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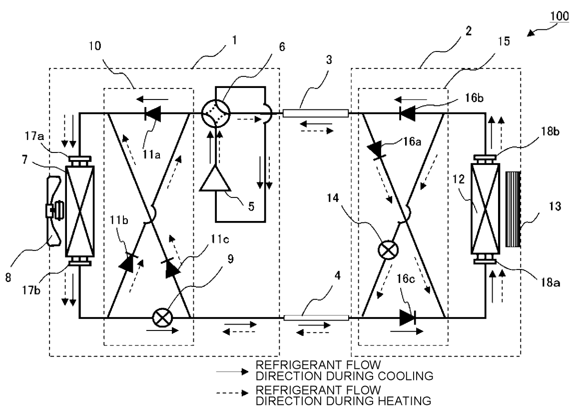
(54) **REFRIGERATION CYCLE DEVICE**

(57) To provide a refrigeration cycle device that has a refrigerant flow path with a structure to form a counter flow of air and refrigerant not only during cooling, but also during heating, and that allows low-pressure two-phase refrigerant to flow through a liquid pipe and can thereby reduce the amount of refrigerant needed. The refrigeration cycle device includes: an outdoor unit 1 including a compressor 5, a four-way valve 6, an outdoor heat exchanger 7, and an outdoor expansion valve 9, the four-way valve 6 being configured to switch between cooling operation and heating operation; an indoor unit 2 including an indoor heat exchanger 12 and an indoor expansion valve 14; and a gas pipe 3 and a liquid pipe 4 configured to connect the outdoor unit 1 and the indoor unit 2; and at least either one of a first bridge circuit 10 having a configuration including a plurality of flow path opening-closing units 11 to allow the refrigerant to flow through the outdoor heat exchanger 7 in the same direction both during the cooling operation and during the heating operation, and a second bridge circuit 15 having a configuration including a plurality of flow path opening-closing units 16 to allow the refrigerant to flow through the indoor heat exchanger 12 in the same direction both during the cooling operation and during the heating operation.

FIG. 1

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## Description

Technical Field

[0001] The present disclosure relates to a refrigeration cycle device that conditions air, and particularly relates to a refrigeration cycle device configured to be capable of switching between cooling operation and heating operation.

Background Art

[0002] Many of the current refrigeration cycle devices that condition air are configured to change the refrigerant flow directions to select either cooling operation or heating operation.

[0003] In recent years, for the purpose of reducing the global warming performance (GWP) of refrigerant filled in a refrigeration cycle device, application of a non-azeotropic refrigerant mixture, in which multiple types of refrigerants with different boiling points are mixed together, has been under consideration.

[0004] The non-azeotropic refrigerant mixture has properties that the saturation temperature varies between the process of condensation and the process of evaporation. In view of that, a heat exchanger that exchanges heat between air and refrigerant is designed to have a flow direction of air and a flow direction of refrigerant such that heat is exchanged between the air on its inlet side and the refrigerant on its outlet side, and such that heat is exchanged between the refrigerant on its inlet side and the air on its outlet side. That is, the heat exchanger is designed to form such a counter flow as to easily ensure a sufficient temperature difference between air and refrigerant in the entirety of the heat exchanger.

[0005] However, in a refrigeration cycle device that switches between the refrigerant flow direction for cooling operation and the refrigerant flow direction for heating operation, when either the flow direction for cooling operation or the flow direction for heating operation is selected, the heat exchanger forms a parallel flow of refrigerant and air, which degrades its performance.

[0006] A method to avoid the problems as described above has been known as employing a bridge circuit that uses a plurality of check valves to thereby prevent the positions of refrigerant inlet and refrigerant outlet of a heat exchanger from being reversed between during cooling and during heating, so that the heat exchanger forms a counter flow of refrigerant and air not only during cooling, but also during heating (for example, Patent Literature 1).

Citation List

Patent Literature

[0007] Patent Literature 1: Japanese Unexamined Patent Application Publication No. H09-178283

Summary of Invention

Technical Problem

[0008] However, in the refrigeration cycle device having the configuration as disclosed in Patent Literature 1, condensed and liquified high-pressure refrigerant flows through a liquid pipe extending between an outdoor heat exchanger and an indoor heat exchanger not only during cooling operation, but also during heating operation. This results in a problem that the amount of refrigerant needed is increased.

