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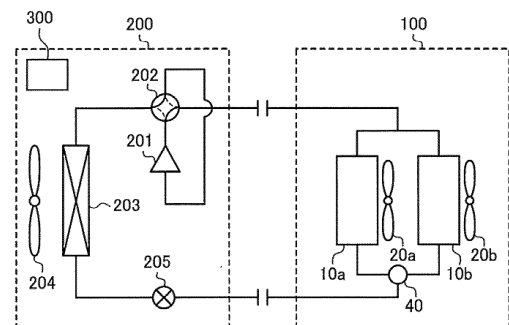
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(54) **INDOOR UNIT AND AIR CONDITIONER**

(57) An indoor unit includes a housing having an air inlet and an air outlet, a refrigerant circuit installed in the housing and provided such that a first heat exchanger, a second heat exchanger, and a refrigerant exchange capacity varying device configured to vary refrigerant temperatures in the first heat exchanger and the second heat exchanger are connected to each other by pipes, and a fan installed in the housing and configured to send air to the first heat exchanger and the second heat exchanger. The air outlet includes a first air outlet through which air passing through the fan and the first heat exchanger is blown, and a second air outlet through which air passing through the fan and the second heat exchanger is blown. The refrigerant exchange capacity varying device includes at least a switching device configured to change a flow of refrigerant in the refrigerant circuit, and a dual-temperature air-blow operation in which streams of air having different temperatures are blown through the first air outlet and the second air outlet is performed by causing the refrigerant exchange capacity varying device to vary the refrigerant temperatures or refrigerant flow rates in the first heat exchanger and the second heat exchanger or to vary both the refrigerant temperatures and the refrigerant flow rates in the first heat exchanger and the second heat exchanger.

FIG. 4



Description

Technical Field

[0001] The present invention relates to an indoor unit and an air-conditioning apparatus.

Background Art

[0002] Hitherto, there is provided an indoor unit including a housing having an air inlet through which indoor air is taken into the indoor unit, and an air outlet through which conditioned air is supplied into a room, the housing including an indoor heat exchanger and a plurality of indoor fans configured to send, to the indoor heat exchanger, the indoor air taken into the indoor unit through the air inlet (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2013-130323

Summary of Invention

Technical Problem

[0004] In recent years, there has been a demand to individually control air-conditioning temperatures for each of users in a room. The indoor unit of Patent Literature 1 is provided with the plurality of indoor fans. Therefore, the indoor fans are individually controlled to blow airflows having different airflow rates through the air outlet, thereby being capable of controlling air-conditioning depending on the users in the room. Specifically, independent air-blow control is performed during, for example, cooling such that air is blown to a user who feels hot by increasing the airflow rate and air is not blown to a user who feels cold by reducing the airflow rate. However, the independent air-blow control that involves changing the airflow rate in this manner has a problem that comfort is insufficient for the user who does not have a blow of air.

[0005] The present invention has been made in view of the circumstances described above and therefore an object thereof is to provide an indoor unit and an air-conditioning apparatus capable of producing streams of blown air having different temperatures at equal airflow rates.

Solution to Problem

[0006] An indoor unit according to one embodiment of the present invention includes a housing having an air inlet and an air outlet, a refrigerant circuit installed in the housing and provided such that a first heat exchanger, a second heat exchanger, and a refrigerant exchange

capacity varying device configured to vary refrigerant temperatures in the first heat exchanger and the second heat exchanger are connected to each other by pipes, and a fan installed in the housing and configured to send air to the first heat exchanger and the second heat exchanger. The air outlet includes a first air outlet through which air passing through the fan and the first heat exchanger is blown, and a second air outlet through which air passing through the fan and the second heat exchanger is blown. The refrigerant exchange capacity varying device includes at least a switching device configured to change a flow of refrigerant in the refrigerant circuit, and a dual-temperature air-blow operation in which streams of air having different temperatures are blown through the first air outlet and the second air outlet is performed by causing the refrigerant exchange capacity varying device to vary the refrigerant temperatures or refrigerant flow rates in the first heat exchanger and the second heat exchanger or to vary both the refrigerant temperatures and the refrigerant flow rates in the first heat exchanger and the second heat exchanger.

[0007] An air-conditioning apparatus according to another embodiment of the present invention includes the indoor unit and an outdoor unit.

Advantageous Effects of Invention

[0008] According to the embodiments of the present invention, the refrigerant exchange capacity varying device configured to vary the refrigerant temperatures in the first heat exchanger and the second heat exchanger is provided in the refrigerant circuit. Thus, streams of blown air having different temperatures can be produced even if the airflow rates are kept equal.

Brief Description of Drawings

[0009]

Fig. 1 is an entire perspective view of an indoor unit of an air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 2 is a schematic vertical sectional view taken along the line A-A in Fig. 1.

Fig. 3 is an exploded perspective view of the indoor unit of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 4 is a diagram illustrating a refrigerant circuit of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 5 is a P-h diagram during a normal heating operation of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 6 is a P-h diagram during a dual-condensing operation of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 7 is a P-h diagram during a heating operation by a single heat exchanger of the air-conditioning

apparatus according to Embodiment 1 of the present invention.

Fig. 8 is a P-h diagram during a normal cooling operation of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 9 is a diagram illustrating a flow of refrigerant during a dual-evaporating operation of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 10 is a P-h diagram during a cooling operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 11 is a diagram illustrating a refrigerant circuit in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 12 is a P-h diagram during the dual-condensing operation in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 13 is a diagram illustrating a flow of the refrigerant during the dual-evaporating operation in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention.

Fig. 14 is a diagram illustrating a refrigerant circuit of an air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 15 is a diagram illustrating a flow of refrigerant during a normal heating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 16 is a P-h diagram during the normal heating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 17 is a diagram illustrating a flow of the refrigerant during a dual-condensing operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 18 is a P-h diagram during the dual-condensing operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 19 is a plan view illustrating an indoor environment suitable by using a cooling and heating simultaneous operation.

Fig. 20 is a P-h diagram during the cooling and heating simultaneous operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 21 is a diagram illustrating a flow of the refrigerant during a heating operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 22 is a diagram illustrating a flow of the refrigerant during a normal cooling operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 23 is a P-h diagram during the normal cooling

operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 24 is a diagram illustrating a flow of the refrigerant during a dual-evaporating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 25 is a P-h diagram during the dual-evaporating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 26 is a P-h diagram during the cooling and heating simultaneous operation of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 27 is a diagram illustrating a flow of the refrigerant during a cooling operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 28 is a diagram illustrating a refrigerant circuit in Modification Example 1 of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 29 is a diagram illustrating a refrigerant circuit in Modification Example 2 of the air-conditioning apparatus according to Embodiment 2 of the present invention.

Fig. 30 is a diagram illustrating Modification Example 1 in which a line flow fan in the air-conditioning apparatus according to each of Embodiments 1 and 2 of the present invention is used.

Fig. 31 is a diagram illustrating Modification Example 2 in which the line flow fan in the air-conditioning apparatus according to each of Embodiments 1 and 2 of the present invention is used.

35 Description of Embodiments

[0010] Indoor units and air-conditioning apparatuses according to Embodiments 1 and 2 of the present invention are described below with reference to, for example, the drawings. Note that the present invention is not limited to Embodiments 1 and 2 described below. Further, elements represented by the same reference signs in the drawings are the same or corresponding elements and are common throughout the description. Further, the forms of constituent elements that are defined throughout the description are illustrative in all respects and the forms are not limited to those in the description. Further, the magnitudes of, for example, temperature and pressure are not particularly determined in relation to absolute values but are determined relative to, for example, conditions and actions of systems or devices.

Embodiment 1

[0011] Fig. 1 is an entire perspective view of the indoor unit of the air-conditioning apparatus according to Embodiment 1 of the present invention. Fig. 2 is a schematic vertical sectional view taken along the line A-A in Fig. 1.

Fig. 3 is an exploded perspective view of the indoor unit of the air-conditioning apparatus according to Embodiment 1 of the present invention. Note that "top", "bottom", "left", "right", "front", and "rear" that are used in the following description mean directions when the indoor unit is viewed from the front, unless otherwise indicated.

[0012] An indoor unit 100 supplies conditioned air (air subjected to heat exchange by an indoor heat exchanger described later) to an air-conditioned area such as a room by using a refrigeration cycle in which refrigerant circulates. A housing 100a of the indoor unit 100 has a base 1 fixed to a wall surface in the room, and a design panel 2 attached to the front of the base 1. An air inlet 3 through which indoor air is taken into the indoor unit 100 is formed on the top of the design panel 2. Further, an air outlet 4 through which air is blown into the room is formed on the bottom of the design panel 2. The air outlet 4 is opened during an operation and closed during a stop of the operation by an opening and closing panel 21 of the design panel 2.

[0013] Airflow direction control devices configured to control air blow directions of air to be blown into the room through the air outlet 4 are disposed near the air outlet. The airflow direction control devices include vertical airflow direction flaps 2a and 2b configured to control vertical airflow directions of the blown air, and lateral airflow direction flaps 1a and 1b configured to control lateral airflow directions of the blown air. The vertical airflow direction flap 2a and the lateral airflow direction flap 1a are disposed on the right of the air outlet 4. The vertical airflow direction flap 2b and the lateral airflow direction flap 1b are disposed on the left of the air outlet 4. Thus, the airflow directions can be controlled independently on the right and left of the air outlet 4.

[0014] The housing 100a includes indoor heat exchangers 10a and 10b disposed laterally adjacent to each other, and indoor fans 20a and 20b provided in conjunction with the indoor heat exchangers 10a and 10b, respectively. The housing 100a further includes fan motors 30a and 30b (30b is not illustrated) configured to drive the indoor fans 20a and 20b, respectively.

[0015] Each of the indoor heat exchangers 10a and 10b is constituted as a fin-and-tube heat exchanger including a plurality of fins 11 disposed with intervals therebetween, and a plurality of heat transfer tubes 12, which run through the plurality of fins 11 and through which refrigerant passes. Note that each of the indoor heat exchangers 10a and 10b has a W-shape when viewed from the right or left but this shape is merely an example and the shape of the indoor heat exchanger is not limited to this shape.

[0016] The indoor fans 20a and 20b are disposed on a downstream side of the air inlet 3 and on an upstream side of the indoor heat exchangers 10a and 10b. For example, each of the indoor fans 20a and 20b is constituted as a propeller fan or a line flow fan.

[0017] In the housing 100a, an airflow passage from the air inlet 3 to the air outlet 4 is roughly divided into a

right airflow passage 5a and a left airflow passage 5b. Further, the indoor heat exchanger 10a and the indoor fan 20a are disposed in the right airflow passage 5a and the indoor heat exchanger 10b and the indoor fan 20b are disposed in the left airflow passage 5b. Further, the air outlet 4 includes a right air outlet 4a communicating with the right airflow passage 5a, and a left air outlet 4b communicating with the left airflow passage 5b. Further, streams of air from the indoor fans 20a and 20b pass through the corresponding indoor heat exchangers 10a and 10b and are supplied into the room through the right air outlet 4a and the left air outlet 4b while the airflow directions are independently controlled by the respective airflow direction control devices. Note that provision of a partition plate between the right airflow passage 5a and the left airflow passage 5b is not indispensable.

[0018] The indoor unit 100 constituted as described above includes two sets of the indoor heat exchanger and the indoor fan on the right and left. Therefore, streams of blown air having different temperatures can be blown through the right air outlet 4a and the left air outlet 4b by varying the rotation speeds of the indoor fans 20a and 20b between the right and left. Further, Embodiment 1 has a feature that streams of blown air having different temperatures can be blown through the right air outlet 4a and the left air outlet 4b even if the rotation speeds of the indoor fans 20a and 20b are kept equal. A refrigerant circuit structure capable of achieving this feature is described below.

[0019] Fig. 4 is a diagram illustrating a refrigerant circuit of the air-conditioning apparatus according to Embodiment 1 of the present invention.

[0020] The air-conditioning apparatus includes the indoor unit 100 and an outdoor unit 200. The indoor unit 100 includes a switching device 40 in addition to the indoor heat exchangers 10a and 10b and the indoor fans 20a and 20b described above. Further, the indoor heat exchanger 10a, the indoor heat exchanger 10b, and the switching device 40 are connected to each other by pipes to form an indoor-side refrigerant circuit. More specifically, the indoor heat exchanger 10a and the indoor heat exchanger 10b are connected in parallel to each other to form a parallel circuit and the switching device 40 is connected to one end of the parallel circuit to form the indoor-side refrigerant circuit.

[0021] The switching device 40 is a device configured to change a flow of refrigerant in the indoor-side refrigerant circuit. Specifically, the switching device 40 is constituted as a flow control valve configured to allow the refrigerant flowing into the indoor unit 100 to be distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b. As described below, in Embodiment 1, the heat exchange capacities of the indoor heat exchangers 10a and 10b are varied by causing the flow control valve to vary the flow rates of streams of refrigerant flowing into the indoor heat exchanger 10a and the indoor heat exchanger 10b. A refrigerant exchange capacity varying device of the present invention includes

at least a switching device configured to change the flow of the refrigerant in the indoor-side refrigerant circuit. The switching device 40 corresponds to this switching device.

[0022] The outdoor unit 200 includes a compressor 201, a four-way valve 202, an outdoor heat exchanger 203, an outdoor fan 204, and a pressure reducing device 205. Further, the compressor 201, the four-way valve 202, the outdoor heat exchanger 203, and the pressure reducing device 205 are connected to each other by pipes to form an outdoor-side refrigerant circuit.

[0023] The compressor 201 sucks refrigerant and compresses the refrigerant into a high-temperature and high-pressure state. The compressor 201 may be capable of changing the operation capacity (frequency) or may have a fixed capacity. The four-way valve 202 changes a refrigerant circulation direction between a cooling operation and a heating operation. The outdoor heat exchanger 203 is constituted as a fin-and-tube heat exchanger.

[0024] The pressure reducing device 205 is constituted as an expansion valve capable of controlling the opening degree. It is appropriate that the expansion valve be constituted as an electronic expansion valve capable of variably controlling the throttle opening degree by a stepping motor (not illustrated). Note that a mechanical expansion valve that employs a diaphragm as a pressure receiving portion or a thermostatic expansion valve may be used instead of the electronic expansion valve. Further, other types of device such as a capillary tube may be used as the pressure reducing device 205 instead of the expansion valve as long as they have similar functions.

[0025] Further, the outdoor-side refrigerant circuit and the indoor-side refrigerant circuit are connected to each other by pipes to form a refrigerant circuit.

[0026] The refrigerant circuit formed as described above is filled with refrigerant. As the refrigerant, the refrigerant circuit is filled with HFC-R32 in Embodiment 1 but other refrigerants may be used. Any refrigerants such as HFC-R410A, HFO-1234yf, HFO-1234ze, and CO₂ may be used as long as they are refrigerants used in the refrigeration cycle.

[0027] The air-conditioning apparatus is further provided with a controller 300 configured to control the entire air-conditioning apparatus. Note that Fig. 4 illustrates a structure in which only the outdoor unit 200 is provided with the controller 300 but there may be employed a structure in which the indoor unit 100 is provided with an indoor controller having a part of the functions of the controller 300 and data communication is performed between the controller 300 and the indoor controller to perform cooperative processing. The controller 300 may be constituted by hardware such as a circuit device that implements the functions or may be constituted by a processor such as a microcomputer or a CPU and software to be executed on the processor.

[0028] The controller 300 performs an operation by switching the cooling operation and the heating operation through a switching action of the four-way valve 202. Fur-

ther, in a state where the four-way valve 202 is switched for the heating operation, the controller 300 switches the operation to a normal heating operation, a dual-condensing operation, or a heating operation by a single heat exchanger through a switching action of the switching device 40 of the indoor unit 100. Further, in a state where the four-way valve 202 is switched for the cooling operation, the controller 300 switches the operation to a normal cooling operation, a dual-evaporating operation, or a cooling operation by a single heat exchanger through the switching action of the switching device 40 of the indoor unit. The dual-condensing operation and the dual-evaporating operation correspond to a dual-temperature air-blow operation of the present invention.

[0029] As described above, Embodiment 1 has a feature in that streams of blown air having different temperatures can be blown while the rotation speeds of the indoor fans 20a and 20b are kept equal. This action is performed during the dual-condensing operation and the dual-evaporating operation. Actions of the air-conditioning apparatus during the respective operations performed by the air-conditioning apparatus, including the operations above, are described below.

[Heating Operation]

[0030] The normal heating operation (1), the dual-condensing operation (2), and the one-sided operation (3) are described below in sequence. Note that, during the heating operation, the four-way valve 202 is switched to a state represented by the solid lines in Fig. 4. The same applies to all the operations (1) to (3).

(1) Normal Heating Operation

[0031] The normal heating operation is an operation in which condensing temperatures are equal at the indoor heat exchangers 10a and 10b and warm air-blow temperatures are equal at the right air outlet 4a and the left air outlet 4b.

[0032] Fig. 5 is a P-h diagram during the normal heating operation of the air-conditioning apparatus according to Embodiment 1 of the present invention. The horizontal axis represents enthalpy [kJ/kg] and the vertical axis represents pressure [MPa]. The same applies to P-h diagrams described below. In Fig. 5, a heat exchanger involved in a condensing process or an evaporating process is illustrated together with the process near the line representing the process. That is, the dotted heat exchanger represents the indoor heat exchanger 10a or 10b and the undotted heat exchanger represents the outdoor heat exchanger 203. The same applies to the P-h diagrams described below. Further, in Fig. 5, the dotted line represents an isothermal line, which shows a standard temperature condition during the heating operation. The upper dotted line represents a standard indoor temperature (for example, 20 degrees Celsius) and the lower dotted line represents a standard outdoor air temperature

(for example, 7 degrees Celsius). The same applies to the dotted lines in the P-h diagrams of the heating operation to be described below.

[0033] In the normal heating operation, the switching device 40 is switched so that the refrigerant flowing into the indoor unit 100 is evenly distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b. Further, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and is then evenly split into two streams. The streams of the respective refrigerants flow into the indoor heat exchangers 10a and 10b. The streams of refrigerant flowing into the indoor heat exchangers 10a and 10b are condensed and liquefied by exchanging heat with streams of air from the indoor fans 20a and 20b (state B) and join at the switching device 40.

[0034] The pressure of the refrigerant whose streams have joined at the switching device 40 is reduced by the pressure reducing device 205 (state C). The refrigerant whose pressure has been reduced by the pressure reducing device 205 flows into the outdoor heat exchanger 203 and is evaporated by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is finished. The cycle described above is repeated continuously to heat the room.

