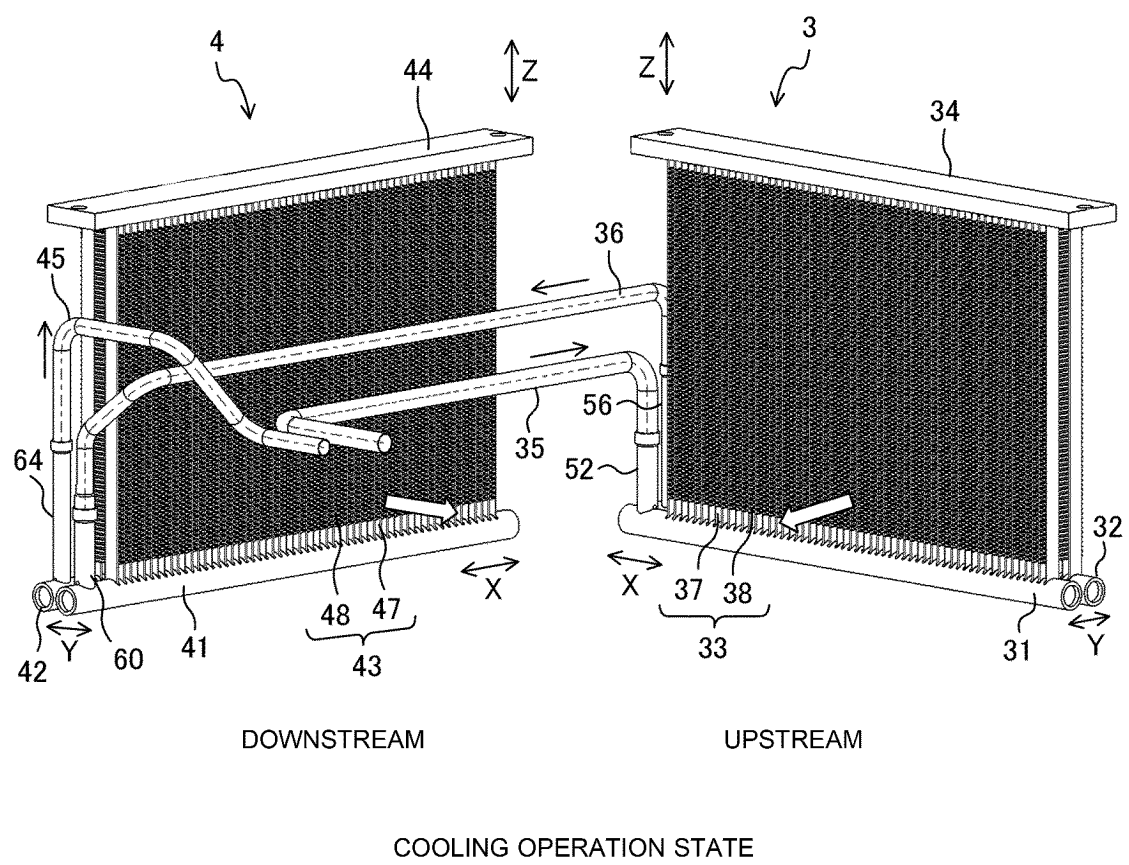


FIG. 3

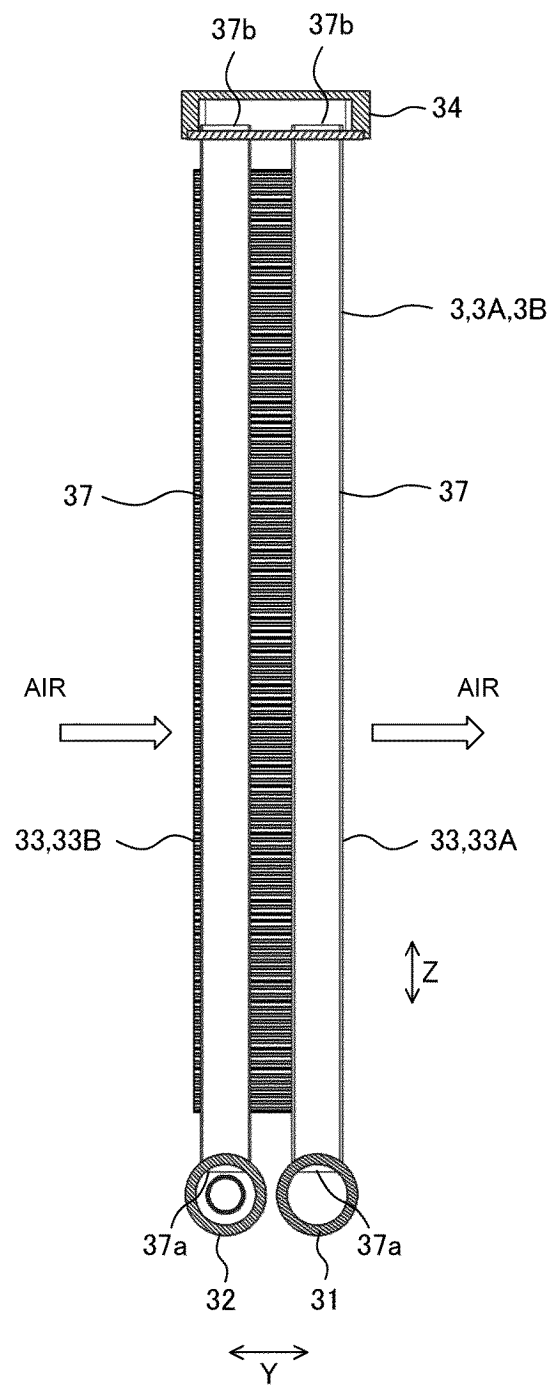


FIG. 4

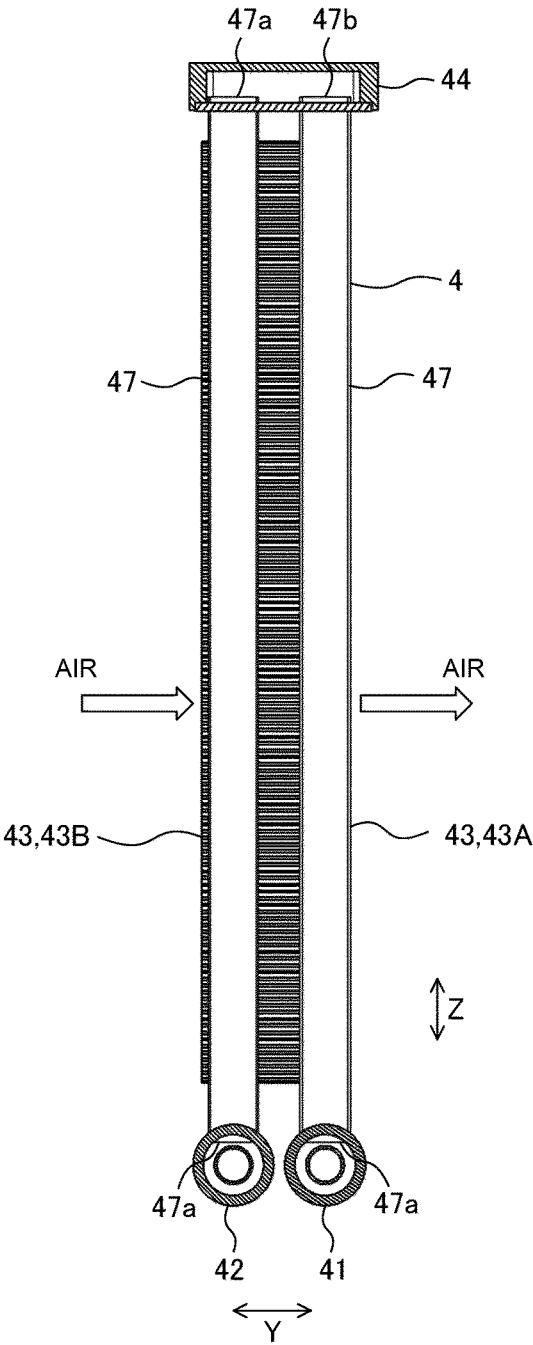