[0009] In addition, the indoor side expansion valve needs to be fully closed when cooling operation is selected, and the outdoor side expansion valve needs to be fully closed when heating operation is selected. This results in a problem that the expansion valves frequently operate to be opened and closed, which degrades the durability of the expansion valves.

[0010] The present disclosure has been made to solve the above problems, and it is an object of the present disclosure to provide a refrigeration cycle device that has a configuration in which at least either one of an outdoor heat exchanger and an indoor heat exchanger forms a counter flow not only during cooling, but also during heating, and that can reduce the amount of refrigerant needed.

Solution to Problem

[0011] To achieve the above object, a refrigeration cycle device according to an embodiment of the present disclosure includes:

an outdoor unit including a compressor, a four-way valve, an outdoor heat exchanger, and an outdoor expansion valve, the four-way valve being configured to switch between cooling operation and heating operation;
an indoor unit including an indoor heat exchanger and an indoor expansion valve; and
a gas pipe and a liquid pipe configured to connect the outdoor unit and the indoor unit to form a refrigerant circuit, the refrigerant circuit being filled with a non-azeotropic refrigerant mixture, wherein
the refrigeration cycle device comprises at least either one of
a first bridge circuit accommodated in the outdoor unit, the first bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the non-azeotropic refrigerant mixture to flow through the outdoor heat exchanger in a same direction both during the cooling operation and during the heating operation, a flow path opening-closing unit of the plurality of flow path opening-closing units, installed in a flow path connecting the liquid pipe and

an outlet side of the outdoor heat exchanger, being the outdoor expansion valve, and

a second bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the non-azeotropic refrigerant mixture to flow through the indoor heat exchanger in a same direction both during the cooling operation and during the heating operation, a flow path opening-closing unit of the plurality of flow path opening-closing units, installed in a flow path connecting the liquid pipe and an outlet side of the indoor heat exchanger, being the indoor expansion valve. Advantageous Effects of Invention

**[0012]** In the refrigeration cycle device according to an embodiment of the present disclosure, the first bridge circuit and the second bridge circuit allow the outdoor heat exchanger and the indoor heat exchanger to form a counter flow both during cooling and during heating. Thus, even when a non-azeotropic refrigerant mixture is applied as refrigerant, the heat exchangers still ensure a sufficient temperature difference between air and the refrigerant from their inlet to outlet, and can thereby exchange heat efficiently, so that the performance of the refrigeration cycle device is improved.

**[0013]** The refrigerant flowing through the liquid pipe is brought into a low-pressure two-phase state not only during cooling operation, but also during heating operation. The liquid pipe is not filled with liquid refrigerant in any operational state, so that the amount of refrigerant filled in the refrigerant circuit can be reduced.

Brief Description of Drawings

**[0014]**

[Fig. 1] Fig. 1 is a refrigerant circuit configuration diagram of a refrigeration cycle device according to Embodiment 1.

[Fig. 2] Fig. 2 is a schematic diagram illustrating a relationship between an air flow direction and a refrigerant flow path of an outdoor heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a graph illustrating an example of temperature variations from when refrigerant and air enter a condenser to when the refrigerant and the air flow out of the condenser.

[Fig. 4] Fig. 4 is a graph illustrating an example of temperature variations from when refrigerant and air enter an evaporator to when the refrigerant and the air flow out of the evaporator.

[Fig. 5] Fig. 5 is a refrigerant circuit configuration diagram of a refrigeration cycle device according to Embodiment 2.

[Fig. 6] Fig. 6 is a sectional view illustrating the configuration of the flow path extending from an indoor heat exchanger outlet to a liquid pipe in an indoor bridge circuit according to Embodiment 2.

[Fig. 7] Fig. 7 is a refrigerant circuit configuration diagram of a refrigeration cycle device according to Embodiment 3.

[Fig. 8] Fig. 8 is a refrigerant circuit configuration diagram of a refrigeration cycle device according to Embodiment 4.

Description of Embodiments

**[0015]** Hereinafter, the refrigeration cycle device according to the embodiments of the present disclosure will be described in detail with reference to the drawings. Note that the same or equivalent components in the drawings below are denoted by the same reference numerals, and descriptions thereof are not repeated.

