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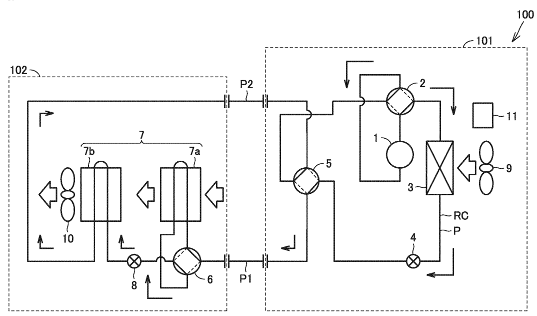
# (54) AIR CONDITIONER

(57) An air-conditioner (100) is provided with a refrigerant circuit (RC) and an indoor fan (10). The refrigerant circuit (RC) has a compressor (1), a first four-way valve (2), an outdoor heat exchanger (3), a first expansion valve (4), a second four-way valve (5), a third four-way valve (6), an indoor heat exchanger (7), and a second expansion valve (8), and is configured to circulate refrigerant. The indoor fan (10) is configured to send air to the indoor heat exchanger (7). The indoor heat exchanger (7) has a first heat exchange portion (7a) and a second heat exchange portion (7b). During a cooling operation, in the first heat exchange portion (7a) and the second heat exchange portion (7b), a flow of refrigerant with respect to a flow of air sent by the indoor fan (10) is a parallel flow. In a reheating dehumidification operation, in the first heat exchange portion (7a), the flow of refrigerant with respect to the flow of air is the parallel flow, and in the second heat exchange portion (7b), the flow of refrigerant with respect to the flow of air is a counterflow.

FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to an air-conditioner.

### BACKGROUND ART

**[0002]** An air-conditioner capable of performing both of a cooling operation and a reheating dehumidification operation has conventionally been proposed. Such an air-conditioner is described, for example, in Japanese Patent Laying-Open No. 2020-125855 (PTL 1). In the air-conditioner described in this literature, a four-way valve provided in a refrigerant circuit switches a flow path of refrigerant so that an orientation of refrigerant that flows in an indoor heat exchanger is different between the cooling operation and the reheating dehumidification operation. In the air-conditioner described in this literature, the indoor heat exchanger is divided into a plurality of heat exchange portions and an expansion valve is provided between the plurality of divided heat exchange portions.

### CITATION LIST

### PATENT LITERATURE

**[0003]** PTL 1: Japanese Patent Laying-Open No. 2020-125855

### SUMMARY OF INVENTION

### TECHNICAL PROBLEM

**[0004]** A heat exchanger is normally designed such that, when the heat exchanger is used as an evaporator, air that flows on the outside of the heat exchanger and refrigerant that flows in the inside of the heat exchanger are parallel flows with orientations thereof being the same, for the following reason. In an evaporator where low-pressure gas-liquid two-phase refrigerant or gas-phase refrigerant flows, a density of refrigerant is low and a flow velocity of refrigerant is high. Therefore, pressure loss in the evaporator is greater than pressure loss in a condenser. Accordingly, a saturation temperature at an outlet of the evaporator is lower than a saturation temperature at an inlet of the evaporator. Therefore, in an example where air and refrigerant flow as parallel flows, a temperature of refrigerant becomes lower with cooling of air, and hence the temperature at the outlet is lower than in an example where air and refrigerant flow as counterflows. Air can thus efficiently be cooled.

**[0005]** In a reheating dehumidification operation of the air-conditioner described in the literature, in each of the plurality of heat exchange portions of the indoor heat exchanger, air and refrigerant flow as counterflows. Therefore, also in the heat exchange portion used also as the evaporator, air and refrigerant flow as counterflows. Since air can thus not efficiently be cooled, sufficient dehumidification cannot be achieved.

**[0006]** The present disclosure was made in view of the problems above, and an object thereof is to provide an air-conditioner capable of sufficient dehumidification in a reheating dehumidification operation.

### SOLUTION TO PROBLEM

**[0007]** An air-conditioner in the present disclosure is provided with a refrigerant circuit and an indoor fan. The refrigerant circuit has a compressor, a first four-way valve, an outdoor heat exchanger, a first expansion valve, a second four-way valve, a third four-way valve, an indoor heat exchanger, and a second expansion valve, and is configured to circulate refrigerant. The indoor fan is configured to send air to the indoor heat exchanger. The indoor heat exchanger has a first heat exchange portion and a second heat exchange portion. The first four-way valve, the second four-way valve, and the third four-way valve are switched to allow refrigerant to flow through the refrigerant circuit in an order of the compressor, the first four-way valve, the outdoor heat exchanger, the first expansion valve, the second four-way valve, the third four-way valve, the first heat exchange portion, the third four-way valve, the second expansion valve, the second heat exchange portion, the second four-way valve, and the first four-way valve during a cooling operation. The first four-way valve, the second four-way valve, and the third four-way valve are switched to allow refrigerant to flow through the refrigerant circuit in an order of the compressor, the first four-way valve, the outdoor heat exchanger, the first expansion valve, the second four-way valve, the second heat exchange portion, the second expansion valve, the third four-way valve, the first heat exchange portion, the third four-way valve, the second four-way valve, and the first four-way valve during a reheating dehumidification operation. During the cooling operation, in the first heat exchange portion and the second heat exchange portion, a flow of refrigerant with respect to a flow of air sent by the indoor fan is a parallel flow. During the reheating dehumidification operation, in the first heat exchange portion, the flow of refrigerant with respect to the flow of air is a parallel flow, and in the second heat exchange portion, the flow of refrigerant with respect to the flow of air is a counterflow.

### ADVANTAGEOUS EFFECTS OF INVENTION

**[0008]** According to the present disclosure, during the reheating dehumidification operation, in the first heat exchange portion, the flow of refrigerant with respect to the flow of air is the parallel flow. Therefore, sufficient dehumidification can be achieved in the reheating dehumidification operation.

BRIEF DESCRIPTION OF DRAWINGS

**[0009]**

Fig. 1 is a diagram of a refrigerant circuit during a cooling operation of an air-conditioner according to a first embodiment.
Fig. 2 is a pressure-enthalpy diagram during the cooling operation of the air-conditioner according to the first embodiment.
Fig. 3 is a diagram of the refrigerant circuit during a reheating dehumidification operation of the air-conditioner according to the first embodiment.
Fig. 4 is a pressure-enthalpy diagram during the reheating dehumidification operation of the air-conditioner according to the first embodiment.
Fig. 5 is a diagram of the refrigerant circuit during a heating operation of the air-conditioner according to the first embodiment.
Fig. 6 is a cross-sectional view schematically showing a construction during the cooling operation, of an indoor unit of the air-conditioner according to the first embodiment.
Fig. 7 is a cross-sectional view schematically showing a construction during the reheating dehumidification operation, of the indoor unit of the air-conditioner according to the first embodiment.
Fig. 8 is a diagram of the refrigerant circuit during the cooling operation of the air-conditioner according to a second embodiment.
Fig. 9 is a diagram of the refrigerant circuit during the reheating dehumidification operation of the air-conditioner according to the second embodiment.
Fig. 10 is a diagram of the refrigerant circuit during the heating operation of the air-conditioner according to the second embodiment.

DESCRIPTION OF EMBODIMENTS

**[0010]** An embodiment will be described below with reference to the drawings. The same or corresponding elements below have the same reference characters allotted and description thereof will not be repeated.

First Embodiment.

**[0011]** A construction of an air-conditioner 100 according to a first embodiment will be described with reference to Fig. 1.

**[0012]** As shown in Fig. 1, air-conditioner 100 is provided with a refrigerant circuit RC, an outdoor fan 9, an indoor fan 10, and a control device 11. Refrigerant circuit RC has a compressor 1, a first four-way valve 2, an outdoor heat exchanger 3, a first expansion valve 4, a second four-way valve 5, a third four-way valve 6, an indoor heat exchanger 7, a second expansion valve 8, and a pipe P. Indoor heat exchanger 7 has a first heat exchange portion 7a and a second heat exchange portion 7b. Pipe P includes a first extension pipe P1 and a second extension pipe P2.

**[0013]** Refrigerant circuit RC is constructed by connection of compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, third four-way valve 6, indoor heat exchanger 7, and second expansion valve 8 through pipe P. Refrigerant circuit RC is constructed to circulate refrigerant.

**[0014]** Air-conditioner 100 includes an outdoor unit 101 and an indoor unit 102. Outdoor unit 101 and indoor unit 102 are connected to each other through first extension pipe P1 and second extension pipe P2. Compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, outdoor fan 9, and control device 11 are accommodated in outdoor unit 101. Third four-way valve 6, indoor heat exchanger 7, second expansion valve 8, and indoor fan 10 are accommodated in indoor unit 102.