[0035] Here, the refrigerant flowing into the indoor unit 100 is evenly distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b by the switching device 40 and therefore the condensing temperatures are equal at the indoor heat exchanger 10a and the indoor heat exchanger 10b. Thus, streams of warm air having equal temperatures are blown through the right air outlet 4a and the left air outlet 4b while the indoor fans 20a and 20b are operating at equal rotation speeds.

(2) Dual-Condensing Operation

[0036] The dual-condensing operation is an operation in which streams of warm air having different temperatures are produced at equal airflow rates by varying the flow rates of streams of refrigerant to be distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b during the heating operation.

[0037] Fig. 6 is a P-h diagram during the dual-condensing operation of the air-conditioning apparatus according to Embodiment 1 of the present invention. Note that Fig. 6 illustrates a case in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a. In Fig. 6, Δ represents a refrigerant state in the indoor heat exchanger 10a and $\square$ represents a refrigerant state in the indoor heat exchanger 10b.

[0038] In the dual-condensing operation, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and is then distributed to the indoor heat exchanger 10a and the indoor heat ex-

changer 10b. Then, the streams of the respective refrigerants flow into the indoor heat exchangers 10a and 10b that function as condensers and are condensed by exchanging heat with streams of air from the indoor fans 20a and 20b to turn into high-pressure liquid refrigerant (state B1) and high-pressure two-phase refrigerant (state B2). The streams of refrigerant join at the switching device 40 and then the pressure of the refrigerant is reduced by the pressure reducing device 205 to turn into low-pressure two-phase refrigerant (state C). The low-pressure two-phase refrigerant flows into the outdoor heat exchanger 203 and is evaporated by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is completed. The cycle described above is repeated continuously to heat the room.

[0039] Here, the refrigerant flowing into the indoor unit 100 is distributed so that the refrigerant in the indoor heat exchanger 10a is less than that in the indoor heat exchanger 10b as described above. Therefore, the heat exchange amount of the indoor heat exchanger 10a is smaller than that of the indoor heat exchanger 10b. Thus, the temperature of the air that has passed through the indoor heat exchanger 10a is lower than the temperature of the air that has passed through the indoor heat exchanger 10b while the indoor fans 20a and 20b are operating at equal rotation speeds. Accordingly, warm air having a lower temperature than that blown through the left air outlet 4b is blown through the right air outlet 4a.

[0040] As described above, the heat exchange capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to vary the refrigerant flow rates in the indoor heat exchanger 10a and the indoor heat exchanger 10b. As a result, streams of warm air having different temperatures can be produced at equal airflow rates.

[0041] Note that description is made on the example in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a, but it is needless to say that the refrigerant may be distributed in a reverse manner. In this case, the temperature of the warm air blown through the left air outlet 4b is lower than the temperature of the warm air blown through the right air outlet 4a.

(3) Heating operation by a single heat exchanger

[0042] The heating operation by a single heat exchanger is an operation in which only one of the indoor heat exchanger 10a and the indoor heat exchanger 10b performs the heating operation. In the heating operation by a single heat exchanger, the switching device 40 is switched so that the refrigerant passes through only one of the indoor heat exchanger 10a and the indoor heat exchanger 10b. Further, the operation of the indoor fan corresponding to the indoor heat exchanger through

which the refrigerant does not pass is stopped.

[0043] Fig. 7 is a P-h diagram during the heating operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 1 of the present invention. Note that Fig. 7 illustrates a case where the switching device 40 is switched so that the refrigerant flows into the indoor heat exchanger 10a alone.

[0044] In the heating operation by a single heat exchanger, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the indoor heat exchanger 10a. The refrigerant flowing into the indoor heat exchanger 10a is condensed and liquefied by exchanging heat with air from the indoor fan 20a (state B) and then passes through the switching device 40. The pressure of the refrigerant that has passed through the switching device 40 is reduced by the pressure reducing device 205 (state C). The refrigerant whose pressure has been reduced by the pressure reducing device 205 flows into the outdoor heat exchanger 203 and is evaporated by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is completed. The cycle described above is repeated continuously to heat the room.

[0045] Here, the refrigerant passes through the indoor heat exchanger 10a but does not pass through the indoor heat exchanger 10b and therefore warm air is blown through the right air outlet 4a alone.

[0046] The operation by a single heat exchanger described above is effective in residences corresponding to ZEHs (net zero energy houses) of recent years. The ZEH is a residence in which an annual net energy consumption amount is substantially zero by producing energy through, for example, solar photovoltaics while simultaneously achieving a comfortable indoor environment and great energy savings through an increase in heat insulation of the residence and use of high-efficiency equipment.

[0047] In recent years, the airtightness of residences has been increasing toward the ZEHs and the air conditioning load is about 1 kW or less in a steady state. When the capacity is reduced in a related-art air-conditioning apparatus, inverter control for a compressor is used and the operation frequency is set to the minimum frequency to achieve a low-capacity operation. However, the capacity can be reduced only to about a half of the rated capacity at the best due to a lower limit frequency or other problems. On the other hand, a low capacity that is appropriate as a capacity required in a steady state can be achieved when the rated capacity is reduced. With this setting, however, it is impossible to provide a capacity that covers an activation load imposed when a high-capacity operation is required as typified by a case in which a person comes home in midsummer, gets out of a bath, or gets out of bed at an extremely low temperature.

[0048] The air-conditioning apparatus of Embodiment 1 includes two indoor heat exchangers 10a and 10b. From other points of view, the air-conditioning apparatus

has such a structure that a single indoor heat exchanger that has been provided in a housing of an indoor unit in the related art is divided into two indoor heat exchangers. Therefore, when the refrigerant is caused to flow into only one of the two indoor heat exchangers 10a and 10b by performing the heating operation by a single heat exchanger, the capacity can further be reduced to a half theoretically while the compressor is operating at the lower limit frequency. That is, when the air conditioning load is small, the capacity of the air-conditioning apparatus can be reduced to a capacity that is appropriate to the air conditioning load, thereby being capable of contributing to reduction in power consumption. Further, the capacity that covers the activation load imposed when the high-capacity operation is required can be provided by causing the refrigerant to flow into both the indoor heat exchangers 10a and 10b. The same applies to the cooling operation by a single heat exchanger described later.

[Cooling Operation]

[0049] Next, the normal cooling operation (1), the dual-evaporating operation (2), and the cooling operation by a single heat exchanger (3) are described in sequence. Note that, during the cooling operation, the four-way valve 202 is switched to a state represented by the dotted lines in Fig. 4. The same applies to all the operations (1) to (3).

(1) Normal Cooling Operation

[0050] The normal cooling operation is an operation in which evaporating temperatures are equal at the indoor heat exchangers 10a and 10b and cool air-blow temperatures are equal at the right air outlet 4a and the left air outlet 4b.

[0051] Fig. 8 is a P-h diagram during the normal cooling operation of the air-conditioning apparatus according to Embodiment 1 of the present invention. In Fig. 8, the dotted line represents an isothermal line, which shows a standard temperature condition during the cooling operation. The upper dotted line represents a standard outdoor air temperature (for example, 25 degrees Celsius) and the lower dotted line represents a standard indoor temperature (for example, 27 degrees Celsius). The same applies to the dotted lines in P-h diagrams of the cooling operation to be described below.

[0052] In the normal cooling operation, the switching device 40 is switched so that the refrigerant flowing into the indoor unit 100 is evenly distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b. Further, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203 that functions as a condenser. The refrigerant flowing into the outdoor heat exchanger 203 is condensed and liquefied by exchanging heat with air from the outdoor fan 204 (state B). The pressure of the condensed and liquefied refrigerant

erant is reduced by the pressure reducing device 205 (state C). The refrigerant whose pressure has been reduced by the pressure reducing device 205 is evenly split into two streams by the switching device 40. The streams of respective refrigerants flow into the indoor heat exchangers 10a and 10b that function as evaporators.

[0053] The streams of respective refrigerants flowing into the indoor heat exchangers 10a and 10b join after being evaporated by exchanging heat with streams of air from the indoor fans 20a and 20b (state D). Then, the refrigerant whose streams have joined passes through the four-way valve 202 and is sucked into the compressor 201 again. Thus, one cycle is completed. The cycle described above is repeated continuously to cool the room.

[0054] Here, the refrigerant flowing into the indoor unit 100 is evenly distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b by the switching device 40 and therefore the evaporating temperatures are equal at the indoor heat exchanger 10a and the indoor heat exchanger 10b. Thus, streams of cool air having equal temperatures are blown through the right air outlet 4a and the left air outlet 4b while the indoor fans 20a and 20b are operating at equal rotation speeds.

(2) Dual-Evaporating Operation

[0055] The dual-evaporating operation is an operation in which streams of cool air having different temperatures are produced at equal airflow rates by varying the evaporating temperatures of the indoor heat exchanger 10a and the indoor heat exchanger 10b during the cooling operation.

[0056] Fig. 9 is a diagram illustrating a flow of the refrigerant during the dual-evaporating operation of the air-conditioning apparatus according to Embodiment 1 of the present invention. Note that Fig. 9 illustrates a case where the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a. In Fig. 9, Δ represents a refrigerant state in the indoor heat exchanger 10a and $\square$ represents a refrigerant state in the indoor heat exchanger 10b.

[0057] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant is condensed by exchanging heat with air from the outdoor fan 204 (state B). The pressure of the condensed refrigerant is reduced by the pressure reducing device 205. Then, the refrigerant is distributed by the switching device 40b to flow into the indoor heat exchanger 10a and the indoor heat exchanger 10b. Refrigerant in a state C1 that has been distributed to the indoor heat exchanger 10a and refrigerant in a state C2 that has been distributed to the indoor heat exchanger 10b join after being evaporated by exchanging heat with streams of air from the indoor fans 20a and 20b (state D). The refrigerant whose streams have joined returns to the compressor 201 via the four-way valve 202 and one cycle is com-

pleted. The cycle described above is repeated continuously to cool the room.

[0058] Here, the refrigerant flowing into the indoor unit 100 is distributed by the switching device 40 so that the refrigerant flow rate in the indoor heat exchanger 10a is lower than that in the indoor heat exchanger 10b. Therefore, the heat exchange amount of the indoor heat exchanger 10a is smaller than that of the indoor heat exchanger 10b. Thus, the temperature of the cool air blown through the right air outlet 4a of the right airflow passage 5a having the indoor heat exchanger 10a is higher than the temperature of the cool air blown through the left air outlet 4b of the left airflow passage 5b having the indoor heat exchanger 10b.

[0059] As described above, the heat exchange capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to vary the refrigerant flow rates in the indoor heat exchanger 10a and the indoor heat exchanger 10b. As a result, streams of cool air having different temperatures can be produced at equal airflow rates.

[0060] Note that description is made on the example in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a. However, it is needless to say that the refrigerant may be distributed in a reverse manner. In this case, the temperature of the cool air blown through the left air outlet 4b is higher than the temperature of the warm air blown through the right air outlet 4a.

(3) Cooling operation by a single heat exchanger

[0061] The cooling operation by a single heat exchanger is an operation in which only one of the indoor heat exchanger 10a and the indoor heat exchanger 10b performs the cooling operation. In the cooling operation by a single heat exchanger, the switching device 40 is switched so that the refrigerant flows into only one of the indoor heat exchanger 10a and the indoor heat exchanger 10b. Further, the operation of the indoor fan corresponding to the indoor heat exchanger through which the refrigerant does not pass is stopped.

[0062] Fig. 10 is a P-h diagram during the cooling operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 1 of the present invention. Here, the switching device 40 is switched so that the refrigerant flows into the indoor heat exchanger 10a alone.

[0063] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant flowing into the indoor heat exchanger 10a is condensed by exchanging heat with air from the indoor fan 20a (state B). The pressure of the condensed refrigerant is reduced by the pressure reducing device 205 (state C). Then, the refrigerant passes through the switching device 40 and flows into the indoor heat ex-

changer 10a. The refrigerant flowing into the indoor heat exchanger 10a is evaporated by exchanging heat with air from the indoor fan 20a (state D). Then, the refrigerant passes through the four-way valve 202 and is sucked into the compressor 201 again. Thus, one cycle is completed. The cycle described above is repeated continuously to cool the room.

[0064] Here, the refrigerant passes through the indoor heat exchanger 10a but does not pass through the indoor heat exchanger 10b and therefore cool air is blown through the right air outlet 4a alone.

[0065] As described above, according to Embodiment 1, the heat exchange capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to vary the refrigerant flow rates in the indoor heat exchanger 10a and the indoor heat exchanger 10b. As a result, streams of blown air having different temperatures can be produced at equal airflow rates.

[0066] Further, in the indoor-side refrigerant circuit, the indoor heat exchanger 10a and the indoor heat exchanger 10b are connected in parallel to each other to form the parallel circuit. Further, the switching device 40 connected to one end of the parallel circuit serves as the flow control valve and therefore the refrigerant flowing into the indoor unit 100 can be distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b.

[0067] Further, the heat exchange capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to serve as the flow control valve and controlling the flow control valve to vary the flow rates of the streams of refrigerant to be distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b.

[0068] Further, the right air outlet 4a and the left air outlet 4b are formed by dividing the air outlet 4 to the right and left. Therefore, streams of blown air can individually be sent to users in the room and thus the comfort of each user can be improved.

[0069] A Modification Example of Embodiment 1 is described below.

(Modification Example 1)

[0070] Fig. 11 is a diagram illustrating a refrigerant circuit in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention.

[0071] Fig. 4 illustrates the structure in which the switching device 40 is provided on a downstream side of the indoor heat exchangers 10a and 10b in the flow of the heating operation. In Modification Example 1 illustrated in Fig. 11, there is provided a structure in which the switching device 40 is provided on an upstream side of the indoor heat exchangers 10a and 10b.

[0072] Changes of the state of the refrigerant in the refrigerant circuit of Modification Example 1 are described for each of the dual-condensing operation and

the dual-evaporating operation. The normal heating operation, the normal cooling operation, and the one-sided operations are the same as those in the refrigerant circuit illustrated in Fig. 4.

[0073] Fig. 12 is a P-h diagram during the dual-condensing operation in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention. In Fig. 12, Δ represents a refrigerant state in the indoor heat exchanger 10a and $\square$ represents a refrigerant state in the indoor heat exchanger 10b.

[0074] In the dual-condensing operation, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and is then distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b by the switching device 40. Then, the streams of the respective refrigerants flow into the indoor heat exchangers 10a and 10b that function as condensers and are condensed by exchanging heat with streams of air from the indoor fans 20a and 20b to turn into high-pressure liquid refrigerant (state B1) and high-pressure two-phase refrigerant (state B2). The streams of the respective refrigerants join and then the pressure of the refrigerant is reduced by the pressure reducing device 205 to turn into low-pressure two-phase refrigerant (state C). The low-pressure two-phase refrigerant flows into the outdoor heat exchanger 203 and is evaporated by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is completed. The cycle described above is repeated continuously to heat the room.

[0075] Here, the refrigerant flowing into the indoor unit 100 is distributed so that the refrigerant in the indoor heat exchanger 10a is in a smaller amount than that in the indoor heat exchanger 10b as described above. Therefore, the heat exchange amount of the indoor heat exchanger 10a is smaller than that of the indoor heat exchanger 10b. Thus, the temperature of the air that has passed through the indoor heat exchanger 10a is lower than the temperature of the air that has passed through the indoor heat exchanger 10b while the indoor fans 20a and 20b are operating at equal rotation speeds. Accordingly, warm air having a lower temperature than that blown through the left air outlet 4b is blown through the right air outlet 4a.

[0076] As described above, the capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to vary the refrigerant flow rates in the indoor heat exchanger 10a and the indoor heat exchanger 10b. As a result, streams of warm air having different temperatures can be produced at equal airflow rates.

[0077] Note that description is made on the example in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a, but it is needless to say that the refrigerant may be distributed in a reverse manner. In

this case, the temperature of the warm air blown through the left air outlet 4b is lower than the temperature of the warm air blown through the right air outlet 4a.

[0078] Fig. 13 is a diagram illustrating a flow of the refrigerant during the dual-evaporating operation in Modification Example 1 of the air-conditioning apparatus according to Embodiment 1 of the present invention. Note that Fig. 13 illustrates a case in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a. In Fig. 13, Δ represents a refrigerant state in the indoor heat exchanger 10a and $\square$ represents a refrigerant state in the indoor heat exchanger 10b.

[0079] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant is condensed by exchanging heat with air from the outdoor fan 204 (state B). The pressure of the condensed refrigerant is reduced by the pressure reducing device 205 (state C). The refrigerant whose pressure has been reduced is distributed to flow into the indoor heat exchanger 10a and the indoor heat exchanger 10b. The streams of refrigerant distributed to the indoor heat exchanger 10a and the indoor heat exchanger 10b are evaporated by exchanging heat with air from the outdoor fan 204 (state D1 and state D2) and then join at the switching device 40. The refrigerant whose streams have joined returns to the compressor 201 via the four-way valve 202 and one cycle is completed. The cycle described above is repeated continuously to cool the room.

[0080] Here, the refrigerant flowing into the indoor unit 100 is distributed by the switching device 40 so that the refrigerant flow rate in the indoor heat exchanger 10a is lower than that in the indoor heat exchanger 10b. Therefore, the heat exchange amount of the indoor heat exchanger 10a is smaller than that of the indoor heat exchanger 10b. Thus, the temperature of the cool air blown through the right air outlet 4a of the right airflow passage 5a having the indoor heat exchanger 10a is higher than the temperature of the cool air blown through the left air outlet 4b of the left airflow passage 5b having the indoor heat exchanger 10b.

[0081] As described above, the heat exchange capacities of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied by causing the switching device 40 to vary the refrigerant flow rates in the indoor heat exchanger 10a and the indoor heat exchanger 10b. As a result, streams of cool air having different temperatures can be produced at equal airflow rates.

[0082] Note that description is made on the example in which the refrigerant is distributed by the switching device 40 so that refrigerant in a smaller amount than that in the indoor heat exchanger 10b flows into the indoor heat exchanger 10a, but it is needless to say that the refrigerant may be distributed in a reverse manner. In this case, the temperature of the cool air blown through the left air outlet 4b is higher than the temperature of the

warm air blown through the right air outlet 4a.

Embodiment 2

[0083] In Embodiment 1 described above, the dual-condensing operation and the dual-evaporating operation are performed as the dual-temperature air-blow operation in which streams of blown air having different temperatures are produced at equal airflow rates. In Embodiment 2, a cooling and heating simultaneous operation in which cool air and warm air are simultaneously blown from the indoor unit 100 can further be performed in addition to those operations.