FIG. 5

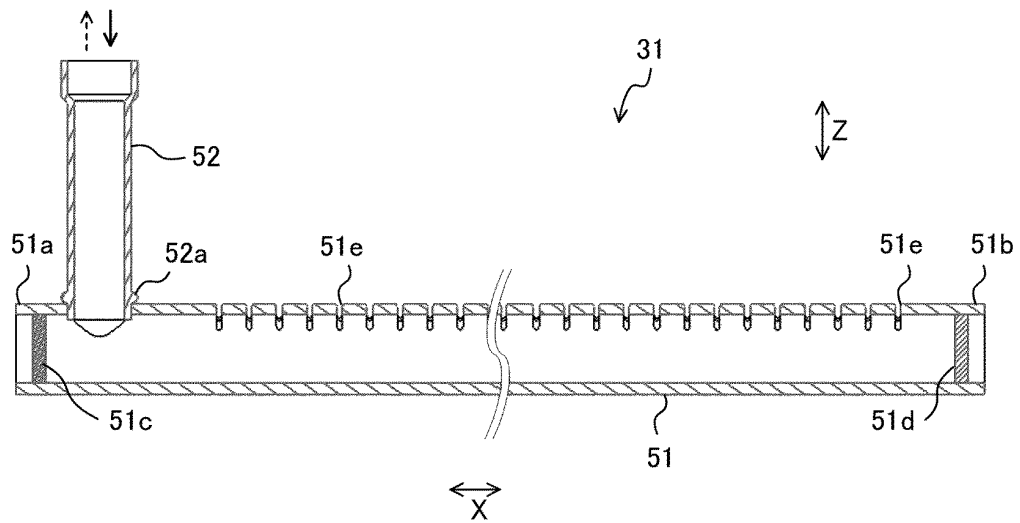


FIG. 6

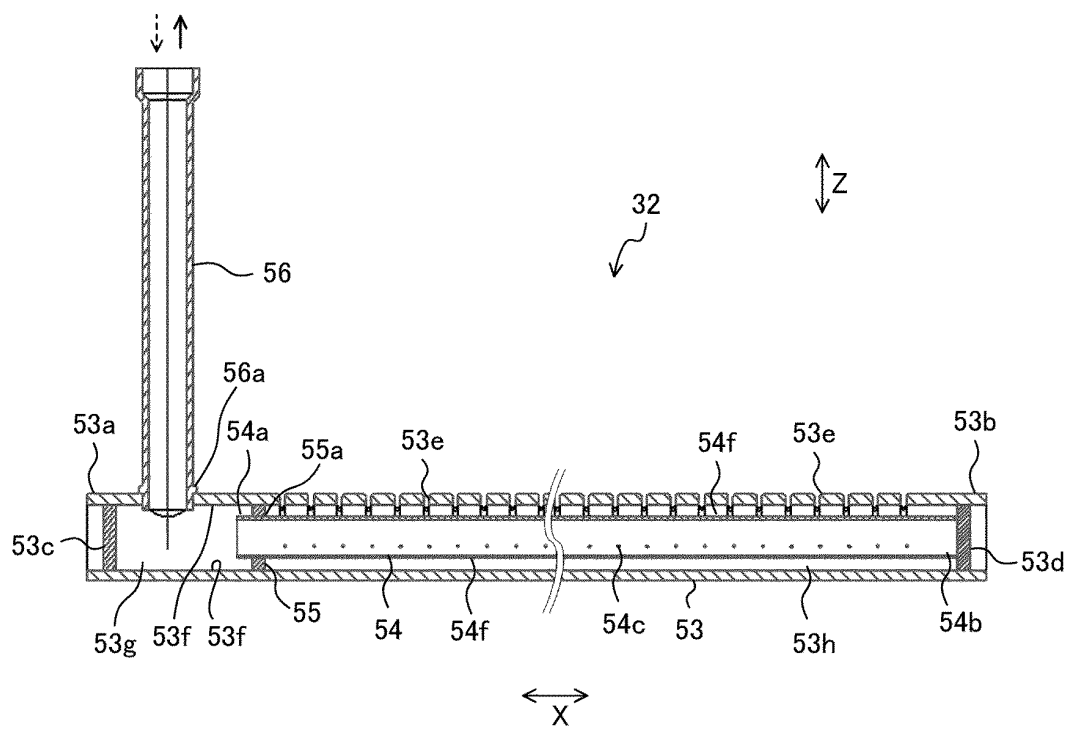


FIG. 7