**[0015]** Compressor 1 is constructed to compress refrigerant. Compressor 1 is constructed to compress and discharge suctioned refrigerant. Compressor 1 is, for example, of a variable displacement type. Compressor 1 is constructed as being variable in capacity, for example, by adjustment of the number of rotations of compressor 1 based on an instruction from control device 11.

**[0016]** First four-way valve 2 is connected to an inlet and an outlet of compressor 1, outdoor heat exchanger 3, and second four-way valve 5. First four-way valve 2 is constructed to switch a flow of refrigerant such that refrigerant compressed by compressor 1 flows to outdoor heat exchanger 3 or indoor heat exchanger 7. When first four-way valve 2 switches the flow of refrigerant such that refrigerant compressed by compressor 1 flows to indoor heat exchanger 7, refrigerant flows from first four-way valve 2 through second four-way valve 5 to indoor heat exchanger 7.

**[0017]** First four-way valve 2 is constructed to allow refrigerant discharged from compressor 1 to flow to outdoor heat exchanger 3 during a cooling operation and a reheating dehumidification operation. First four-way valve 2 is constructed to allow refrigerant discharged from compressor 1 to flow to indoor heat exchanger 7 during a heating operation.

**[0018]** Outdoor heat exchanger 3 is constructed to exchange heat between refrigerant that flows in the inside of outdoor heat exchanger 3 and air that flows on the outside of outdoor heat exchanger 3. Outdoor heat exchanger 3 is constructed to function as a condenser that condenses refrigerant during the cooling operation and the reheating dehumidification operation. Outdoor heat exchanger 3 is constructed to function as an evaporator that evaporates refrigerant during the heating operation. Outdoor heat exchanger 3 is, for example, a finned tube heat exchanger having a plurality of fins and a heat transfer tube that passes through the plurality of fins.

**[0019]** First expansion valve 4 is constructed to decompress by expanding, refrigerant condensed by the condenser. First expansion valve 4 is constructed to decompress refrigerant condensed by outdoor heat exchanger 3 during the cooling operation and the reheating dehumidification operation. First expansion valve 4 is constructed to decompress refrigerant condensed by indoor heat exchanger 7 during the heating operation. For example, a solenoid expansion valve is employed as the first expansion valve.

**[0020]** Second four-way valve 5 is connected to first four-way valve 2, first expansion valve 4, third four-way valve 6, and second heat exchange portion 7b of indoor heat exchanger 7. Second four-way valve 5 is constructed to switch the flow of refrigerant such that refrigerant that flows out of first expansion valve 4 flows through third four-way valve 6 to first heat exchange portion 7a of indoor heat exchanger 7 and refrigerant that flows out of second heat exchange portion 7b of indoor heat exchanger 7 flows to first four-way valve 2 during the cooling operation.

**[0021]** Second four-way valve 5 is constructed to switch the flow of refrigerant such that refrigerant that flows out of first expansion valve 4 flows to second heat exchange portion 7b of indoor heat exchanger 7 and refrigerant that flows out of first heat exchange portion 7a of indoor heat exchanger 7 and passes through third four-way valve 6 flows to first four-way valve 2 during the reheating dehumidification operation.

**[0022]** Second four-way valve 5 is constructed to switch the flow of refrigerant such that refrigerant that is discharged from compressor 1 and passes through first four-way valve 2 flows to second heat exchange portion 7b of indoor heat exchanger 7 and refrigerant that flows out of first heat exchange portion 7a of indoor heat exchanger 7 and passes through third four-way valve 6 flows to first expansion valve 4 during the heating operation.

**[0023]** Third four-way valve 6 is connected to second four-way valve 5, an inlet and an outlet of first heat exchange portion 7a of indoor heat exchanger 7, and second expansion valve 8. Third four-way valve 6 is constructed to switch the flow of refrigerant such that refrigerant that flows out of second four-way valve 5 flows to a heat transfer tube on a windward side of first heat exchange portion 7a and refrigerant that flows out of a heat transfer tube on a leeward side of first heat exchange portion 7a flows through second expansion valve 8 to a heat transfer tube on the windward side of second heat exchange portion 7b of indoor heat exchanger 7 during the cooling operation.

**[0024]** Third four-way valve 6 is constructed to switch the flow of refrigerant such that refrigerant that flows out of second expansion valve 8 flows to the heat transfer tube on the windward side of first heat exchange portion 7a and refrigerant that flows out of the heat transfer tube on the leeward side of first heat exchange portion 7a flows to second four-way valve 5 during the reheating dehumidification operation.

**[0025]** Third four-way valve 6 is constructed to switch the flow of refrigerant such that refrigerant that flows out of second expansion valve 8 flows to the heat transfer tube on the leeward side of first heat exchange portion 7a and refrigerant that flows out of the heat transfer tube on the windward side of first heat exchange portion 7a flows to second four-way valve 5 during the heating operation.

**[0026]** Indoor heat exchanger 7 is constructed to exchange heat between refrigerant that flows in the inside of indoor heat exchanger 7 and air that flows on the outside of indoor heat exchanger 7. Indoor heat exchanger 7 is constructed to function as the evaporator that evaporates refrigerant during the cooling operation. Both of first heat exchange portion 7a and second heat exchange portion 7b are constructed to function as the evaporator that evaporates refrigerant during the cooling operation.

**[0027]** Indoor heat exchanger 7 is constructed to function as the evaporator that evaporates refrigerant and the condenser that condenses refrigerant during the reheating dehumidification operation. First heat exchange portion 7a is constructed to function as the evaporator that evaporates refrigerant during the reheating dehumidification operation. Second heat exchange portion 7b is constructed to function as the condenser that condenses refrigerant during the reheating dehumidification operation.

**[0028]** Indoor heat exchanger 7 is constructed to function as the condenser that condenses refrigerant during the heating operation. Both of first heat exchange portion 7a and second heat exchange portion 7b are constructed to function as the condenser that condenses refrigerant during the heating operation.

**[0029]** Indoor heat exchanger 7 is, for example, a finned tube heat exchanger having a plurality of fins and a heat transfer tube that passes through the plurality of fins.

**[0030]** First heat exchange portion 7a and second heat exchange portion 7b are arranged as being aligned in a direction of flow of air sent by indoor fan 10. First heat exchange portion 7a is arranged on the windward side relative to second heat exchange portion 7b in the flow of air sent by indoor fan 10. Second heat exchange portion 7b is arranged on the leeward side relative to first heat exchange portion 7a in the flow of air sent by indoor fan 10.

**[0031]** First heat exchange portion 7a has the heat transfer tube on the windward side and the heat transfer tube on the leeward side. The heat transfer tube on the windward side is connected to the heat transfer tube of the leeward side. First heat exchange portion 7a is constructed such that refrigerant flows from the heat transfer tube on the windward side to the heat transfer tube on the leeward side during the cooling operation and the reheating dehumidification operation. During the cooling operation and the reheating dehumidification operation, refrigerant and air that flow in first heat exchange portion 7a flow as parallel flows. First heat exchange portion 7a is constructed such that refrigerant flows from the heat transfer tube on the leeward side to the heat transfer tube on the windward side during the heating operation. During the heating operation, refrigerant and air that flow in first heat exchange portion 7a flow as counterflows.

**[0032]** Second heat exchange portion 7b has the heat transfer tube on the windward side and a heat transfer tube on the leeward side. The heat transfer tube on the windward side is connected to the heat transfer tube on the leeward side. Second heat exchange portion 7b is constructed such that refrigerant flows from the heat transfer tube on the windward side to the heat transfer tube on the leeward side during the cooling operation. During the cooling operation, refrigerant and air that flow in second heat exchange portion 7b flow as parallel flows. Second heat exchange portion 7b is constructed such that refrigerant flows from the heat transfer tube on the leeward side to the heat transfer tube on the windward side during the reheating dehumidification operation and the heating operation. During the reheating dehumidification operation and the heating operation, refrigerant and air that flow in second heat exchange portion 7b flow as counterflows.

**[0033]** Second expansion valve 8 is constructed to decompress refrigerant condensed in second heat exchange portion 7b of indoor heat exchanger 7 during the reheating dehumidification operation. Second expansion valve 8 is constructed to suppress decompression of refrigerant by increasing an opening of the valve during the cooling operation and the heating operation. For example, a solenoid expansion valve is employed as second expansion valve 8.