[0084] Fig. 14 is a diagram illustrating a refrigerant circuit of an air-conditioning apparatus according to Embodiment 2 of the present invention. Differences between Embodiment 2 and Embodiment 1 are mainly described below.

[0085] The indoor-side refrigerant circuit has a structure in which the indoor heat exchanger 10a, the indoor heat exchanger 10b, and a pressure reducing device 50 are connected in parallel to each other to form a parallel circuit and switching devices 40a and 40b are connected to both ends of the parallel circuit. The switching devices 40a and 40b and the pressure reducing device 50 constitute the refrigerant exchange capacity varying device of the present invention.

[0086] The pressure reducing device 50 is constituted as an expansion valve capable of controlling the opening degree. It is appropriate that the expansion valve be constituted as an electronic expansion valve capable of variably controlling the throttle opening degree by a stepping motor (not illustrated). Note that a mechanical expansion valve that employs a diaphragm as a pressure receiving portion or a thermostatic expansion valve may be used instead of the electronic expansion valve. Further, other types of device such as a capillary tube may be used as the pressure reducing device 205 instead of the expansion valve as long as they have similar functions. Note that the electronic expansion valve is used in the following description.

[0087] Each of the switching devices 40a and 40b is constituted as a four-way switching valve capable of switching passages in four directions. The switching devices 40a and 40b switch connections between connection ports 101a and 101b of the indoor unit 100 to the outdoor unit 200 and the devices constituting the indoor-side refrigerant circuit.

[0088] Specifically, the switching device 40a switches the connection port 101a among first to third states. The first state is a state in which the connection port 101a is connected to one end of the indoor heat exchanger 10a and one end of the indoor heat exchanger 10b (see Fig. 15 and Fig. 22). The second state is a state in which the connection port 101a is connected to one end of the indoor heat exchanger 10a and one end of the pressure reducing device 50 is connected to one end of the indoor heat exchanger 10b (see Fig. 17 and Fig. 21). The third

state is a state in which the connection port 101a is connected to one end of the indoor heat exchanger 10b and one end of the pressure reducing device 50 is connected to one end of the indoor heat exchanger 10a.

[0089] Specifically, the switching device 40b switches the connection port 101b among fourth to sixth states. The fourth state is a state in which the connection port 101b is connected to the other end of the indoor heat exchanger 10a and the other end of the indoor heat exchanger 10b (see Fig. 15 and Fig. 22). The fifth state is a state in which the connection port 101b is connected to the other end of the indoor heat exchanger 10a and the other end of the pressure reducing device 50 is connected to the other end of the indoor heat exchanger 10b (see Fig. 21, Fig. 24, and Fig. 27). The sixth state is a state in which the connection port 101b is connected to the other end of the indoor heat exchanger 10b and the other end of the pressure reducing device 50 is connected to the other end of the indoor heat exchanger 10a (see Fig. 17).

[0090] The indoor-side refrigerant circuit is switched to a parallel passage (see Fig. 15 and Fig. 22), a series passage (see Fig. 17 and Fig. 24), or a single-directed passage (see Fig. 21 and Fig. 27) through switching actions of the switching devices 40a and 40b. The parallel passage is a passage through which streams of refrigerant flow parallel into the indoor heat exchangers 10a and 10b. The series passage is a passage through which refrigerant flows into one of the indoor heat exchangers 10a and 10b and then flows into the other. The single-directed passage is a passage through which refrigerant flows into only one of the indoor heat exchangers 10a and 10b.

[0091] The air-conditioning apparatus constituted as described above performs an operation by switching the cooling operation and the heating operation through the switching action of the four-way valve 202. Further, during the heating operation, the controller 300 switches the operation to the normal heating operation, the dual-condensing operation, the cooling and heating simultaneous operation, or the heating operation by a single heat exchanger through the switching actions of the switching devices 40a and 40b. Further, during the cooling operation, the controller 300 switches the operation to the normal cooling operation, the dual-condensing operation, the cooling and heating simultaneous operation, or the cooling operation by a single heat exchanger. The dual-condensing operation, the cooling and heating simultaneous operation (during heating), the dual-evaporating operation, and the cooling and heating simultaneous operation (during cooling) correspond to the dual-temperature air-blow operation of the present invention.

[0092] The dual-temperature air-blow operation during the heating operation includes the dual-condensing operation in which both the indoor heat exchangers 10a and 10b function as condensers, and the cooling and heating simultaneous operation in which one of the indoor heat exchangers 10a and 10b functions as a con-

denser and the other functions as an evaporator. Those operations are switched under control over the pressure reducing device 50. Further, the dual-temperature air-blow operation during the cooling operation includes the dual-evaporating operation in which both the indoor heat exchangers 10a and 10b function as evaporators, and the cooling and heating simultaneous operation in which one of the indoor heat exchangers 10a and 10b functions as a condenser and the other functions as an evaporator. Those operations are switched under control over the pressure reducing device 50. The pressure reducing device 50 is controlled by the controller 300.

[0093] Actions of the air-conditioning apparatus during the respective operations are described below.

[Heating Operation]

[0094] The normal heating operation (1), the dual-condensing operation (2), the cooling and heating simultaneous operation (3), and the heating operation by a single heat exchanger (4) are described below in sequence. Note that, during the heating operation, the four-way valve 202 is switched to a state represented by the solid lines in Fig. 14. The same applies to all the operations (1) to (4).

(1) Normal Heating Operation

[0095] Fig. 15 is a diagram illustrating a flow of the refrigerant during the normal heating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 15, the arrow shows a flow of the refrigerant. Fig. 16 is a P-h diagram during the normal heating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 16, A to D each represents refrigerant states at the respective pipe positions represented by A to D in Fig. 15.

[0096] In the normal heating operation, the switching device 40a is switched to the first state and the switching device 40a is switched to the fourth state to form the parallel passage. Further, the refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and is then evenly split into two streams by the switching device 40a. The streams of respective refrigerants flow into the indoor heat exchangers 10a and 10b. The streams of refrigerant flowing into the indoor heat exchangers 10a and 10b are condensed and liquefied by exchanging heat with streams of air from the indoor fans 20a and 20b (state B) and then join at the switching device 40b. Then, the pressure of the refrigerant that has passed through the switching device 40b is reduced by the pressure reducing device 205 (state C). The refrigerant whose pressure has been reduced by the pressure reducing device 205 is evaporated by the outdoor heat exchanger 203 by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant passes through the four-way valve 202 and is sucked

into the compressor 201 again. Thus, one cycle is completed. The cycle described above is repeated continuously to heat the room.

(2) Dual-Condensing Operation

[0097] Fig. 17 is a diagram illustrating a flow of the refrigerant during the dual-condensing operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 17, the arrow shows a flow of the refrigerant. Fig. 18 is a P-h diagram during the dual-condensing operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 18, A to D each represents a refrigerant state at the respective pipe positions represented by A to D in Fig. 17.

[0098] The dual-condensing operation is performed by causing the switching devices 40a and 40b to set the indoor-side refrigerant circuit to the series passage. There are two types of series passage. That is, one series passage is a first route in which the refrigerant flowing through the connection port 101a passes through the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by switching the switching device 40a to the second state and the switching device 40b to the sixth state as illustrated in Fig. 17. The other series passage is a second route in which the refrigerant flowing through the connection port 101a passes through the indoor heat exchanger 10b, the pressure reducing device 50, and the indoor heat exchanger 10a in sequence by switching the switching device 40a to the third state and the switching device 40b to the fifth state as illustrated in Fig. 24. Here, the dual-condensing operation is described taking as an example a case in which the series passage is set to the first route.

[0099] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then passes through the switching device 40a. The refrigerant that has passed through the switching device 40a flows into the indoor heat exchanger 10a that functions as a condenser and is condensed by exchanging heat with air from the indoor fan 20a to turn into high-pressure two-phase refrigerant (state B1). The high-pressure two-phase refrigerant passes through the switching device 40b and then the pressure is reduced by the pressure reducing device 50 (state B2). The refrigerant whose pressure has been reduced by the pressure reducing device 50 passes through the switching device 40a. Then, the refrigerant flows into the indoor heat exchanger 10b and is further condensed by exchanging heat with air from the indoor fan 20b (state B3). Here, the pressure reducing device 50 reduces the pressure within a range in which the pressure is not equal to or lower than a "pressure P1 corresponding to the standard indoor temperature" so that the indoor heat exchanger 10b functions as a condenser.

[0100] Then, the refrigerant condensed by the indoor

heat exchanger 10b passes through the switching device 40b and then the pressure is reduced by the pressure reducing device 205 (state C). Here, the pressure is reduced below a "pressure P2 corresponding to the standard outdoor air temperature" so that the outdoor heat exchanger 203 functions as an evaporator. Then, the refrigerant whose pressure has been reduced by the pressure reducing device 205 is evaporated by the outdoor heat exchanger 203 by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is completed. The cycle described above is repeated continuously to heat the room.

[0101] As described above, the pressure of the refrigerant flowing out of the indoor heat exchanger 10a is reduced by the pressure reducing device 50 and the refrigerant flows into the indoor heat exchanger 10b. Therefore, the condensing temperature of the indoor heat exchanger 10b on the downstream side is lower than the condensing temperature of the indoor heat exchanger 10a on the upstream side. Thus, the temperature of the air that has passed through the indoor heat exchanger 10b is lower than the temperature of the air that has passed through the indoor heat exchanger 10a while the indoor fans 20a and 20b are operating at equal rotation speeds. Accordingly, the temperature of the warm air blown through the left air outlet 4b is lower than the temperature of the warm air blown through the right air outlet 4a. That is, in the dual-condensing operation, the condensing temperatures of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied through the pressure reduction performed by the pressure reducing device 50 provided between the indoor heat exchanger 10a and the indoor heat exchanger 10b in the series passage. As a result, streams of warm air having different temperatures can be produced at equal airflow rates.

[0102] Note that the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by causing the switching devices 40a and 40b to switch the indoor-side refrigerant circuit to the first route of the series passage, but it is needless to say that the indoor-side refrigerant circuit may be switched to the second route. In the case of the second route, warm air having a lower temperature than that blown through the left air outlet 4b is blown through the right air outlet 4a.

(3) Cooling and Heating Simultaneous Operation

[0103] The dual-condensing operation described above is the operation in which both the indoor heat exchangers 10a and 10b function as condensers by causing the pressure reducing device 50 to reduce the refrigerant pressure within the range in which the pressure is not equal to or lower than the "pressure P1 corresponding to the standard indoor temperature". On the other hand, the cooling and heating simultaneous operation is an operation in which the indoor heat exchanger 10a or 10b

on the upstream side functions as a condenser and the indoor heat exchanger 10a or 10b on the downstream side functions as an evaporator by causing the pressure reducing device 50 to reduce the refrigerant pressure below the "pressure P1 corresponding to the standard indoor temperature". Then, warm air is blown through one of the right air outlet 4a and the left air outlet 4b and cool air is blown through the other. The cooling and heating simultaneous operation is described below in the example in which the indoor-side refrigerant circuit is set to the first route in which the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence.

[0104] Here, a preferable indoor environment created by using the cooling and heating simultaneous operation is described with reference to Fig. 19 below prior to the description of the cooling and heating simultaneous operation.

[0105] Fig. 19 is a plan view illustrating the preferable indoor environment created by using the cooling and heating simultaneous operation.

[0106] In combinations of a living room, a dining room, and a kitchen, it is desired that air conditioning of both a kitchen 110 and a living room 120 be performed by a single air-conditioning apparatus for adaptation to living rooms that have been increased in size in recent years. Further, in early fall or other transitional seasons, warm air supply is desired in the living room 120 as measures against the cold but cool air supply is desired in the kitchen 110 that is hot due to, for example, use of cooking appliances. In this indoor environment, the indoor unit 100 is installed so that the kitchen 110 and the living room 120 are located on the right and left when viewed from the indoor unit 100. By performing the cooling and heating simultaneous operation, warm air and cool air can independently be blown into the kitchen 110 and the living room 120. As a result, comfort in the space can be improved.

[0107] Fig. 20 is a P-h diagram during the cooling and heating simultaneous operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. The flow of the refrigerant during the cooling and heating simultaneous operation is similar to that during the dual-condensing operation illustrated in Fig. 17. In Fig. 20, A to D each represents refrigerant states at the respective pipe positions represented by A to D in Fig. 17.

[0108] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then passes through the switching device 40a. The refrigerant that has passed through the switching device 40a flows into the indoor heat exchanger 10a that functions as a condenser and is condensed by exchanging heat with air from the indoor fan 20a to turn into high-pressure two-phase refrigerant (state B1). The high-pressure two-phase refrigerant passes through the switching device 40b and then the pressure is reduced by the pressure reducing device 50 (state B2). The refrigerant whose pressure has been reduced by the pres-

sure reducing device 50 passes through the switching device 40a. Then, the refrigerant flows into the indoor heat exchanger 10b and is evaporated by exchanging heat with air from the indoor fan 20b (state B3). Here, the pressure reducing device 50 reduces the pressure below the "pressure P1 corresponding to the standard indoor temperature" so that the indoor heat exchanger 10b functions as an evaporator.

[0109] Then, the refrigerant evaporated by the indoor heat exchanger 10b passes through the switching device 40b and then the pressure is reduced by the pressure reducing device 205 (state C). Here, the pressure is reduced below the "pressure P2 corresponding to the standard outdoor air temperature" so that the outdoor heat exchanger 203 functions as an evaporator. Then, the refrigerant whose pressure has been reduced by the pressure reducing device 205 is evaporated by the outdoor heat exchanger 203 by exchanging heat with air from the outdoor fan 204 (state D). Then, the refrigerant returns to the compressor 201 via the four-way valve 202 and one cycle is finished.

[0110] As described above, in the cooling and heating simultaneous operation, the pressure of the refrigerant flowing out of the indoor heat exchanger 10a is reduced below the "pressure P1 corresponding to the standard indoor temperature" by the pressure reducing device 50. Therefore, the indoor heat exchanger 10a on the upstream side functions as a condenser and the indoor heat exchanger 10b on the downstream side functions as an evaporator. Thus, streams of air having different temperatures can be produced at equal airflow rates. Accordingly, warm air is blown through the right air outlet 4a and cool air is blown through the left air outlet 4b.

[0111] Note that the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by causing the switching devices 40a and 40b to switch the indoor-side refrigerant circuit to the first route of the series passage, but it is needless to say that the indoor-side refrigerant circuit may be switched to the second route. In the case of the second route, cool air is blown through the right air outlet 4a and warm air is blown through the left air outlet 4b.

[0112] Further, in the cooling and heating simultaneous operation during the heating operation, heating dehumidification can also be performed because one of the indoor heat exchangers 10a and 10b is used as a condenser and the other is used as an evaporator. Specifically, the streams of air blown through the right air outlet 4a and the left air outlet 4b are mixed by the lateral airflow direction flaps 1a and 1b. Therefore, dehumidified dry warm air can be produced. Thus, the dehumidified dry warm air is sent toward, for example, clothing hung in the room, which is effective in accelerating the drying of clothing.

(4) Heating operation by a single heat exchanger

[0113] In the heating operation by a single heat exchanger, the switching devices 40a and 40b are switched so that the indoor-side refrigerant circuit is set to the single-directed passage through which the refrigerant flows into only one of the indoor heat exchangers 10a and 10b. Further, the operation of the indoor fan corresponding to the indoor heat exchanger through which the refrigerant does not pass is stopped.

[0114] Fig. 21 is a diagram illustrating a flow of the refrigerant during the heating operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 21, the arrow shows a flow of the refrigerant. The P-h diagram during the heating operation by a single heat exchanger is similar to that during the heating operation by a single heat exchanger of Embodiment 1 illustrated in Fig. 7. The refrigerant states at the respective pipe positions A to D in Fig. 21 are represented by A to D in Fig. 7. Description is made on the example in which the switching device 40a is switched to the second state and the switching device 40b is switched to the fifth state so that the refrigerant flows into the indoor heat exchanger 10a alone. The flow of the refrigerant and changes of its state are similar to those of Embodiment 1. Further, description is made on the example in which the refrigerant flows into the indoor heat exchanger 10a, but it is needless to say that the refrigerant may flow into the indoor heat exchanger 10b by switching the switching device 40a to the third state and the switching device 40b to the sixth state.

[Cooling Operation]

[0115] The normal cooling operation (1), the dual-evaporating operation (2), the cooling and heating simultaneous operation (3), and the cooling operation by a single heat exchanger (4) are described below in sequence. Note that, during the cooling operation, the four-way valve 202 is switched to a state represented by the dotted lines in Fig. 14. The same applies to all the operations (1) to (4).

(1) Normal Cooling Operation

[0116] Fig. 22 is a diagram illustrating a flow of the refrigerant during the normal cooling operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 22, the arrow shows a flow of the refrigerant. Fig. 23 is a P-h diagram during the normal cooling operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 23, A to D represent refrigerant states at the respective pipe positions represented by A to D in Fig. 22.

[0117] In the normal cooling operation, the switching device 40a is switched to the first state and the switching device 40a is switched to the fourth state to form the parallel passage. Further, the refrigerant discharged

from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant flowing into the outdoor heat exchanger 203 is condensed and liquefied by exchanging heat with air from the outdoor fan 204 (state B) and then the pressure is reduced by the pressure reducing device 205.

[0118] The refrigerant whose pressure has been reduced by the pressure reducing device 205 is evenly split into two streams by the switching device 40b. The streams of the respective refrigerants flow into the indoor heat exchangers 10a and 10b (state C). The streams of refrigerant flowing into the indoor heat exchangers 10a and 10b are evaporated by exchanging heat with streams of air from the indoor fans 20a and 20b and then join at the switching device 40a. Then, the refrigerant passes through the four-way valve 202 and is sucked into the compressor 201 again (state D). Thus, one cycle is completed. The cycle described above is repeated continuously to cool the room.

(2) Dual-Evaporating Operation

[0119] Fig. 24 is a diagram illustrating a flow of the refrigerant during the dual-evaporating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. Fig. 25 is a P-h diagram during the dual-evaporating operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 25, A to D each represents a refrigerant state at the respective pipe positions represented by A to D in Fig. 24.