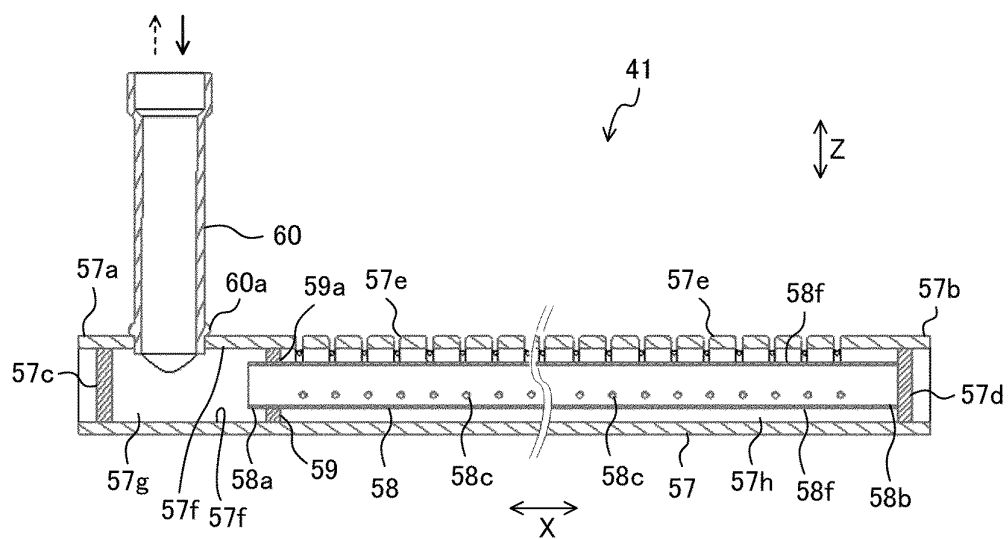


FIG. 8

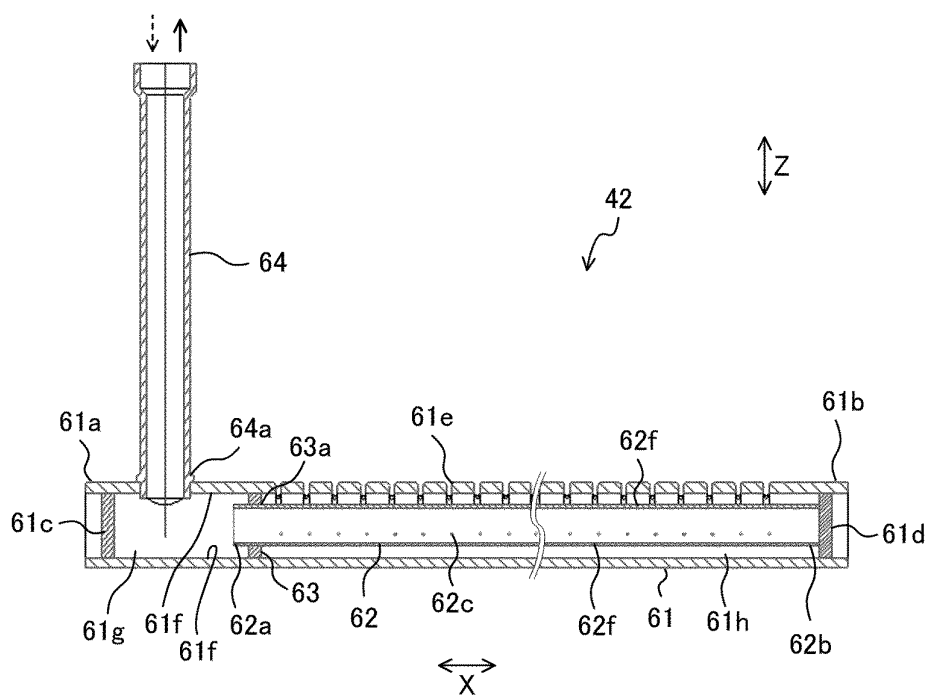


FIG. 9

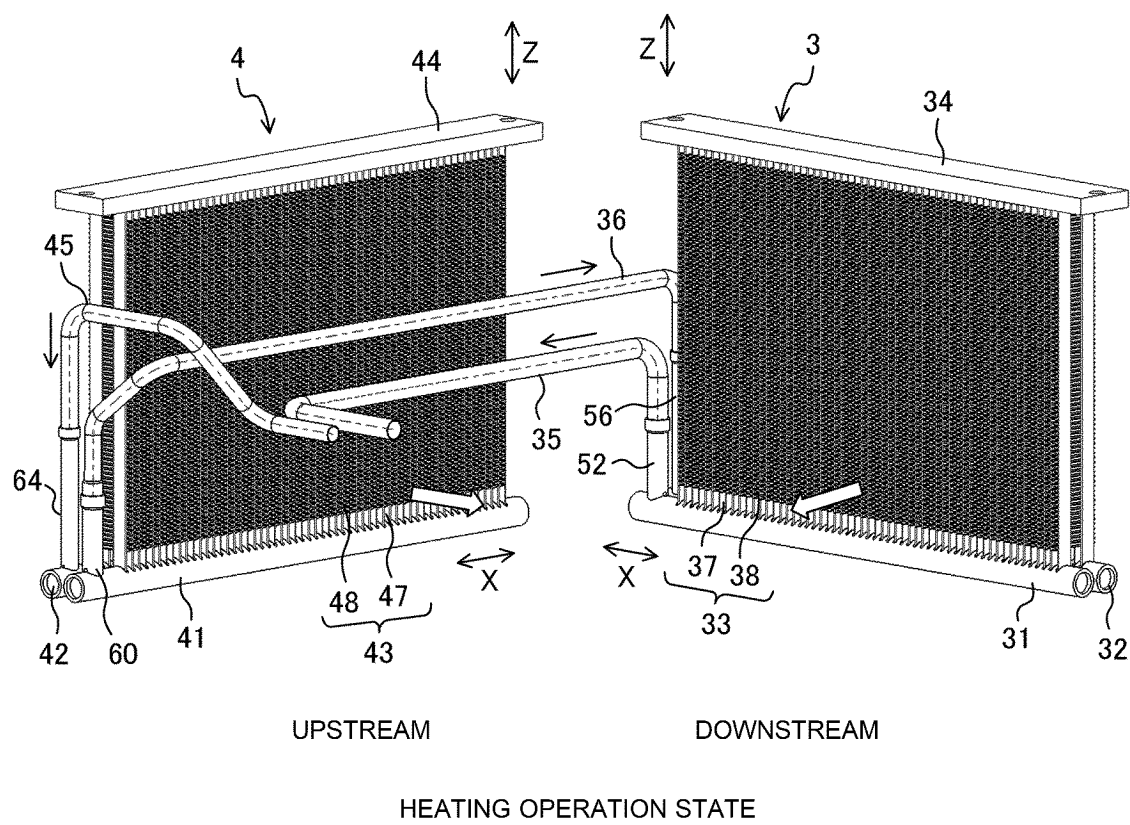