**[0034]** First four-way valve 2, second four-way valve 5, and third four-way valve 6 are switched such that refrigerant flows through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, third four-way valve 6, first heat exchange portion 7a, third four-way valve 6, second expansion valve 8, second heat exchange portion 7b, second four-way valve 5, and first four-way valve 2 during the cooling operation.

**[0035]** First four-way valve 2, second four-way valve 5, and third four-way valve 6 are switched such that refrigerant flows through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, second heat exchange portion 7b, second expansion valve 8, third four-way valve 6, first heat exchange portion 7a, third four-way valve 6, second four-way valve 5, and first four-way valve 2 during the reheating dehumidification operation.

**[0036]** First four-way valve 2, second four-way valve 5, and third four-way valve 6 are switched such that refrigerant flows through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, second four-way valve 5, second heat exchange portion 7b, second expansion valve 8, third four-way valve 6, first heat exchange portion 7a, third four-way valve 6, second four-way valve 5, first expansion valve 4, outdoor heat exchanger 3, and first four-way valve 2 during the heating operation.

**[0037]** Outdoor fan 9 is constructed to send air to outdoor heat exchanger 3. In other words, outdoor fan 9 is constructed to supply outdoor air to outdoor heat exchanger 3.

**[0038]** Indoor fan 10 is constructed to send air to indoor heat exchanger 7. In other words, indoor fan 10 is constructed to supply indoor air to indoor heat exchanger 7.

**[0039]** During the cooling operation, in first heat exchange portion 7a and second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air sent by indoor fan 10 is the parallel flow. During the reheating dehumidification operation, in first heat exchange portion 7a, the flow of refrigerant with respect to the flow of air sent by indoor fan 10 is the parallel flow, and in second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air is the counterflow. During the heating operation, in first heat exchange portion 7a and second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air sent by indoor fan 10 is the counterflow.

**[0040]** Control device 11 is configured to control each device in air-conditioner 100 by performing computation and giving an instruction. Control device 11 is electrically connected to compressor 1, first four-way valve 2, first expansion valve 4, second four-way valve 5, third four-way valve 6, second expansion valve 8, outdoor fan 9, indoor fan 10, and the like and configured to control operations thereof.

**[0041]** Operations of air-conditioner 100 according to the first embodiment will now be described with reference to Figs. 1 to 5. In Figs. 1 to 5, a solid arrow shows a flow of refrigerant and a hollow arrow shows a flow of air. Air-conditioner 100 according to the first embodiment can selectively perform the cooling operation, the reheating dehumidification operation, and the heating operation.

**[0042]** The cooling operation performed by air-conditioner 100 will be described with reference to Figs. 1 and 2. During the cooling operation, refrigerant circulates through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, third four-way valve 6, first heat exchange portion 7a of indoor heat exchanger 7, third four-way valve 6, second expansion valve 8, second heat exchange portion 7b of indoor heat exchanger 7, second four-way valve 5, and first four-way valve 2.

**[0043]** High-pressure gas refrigerant discharged from compressor 1 flows into outdoor heat exchanger 3 through first four-way valve 2. In outdoor heat exchanger 3, heat is exchanged between high-pressure gas refrigerant and air sent by outdoor fan 9, so that refrigerant radiates heat and changes to liquid refrigerant. Liquid refrigerant flows from outdoor heat exchanger 3 into first expansion valve 4. In first expansion valve 4, liquid refrigerant is decompressed and becomes gas-liquid two-phase refrigerant.

**[0044]** Gas-liquid two-phase refrigerant flows into second four-way valve 5 from first expansion valve 4. In the cooling operation, a flow path in second four-way valve 5 is switched to connect first expansion valve 4 and first extension pipe P1 to each other. Gas-liquid two-phase refrigerant passes through first extension pipe P1 from second four-way valve 5 and flows into third four-way valve 6. In third four-way valve 6, the flow path is switched to connect first extension pipe P1 and the heat transfer tube on the windward side of first heat exchange portion 7a of indoor heat exchanger 7 to each other.

**[0045]** Heat is exchanged between refrigerant that flows into the heat transfer tube on the windward side of first heat exchange portion 7a of indoor heat exchanger 7 and air sent by indoor fan 10 and thereafter refrigerant flows out of the heat transfer tube on the leeward side of first heat exchange portion 7a. At this time, air that flows on the outside of first heat exchange portion 7a and refrigerant that flows in the inside of first heat exchange portion 7a are in the same orientation. In other words, in first heat exchange portion 7a, the flow of refrigerant with respect to the flow of air is the parallel flow.

**[0046]** Refrigerant flows again into third four-way valve 6 from first heat exchange portion 7a and thereafter flows into second expansion valve 8. In the cooling operation, the opening of second expansion valve 8 is set to increase. Therefore, since the pressure loss of refrigerant is less likely in second expansion valve 8, refrigerant flows as it is into the heat transfer tube on the windward side of second heat exchange portion 7b of indoor heat exchanger 7 from second expansion valve 8.

**[0047]** Air cooled in first heat exchange portion 7a is sent to second heat exchange portion 7b. At this time, air that flows on the outside of second heat exchange portion 7b and refrigerant that flows in the inside of second heat exchange portion 7b are in the same orientation. In other words, in second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air is the parallel flow.

**[0048]** Gas refrigerant that has evaporated in second heat exchange portion 7b flows from second heat exchange portion 7b through second extension pipe P2 into second four-way valve 5. In second four-way valve 5, the flow path is switched to connect second extension pipe P2 and first four-way valve 2 to each other. Gas refrigerant flows from second four-way valve 5 through first four-way valve 2 into the inlet of compressor 1.

**[0049]** The reheating dehumidification operation performed by air-conditioner 100 will be described with reference to Figs. 3 and 4. During the reheating dehumidification operation, refrigerant circulates through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, outdoor heat exchanger 3, first expansion valve 4, second four-way valve 5, second heat exchange portion 7b of indoor heat exchanger 7, second expansion valve 8, third four-way valve 6, first heat exchange portion 7a of indoor heat exchanger 7, third four-way valve 6, second four-way valve 5, and first four-way valve 2.

**[0050]** In the reheating dehumidification operation, second four-way valve 5 and third four-way valve 6 are switched from a state thereof in the cooling operation shown in Fig. 1. Liquid refrigerant that has exchanged heat with air sent by outdoor fan 9 in outdoor heat exchanger 3 flows into first expansion valve 4. At this time, by increasing the opening of first expansion valve 4 as compared with the opening during the cooling operation, the temperature of refrigerant at an outlet of first expansion valve 4 can be higher than the temperature of indoor air. Refrigerant flows from first expansion valve 4 into second four-way valve 5.

**[0051]** In the reheating dehumidification operation, the flow path in second four-way valve 5 is switched to connect first expansion valve 4 and second extension pipe P2 to each other. Refrigerant passes through second extension pipe P2 from second four-way valve 5 and flows into second heat exchange portion 7b of indoor heat exchanger 7. Refrigerant flows from the heat transfer tube on the leeward side to the heat transfer tube on the windward side in second heat exchange portion 7b of indoor heat exchanger 7. In second heat exchange portion 7b, refrigerant heats air cooled in first heat exchange portion 7a. At this time, air that flows on the outside of second heat exchange portion 7b and refrigerant that flows in the inside of second heat exchange portion 7b are in orientations reverse to each other. In other words, in second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air is the counterflow.

**[0052]** Refrigerant flows into second expansion valve 8 from second heat exchange portion 7b. Refrigerant is decompressed in second expansion valve 8 and thereafter flows into third four-way valve 6. Refrigerant flows from third four-way valve 6 into the heat transfer tube on the windward side of first heat exchange portion 7a. Refrigerant flows from the heat transfer tube on the windward side to the heat transfer tube on the leeward side in first heat exchange portion 7a. Refrigerant cools air in first heat exchange portion 7a. At this time, air that flows on the outside of first heat exchange portion 7a and refrigerant that flows in the inside of first heat exchange portion 7a are in the same orientation. In other words, in first heat exchange portion 7a, the flow of refrigerant with respect to the flow of air is the parallel flow.

**[0053]** Refrigerant that has cooled indoor air flows again into third four-way valve 6 from first heat exchange portion 7a and then passes through first extension pipe P1 and flows into second four-way valve 5. In second four-way valve 5, the flow path is switched to connect first extension pipe P1 and first four-way valve 2 to each other. Refrigerant flows from second four-way valve 5 through first four-way valve 2 into the inlet of compressor 1.

**[0054]** The heating operation performed by air-conditioner 100 will be described with reference to Fig. 5. During the heating operation, refrigerant circulates through refrigerant circuit RC in the order of compressor 1, first four-way valve 2, second four-way valve 5, second heat exchange portion 7b of indoor heat exchanger 7, second expansion valve 8, third four-way valve 6, first heat exchange portion 7a of indoor heat exchanger 7, third four-way valve 6, second four-way valve 5, first expansion valve 4, outdoor heat exchanger 3, and first four-way valve 2.