[0120] The dual-evaporating operation is performed by causing the switching devices 40a and 40b to set the indoor-side refrigerant circuit to the series passage. There are two types of series passage. That is, one series passage is a first route in which the refrigerant flowing through the connection port 101b passes through the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by switching the switching device 40a to the third state and the switching device 40b to the fifth state as illustrated in Fig. 24. The other series passage is a second route in which the refrigerant flowing through the connection port 101b passes through the indoor heat exchanger 10b, the pressure reducing device 50, and the indoor heat exchanger 10a in sequence by switching the switching device 40a to the second state and the switching device 40b to the sixth state as illustrated in Fig. 17. Here, the dual-evaporating operation is described in the example in which the series passage is set to the first route.

[0121] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant is condensed and liquefied by exchanging heat with air from the outdoor fan 204 (state B). The pressure of the condensed and liquefied refrigerant is reduced by the pressure reducing device 205. The pres-

sure reducing device 205 reduces the pressure below the "pressure P1 corresponding to the standard indoor temperature" so that the indoor heat exchanger 10a functions as an evaporator. Then, the refrigerant whose pressure has been reduced by the pressure reducing device 205 passes through the switching device 40b and flows into the indoor heat exchanger 10a that functions as an evaporator (state C1).

[0122] The refrigerant flowing into the indoor heat exchanger 10a is evaporated by exchanging heat with air from the indoor fan 20a. Then, the refrigerant passes through the switching device 40a and flows into the pressure reducing device 50 (state C2). Then, the pressure of the refrigerant flowing into the pressure reducing device 50 is further reduced by the pressure reducing device 50. The refrigerant passes through the switching device 40b and then flows into the indoor heat exchanger 10b that functions as an evaporator (state C3). The refrigerant flowing into the indoor heat exchanger 10b is evaporated by exchanging heat with air from the indoor fan 20b (state D) and then passes through the switching device 40a. The refrigerant that has passed through the switching device 40a returns to the compressor 201 via the four-way valve 202 and one cycle is finished. The cycle described above is repeated continuously to cool the room.

[0123] As described above, the pressure of the refrigerant flowing out of the indoor heat exchanger 10a is reduced by the pressure reducing device 50 and the refrigerant flows into the indoor heat exchanger 10b. Therefore, the evaporating temperature of the indoor heat exchanger 10b on the downstream side is lower than the evaporating temperature of the indoor heat exchanger 10a on the upstream side. Thus, the temperature of the air that has passed through the indoor heat exchanger 10b is lower than the temperature of the air that has passed through the indoor heat exchanger 10a while the indoor fans 20a and 20b are operating at equal rotation speeds. Accordingly, the temperature of the cool air blown through the left air outlet 4b is lower than the temperature of the cool air blown through the right air outlet 4a. That is, in the dual-evaporating operation, the evaporating temperatures of the indoor heat exchanger 10a and the indoor heat exchanger 10b can be varied through the pressure reduction performed by the pressure reducing device 50 provided between the indoor heat exchanger 10a and the indoor heat exchanger 10b in the series passage. As a result, streams of cool air having different temperatures can be produced at equal airflow rates.

[0124] Note that the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by causing the switching devices 40a and 40b to switch the indoor-side refrigerant circuit to the first route of the series passage, but it is needless to say that the indoor-side refrigerant circuit may be switched to the second route. In the case of the second route, cool air having a lower temperature than that blown through the left air outlet 4b is blown through the right air outlet 4a.

(3) Cooling and Heating Simultaneous Operation

[0125] The dual-evaporating operation described above is the operation in which both the indoor heat exchangers 10a and 10b function as evaporators by causing the pressure reducing device 205 to reduce the refrigerant pressure below the "pressure P1 corresponding to the standard indoor temperature". In the cooling and heating simultaneous operation, on the other hand, the pressure reducing device 205 reduces the refrigerant pressure within the range in which the pressure is not equal to or lower than the "pressure P1 corresponding to the standard indoor temperature". Thus, the indoor heat exchanger 10a or 10b on the upstream side functions as a condenser. Further, the pressure reducing device 50 reduces the refrigerant pressure below the "pressure P1 corresponding to the standard indoor temperature". Thus, the indoor heat exchanger 10a or 10b on the downstream side functions as an evaporator. Then, warm air is blown through the air outlet corresponding to the indoor heat exchanger on the upstream side and cool air is blown through the air outlet corresponding to the indoor heat exchanger on the downstream side. The cooling and heating simultaneous operation is described below in the example in which the indoor-side refrigerant circuit is set to the first route in which the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence.

[0126] Fig. 26 is a P-h diagram during the cooling and heating simultaneous operation of the air-conditioning apparatus according to Embodiment 2 of the present invention. The flow of the refrigerant during the cooling and heating simultaneous operation is similar to that in Fig. 24. In Fig. 26, A to D each represents a refrigerant state at the respective pipe positions represented by A to D in Fig. 24.

[0127] The refrigerant discharged from the compressor 201 (state A) passes through the four-way valve 202 and then flows into the outdoor heat exchanger 203. The refrigerant is condensed by exchanging heat with air from the outdoor fan 204 (state B). The pressure of the condensed refrigerant is reduced by the pressure reducing device 205. The refrigerant whose pressure has been reduced by the pressure reducing device 205 passes through the switching device 40b and flows into the indoor heat exchanger 10a (state C1). The pressure reducing device 205 reduces the refrigerant pressure within the range in which the pressure is not equal to or lower than the "pressure P1 corresponding to the standard indoor temperature" so that the indoor heat exchanger 10a functions as a condenser.

[0128] Then, the refrigerant flowing into the indoor heat exchanger 10a is condensed by exchanging heat with air from the indoor fan 20a. Then, the refrigerant passes through the switching device 40a and flows into the pressure reducing device 50 (state C2). The pressure of the refrigerant flowing into the pressure reducing device 50

is reduced. The refrigerant passes through the switching device 40b and then flows into the indoor heat exchanger 10b (state C3). The pressure reducing device 50 reduces the pressure below the "pressure P1 corresponding to the standard indoor temperature" so that the indoor heat exchanger 10b functions as an evaporator.

[0129] Then, the refrigerant flowing into the indoor heat exchanger 10b is evaporated by exchanging heat with air from the indoor fan 20b (state D) and then passes through the switching device 40a. The refrigerant that has passed through the switching device 40a returns to the compressor 201 via the four-way valve 202 and one cycle is completed.

[0130] As described above, in the cooling and heating simultaneous operation, the pressure of the refrigerant flowing out of the indoor heat exchanger 10a is reduced below the "pressure P1 corresponding to the standard indoor temperature" by the pressure reducing device 50 and the refrigerant flows into the indoor heat exchanger 10b. Therefore, the indoor heat exchanger 10a on the upstream side functions as a condenser and the indoor heat exchanger 10b on the downstream side functions as an evaporator. Thus, streams of air having different temperatures can be produced at equal airflow rates. Accordingly, warm air is blown through the right air outlet 4a and cool air is blown through the left air outlet 4b.

[0131] Note that the refrigerant flows into the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b in sequence by causing the switching devices 40a and 40b to switch the indoor-side refrigerant circuit to the first route of the series passage, but it is needless to say that the indoor-side refrigerant circuit may be switched to the second route. In the case of the second route, cool air is blown through the right air outlet 4a and warm air is blown through the left air outlet 4b.

[0132] Further, in the cooling and heating simultaneous operation during the cooling operation, reheating dehumidification can also be performed because one indoor heat exchanger is used as a condenser and the other is used as an evaporator. Specifically, the streams of air blown through the right air outlet 4a and the left air outlet 4b are mixed by the lateral airflow direction flaps 1a and 1b. Therefore, dehumidified dry cool air can be produced. Thus, the dehumidified dry cool air is supplied into the room and accordingly the room can be dehumidified.

(4) Cooling operation by a single heat exchanger

[0133] In the cooling operation by a single heat exchanger, the switching devices 40a and 40b are switched so that the indoor-side refrigerant circuit is set to the single-directed passage through which the refrigerant flows into only one of the indoor heat exchangers 10a and 10b. Further, the operation of the indoor fan corresponding to the indoor heat exchanger through which the refrigerant does not pass is stopped.

[0134] Fig. 27 is a diagram illustrating a flow of the

refrigerant during the cooling operation by a single heat exchanger of the air-conditioning apparatus according to Embodiment 2 of the present invention. In Fig. 27, the arrow shows a flow of the refrigerant. The P-h diagram during the cooling operation by a single heat exchanger is similar to that of Embodiment 1 illustrated in Fig. 10. The refrigerant states at the respective pipe positions A to D in Fig. 27 are represented by A to D in Fig. 10. Description is made on the example in which the switching device 40a is switched to the second state and the switching device 40b is switched to the fifth state so that the refrigerant flows into the indoor heat exchanger 10a alone. The flow of the refrigerant and changes of its state are similar to those of Embodiment 1. Further, description is made on the example in which the refrigerant flows into the indoor heat exchanger 10a, but it is needless to say that the refrigerant may flow into the indoor heat exchanger 10b by switching the switching device 40a to the third state and the switching device 40b to the sixth state.

[0135] As described above, in Embodiment 2, advantages similar to those of Embodiment 1 are attained and the cooling and heating simultaneous operation can further be performed. Thus, warm air can be blown through one of the right air outlet 4a and the left air outlet 4b and cool air can be blown through the other.

[0136] Further, in Embodiment 2, the switching devices 40a and 40b and the pressure reducing device 50 are provided as the refrigerant exchange capacity varying device and the four-way switching valve capable of switching passages in four directions is used as each of the switching devices 40a and 40b. Further, the indoor-side refrigerant circuit has the structure in which the indoor heat exchanger 10a, the pressure reducing device 50, and the indoor heat exchanger 10b are connected in parallel to each other and the switching device 40a and the switching device 40b each constituted as the four-way switching valve are connected separately to the joining portions at both ends of the parallel circuit. Further, the switching device 40a is switched to the first state to the third state described above and the switching device 40b is switched to the fourth state to the sixth state described above.

[0137] Thus, the indoor-side refrigerant circuit can be switched to the parallel passage, the series passage, or the single-directed passage. During the heating operation, the operation can be switched to the normal heating operation, the dual-condensing operation, the cooling and heating simultaneous operation, or the heating operation by a single heat exchanger. Further, during the cooling operation, the operation can be switched to the normal cooling operation, the dual-evaporating operation, the cooling and heating simultaneous operation, or the cooling operation by a single heat exchanger.

[0138] Specifically, the series passage can be formed by switching the switching device 40a to the second state and the switching device 40b to the sixth state or by switching the switching device 40a to the third state and the switching device 40b to the fifth state. Then, the dual-

temperature air-blow operation can be performed by causing the controller 300 to control the pressure reducing device 50.

[0139] Further, the dual-condensing operation or the dual-evaporating operation in which both the indoor heat exchangers 10a and 10b function as condensers or evaporators and the cooling and heating simultaneous operation in which one of the indoor heat exchangers 10a and 10b functions as a condenser and the other functions as an evaporator can be performed depending on the pressure reduction amount of the pressure reducing device 50.

[0140] Note that, in Embodiments 1 and 2 described above, the electronic expansion valve capable of controlling the opening degree is used as the pressure reducing device 50. Therefore, when description is made taking as an example a case of the heating operation, both the dual-condensing operation and the cooling and heating simultaneous operation can be performed. If either the dual-condensing operation or the cooling and heating simultaneous operation is chosen, however, a pressure reducing device having a fixed pressure reduction amount may be used.

[0141] The air-conditioning apparatus of Embodiment 2 has the structure in which the indoor-side refrigerant circuit includes the indoor heat exchangers 10a and 10b, the pressure reducing device 50, and the switching devices 40a and 40b but the air-conditioning apparatus may employ Modification Example 1 or 2 described below. In Modification Examples 1 and 2, the circuit connection structure is changed and a three-way valve is used as each of the switching devices 40a and 40b instead of the four-way switching valve. Modification Examples 1 and 2 are described below in sequence.

(Modification Example 1)

[0142] Fig. 28 is a diagram illustrating a refrigerant circuit in Modification Example 1 of the air-conditioning apparatus according to Embodiment 2 of the present invention.

[0143] In Modification Example 1, in the indoor-side refrigerant circuit, a parallel circuit in which the indoor heat exchanger 10a and a refrigerant pipe 60a are connected in parallel to each other and a parallel circuit in which the indoor heat exchanger 10b and a refrigerant pipe 60b are connected in parallel to each other are connected in series via the pressure reducing device 50. Further, the respective parallel circuits have structures in which the switching devices 40a and 40b are provided at joining portions located opposite to the pressure reducing device 50. Each of the switching devices 40a and 40b is constituted as a three-way valve. The switching device 40a connects the connection port 101a to the indoor heat exchanger 10a or the refrigerant pipe 60a. The switching device 40b connects the connection port 101b to the indoor heat exchanger 10b or the refrigerant pipe 60b. The switching devices 40a and 40b and the pressure

reducing device 50 constitute the refrigerant exchange capacity varying device of the present invention.

[0144] In the indoor-side refrigerant circuit, a series passage through which refrigerant flows into both the indoor heat exchangers 10a and 10b in sequence is formed by switching the switching device 40a toward the indoor heat exchanger 10a and the switching device 40b toward the indoor heat exchanger 10a. Further, a single-directed passage through which refrigerant flows into the indoor heat exchanger 10a alone is formed by switching the switching device 40a toward the indoor heat exchanger 10a and the switching device 40b toward the refrigerant pipe 60b. Further, a single-directed passage through which refrigerant flows into the indoor heat exchanger 10b alone is formed by switching the switching device 40a toward the refrigerant pipe 60a and the switching device 40b toward the indoor heat exchanger 10b.

[0145] The air-conditioning apparatus of Modification Example 1 that is constituted as described above can basically perform operations similar to those of the air-conditioning apparatus of Embodiment 2 illustrated in Fig. 14. That is, the normal heating operation, the dual-condensing operation, the cooling and heating simultaneous operation, and the heating operation by a single heat exchanger can be performed in a state in which the four-way valve 202 is switched toward the solid lines in Fig. 14 and the normal cooling operation, the dual-evaporating operation, the cooling and heating simultaneous operation, and the cooling operation by a single heat exchanger can be performed in a state in which the four-way valve 202 is switched toward the dotted lines in Fig. 14.

[0146] Note that differences between the air-conditioning apparatus of Modification Example 1 and the air-conditioning apparatus of Embodiment 2 in terms of operations are as follows. That is, in the air-conditioning apparatus of Embodiment 2, the normal heating operation and the normal cooling operation are performed by using the parallel passage through which the flow of the refrigerant is split into two streams and the streams of refrigerant flow parallel into the indoor heat exchangers 10a and 10b. In Modification Example 1, however, the parallel passage cannot be achieved. Therefore, when the normal heating operation and the normal cooling operation are performed in Modification Example 1, those operations are performed by setting the refrigerant passage to the series passage through which the refrigerant flows into the indoor heat exchangers 10a and 10b in sequence.

[0147] Further, in the air-conditioning apparatus of Embodiment 2 illustrated in Fig. 14, the switching devices 40a and 40b can switch the direction of the flow of the refrigerant to the direction from the indoor heat exchanger 10a to the indoor heat exchanger 10b or the direction opposite to this direction. That is, the upstream side and the downstream side can be switched. Therefore, when description is made taking as an example the case of, for example, the cooling and heating mixed operation,

the indoor heat exchanger 10a may function as a condenser and the indoor heat exchanger 10b may function as an evaporator or the indoor heat exchanger 10a may function as an evaporator and the indoor heat exchanger 10b may function as a condenser.

[0148] In the air-conditioning apparatus of Modification Example 1 illustrated in Fig. 28, however, the upstream side and the downstream side cannot be switched. Therefore, when description is made taking as an example, for example, the cooling and heating simultaneous operation during the heating operation in which the four-way valve 202 is switched toward the solid lines in Fig. 28, the direction of the flow of the refrigerant is only the direction from the indoor heat exchanger 10a to the indoor heat exchanger 10b. Thus, in the cooling and heating simultaneous operation during the heating operation, warm air is blown through the indoor heat exchanger 10a and cool air is blown through the indoor heat exchanger 10b at any time.

[0149] Further, the single-directed passage through which the refrigerant selectively flows into one of the indoor heat exchangers 10a and 10b can be formed by switching the switching devices 40a and 40b and therefore the heating operation by a single heat exchanger and the cooling operation by a single heat exchanger can be performed as in the case of Embodiments 1 and 2 described above.

(Modification Example 2)

[0150] Fig. 29 is a diagram illustrating a refrigerant circuit in Modification Example 2 of the air-conditioning apparatus according to Embodiment 2 of the present invention.

[0151] In Modification Example 2, the positions where the switching devices 40a and 40b are disposed are changed from those in Modification Example 1. In Modification Example 1, the switching devices 40a and 40b are provided at the joining portions located opposite to the pressure reducing device 50 in the respective parallel circuits. In Modification Example 2, the respective parallel circuits have structures in which the switching devices 40a and 40b are provided at joining portions located near the pressure reducing device 50. Each of the switching devices 40a and 40b is constituted as a three-way valve similarly to Modification Example 1. The switching device 40a connects the pressure reducing device 50 to the indoor heat exchanger 10a or the refrigerant pipe 60a. The switching device 40b connects the pressure reducing device 50 to the indoor heat exchanger 10b or the refrigerant pipe 60b. The other structures are similar to those in Modification Example 1.

[0152] As described above, advantages similar to those of Modification Example 1 described above can also be attained with the structure of Modification Example 2.

[0153] Note that, in Modification Examples 1 and 2, the respective parallel circuits have the structures in which

the switching devices 40a and 40b are connected separately to the joining portions located opposite to the pressure reducing device 50 or the joining portions located near the pressure reducing device 50. However, the respective parallel circuits are not limited to those structures. That is, it is only necessary to provide structures in which the switching device 40a and the switching device 40b are connected separately to the joining portions of the respective parallel circuits. The structures may be such that the switching device 40a is connected to the joining portion located opposite to the pressure reducing device 50 and the switching device 40b is connected to the joining portion located near the pressure reducing device 50.

[0154] Further, the indoor unit of the present invention is not limited to the structures described above but various modifications may be made, for example, as follows without departing from the spirit of the present invention. For example, in Embodiments 1 and 2 described above, description is made taking as an example a case in which the propeller fan is used as the indoor fan and the number of propeller fans is plural. However, the following structure illustrated in Fig. 30 may be employed.

(Modification Example 1 Using Line Flow Fan)

[0155] Fig. 30 is a diagram illustrating Modification Example 1 that uses a line flow fan in the air-conditioning apparatus according to each of Embodiments 1 and 2 of the present invention.