FIG. 10

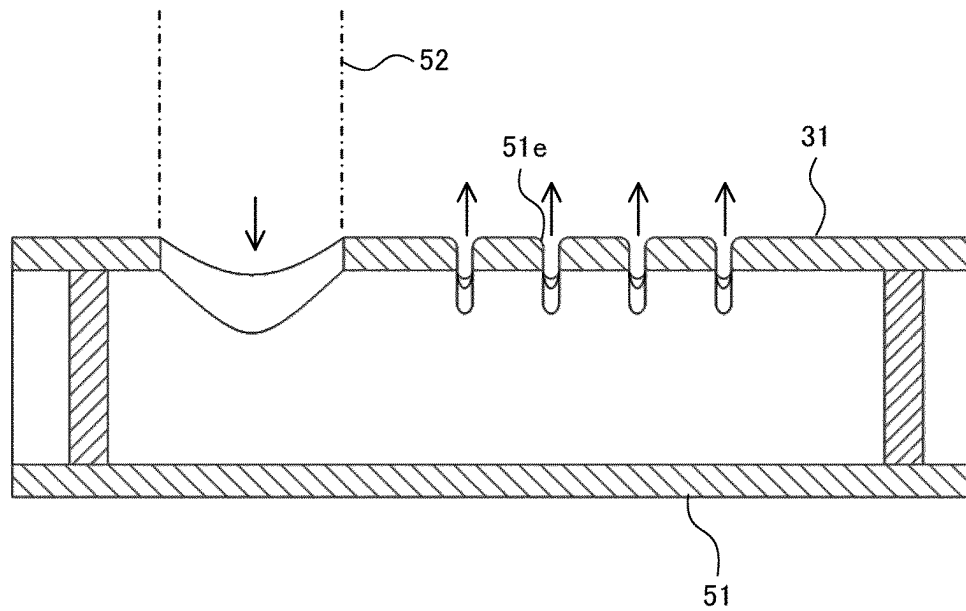


FIG. 11

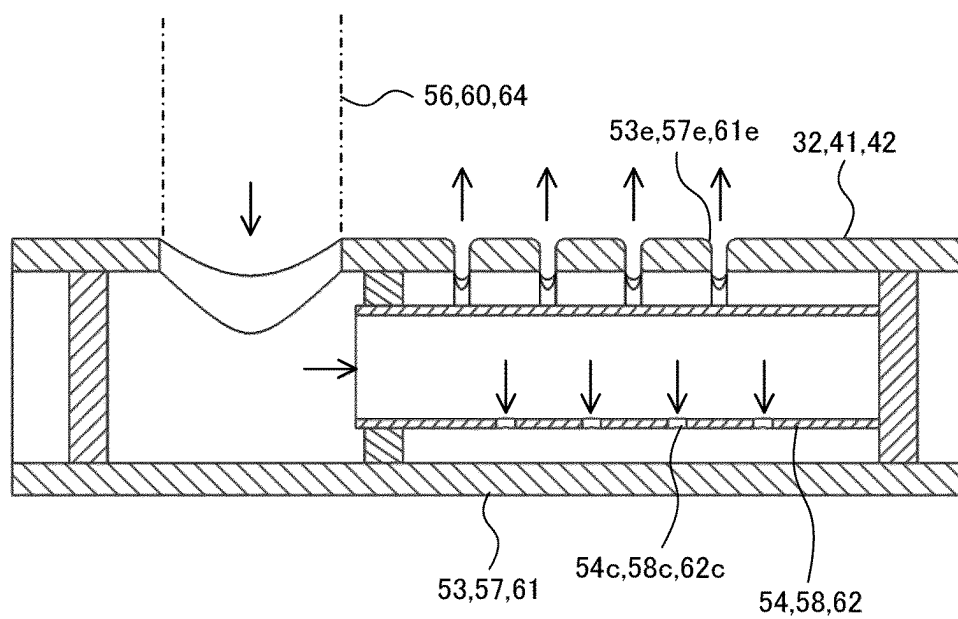


FIG. 12