**[0055]** During the heating operation, first four-way valve 2 is switched from the state thereof in the cooling operation shown in Fig. 1. High-pressure gas refrigerant discharged from compressor 1 flows through first four-way valve 2 and second four-way valve 5 into second heat exchange portion 7b of indoor heat exchanger 7. Refrigerant is condensed in second heat exchange portion 7b. Air that flows on the outside of second heat exchange portion 7b and refrigerant that flows in the inside of second heat exchange portion 7b are in orientations reverse to each other. In other words, in second heat exchange portion 7b, the flow of refrigerant with respect to the flow of air is the counterflow.

**[0056]** Refrigerant flows into second expansion valve 8 from second heat exchange portion 7b. In the heating operation, the opening of second expansion valve 8 is set to increase. Refrigerant flows from second expansion valve 8 through third four-way valve 6 into first heat exchange portion 7a of indoor heat exchanger 7. Refrigerant is condensed in first heat exchange portion 7a. Air that flows on the outside of first heat exchange portion 7a and refrigerant that flows in the inside of first heat exchange portion 7a are in orientations reverse to each other. In other words, in first heat exchange portion 7a, the flow of refrigerant with respect to the flow of air is the counterflow.

**[0057]** Refrigerant flows from first heat exchange portion 7a through third four-way valve 6 and second four-way valve 5 into first expansion valve 4. Refrigerant is decompressed in first expansion valve 4. Refrigerant flows into outdoor heat exchanger 3 from first expansion valve 4. Refrigerant that has evaporated in outdoor heat exchanger 3 flows through first four-way valve 2 into the inlet of compressor 1.

**[0058]** A construction of indoor unit 102 of air-conditioner 100 according to the first embodiment will now be described with reference to Figs. 6 and 7. In Figs. 6 and 7, a solid arrow shows a flow of refrigerant and a hollow arrow shows a flow of air. The construction of indoor unit 102 shown Figs. 6 and 7 is by way of example, and not limited as such.

**[0059]** Indoor unit 102 includes a housing 102a. An inlet 102b for intake of air is provided in a front surface and an upper surface of housing 102a. An outlet 102c for blowing air is provided in a lower surface of housing 102a. First heat exchange portion 7a is arranged such that air suctioned through inlet 102b passes therethrough before air passes through second heat exchange portion 7b. Second heat exchange portion 7b is arranged such that air that has passed through first heat exchange portion 7a passes therethrough. Indoor fan 10 is arranged in the rear of second heat exchange portion 7b. For example, a cross flow fan is employed as indoor fan 10. Air that has passed through first heat exchange portion 7a, second heat exchange portion 7b, and indoor fan 10 is blown indoors through outlet 102c.

**[0060]** A function and effect of air-conditioner 100 according to the first embodiment will now be described.

**[0061]** According to air-conditioner 100 according to the first embodiment, during the reheating dehumidification operation, in first heat exchange portion 7a, the flow of refrigerant with respect to the flow of air is the parallel flow. Therefore, in first heat exchange portion 7a that functions as the evaporator during the reheating dehumidification operation, the flow of refrigerant with respect to the flow of air can be the parallel flow. Air can thus efficiently be cooled in first heat exchange portion 7a. Therefore, sufficient dehumidification can be achieved in the reheating dehumidification operation.

**[0062]** In addition, the cooling operation in which a sensible heat factor (SHF) is controlled can be performed owing to the reheating dehumidification operation.

**[0063]** Since first heat exchange portion 7a that functions as the evaporator during the reheating dehumidification operation and second heat exchange portion 7b that functions as the condenser during the reheating dehumidification operation are arranged along the direction of flow of air, air does not have to separately be sent to first heat exchange portion 7a and second heat exchange portion 7b. Therefore, increase in input to indoor fan 10 can be suppressed.

**[0064]** Furthermore, during the reheating dehumidification operation, in second heat exchange portion 7b that functions as the condenser, the flow of refrigerant with respect to the flow of air is the counterflow. Therefore, performance of the condenser can be improved.

Second Embodiment.

**[0065]** Air-conditioner 100 according to a second embodiment is identical in construction, operations, and function and effect to air-conditioner 100 according to the first embodiment, unless particularly described.

**[0066]** Air-conditioner 100 according to the second embodiment is different from air-conditioner 100 according to the first embodiment in position of second four-way valve 5.

**[0067]** Air-conditioner 100 according to the second embodiment will be described with reference to Figs. 8 to 10. As shown in Fig. 8, in air-conditioner 100 according to the second embodiment, second four-way valve 5 is accommodated in indoor unit 102. Refrigerant circuit RC has first extension pipe P1 and second extension pipe P2. First extension pipe P1 connects first expansion valve 4 and second four-way valve 5 to each other. Second extension pipe P2 connects first four-way valve 2 and second four-way valve 5 to each other. First extension pipe P1 is smaller in inner diameter than second extension pipe P2.

**[0068]** As shown in Figs. 8 to 10, air-conditioner 100 according to the second embodiment operates in the cooling operation, the reheating dehumidification operation, and the heating operation similarly to air-conditioner 100 according to the first embodiment.

**[0069]** A function and effect of air-conditioner 100 according to the second embodiment will now be described as compared with air-conditioner 100 according to the first embodiment.

**[0070]** In air-conditioner 100 according to the first embodiment, during the cooling operation, low-pressure gas-liquid two-phase refrigerant throttled down by first expansion valve 4 that contains much liquid phase flows into first extension pipe P1 and refrigerant flows into indoor unit 102. During the reheating dehumidification operation, low-pressure gas refrigerant that has exchanged heat in indoor unit 102 flows into first extension pipe P1. First extension pipe P1 is smaller in inner diameter than second extension pipe P2, in expectation of flow of liquid refrigerant or gas-liquid two-phase refrigerant that contains much liquid phase. In the first embodiment, gas refrigerant flows into first extension pipe P1 during the reheating dehumidification operation. Since the flow velocity of refrigerant is thus higher than that in an example where liquid-phase refrigerant flows, the pressure loss of refrigerant that occurs in the pipe increases.

**[0071]** According to air-conditioner 100 according to the second embodiment, first extension pipe P1 connects first expansion valve 4 and second four-way valve 5 to each other. Second extension pipe P2 connects first four-way valve 2 and second four-way valve 5 to each other. First extension pipe P1 is smaller in inner diameter than second extension pipe P2. Therefore, in both of the cooling operation and the reheating dehumidification operation, gas-liquid two-phase refrigerant throttled down by first expansion valve 4 flows into first extension pipe P1. Therefore, occurrence of the pressure loss of refrigerant can be suppressed as compared with the pressure loss in an example where gas refrigerant flows through first extension pipe P1 in the reheating dehumidification operation.

**[0072]** It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims rather than the description above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

**[0073]** 1 compressor; 2 first four-way valve; 3 outdoor heat exchanger; 4 first expansion valve; 5 second four-way valve; 6 third four-way valve; 7 indoor heat exchanger; 7a first heat exchange portion; 7b second heat exchange portion; 8 second expansion valve; 9 outdoor fan; 10 indoor fan; 11 control device; 100 air-conditioner; 101 outdoor unit; 102 indoor unit; 102a housing; 102b inlet; 102c outlet; P pipe; P1 first extension pipe; P2 second extension pipe; RC refrigerant circuit

**Claims**

**1.** An air-conditioner comprising:

a refrigerant circuit having a compressor, a first four-way valve, an outdoor heat exchanger, a first expansion valve, a second four-way valve, a third four-way valve, an indoor heat exchanger, and a second expansion valve, the refrigerant circuit being configured to circulate refrigerant; and

an indoor fan configured to send air to the indoor heat exchanger, wherein

the indoor heat exchanger has a first heat exchange portion and a second heat exchange portion,

the first four-way valve, the second four-way valve, and the third four-way valve are switched to allow refrigerant to flow through the refrigerant circuit in an order of the compressor, the first four-way valve, the outdoor heat exchanger, the first expansion valve, the second four-way valve, the third four-way valve, the first heat exchange portion, the third four-way valve, the second expansion valve, the second heat exchange portion, the second four-way valve, and the first four-way valve during a cooling operation,

the first four-way valve, the second four-way valve, and the third four-way valve are switched to allow refrigerant to flow through the refrigerant circuit in an order of the compressor, the first four-way valve, the outdoor heat exchanger, the first expansion valve, the second four-way valve, the second heat exchange portion, the second expansion valve, the third four-way valve, the first heat exchange portion, the third four-way valve, the second four-way valve, and the first four-way valve during a reheating dehumidification operation,

during the cooling operation, in the first heat exchange portion and the second heat exchange portion, a flow of refrigerant with respect to a flow of air sent by the indoor fan is a parallel flow, and

during the reheating dehumidification operation, in the first heat exchange portion, the flow of refrigerant with respect to the flow of air is a parallel flow, and in the second heat exchange portion, the flow of refrigerant with respect to the flow of air is a counterflow.