[0156] In Modification Example 1, a line flow fan 20c is used as an indoor fan configured to send air into a housing 100b. Further, in Embodiments 1 and 2 described above, the indoor fans are provided in conjunction with the two indoor heat exchangers, respectively, but a single common indoor fan is provided in the structure. Further, in the housing 100b, indoor heat exchangers 10c and 10d (10d is not illustrated) are disposed on the right and left. In Embodiments 1 and 2 described above, the indoor heat exchanger has a W-shape when viewed from the right or left but, in Modification Example 1, the indoor heat exchanger has an inverted V-shape. Further, the airflow passage is vertically divided by a vertical airflow direction flap 2c and a vertical airflow direction flap 2d. Further, unillustrated lateral airflow direction flaps are provided and therefore streams of air can independently be blown on the right and left.

[0157] In the air-conditioning apparatus constituted as described above, streams of air taken into the indoor unit through an air inlet 3b pass through the indoor heat exchangers 10c and 10d (not illustrated) and the line flow fan 20c and are then blown into the room through the air outlet 4 while the airflow directions are controlled by the vertical airflow direction flaps 2c and 2d and the lateral airflow direction flaps (not illustrated). Even when the single line flow fan 20c is provided as described above, streams of air having different temperatures can independently be blown on the right and left by performing

the dual-condensing operation or the dual-evaporating operation of Embodiments 1 and 2 described above.

(Modification Example 2 Using Line Flow Fan)

[0158] Fig. 31 is a diagram illustrating Modification Example 2 that uses the line flow fan in the air-conditioning apparatus according to each of Embodiments 1 and 2 of the present invention.

[0159] Modification Example 1 illustrated in Fig. 30 described above shows the structure in which the indoor heat exchangers are disposed to the right and left. Modification Example 2 illustrated in Fig. 31 shows a structure in which the indoor heat exchangers are disposed on the front and rear. That is, an indoor heat exchanger 10e is disposed on the front of the housing 100b and an indoor heat exchanger 10f is disposed on the rear of the housing 100b. Note that the single common line flow fan 20c is provided for the two indoor heat exchangers 10e and 10f as in the case of Modification Example 1.

[0160] The arrow represented by the solid line in Fig. 31 shows a rotation direction of the line flow fan 20c. Further, each of the arrows A and B represented by the dotted lines in Fig. 31 shows a flow of air that is taken into the indoor unit through the air inlet 3b, passes through the indoor heat exchanger 10e and the line flow fan 20c, and is then blown through the air outlet 4. The arrow C represented by the dotted line in Fig. 31 shows a flow of air that is taken into the indoor unit through the air inlet 3b, passes through the indoor heat exchanger 10f and the line flow fan 20c, and is then blown through the air outlet 4.

[0161] In this structure, when refrigerant in a larger amount than that in the indoor heat exchanger 10e is distributed to the indoor heat exchanger 10f, the heat exchange capacity of the indoor heat exchanger 10f is higher than that of the indoor heat exchanger 10e. Thus, in the case of the dual-condensing operation, the temperature of the airflow C that has passed through the indoor heat exchanger 10f is higher than the temperatures of the airflows A and B that have passed through the indoor heat exchanger 10e even when the single line flow fan 20c is provided. The airflow passages of the streams of air produced in this manner and having different temperatures are divided by the vertical airflow direction flap 2c and the vertical airflow direction flap 2d and the airflow directions are further controlled on the right and left by the unillustrated lateral airflow direction flaps. Thus, the airflow C having a high temperature and the airflows A and B having low temperatures can be blown to the right and the left, separately.

[0162] Note that description is made taking as an example a case in which the refrigerant is distributed so that refrigerant in a larger amount larger than that in the indoor heat exchanger 10e flows into the indoor heat exchanger 10f, but it is needless to say that the refrigerant may be distributed in a reverse manner or the indoor heat exchanger 10f and the indoor heat exchanger 10e may

be constituted so that the temperatures of the airflows B and C are higher than the temperature of the airflow A. Further, description is made taking as an example a case of the dual-condensing operation, but it is needless to say that the dual-evaporating operation may be performed in the structure of Fig. 31 as a matter of course.

Reference Signs List

- [0163]** 1 base 1a lateral airflow direction flap 1b lateral airflow direction flap 2 design panel 2a vertical airflow direction flap 2b vertical airflow direction flap 2c vertical airflow direction flap 2d vertical airflow direction flap 3 air inlet 4 air outlet 4a right air outlet (first air outlet) 4b left air outlet (second air outlet) 5a right airflow passage 5b left airflow passage 10a indoor heat exchanger (first heat exchanger) 10b indoor heat exchanger (second heat exchanger) 10c indoor heat exchanger (first heat exchanger) 10d indoor heat exchanger (second heat exchanger) 10e indoor heat exchanger (first heat exchanger) 10f indoor heat exchanger (second heat exchanger) 11 fin 12 heat transfer tube 20a indoor fan (first fan) 20b indoor fan (second fan) 20c line flow fan (fan) 30a fan motor 30b fan motor 40 switching device (flow control valve) 40a switching device (first four-way switching valve, first three-way valve) 40b switching device (second four-way switching valve, second three-way valve) 50 pressure reducing device 60a refrigerant pipe (first refrigerant pipe) 60b refrigerant pipe (second refrigerant pipe) 100 indoor unit 100a housing 100b housing 101a connection port 101b connection port 110 kitchen 120 living room 200 outdoor unit 201 compressor 202 four-way valve 203 outdoor heat exchanger 204 outdoor fan 205 pressure reducing device 300 controller

Claims

1. An indoor unit, comprising:

a housing having an air inlet and an air outlet;
a refrigerant circuit installed in the housing and provided such that a first heat exchanger, a second heat exchanger, and a refrigerant exchange capacity varying device configured to vary refrigerant temperatures in a first heat exchanger and a second heat exchanger are connected to each other by pipes; and
a fan installed in the housing and configured to send air to the first heat exchanger and the second heat exchanger,
wherein the air outlet comprises a first air outlet through which air passing through the fan and the first heat exchanger is blown, and a second air outlet through which air passing through the fan and the second heat exchanger is blown, and
wherein the refrigerant exchange capacity var-

ying device comprises at least a switching device configured to change a flow of refrigerant in the refrigerant circuit, and a dual-temperature air-blow operation in which streams of air having different temperatures are blown through the first air outlet and the second air outlet is performed by causing the refrigerant exchange capacity varying device to vary the refrigerant temperatures or refrigerant flow rates in the first heat exchanger and the second heat exchanger or to vary both the refrigerant temperatures and the refrigerant flow rates in the first heat exchanger and the second heat exchanger.

2. The indoor unit of claim 1, wherein the refrigerant circuit has a structure in which the first heat exchanger and the second heat exchanger are connected in parallel to each other to form a parallel circuit and the switching device is connected to one end of the parallel circuit, and wherein the switching device is a flow control valve configured such that the refrigerant flowing into the indoor unit is distributed to the first heat exchanger and the second heat exchanger.
3. The indoor unit of claim 2, further comprising a controller configured to perform the dual-temperature air-blow operation by controlling the flow control valve to vary flow rates of streams of the refrigerant to be distributed to the first heat exchanger and the second heat exchanger.
4. The indoor unit of claim 1, wherein the switching device of the refrigerant exchange capacity varying device comprises a first four-way switching valve and a second four-way switching valve each capable of switching passages in four directions, and the refrigerant exchange capacity varying device further comprises a pressure reducing device, and wherein the refrigerant circuit has a structure in which the first heat exchanger, the pressure reducing device, and the second heat exchanger are connected in parallel to each other and a first four-way switching valve and a second four-way switching valve are connected separately to joining portions at both ends of the parallel circuit.
5. The indoor unit of claim 4, wherein the indoor unit has two connection ports connecting the refrigerant circuit to an outdoor refrigerant circuit of an outdoor unit, wherein the first four-way switching valve is switched to:

a first state in which one of the two connection ports is connected to one end of the first heat exchanger and one end of the second heat ex-

changer;

a second state in which the one of the two connection ports is connected to the one end of the first heat exchanger and one end of the pressure reducing device is connected to the one end of the second heat exchanger; or
a third state in which the one of the two connection ports is connected to the one end of the second heat exchanger and the one end of the pressure reducing device is connected to the one end of the first heat exchanger, and

wherein the second four-way switching valve is switched to:

a fourth state in which an other one of the two connection ports is connected to an other end of the first heat exchanger and an other end of the second heat exchanger;

a fifth state in which the other one of the two connection ports is connected to the other end of the first heat exchanger and an other end of the pressure reducing device is connected to the other end of the second heat exchanger; or
a sixth state in which the other one of the two connection ports is connected to the other end of the second heat exchanger and the other end of the pressure reducing device is connected to the other end of the first heat exchanger.

6. The indoor unit of claim 5, further comprising a controller configured to form a series passage in which the first heat exchanger, the pressure reducing device, and the second heat exchanger are connected to each other in sequence by switching the first four-way switching valve to the second state and the second four-way switching valve to the sixth state or by switching the first four-way switching valve to the third state and the second four-way switching valve to the fifth state, and to perform the dual-temperature air-blow operation by controlling the pressure reducing device.
7. The indoor unit of claim 6, wherein the dual-temperature air-blow operation comprises, depending on a pressure reduction amount of the pressure reducing device, an operation in which both the first heat exchanger and the second heat exchanger function as condensers or evaporators, and an operation in which one of the first heat exchanger and the second heat exchanger functions as a condenser and an other one of the first heat exchanger and the second heat exchanger functions as an evaporator.
8. The indoor unit of claim 1, wherein the switching device of the refrigerant exchange capacity varying device comprises a first three-way valve and a second three-way valve, and

the refrigerant exchange capacity varying device further comprises a pressure reducing device, and wherein the refrigerant circuit has a structure in which a parallel circuit in which the first heat exchanger and a first refrigerant pipe are connected in parallel to each other and a parallel circuit in which the second heat exchanger and a second refrigerant pipe are connected in parallel to each other are connected in series via the pressure reducing device and the first three-way valve and the second three-way valve are connected separately to joining portions of the respective parallel circuits.

9. The indoor unit of claim 8, further comprising a controller configured to form a series passage in which the first heat exchanger, the pressure reducing device, and the second heat exchanger are connected to each other in sequence by controlling the first three-way valve and the second three-way valve, and to perform the dual-temperature air-blow operation by controlling the pressure reducing device.
10. The indoor unit of claim 9, wherein the dual-temperature air-blow operation comprises, depending on a pressure reduction amount of the pressure reducing device, an operation in which both the first heat exchanger and the second heat exchanger function as condensers or evaporators, and an operation in which one of the first heat exchanger and the second heat exchanger functions as a condenser and an other one of the first heat exchanger and the second heat exchanger functions as an evaporator.
11. The indoor unit of any one of claims 1 to 10, wherein the fan comprises a first fan configured to send air to the first heat exchanger, and a second fan configured to send air to the second heat exchanger, and wherein air passing through the first fan and the first heat exchanger is blown through the first air outlet, and air passing through the second fan and the second heat exchanger is blown through the second air outlet.
12. The indoor unit of claim 11, wherein, in the dual-temperature air-blow operation, rotation speeds of the first fan and the second fan are equal to each other.
13. The indoor unit of any one of claims 1 to 12, wherein the indoor unit has a structure in which the first air outlet and the second air outlet are arranged side by side.
14. An air-conditioning apparatus, comprising the indoor unit of any one of claims 1 to 13, and an outdoor unit.