Embodiment 1

Configuration of refrigeration cycle device

**[0016]** Fig. 1 is a refrigerant circuit configuration diagram of a refrigeration cycle device according to Embodiment 1 of the present disclosure. As illustrated in Fig. 1, in a refrigeration cycle device 100, an outdoor unit 1 and an indoor unit 2 are connected by a gas pipe 3 and a liquid pipe 4, forming a single refrigerant circuit. This refrigerant circuit is filled with R407C that is a refrigerant mixture of three types of HFC refrigerants with different boiling points. The refrigerant to be filled is not limited to this refrigerant mixture. For example, a refrigerant mixture of HFO refrigerants, R1234yf and R32, may also be employed. A refrigerant mixture containing an HC refrigerant such as R290 or a natural refrigerant such as $CO_2$ as one of the components may also be employed.

**[0017]** The outdoor unit 1 has a compressor 5, a four-way valve 6, an outdoor heat exchanger 7, an outdoor fan 8, and an outdoor bridge circuit 10 incorporated therein. The operational capacity of the compressor 5 is adjustable. On the upstream side and the downstream side of the outdoor heat exchanger 7, an outdoor inlet header 17a and an outdoor outlet header 17b are installed that each have an end connected to the outdoor bridge circuit 10 on the opposite side to the outdoor heat exchanger 7. The outdoor fan 8 provided along with the outdoor heat exchanger 7 changes the amount of air delivered to the outdoor heat exchanger 7 to adjust the amount of heat exchange between refrigerant and outside air.

**[0018]** The outdoor bridge circuit 10 includes four inlet/outlet ports in total at one end of the outdoor inlet header 17a described above, at one end of the outdoor outlet header 17b described above, at one end of the four-way valve 6, and at a connection end with the liquid pipe 4. The outdoor bridge circuit 10 is made up of three check valves 11a, 11b, and 11c, and an outdoor expansion valve 9. The outdoor expansion valve 9 has a configuration in which its valve body is movable by a pulse motor or other motor. The opening degree of the outdoor expansion valve 9 is adjustable continuously from a fully closed state to a fully opened state. In the outdoor bridge circuit 10, a refrigerant flow path is formed such that refrigerant flows toward the indoor inlet header 17a not only during cooling operation in which refrigerant enters from the four-way valve 6, but also during heating operation in which refrigerant enters from the liquid pipe 4.

**[0019]** The indoor unit 2 has an indoor heat exchanger 12, an indoor fan 13, and an indoor bridge circuit 15 incorporated therein. The indoor fan 13 is configured to adjust the amount of heat exchange between refrigerant flowing through the indoor heat exchanger 12 and the room air. At opposite ends of the indoor heat exchanger 12, an indoor inlet header 18a and an indoor outlet header 18b are installed, while being connected to the indoor bridge circuit 15 at an end of the respective headers on the opposite side to the indoor heat exchanger 12.

**[0020]** The indoor bridge circuit 15 includes three check valves 16a, 16b, and 16c, and an indoor expansion valve 14. Similarly to the outdoor expansion valve 9, the opening degree of the indoor expansion valve 14 is adjustable continuously from a fully closed state to a fully opened state. In the indoor bridge circuit 15, a refrigerant flow path is formed such that refrigerant flows through the indoor heat exchanger 12 from the indoor inlet header 18a not only during cooling operation in which refrigerant enters from the liquid pipe 4, but also during heating operation in which refrigerant enters from the gas pipe 3.

**[0021]** Fig. 2 is a schematic diagram illustrating a relationship between an air flow direction and a refrigerant flow path of the outdoor heat exchanger 7. The outdoor heat exchanger 7 is made up of a plurality of heat transfer tubes 19 and a plurality of layered fins 20. The heat transfer tubes 19 are circular tubes made of copper. In the present embodiment, the heat transfer tubes 19 are lined up in six in the vertical direction and arranged in four rows in the air flow direction. The fins 20, each of which is a thin plate made of aluminum with a thickness of approximately 0.1 mm, are layered with a 1 to 2 mm spacing in between.