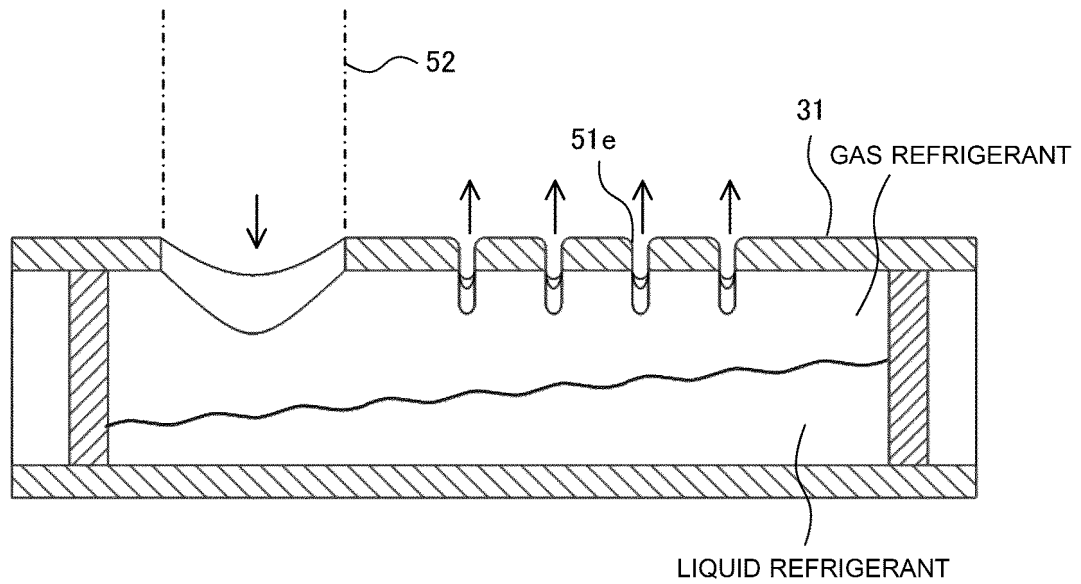


FIG. 13

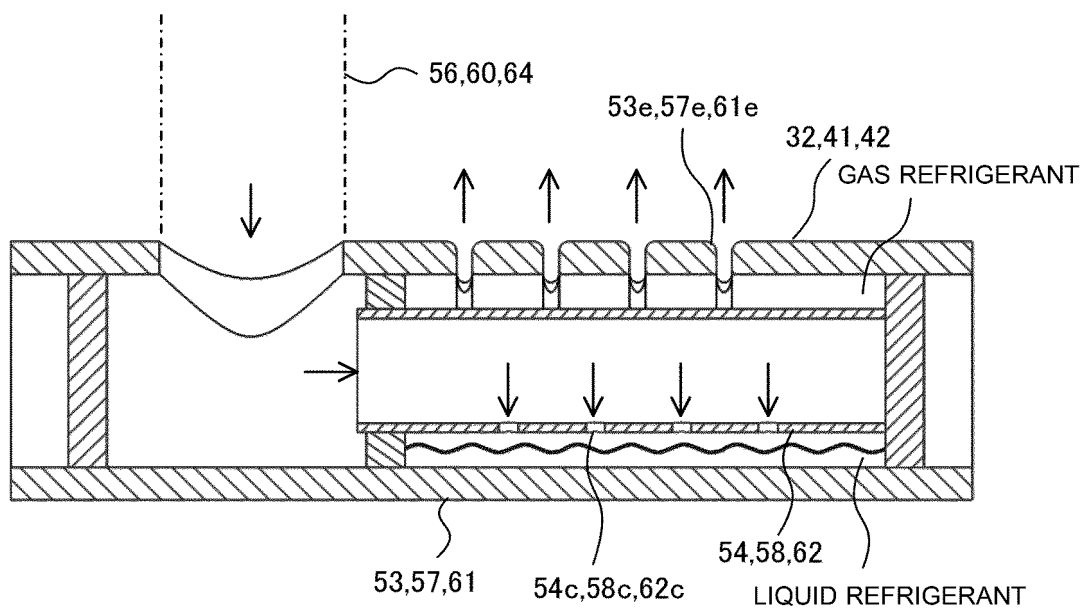
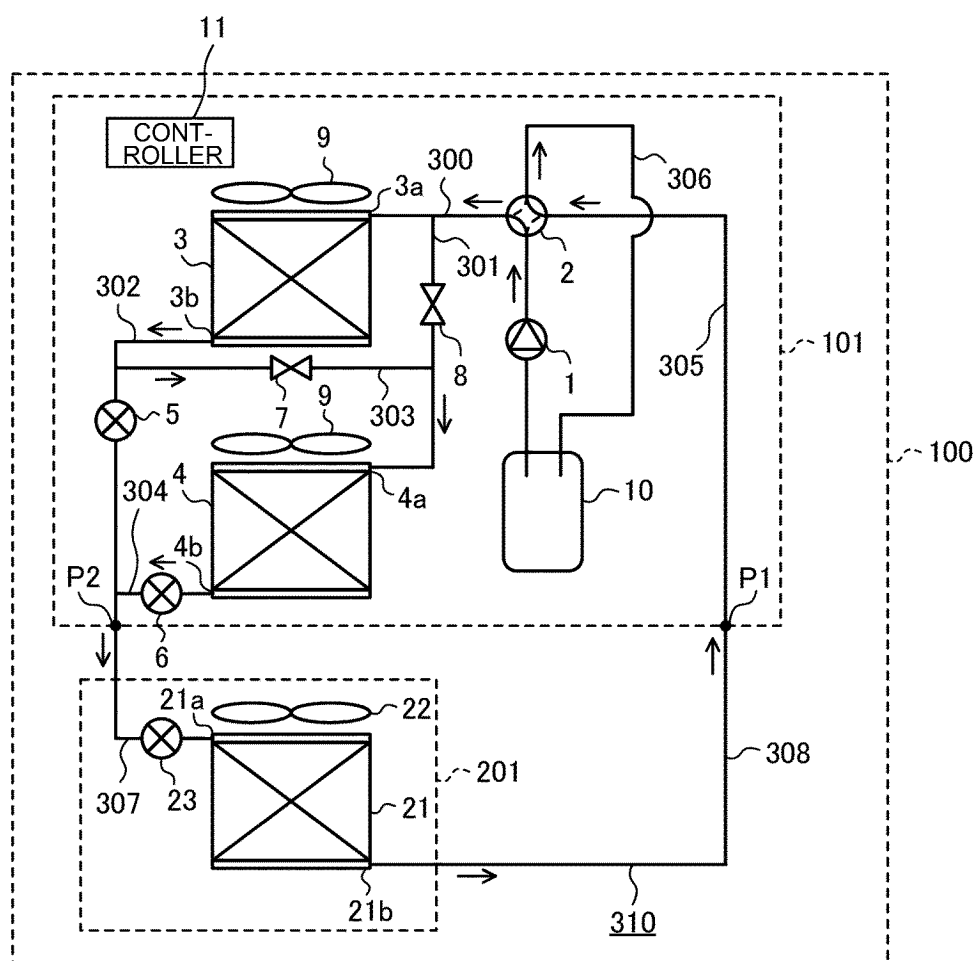