FIG. 1

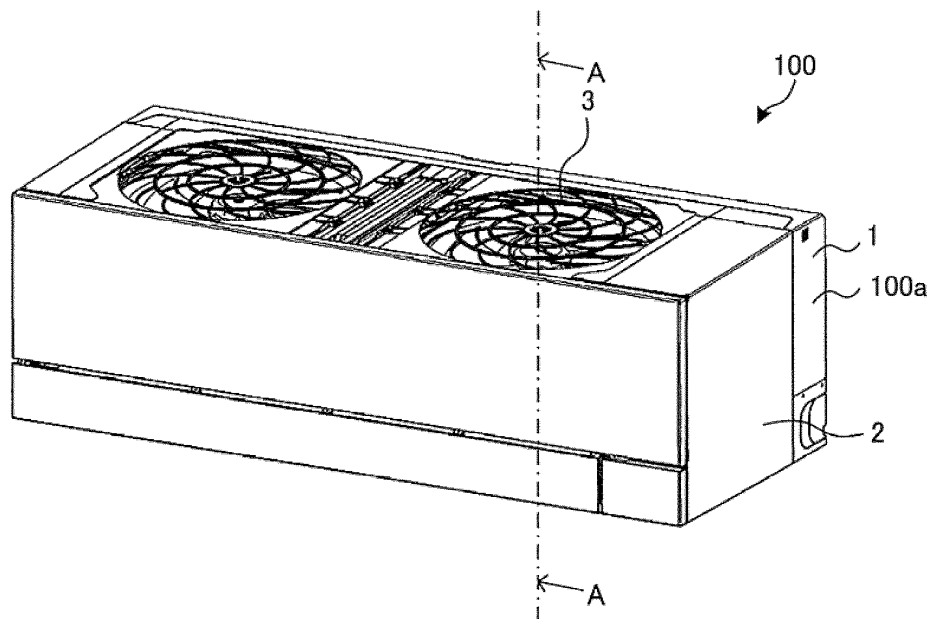


FIG. 2

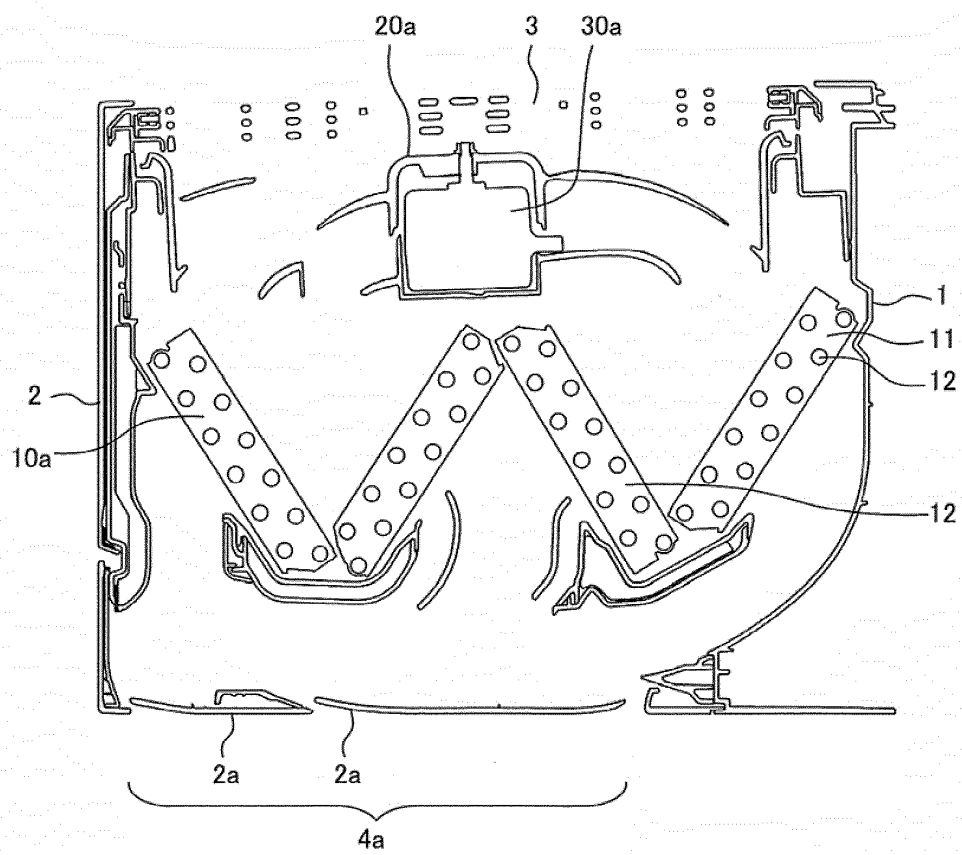


FIG. 3

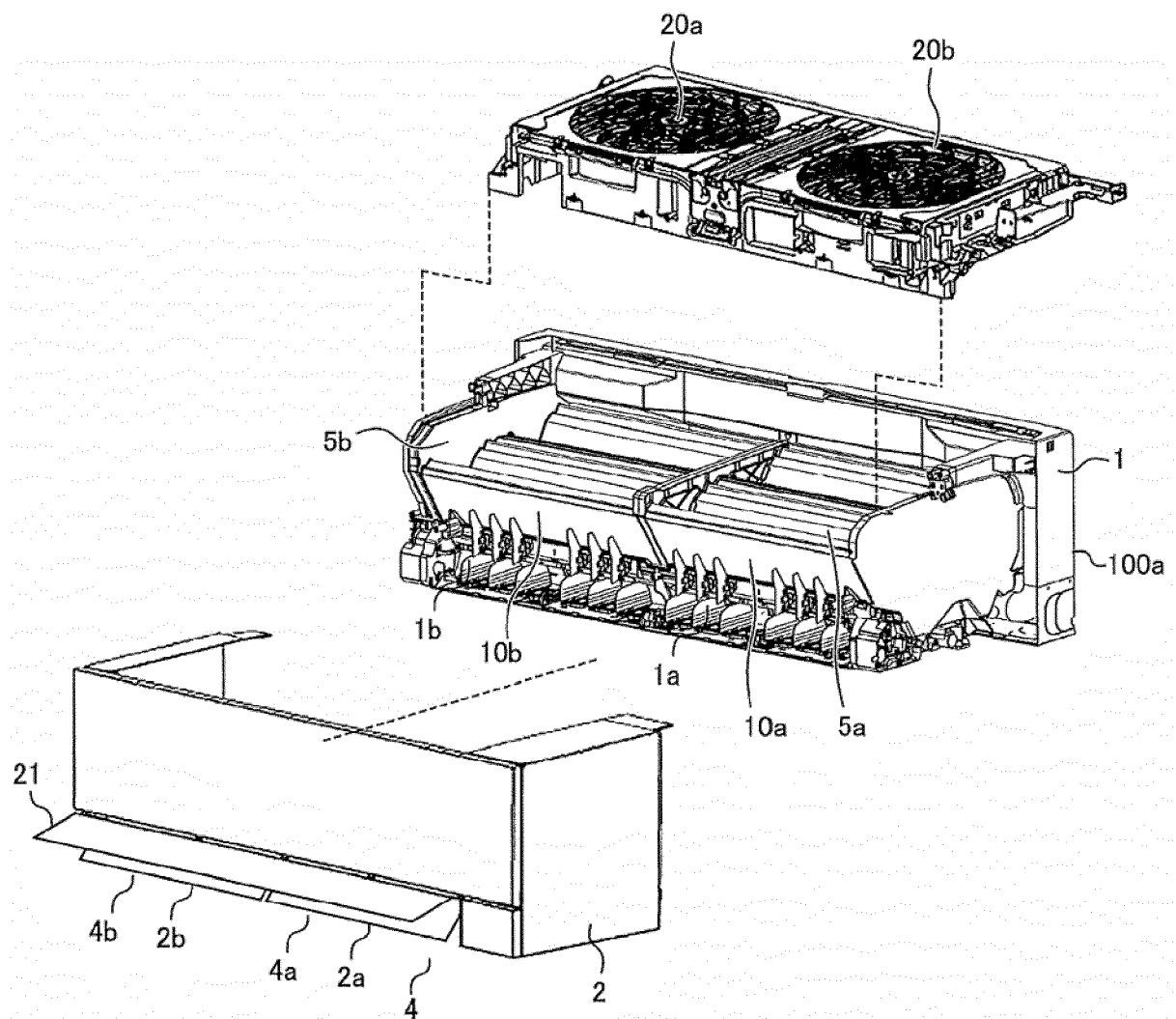


FIG. 4

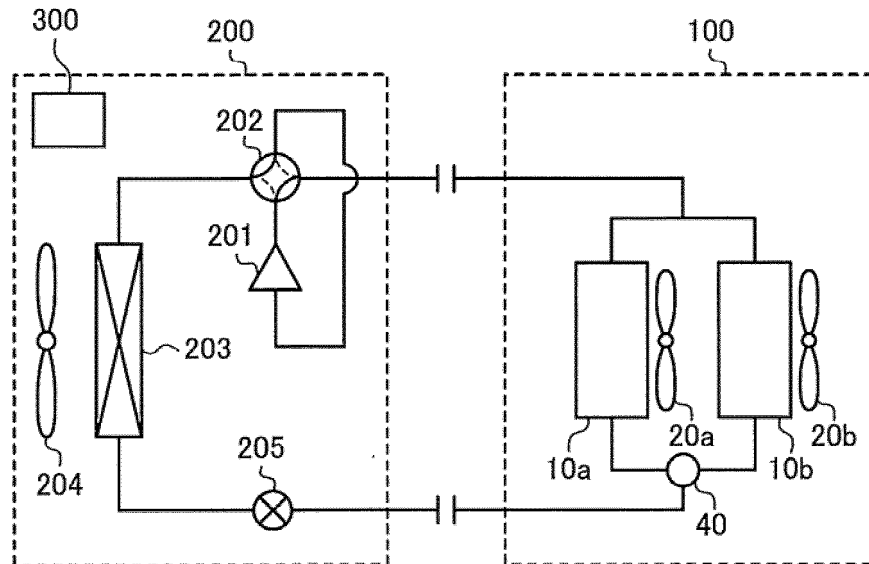


FIG. 5

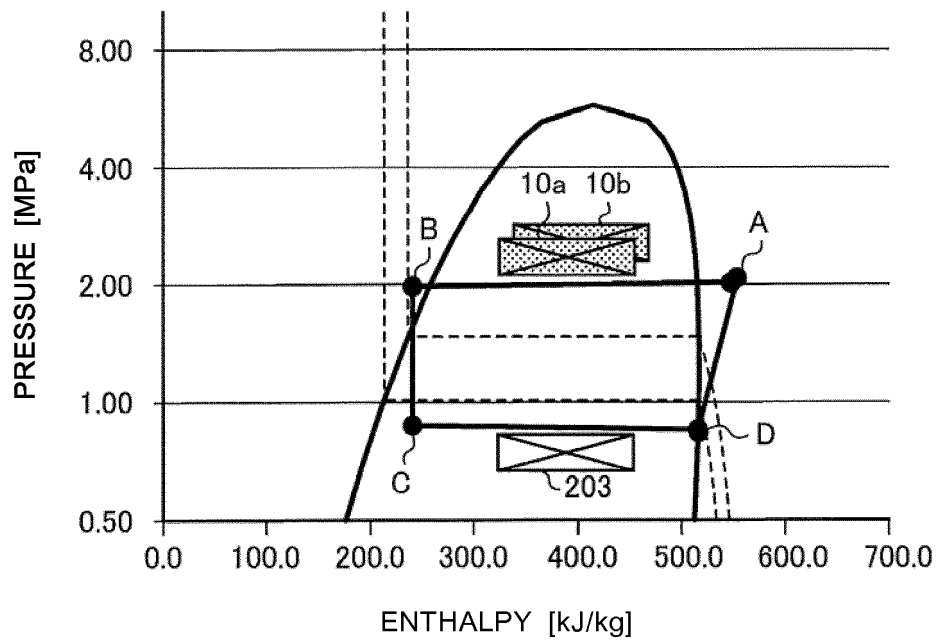


FIG. 6

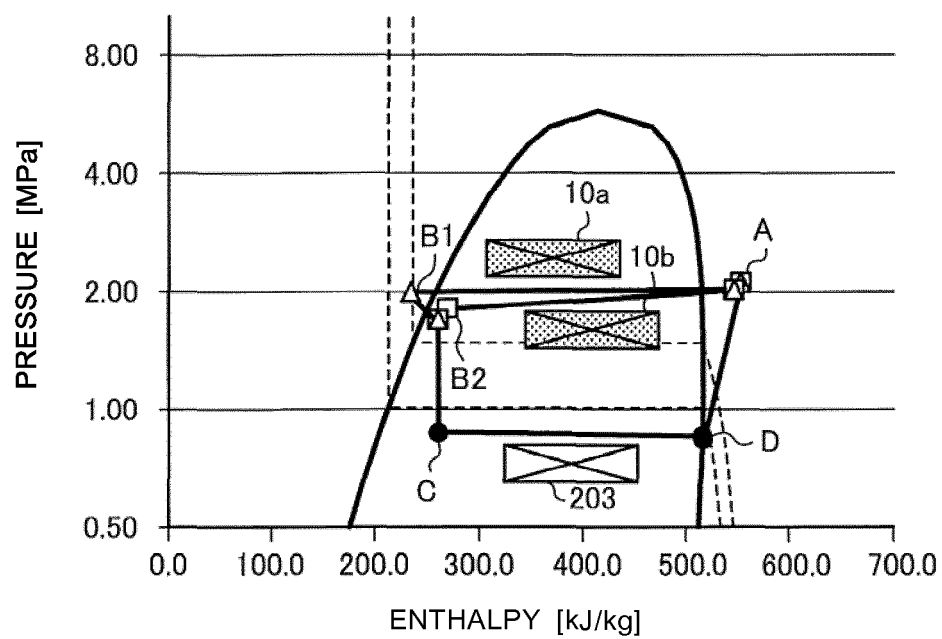


FIG. 7

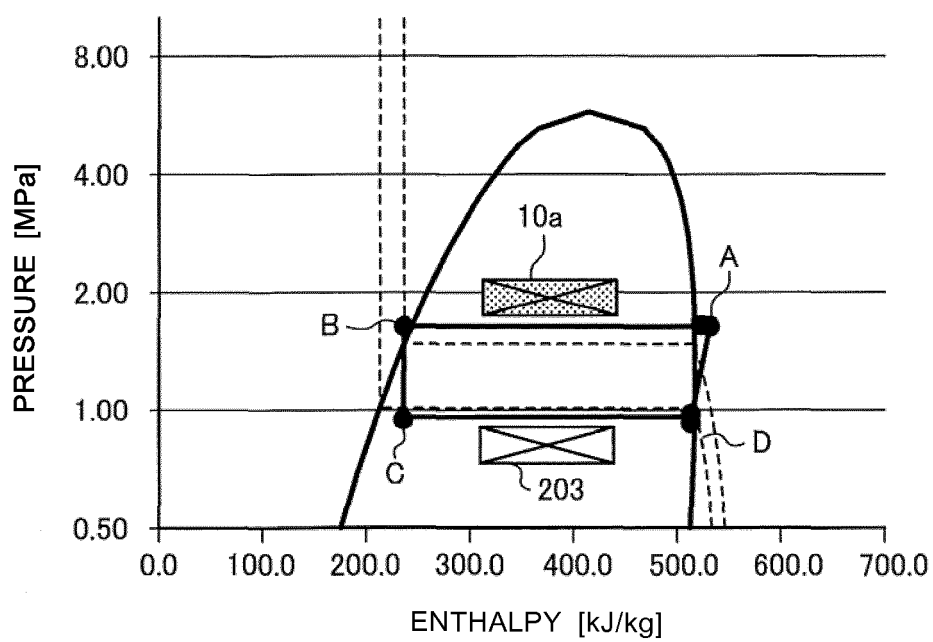


FIG. 8

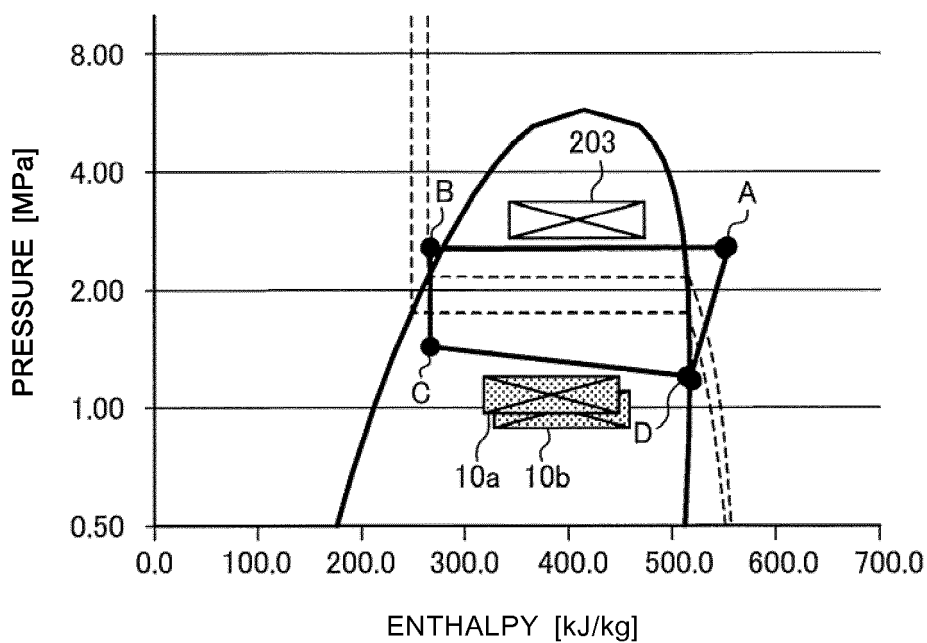


FIG. 9

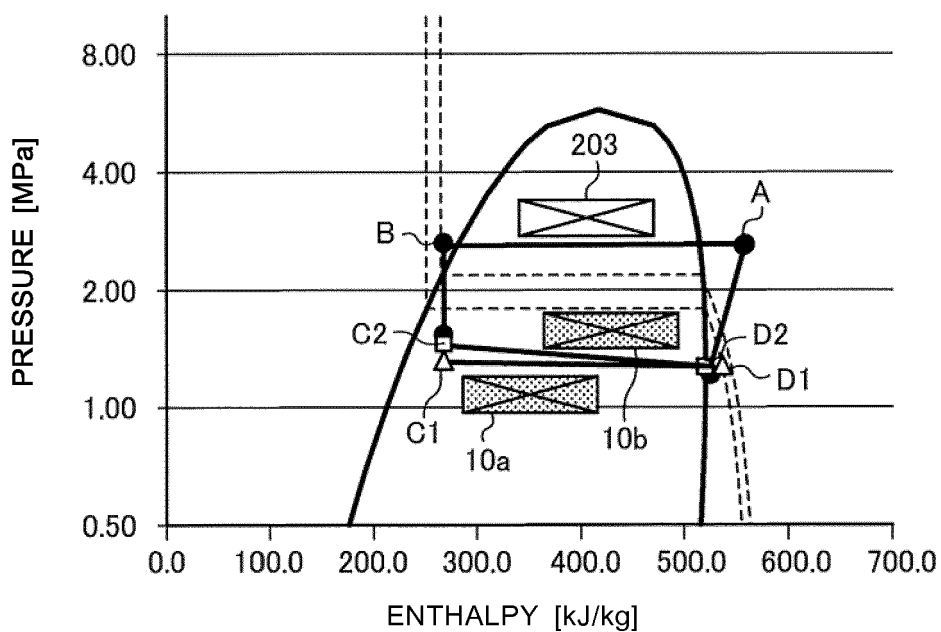


FIG. 10

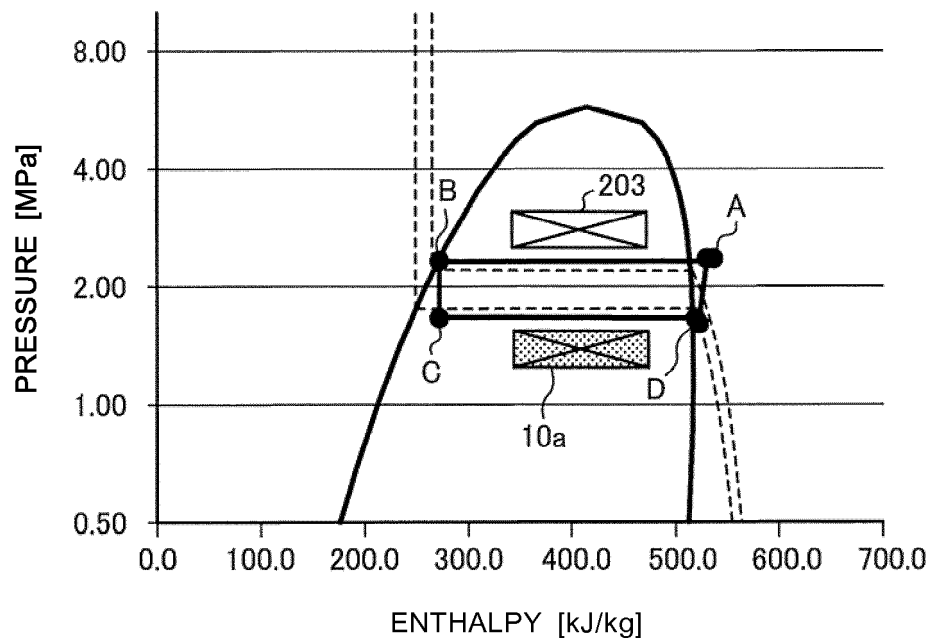


FIG. 11

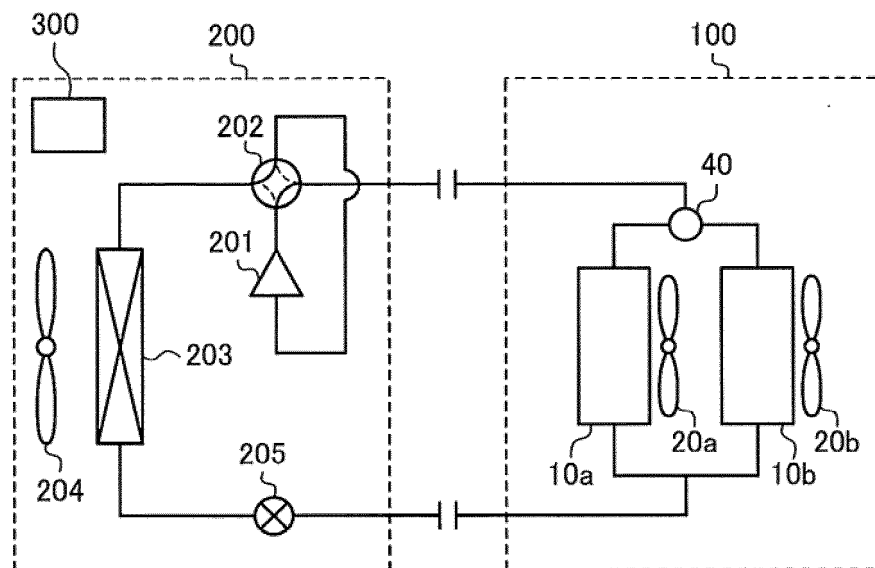


FIG. 12

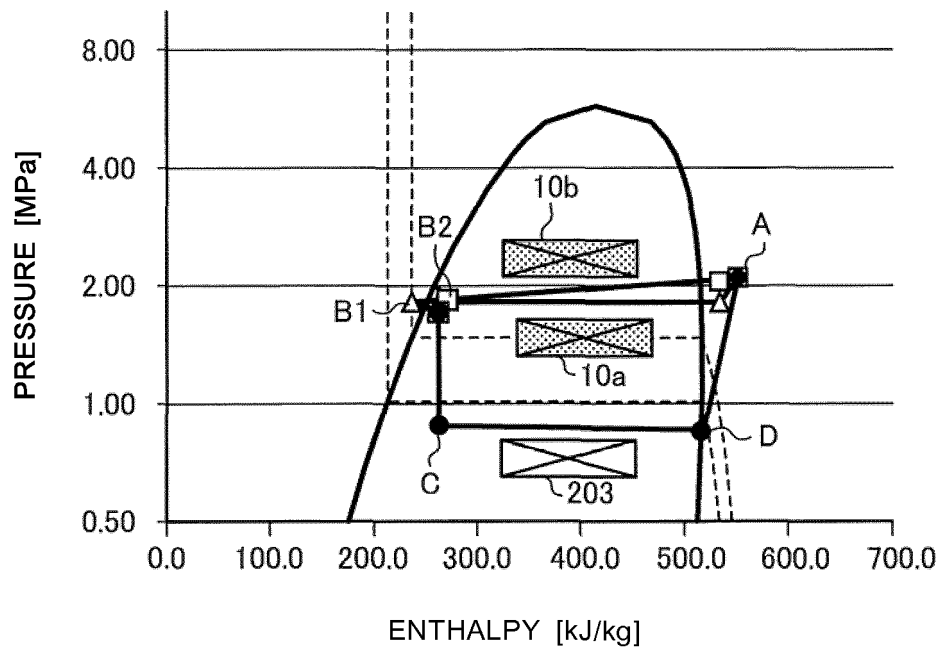


FIG. 13

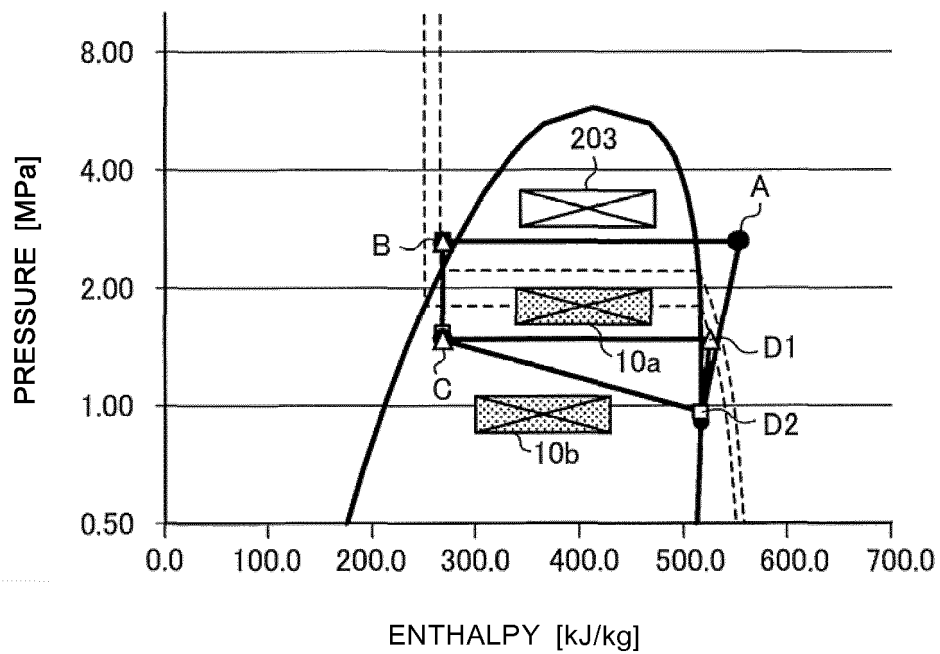


FIG. 14

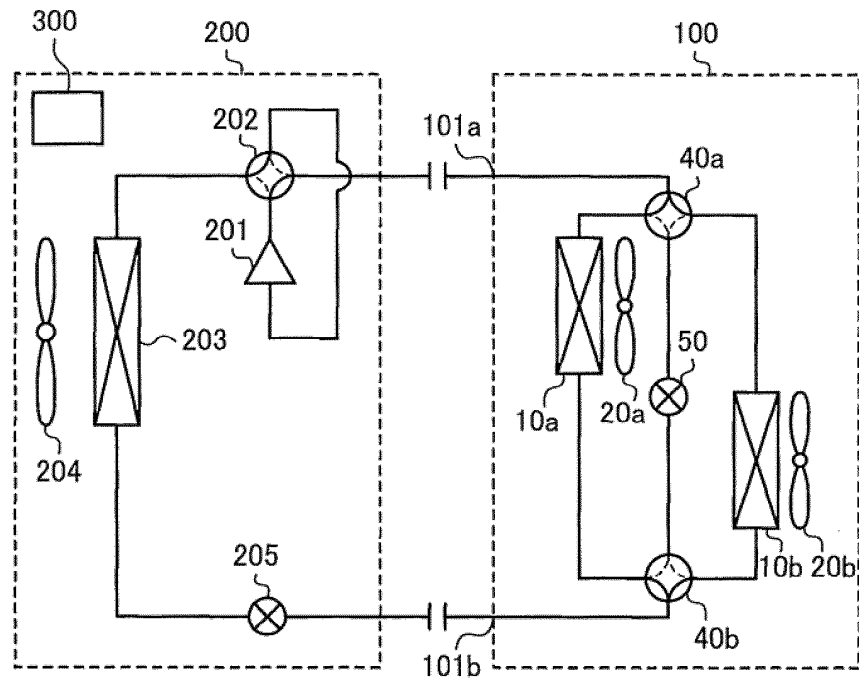


FIG. 15

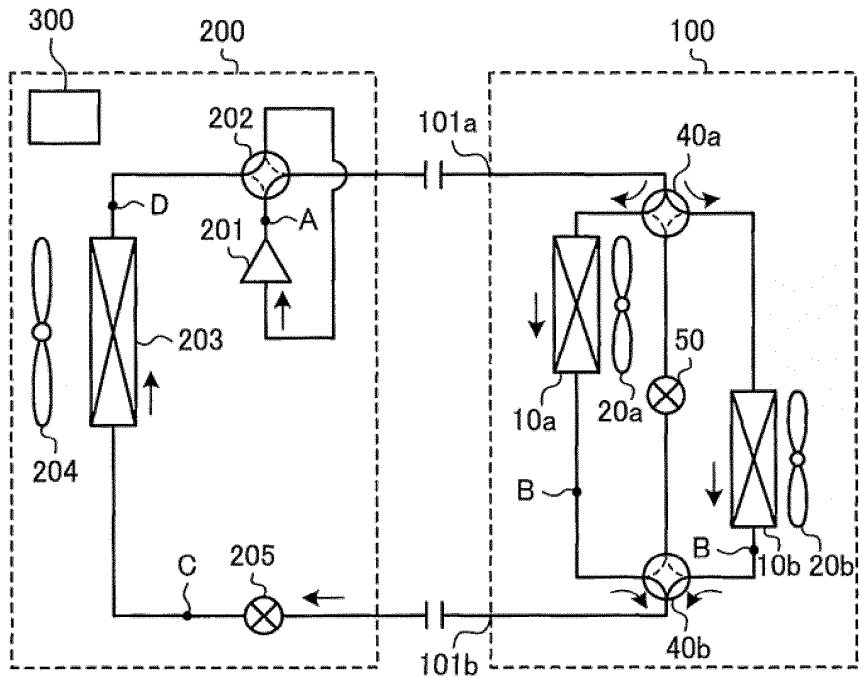


FIG. 16

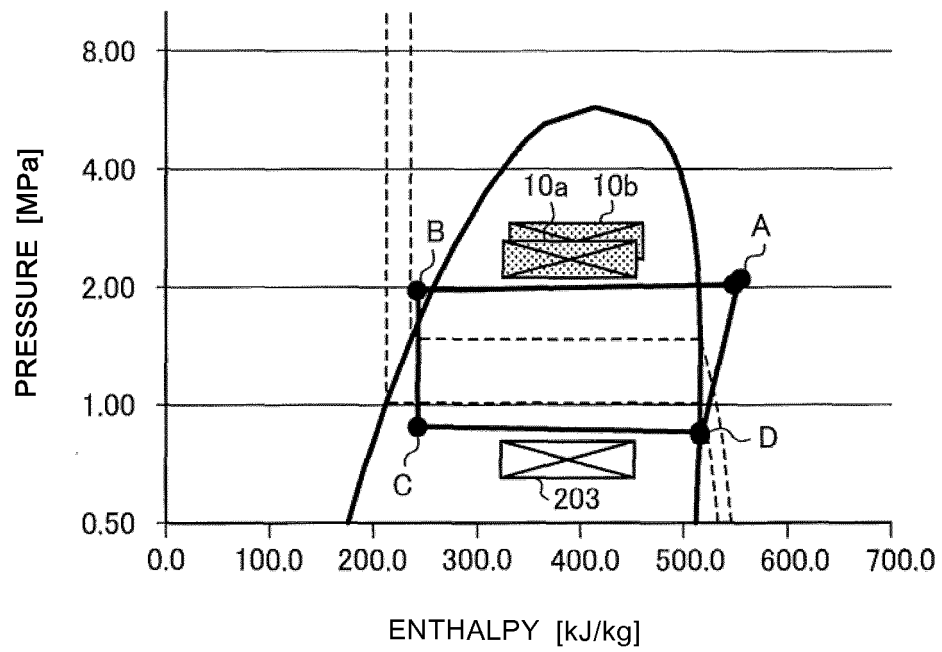


FIG. 17

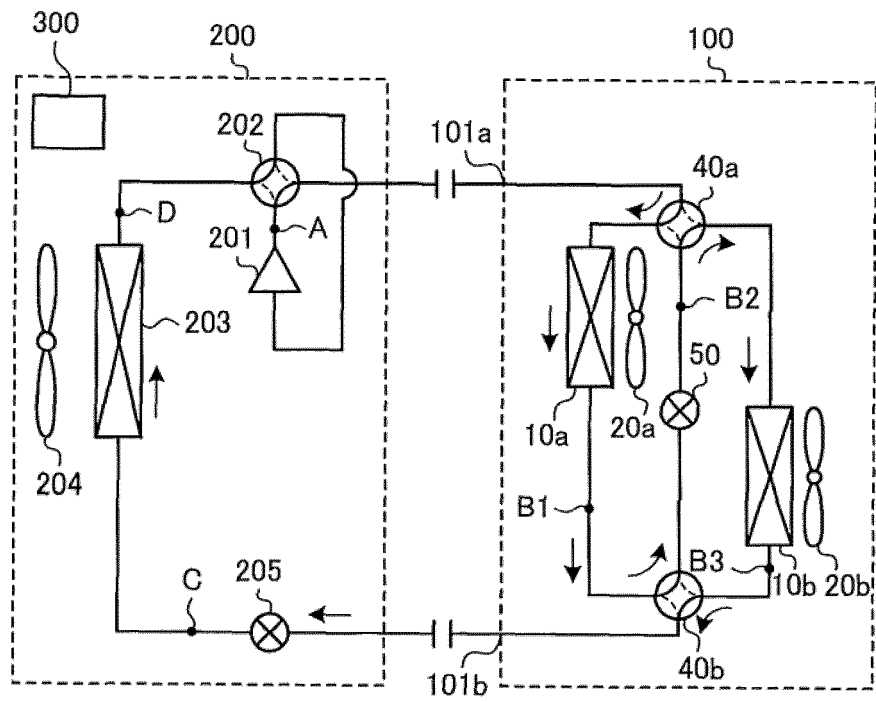


FIG. 18

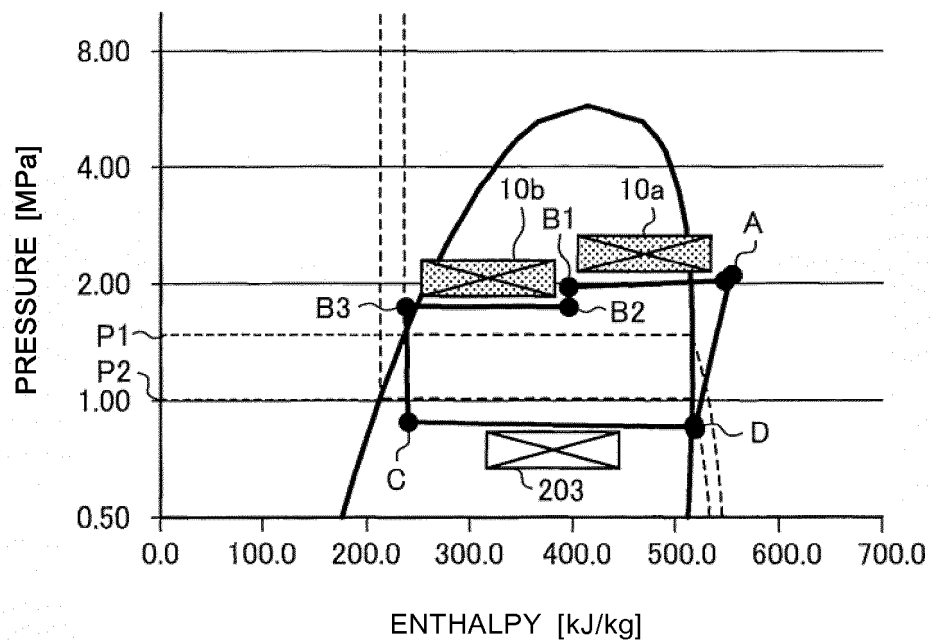