**2.** The air-conditioner according to claim 1, wherein

the refrigerant circuit has a first extension pipe that connects the first expansion valve and the second four-way valve to each other and a second extension pipe that connects the first four-way valve and the second four-way valve to each other, and

the first extension pipe is smaller in inner diameter than the second extension pipe.

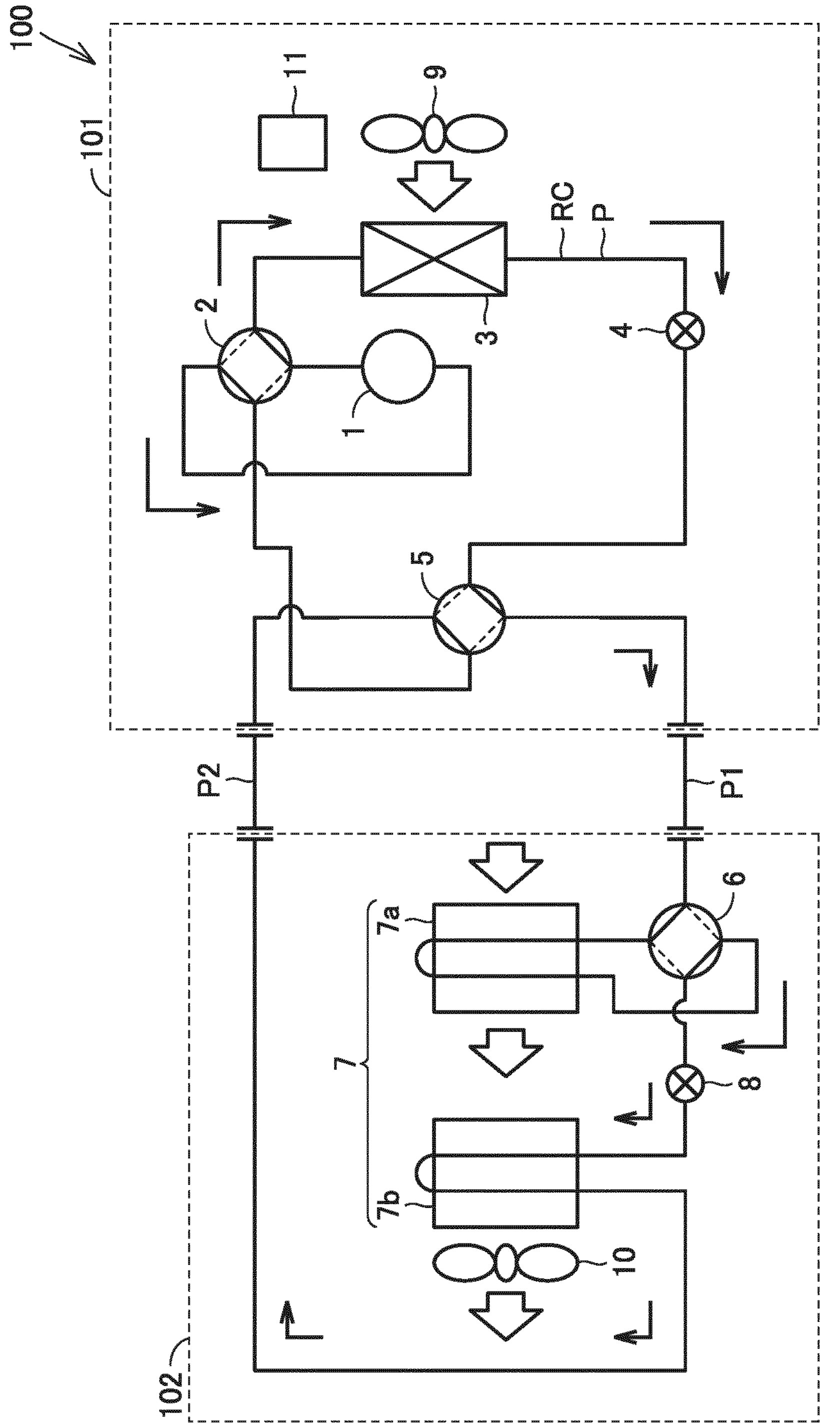
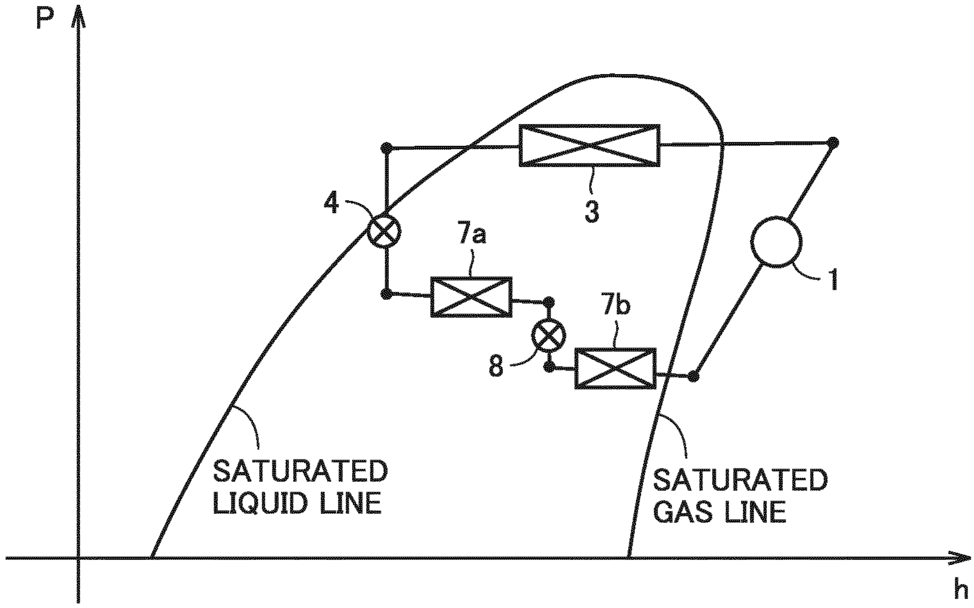