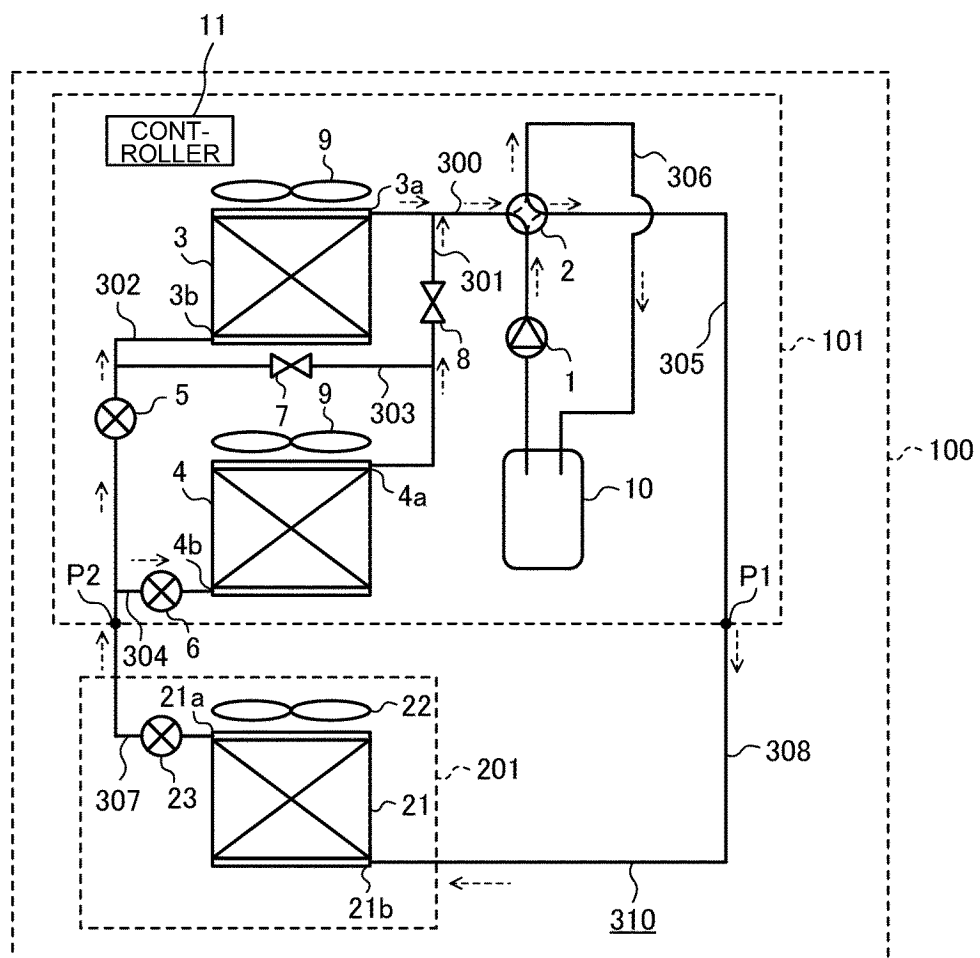
FIG. 14



COOLING OPERATION STATE

SERIES REFRIGERANT FLOW PASSAGE

FIG. 15



HEATING OPERATION STATE

PARALLEL REFRIGERANT FLOW PASSAGE

FIG. 16

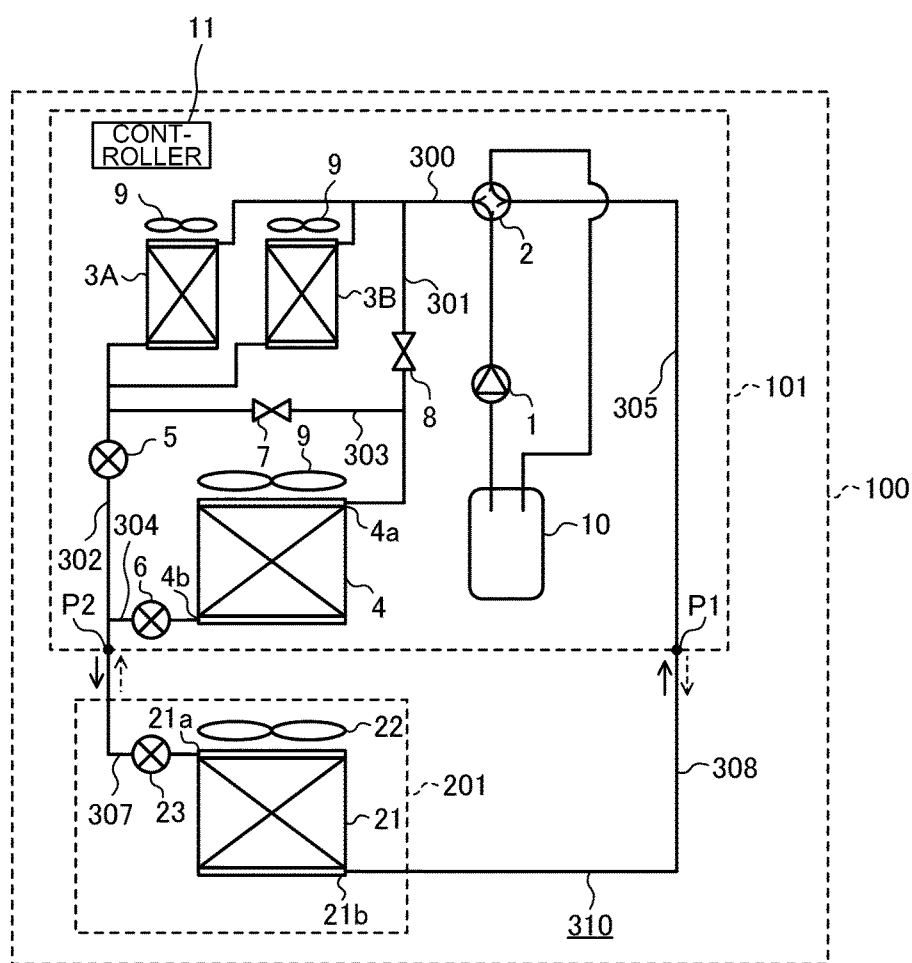
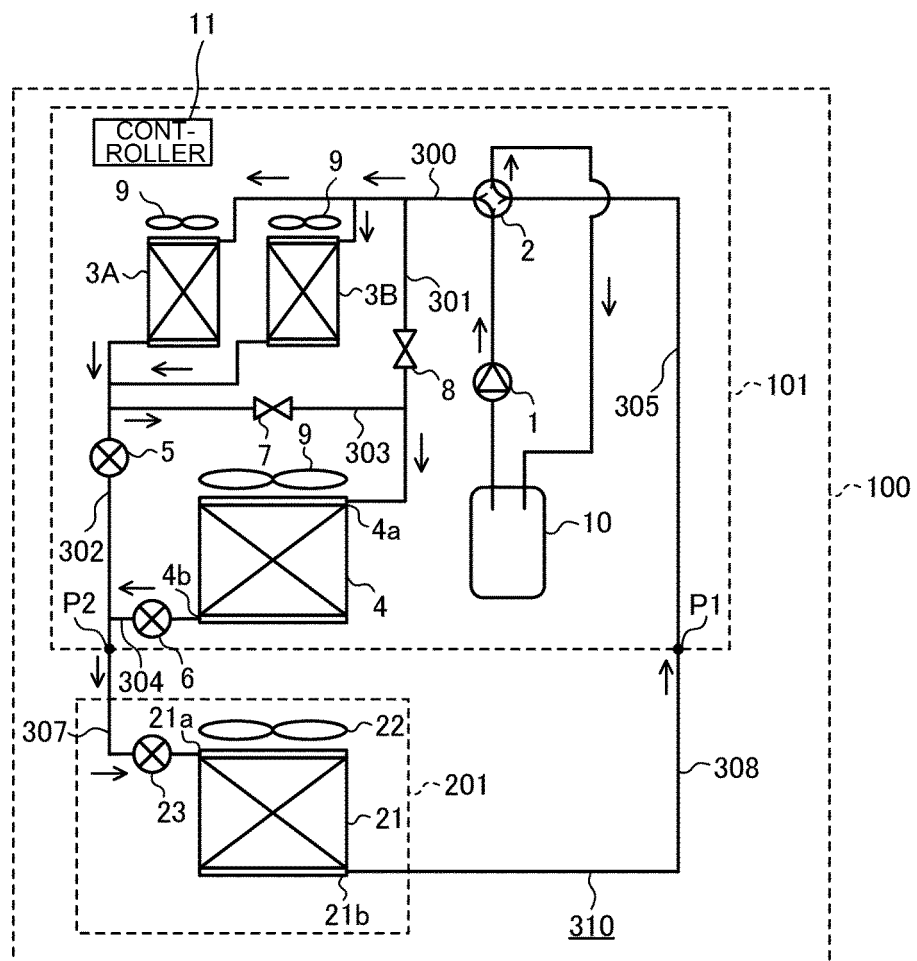