**[0022]** A flow of refrigerant into the outdoor heat exchanger 7 is divided at the outdoor inlet header 17a into three flows. The three flows of refrigerant enter the outdoor heat exchanger 7, move in the row direction while flowing back and forth in the direction in which the fins 20 are layered, and then merge at the outdoor outlet header 17b. In contrast, a flow of the outside air generated by the outdoor fan 8 (not illustrated) moves from the right side to the left side on the drawing, so that a commonly-called counter flow is formed, in which the air and the refrigerant exchange heat between the air inlet side and the refrigerant outlet side and between the air outlet side and the refrigerant inlet side. The indoor heat exchanger 12 also has the same configuration as this configuration, in which the refrigerant inlet and the air outlet are thermally in contact with each other, while the refrigerant outlet and the air inlet are thermally in contact with each other. Subsequently, refrigerant control during cooling operation and during heating operation is described.

Cooling operation

**[0023]** During cooling operation, in the four-way valve 6 illustrated in Fig. 1, an internal flow path is set in a direction of the solid line. Refrigerant discharged from the compressor 5 enters the outdoor bridge circuit 10 via the four-way valve 6. The refrigerant having entered the outdoor bridge circuit 10 passes through the check valve 11a, and enters the indoor heat exchanger 12 from the inlet header 17a. At this time, the check valve 11b is closed because the pressure on the outlet side is increased to a high level. The refrigerant, having transferred heat to the outside air in the indoor heat exchanger 12 and then condensed and liquified, passes through the outdoor outlet header 17b, enters the outdoor bridge circuit 10 again, and is then reduced in pressure by the outdoor expansion valve 9 into low-pressure two-phase refrigerant. The opening degree of the outdoor expansion valve is controlled, for example, in such a manner that the temperature of gas refrigerant discharged from the compressor 5 reaches its target value.

**[0024]** The refrigerant in a low-pressure two-phase state having flowed out of the outdoor unit 1 passes through the liquid pipe 4 and enters the indoor unit 2. In the indoor unit 2, the refrigerant enters the indoor bridge circuit 15, passes through the check valve 16c, and enters the indoor heat exchanger 12 from the indoor inlet header 18a. At this time, the indoor expansion valve 14 is closed to prevent the refrigerant from flowing through the indoor expansion valve 14.

**[0025]** The refrigerant having entered the indoor heat exchanger 12 is heated by the room air, then evaporates into low-pressure gas refrigerant, and flows out of the indoor outlet header 18b. The refrigerant having flowed out of the indoor heat exchanger 12 enters the indoor bridge circuit 15 again, passes through the check valve 16b, and flows out of the indoor unit 2.

**[0026]** The refrigerant having flowed out of the indoor unit 2 flows through the gas pipe 3, returns to the outdoor unit 1, and is then suctioned into the compressor 5 via the four-way valve 6. In this manner, the non-azeotropic refrigerant filled in the refrigeration cycle device 100 circulates in the refrigerant circuit to perform cooling operation.

**[0027]** As explained above, during cooling operation, since the refrigerant having condensed in the outdoor heat exchanger 7 is reduced in pressure by the outdoor expansion valve 9, the refrigerant flowing through the liquid pipe 4 is low-pressure two-phase refrigerant. The temperature of the low-pressure two-phase refrigerant is relatively low. When the liquid pipe 4 is in contact with the outside air, condensation of water contained in the outside air can occur. It is thus necessary to insulate the liquid pipe 4 sufficiently. Meanwhile, the density of the low-pressure two-phase refrigerant is lower than that of high-pressure liquid refrigerant having condensed in the outdoor heat exchanger 7. Thus, the amount of refrigerant filled in the refrigerant circuit can be reduced.

**[0028]** Fig. 3 is a graph illustrating an example of temperature variations from when refrigerant and air enter the condenser to when the refrigerant and the air flow out of the condenser. Fig. 4 is a graph illustrating an example of temperature variations from when refrigerant and air enter the evaporator to when the refrigerant and the air flow out of the evaporator. In Figs. 3 and 4, the vertical axis represents the temperature, while the horizontal axis represents the relative positions of refrigerant and air on the path extending from the inlet to the outlet of the heat exchanger. Since the condenser and evaporator illustrated in Figs. 3 and 4 have a structure to form a counter flow, refrigerant flows through the condenser or the evaporator from the left-side end A toward the right-side end B on the horizontal axis, while air flows through the condenser or the evaporator from the right-side end B toward the left-side end A. The section C on the horizontal axis shows that the refrigerant is in a two-phase gas-liquid state.