FIG.1

FIG.2



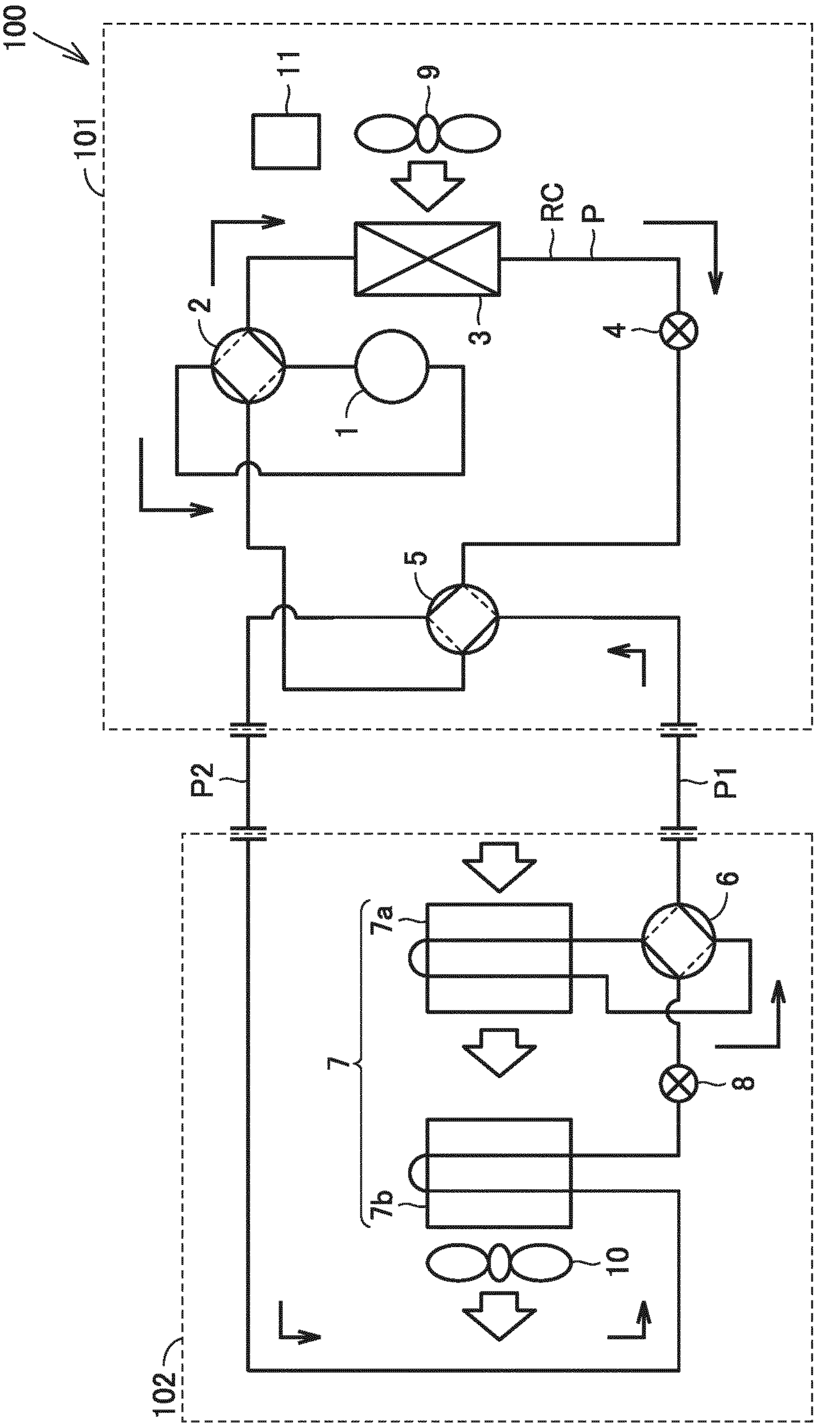
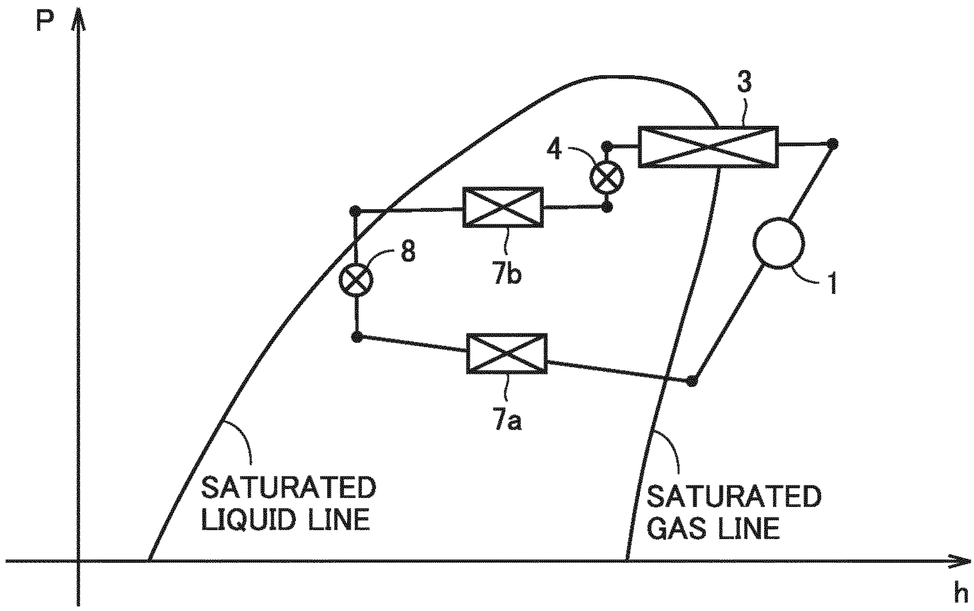