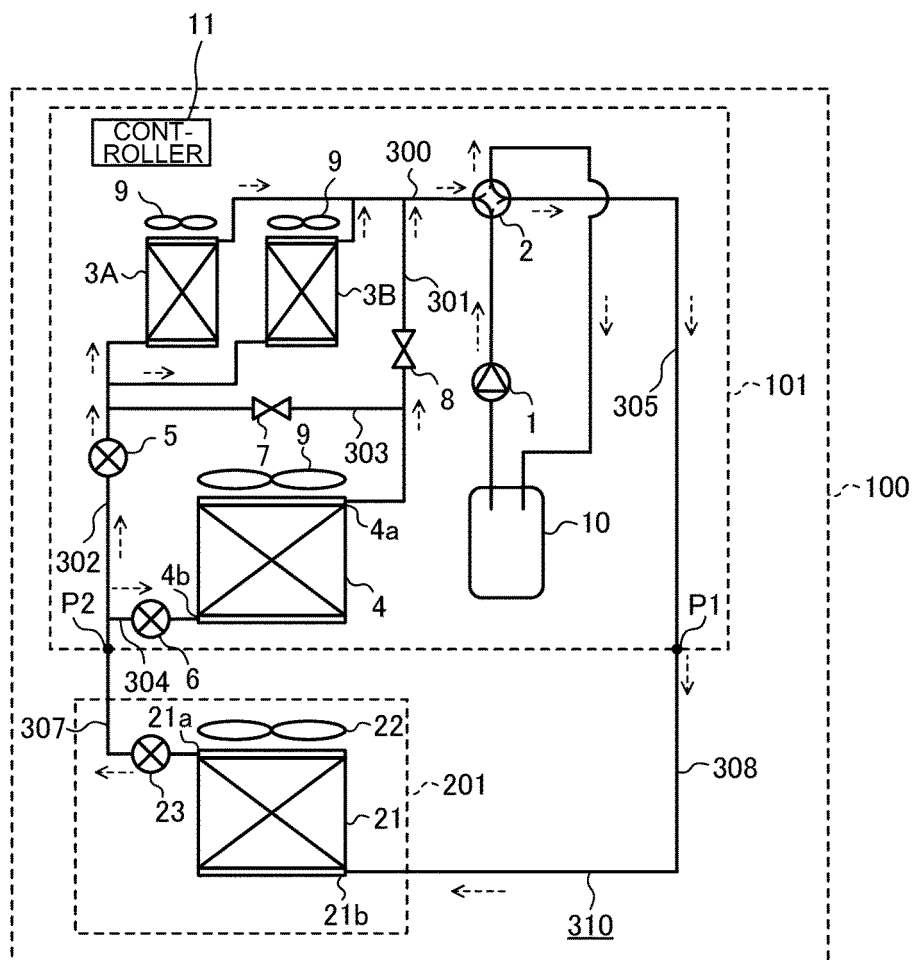
FIG. 17



COOLING OPERATION STATE

SERIES REFRIGERANT FLOW PASSAGE

FIG. 18



HEATING OPERATION STATE

PARALLEL REFRIGERANT FLOW PASSAGE

FIG. 19

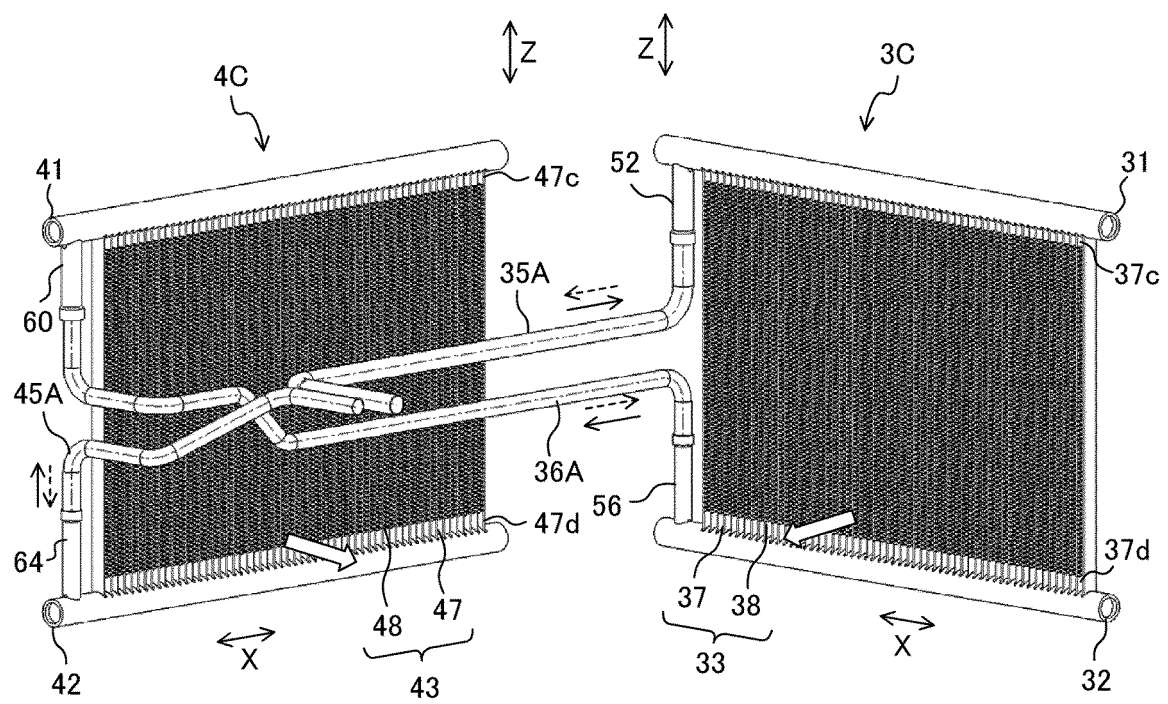


FIG. 20

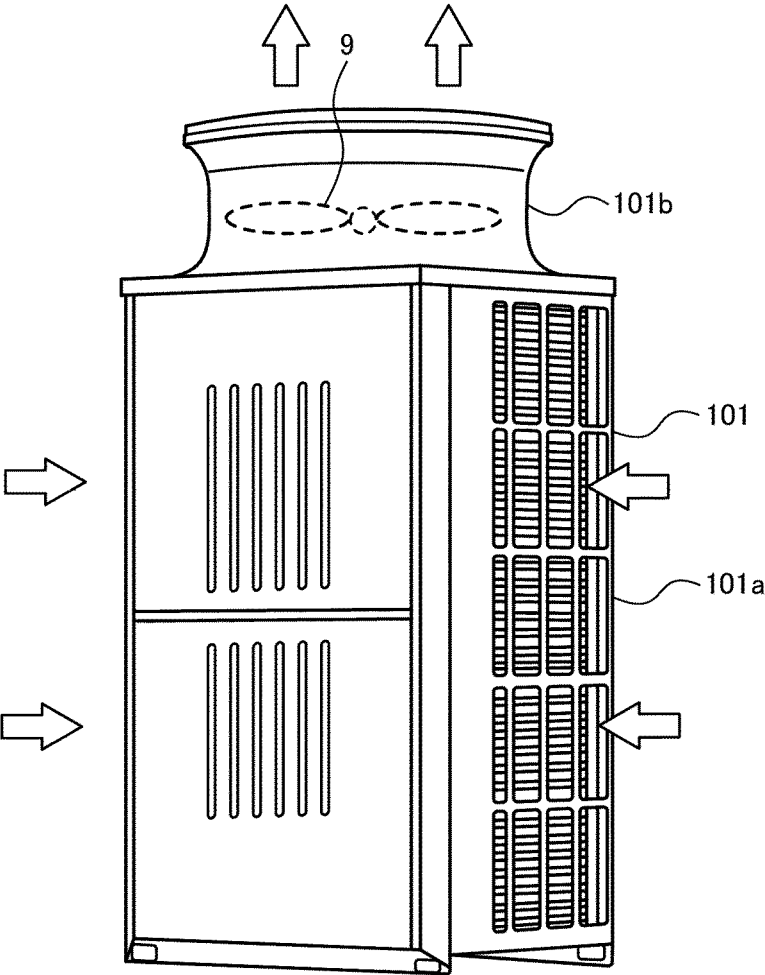


FIG. 21

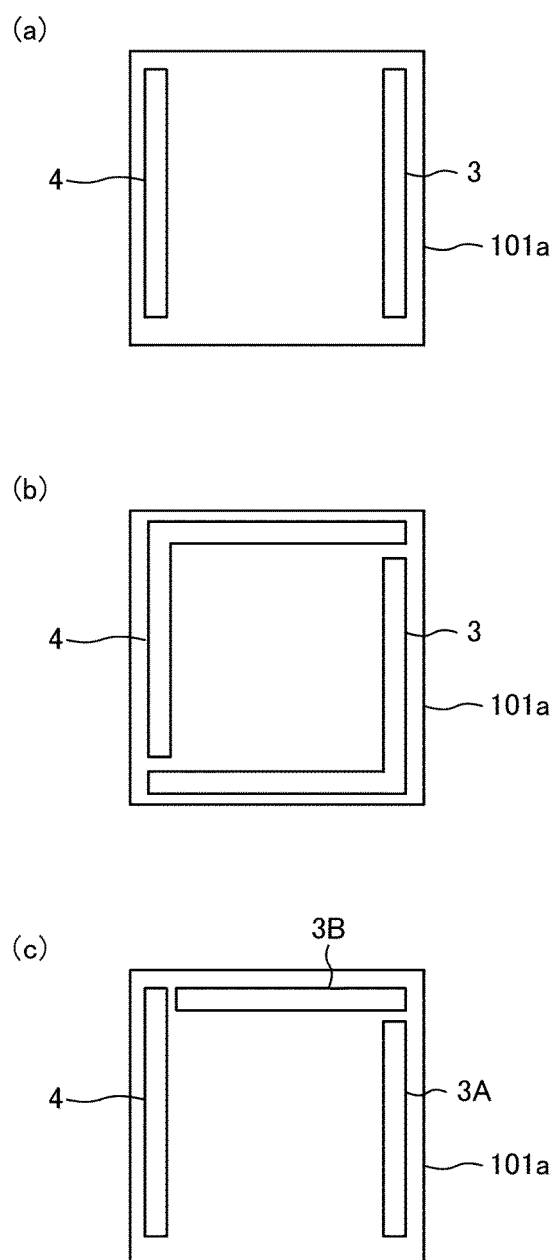


FIG. 22

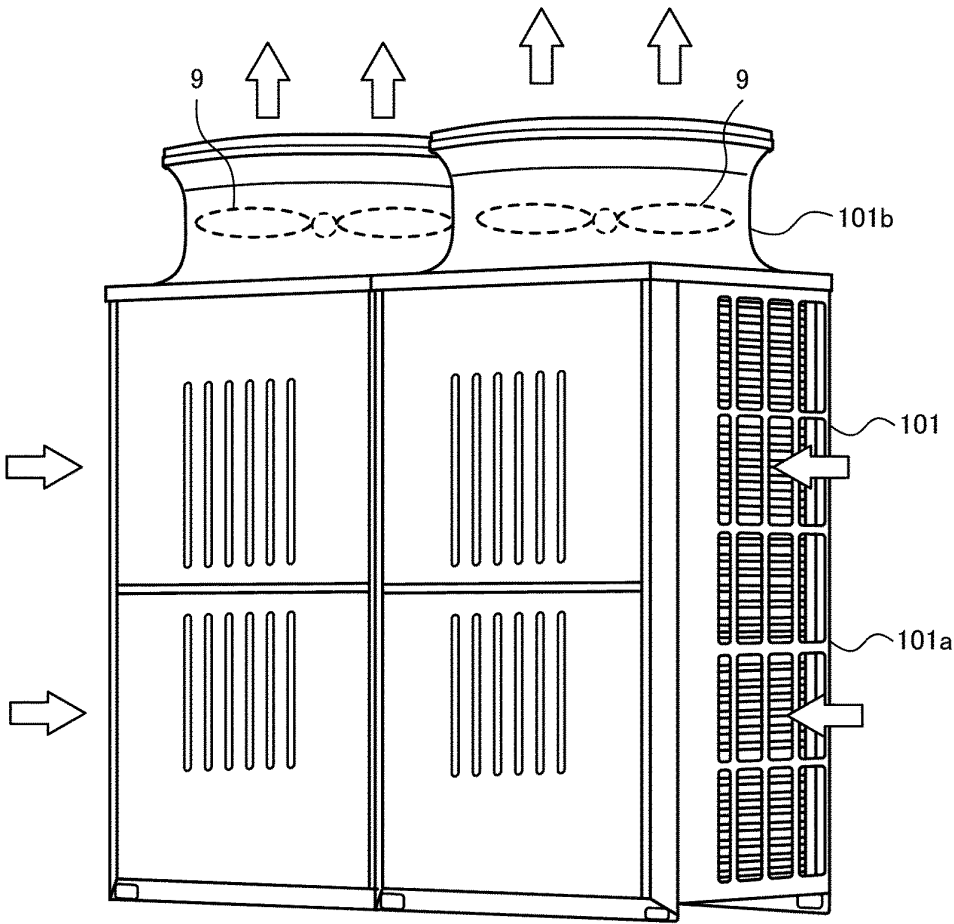
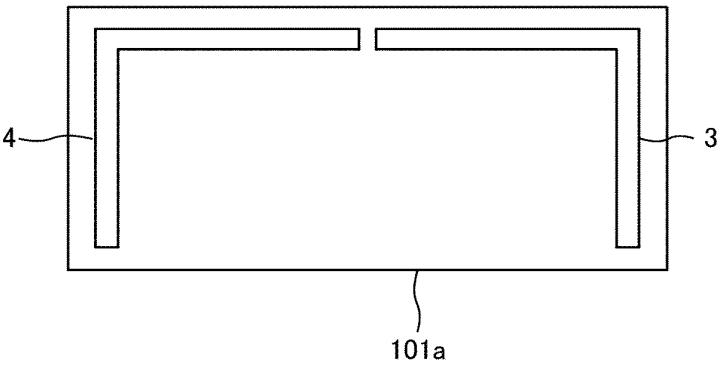


FIG. 23



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/031523

A. CLASSIFICATION OF SUBJECT MATTER

F28F 9/02(2006.01); *F28D 1/053*(2006.01);

FI: F28F9/02 301D; F28D1/053 A

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)

F28F9/02; F28D1/053

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2019/239446 A1 (MITSUBISHI ELECTRIC CORP) 19 December 2019 (2019-12-19) paragraphs [0015]-[0035], [0050]-[0064], fig. 2-7	1-11
Y	JP 2014-533819 A (LG ELECTRONICS INC) 15 December 2014 (2014-12-15) paragraphs [0080]-[0090], fig. 8-9	1-11
Y	WO 2019/008664 A1 (MITSUBISHI ELECTRIC CORP) 10 January 2019 (2019-01-10) paragraphs [0032]-[0037], fig. 6	3-11
A	JP 2012-102992 A (MORIKAWA, Atsuo) 31 May 2012 (2012-05-31) paragraphs [0024]-[0047], fig. 3-4	1-11

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

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

26 September 2022

Date of mailing of the international search report

11 October 2022

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/031523

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JP 2012-102992 A	31 May 2012	(Family: none)	

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Patent documents cited in the description

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