**[0029]** Fig. 3 illustrates variations in the temperature of air and the temperature of refrigerant inside the outdoor heat exchanger 7 that operates as a condenser during cooling operation in this embodiment. The refrigerant enters the outdoor heat exchanger 7 in a high-temperature gas state at a temperature of approximately 70 degrees C. This refrigerant flows through the outdoor heat exchanger 7, is cooled by the air, and then starts liquefying at a temperature of around 50 degrees C. Since the refrigerant is a non-azeotropic refrigerant mixture, the temperature of this refrigerant gradually decreases even in the section C in which the refrigerant is in a two-phase state, and further decreases even after the refrigerant has liquefied completely. On the outlet side of the outdoor heat exchanger 7, the refrigerant is cooled to a temperature close to the air inlet temperature at 35 degrees C to ensure a predetermined degree of subcooling. Thereafter, the refrigerant flows out of the outdoor heat exchanger 7. In contrast, a phase change of the air does not occur during the process of exchanging heat. Thus, after entering the outdoor heat exchanger 7 at a temperature of 35 degrees C, the air is heated with heat from the refrigerant, which simply increases the air temperature.

**[0030]** In the condenser having the structure to form a counter flow as described above, the air at a sufficiently high temperature on the air outlet side exchanges heat with high-temperature gas refrigerant on the refrigerant inlet side, while the subcooled liquid refrigerant on the refrigerant outlet side exchanges heat with the outside air on the air inlet side. Even after the refrigerant has changed from the two-phase gas-liquid state to a single-phase liquid state, a sufficient temperature difference between this refrigerant and the air is still ensured, so that the condenser can exchange heat with high efficiency.

**[0031]** Fig. 4 illustrates temperature variations in the indoor heat exchanger 12 that serves as an evaporator during cooling operation in this embodiment. Refrigerant that enters the indoor heat exchanger 12 is in a low-pressure two-phase state at a temperature of approximately 10 degrees C at the refrigerant inlet A. The temperature of the refrigerant gradually increases, while this refrigerant exchanges heat with the room air. This refrigerant flows out of the section C showing that the refrigerant is in a two-phase state. Thereafter, the refrigerant further exchanges heat with the room air, and then flows out of the refrigerant outlet B in a low-pressure gas state with a predetermined degree of superheat.

**[0032]** In contrast, the temperature of air at the air inlet B is the room temperature at approximately 27 degrees C. The air is cooled by the refrigerant to a lower temperature of approximately 15 degrees C at the air outlet A. The cooling operation is performed by delivering this lower-temperature air to the room.

**[0033]** In the evaporator having the structure to form a counter flow as described above, due to the properties of non-azeotropic refrigerant mixture, the refrigerant and the air exchange heat at the refrigerant inlet where the refrigerant temperature is lowest and at the air outlet where the air temperature is lowest. This allows the evaporator to efficiently cool the air, and also allows the refrigerant to exchange heat with the room air on the refrigerant outlet side where the room air is maintained at a high temperature. Thus, the refrigerant can obtain a sufficient degree of superheat.

Heating operation

**[0034]** During heating operation, in the four-way valve 6 illustrated in Fig. 1, an internal flow path is set in a direction of the dotted line. Refrigerant discharged from the compressor 5 flows out of the outdoor unit 1 via the four-way valve 6. The refrigerant having flowed out of the outdoor unit 1 enters the indoor unit 2 via the gas pipe 3, and initially enters the indoor bridge circuit 15. In the indoor bridge circuit 15, the refrigerant passes through the check valve 16a, then flows out of the indoor bridge circuit 15, and enters the indoor heat exchanger 12 from the indoor inlet header 18a. At this time, the check valve 16b is closed because the pressure on the outlet side is increased to a high level.

**[0035]** In the indoor heat exchanger 12, refrigerant transfers heat to the room air to condense and liquify, and then flows out of the indoor heat exchanger 12 from the indoor outlet header 18b. The refrigerant having flowed out of the indoor heat exchanger 12 enters the indoor bridge circuit 15 again, and is reduced in pressure by the indoor expansion valve 14 to be brought into a low-pressure two-phase state.

**[0036]** The refrigerant having been brought into a low-pressure two-phase state flows out of the indoor unit 2, and then enters the outdoor unit 1 via the liquid pipe 4. In the outdoor unit 1, the refrigerant passes through the check valve 11c provided in the outdoor bridge circuit 10, and enters the outdoor heat exchanger 7 from the outdoor inlet header 17a.