FIG.3

FIG.4



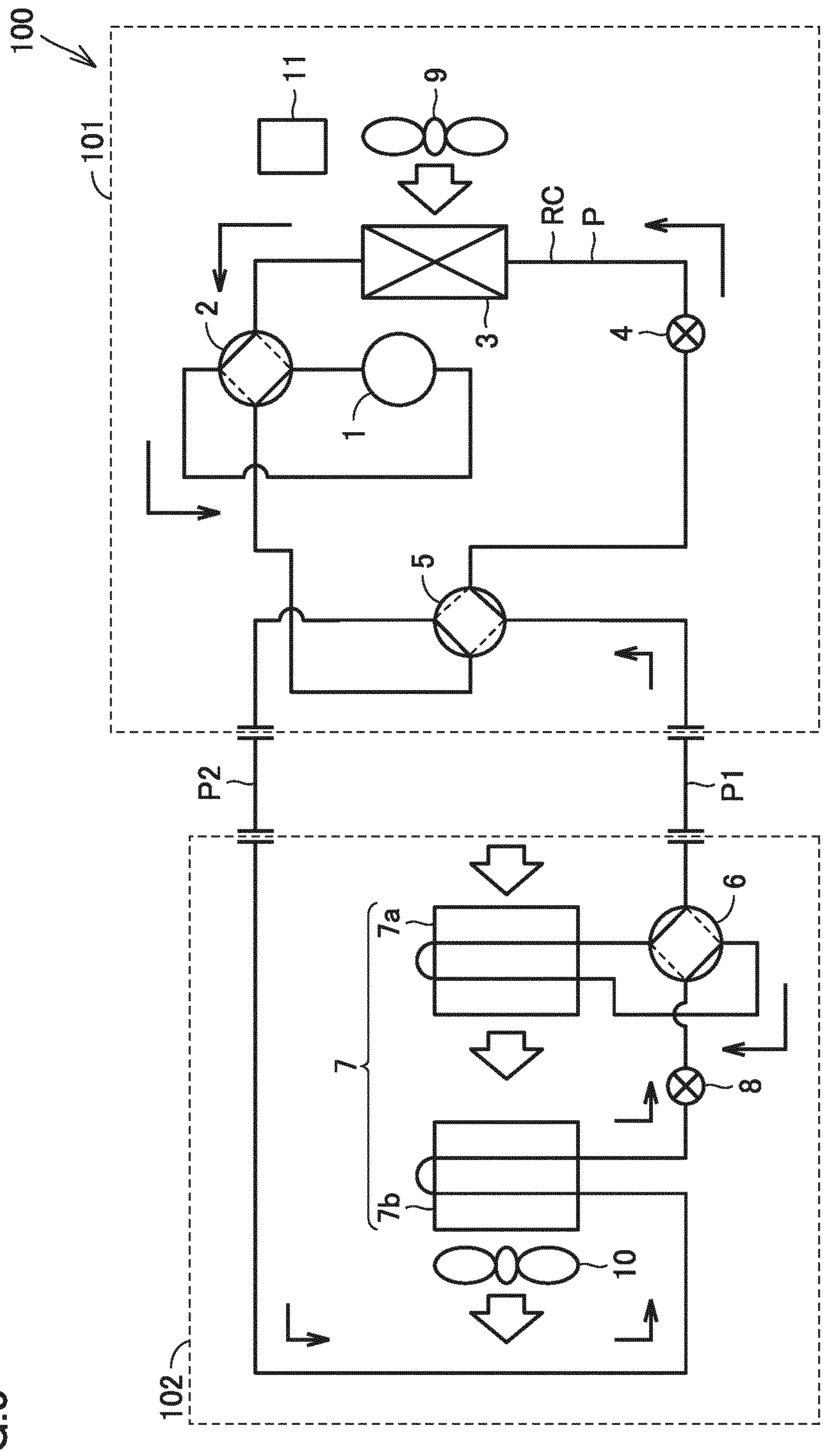



FIG.5

FIG.6

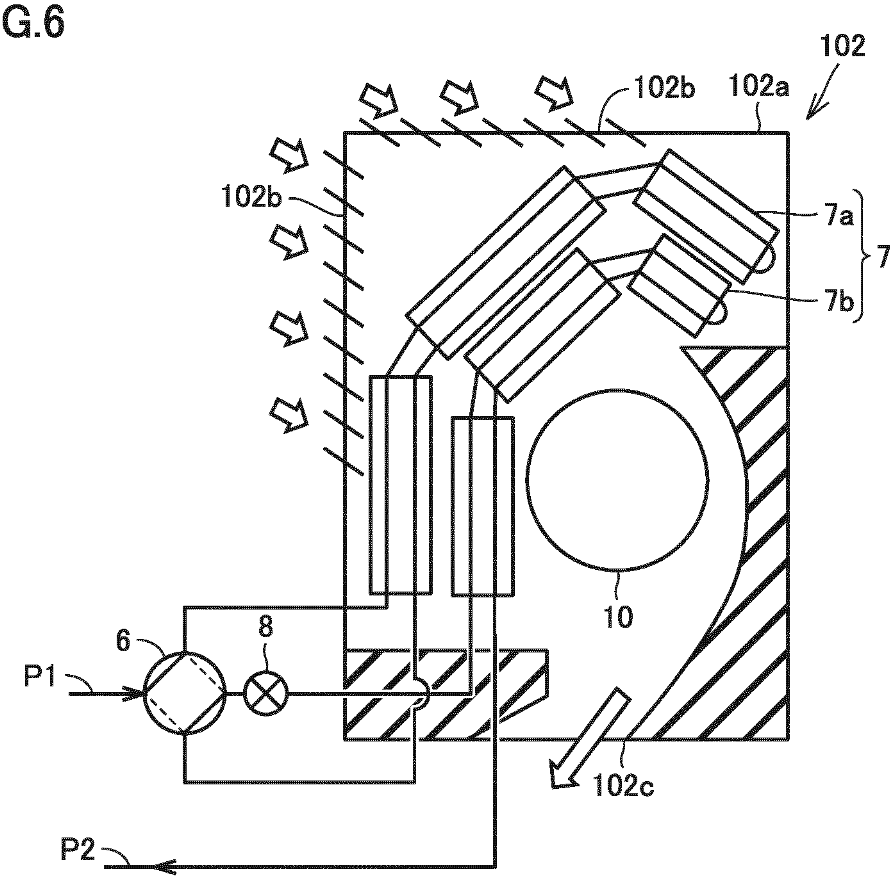
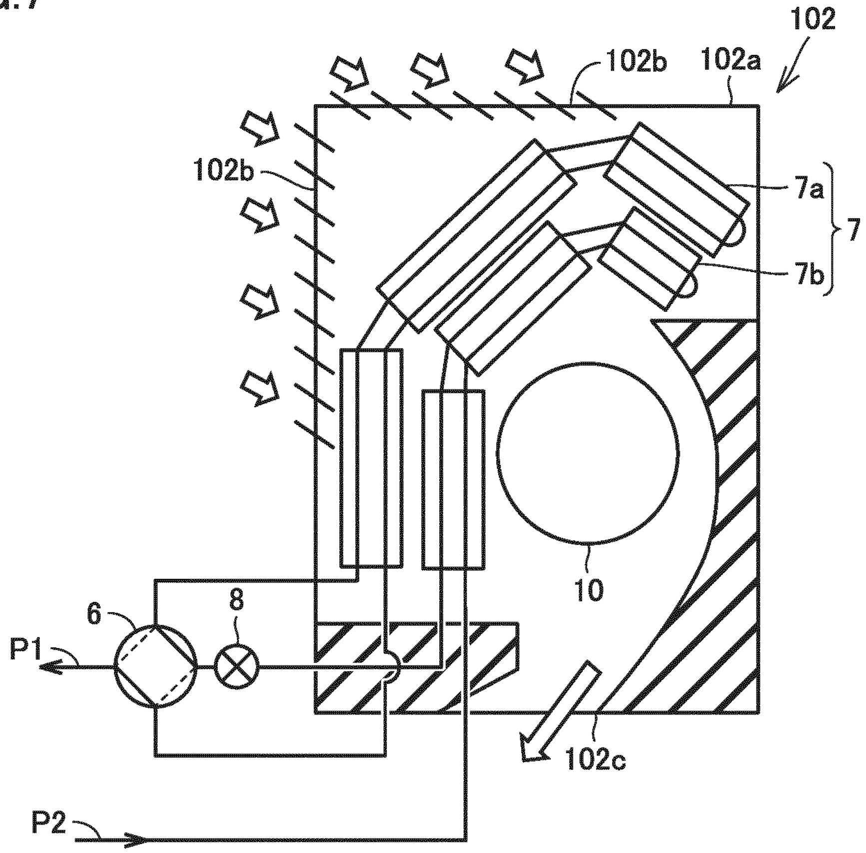


FIG.7



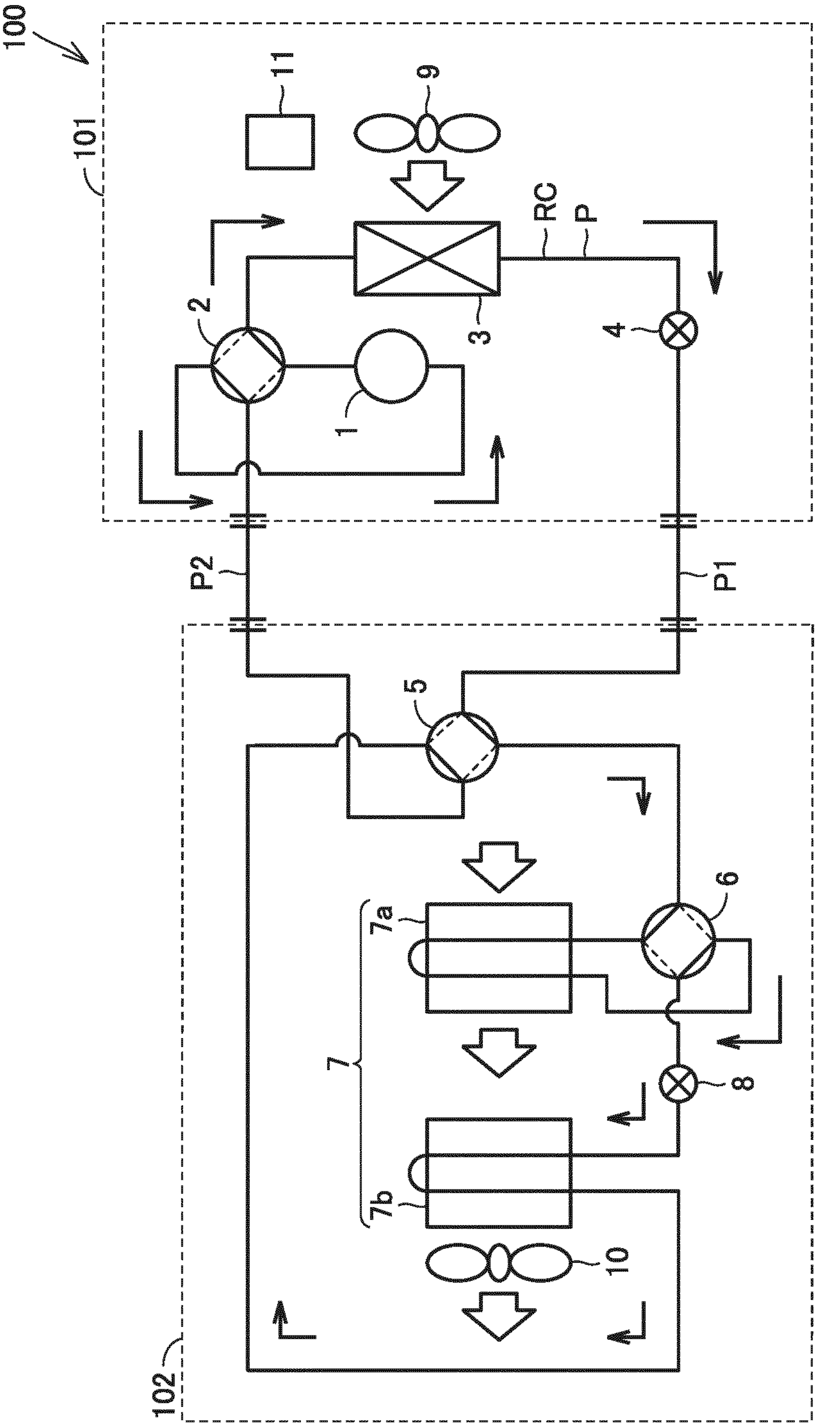
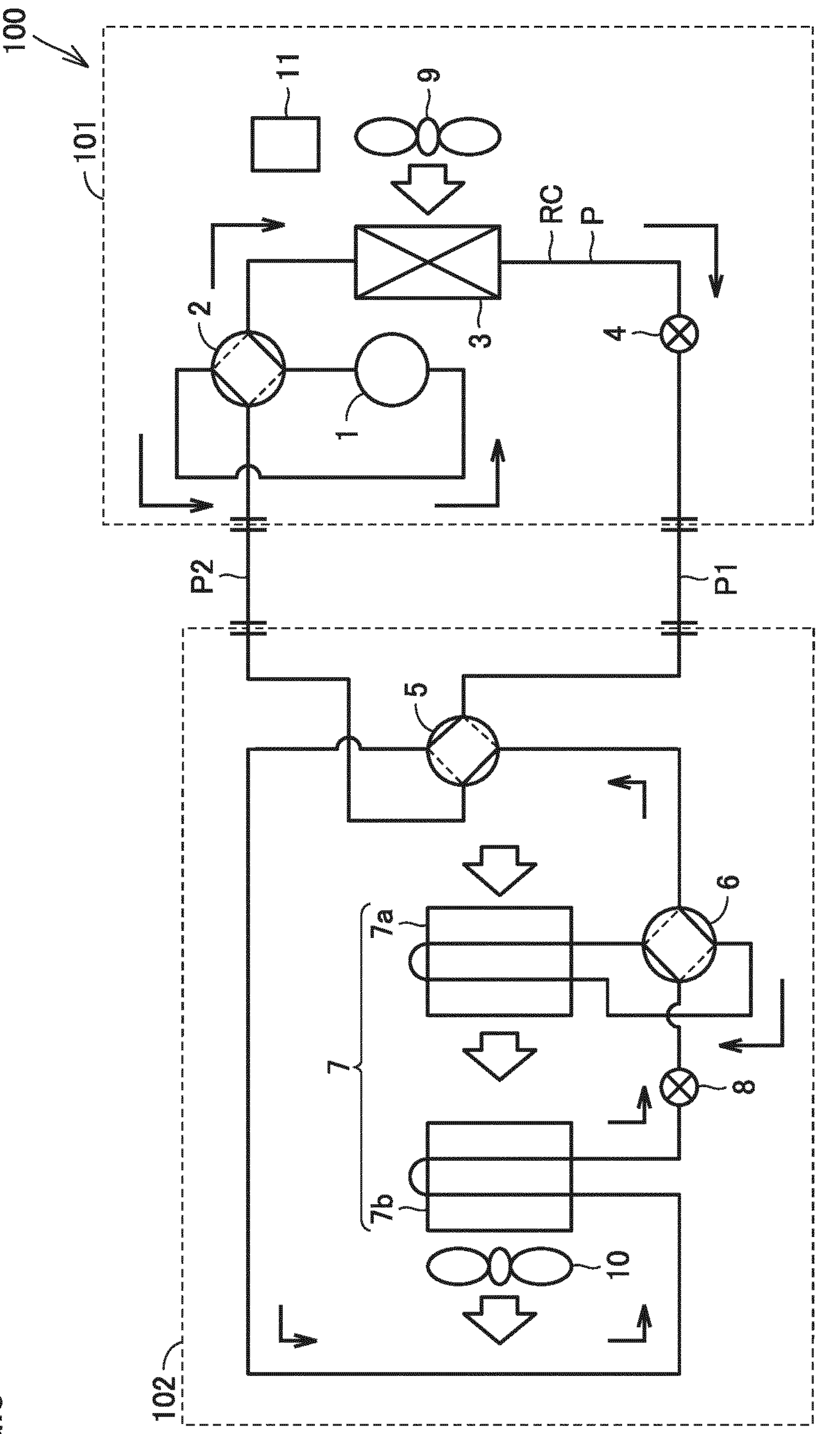