FIG. 19

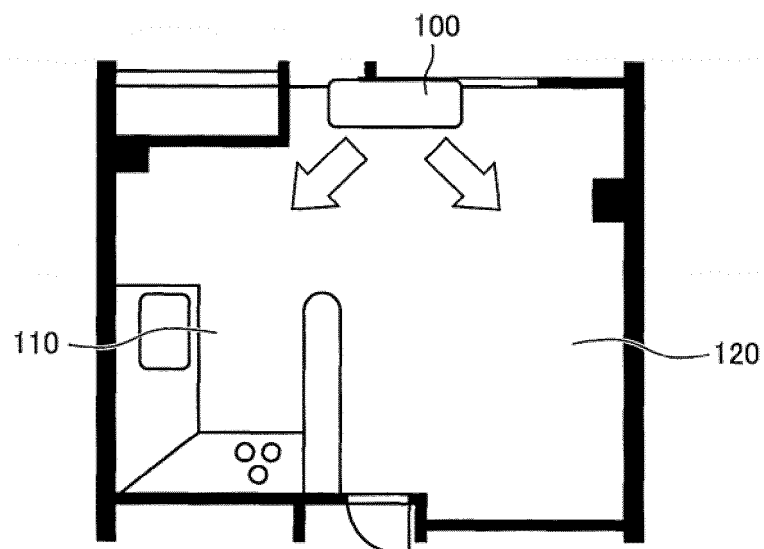


FIG. 20

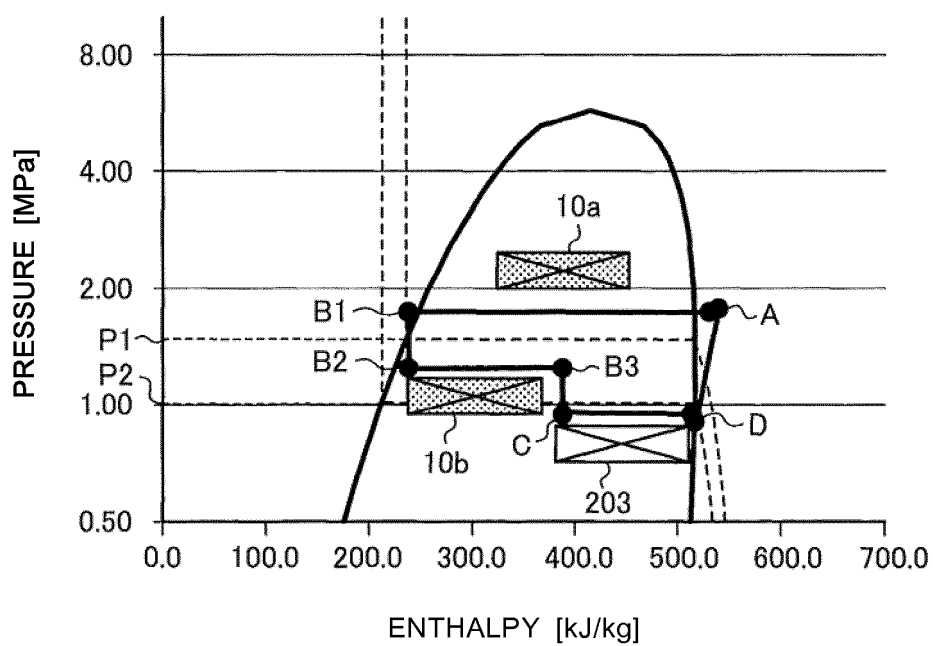


FIG. 21

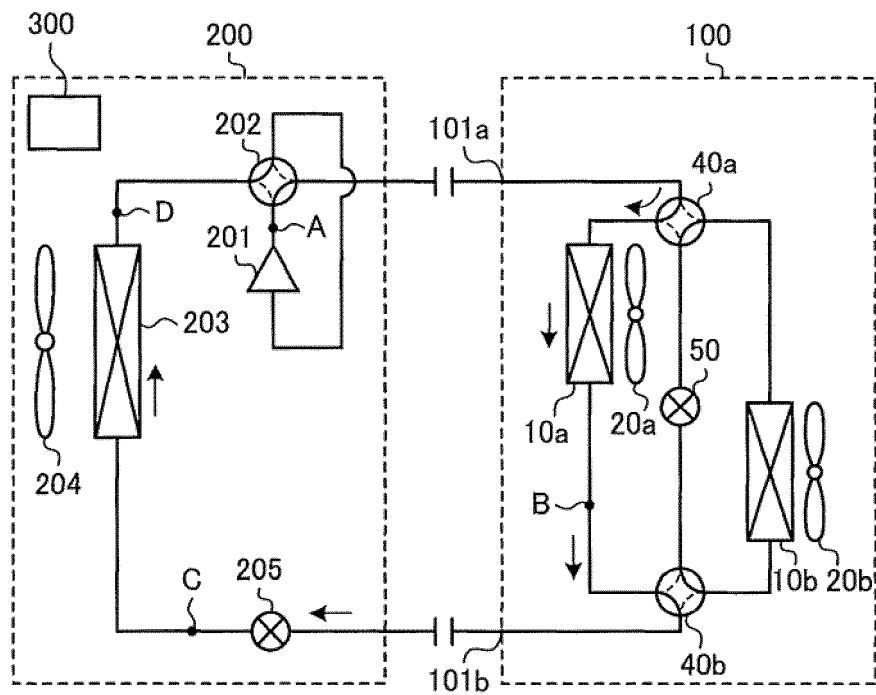


FIG. 22

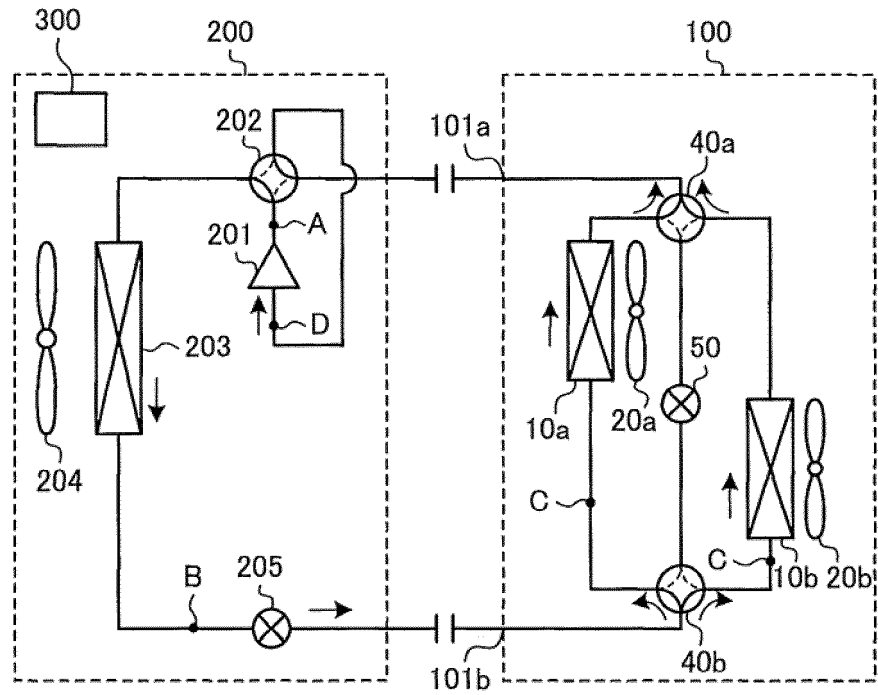


FIG. 23

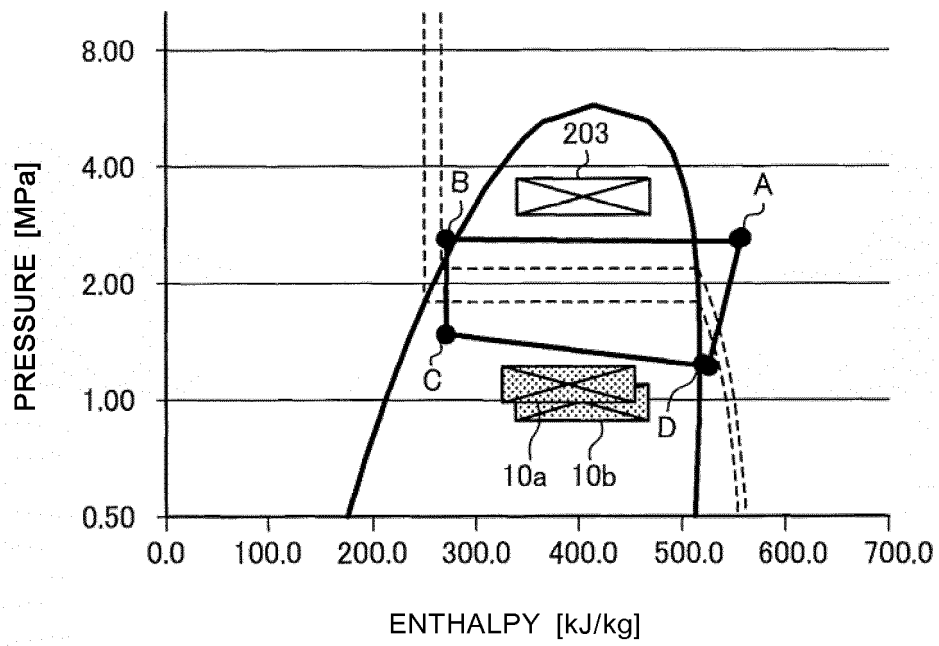


FIG. 24

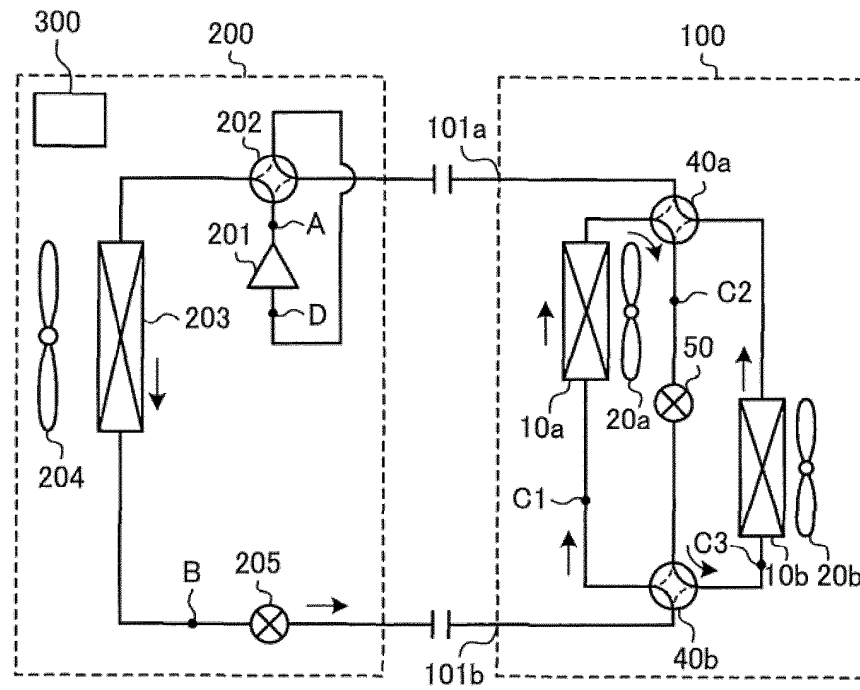


FIG. 25

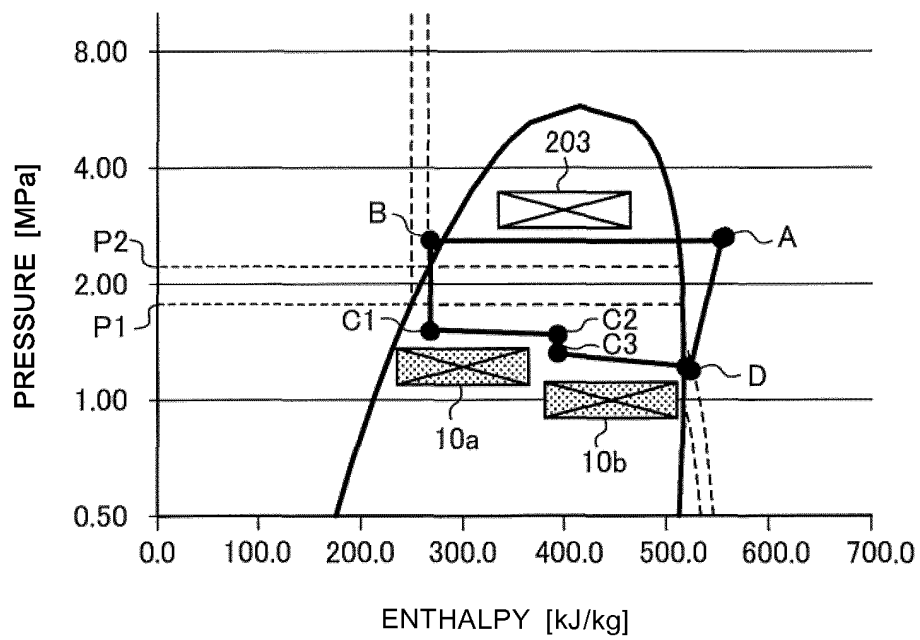


FIG. 26

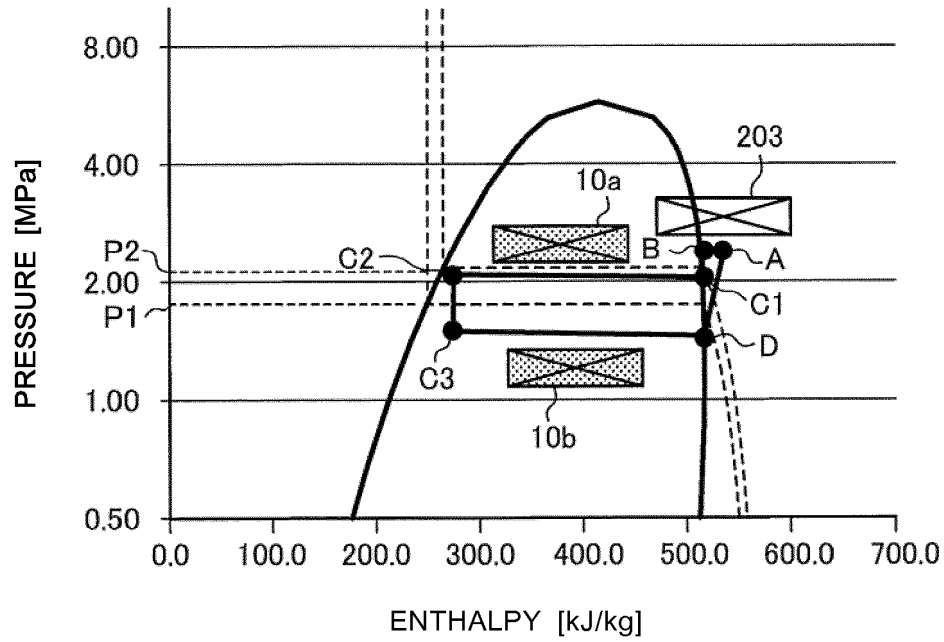


FIG. 27

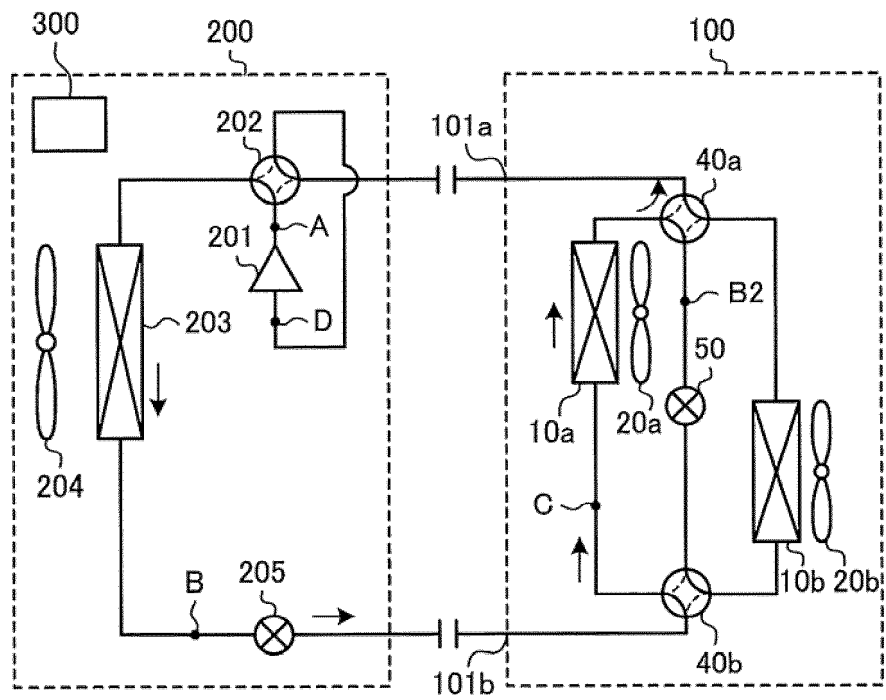


FIG. 28

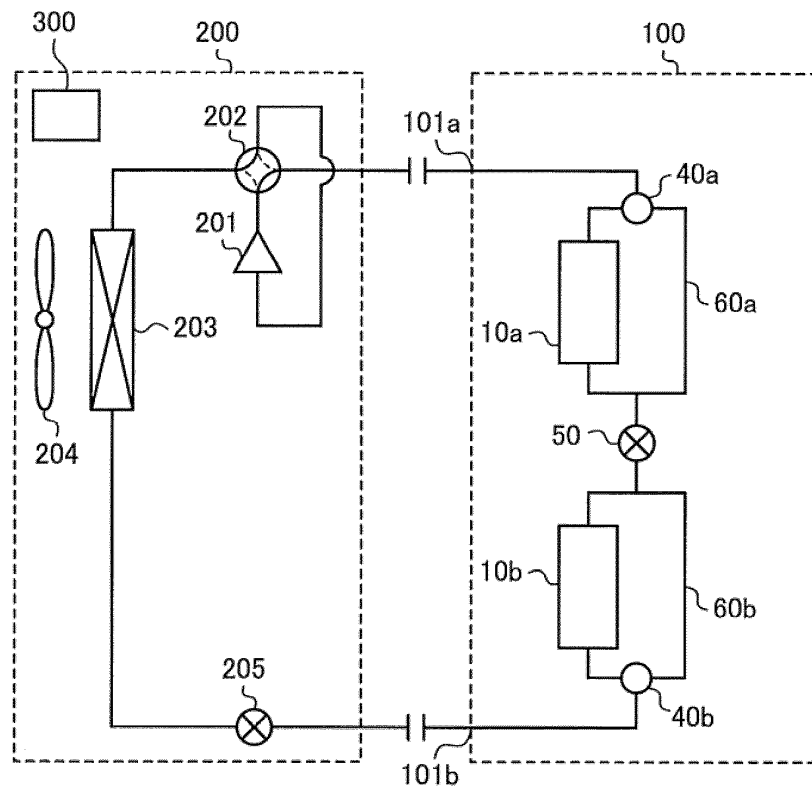


FIG. 29

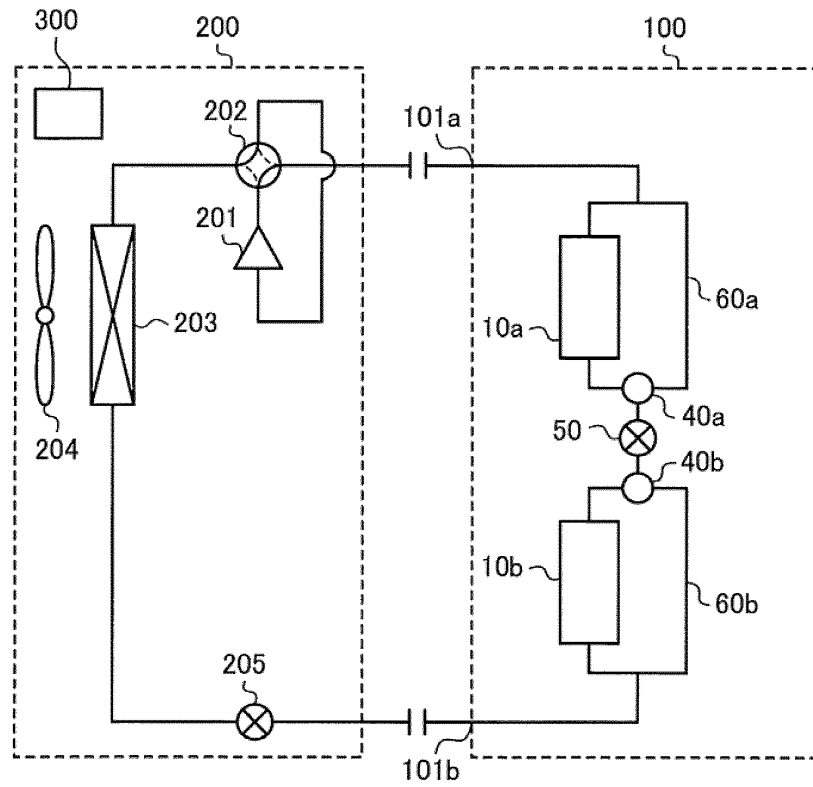


FIG. 30

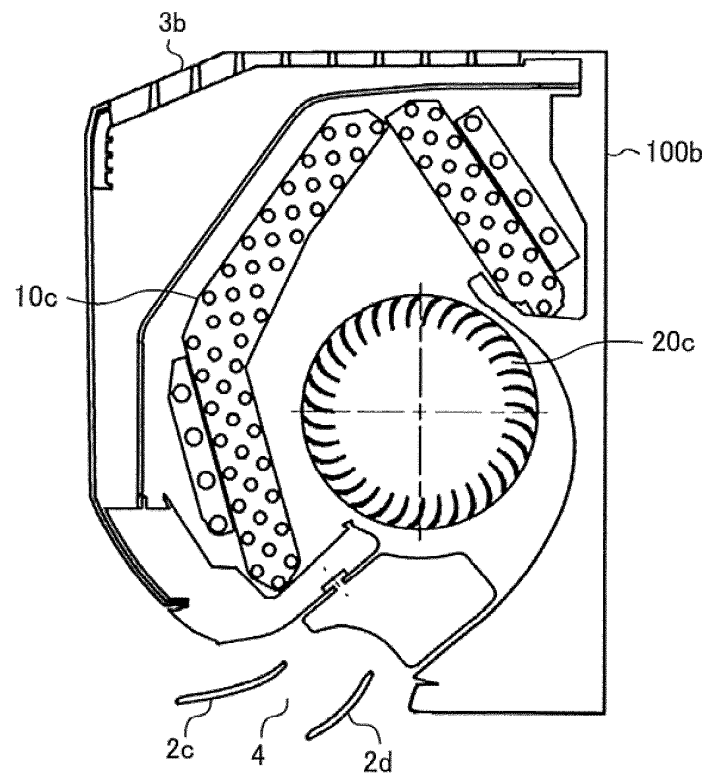
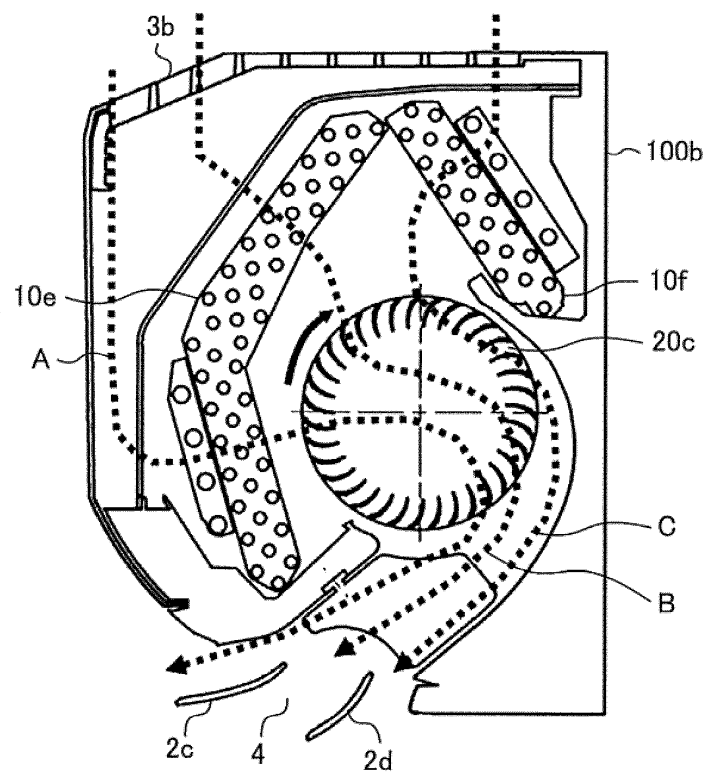


FIG. 31



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/079048

A. CLASSIFICATION OF SUBJECT MATTER

F24F11/02(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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.
X A	JP 2016-142457 A (Johnson Controls-Hitachi Air Conditioning Technology (Hong Kong) Ltd.), 08 August 2016 (08.08.2016), paragraphs [0010] to [0063]; fig. 1 to 8 (Family: none)	1-3, 11-14 4-10
A	JP 2013-178019 A (Yanmar Co., Ltd.), 09 September 2013 (09.09.2013), paragraphs [0012] to [0034]; fig. 1 to 4 (Family: none)	4-7
A	JP 2010-281492 A (Hitachi Appliances, Inc.), 16 December 2010 (16.12.2010), paragraphs [0013] to [0047]; fig. 1 to 2 (Family: none)	8-10

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

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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search
29 November 2016 (29.11.16)Date of mailing of the international search report
06 December 2016 (06.12.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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Patent documents cited in the description

- JP 2013130323 A [0003]