**[0037]** In the outdoor heat exchanger 7, refrigerant is heated by the outside air to be brought into a low-pressure gas state, and enters the outdoor bridge circuit 10 again via the outdoor outlet header 17b. At this time, the outdoor expansion valve 9 is closed, and thus the refrigerant passes through the check valve 11b and flows out of the outdoor bridge circuit 10. Subsequently, the refrigerant is suctioned into the compressor 5 again via the four-way valve 6.

**[0038]** As described above, in the refrigeration cycle device 100 in the present Embodiment 1, refrigerant flowing through the outdoor heat exchanger 7 and the indoor heat exchanger 12 forms, along with the air, a counter flow not only during cooling operation, but also during heating operation. With this configuration, the heat exchangers ensure a sufficient temperature difference between the air and the refrigerant from their inlet to outlet, and can thereby exchange heat efficiently, so that the performance of the refrigeration cycle device is improved. This effect is exhibited significantly when the refrigeration cycle device 100 uses a non-azeotropic refrigerant mixture.

**[0039]** Note that while a bridge circuit is accommodated in each of the outdoor unit 1 and the indoor unit 2 in the present embodiment, even when either the outdoor unit 1 or the indoor unit 2 is provided with the bridge circuit, the heat exchange efficiency in either one provided with the bridge circuit is still improved. Therefore, the effect of improving the performance of the refrigeration cycle device can be obtained.

**[0040]** Further, in the refrigeration cycle device in the present embodiment, refrigerant flowing through the liquid pipe 4 is brought into a low-pressure two-phase state not only during cooling operation, but also during heating operation. The liquid pipe 4 is not filled with liquid refrigerant in any operational state, so that the amount of refrigerant filled in the refrigerant circuit can be reduced.

Embodiment 2

**[0041]** Fig. 5 is a refrigerant circuit configuration diagram of a refrigeration cycle device 101 according to Embodiment 2 of the present disclosure. In contrast to the refrigeration cycle device 100 according to Embodiment 1, the refrigeration cycle device 101 includes a check valve 11d installed in the flow path of an outdoor bridge circuit 110, in which the outdoor expansion valve 9 is located. In the flow path of an indoor bridge circuit 115, in which the indoor expansion valve 14 is located, a check valve 16d is installed and also a rectifier 20 is installed on the upstream side of the indoor expansion valve 14.

**[0042]** In the outdoor bridge circuit 110, the check valve 11d mechanically blocks the flow path provided with the outdoor expansion valve 9 to prevent the refrigerant, entering the outdoor unit 1 from the liquid pipe 4 during heating operation, from flowing toward the outlet side of the indoor heat exchanger 12. Due to this configuration, a refrigerant circuit for heating operation is formed without fully closing the outdoor expansion valve 9 during heating operation.

**[0043]** The operation of the expansion valve to be fully closed often involves operation of the valve body frequently colliding against the valve seat. Thus, particularly on such an operational condition that cooling and heating are alternately performed, this operation promotes the wearing out of the expansion valve. According to the present embodiment, the number of times of controlling the opening degree of the outdoor expansion valve 9 is decreased, so that deterioration of the outdoor expansion valve 9 over time can be reduced.

**[0044]** Similarly to the outdoor bridge circuit 110, in the indoor bridge circuit 115, the check valve 16d mechanically stops refrigerant from flowing from the liquid pipe 4 toward the outlet side of the indoor heat exchanger 12 during cooling operation. This eliminates the need for fully closing the outdoor expansion valve 14 during cooling operation. This decreases the number of times of controlling the opening degree of the indoor expansion valve 14, so that deterioration of the indoor expansion valve 14 over time can be reduced.

**[0045]** Fig. 6 is a sectional view illustrating the flow path configuration provided with the indoor expansion valve 14 in the indoor bridge circuit 115. A rectifier 20 includes a rectification portion 21 therein. The rectification portion 21 is made of metallic mesh or foam metal. Even in a circumstance where bubbles do not continuously flow to the inlet of the expansion valve 14, such as a case where a refrigerant distribution is unstable immediately after the refrigeration cycle device 100 has started heating operation, the rectifier 20 still converts the bubbles to a uniform flow of bubbles in the rectification portion 21. This prevents generation of irregular vibration or refrigerant flow sound in the indoor expansion valve 14, and ensures the comfort of the room environment without being impaired by noise from the refrigeration cycle device.