FIG.8

FIG.9



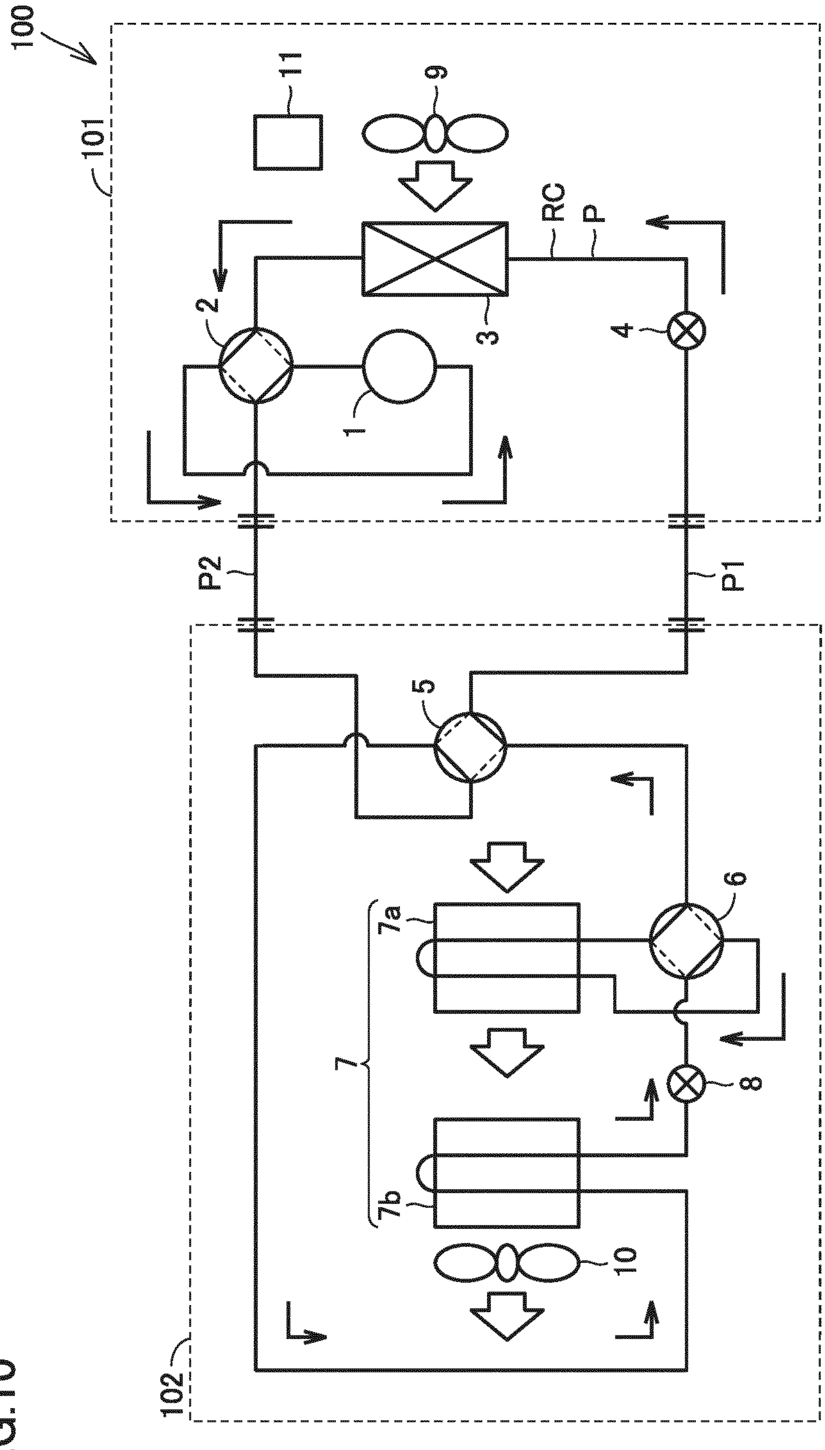



FIG.10

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/014805

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B5/04(2006.01)i, F25B13/00(2006.01)i, F25B29/00(2006.01)i, F25B1/00(2006.01)i, F24F11/86(2018.01)i, F24F1/0063(2019.01)i
FI: F25B13/00103, F25B1/00303, F25B1/00383, F25B5/04Z, F25B29/00391Z, F25B29/00411C, F24F1/0063, F24F11/86
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F25B1/00, F25B5/04, F25B13/00, F25B29/00, F24F1/0063, F24F11/86

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

| | |
|---|---|
| Published examined utility model applications of Japan | 1922-1996 |
| Published unexamined utility model applications of Japan | 1971-2021 |
| Registered utility model specifications of Japan | 1996-2021 |
| Published registered utility model applications of Japan | 1994-2021 |

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. |
|---|---|---|
| A | JP 2020-125855 A (DAIKIN INDUSTRIES, LTD.) 20 August 2020 (2020-08-20), fig. 1, 5 | 1-2 |
| A | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 113477/1973 (Laid-open No. 60840/1975) (SANYO ELECTRIC CO., LTD.) 04 June 1975 (1975-06-04), fig. 2 | 1-2 |
| A | JP 2009-109064 A (HITACHI APPLIANCES INC.) 21 May 2009 (2009-05-21), fig. 11, 21-23 | 1-2 |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 23 April 2021 | 11 May 2021 |

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

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

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
PCT/JP2021/014805

| | | |
|---|---|---|
| JP 2020-125855 A | 20 August 2020 | (Family: none) |
| JP 50-60840 U1 | 04 June 1975 | (Family: none) |
| JP 2009-109064 A | 21 May 2009 | (Family: none) |

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

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2020125855 A **[0002] [0003]**