**[0046]** As described above, the refrigeration cycle device 101 according to Embodiment 2 can achieve the same effects as those obtained by the refrigeration cycle device 100 according to Embodiment 1. Further, the refrigeration cycle device 101 includes the check valves 11d and 16d, so that the number of times of controlling the opening degree of the outdoor expansion valve 9 and the indoor expansion valve 14 is decreased, and thus deterioration of the expansion valves over time can be reduced. Furthermore, the refrigeration cycle device 101 includes the rectifier 20, and therefore can provide comfortable air-conditioned environment without generating refrigerant flow sound or irregular vibration in the room.

Embodiment 3

**[0047]** Fig. 7 is a refrigerant circuit configuration diagram of a refrigeration cycle device 102 according to Embodiment 3 of the present disclosure. In contrast to the refrigeration cycle device 100 according to Embodiment 1, the refrigeration cycle device 102 has an indoor bridge circuit 215 that is located independently from the indoor unit 2, instead of being incorporated in the indoor unit 2. Indoor units 2a, 2b, and 2c are connected in parallel to the indoor bridge circuit 215, and include opening-closing valves 22a, 22b, and 22c, respectively, on the refrigerant inlet side of indoor heat exchangers 12a, 12b, and 12c. The opening-closing valves 22a, 22b, and 22c can block refrigerant from flowing through the indoor heat exchangers 12a, 12b, and 12c.

**[0048]** The refrigeration cycle device 102 is an air-conditioning device for multiple rooms. The indoor units 2a, 2b, and 2c are installed in the respective rooms to control the air temperature in their respective rooms. At this time, assuming that each of the indoor units 2a, 2b, and 2c is provided with each individual indoor bridge circuit 15 as described in Embodiment 1 or Embodiment 2, the air conditioning capacity cannot be adjusted for each individual room during cooling operation. For this reason, when the air conditioning loads are unbalanced between the rooms, the air conditioning capacity may be excessive or insufficient depending on the air conditioning load in each of the rooms.

**[0049]** The refrigeration cycle device 102 includes the opening-closing valves 22a, 22b, and 22c in individual indoor units. Thus, when the air conditioning capacity becomes excessive for a certain room during cooling operation or heating operation, the corresponding opening-closing valve is closed temporarily to prevent the air conditioning capacity for the certain room from being fully utilized. With this configuration, even when a plurality of indoor units are connected, it is still possible to independently control the air conditioning capacity for each individual indoor unit, so that the refrigeration cycle device 102 can provide comfortable air-conditioned environment.

**[0050]** Since the refrigeration cycle device 102 has a configuration in which a plurality of indoor units are connected to a single unit of indoor bridge circuit 215, the number of components that make up the bridge circuit, such as a check valve, is reduced, and accordingly the manufacturing costs are reduced.

**[0051]** As described above, the refrigeration cycle device 102 according to Embodiment 3 can still achieve the same effects as those obtained by the refrigeration cycle device 100 according to Embodiment 1, even when the refrigeration cycle device 102 connects to a plurality of indoor units to serve as an air-conditioning device for multiple rooms. That is, the outdoor heat exchanger 7 and the indoor heat exchangers 12a, 12b, and 12c can form a counter flow, and also change the refrigerant flowing through the liquid pipe 4 to low-density two-phase refrigerant not only during cooling, but also during heating. Further, the air conditioning capacity for each individual indoor unit can be adjusted, so that even when the air conditioning loads are unbalanced between the rooms, the refrigeration cycle device 102 can still provide comfortable air-conditioned environment.

**[0052]** The refrigerant circuit is made up of a single unit of indoor bridge circuit 215 for a plurality of indoor units 2a, 2b, and 2c, so that the number of components that make up the refrigerant circuit, such as a check valve, is reduced and accordingly the manufacturing costs can be reduced.

Embodiment 4

**[0053]** Fig. 8 is a refrigerant circuit configuration diagram of a refrigeration cycle device 103 according to Embodiment 4 of the present disclosure. In contrast to the refrigeration cycle device 100 according to Embodiment 1, the refrigeration cycle device 103 uses a mechanical fixed throttle 31 such as a capillary tube as an expansion unit incorporated in an indoor bridge circuit 315. The outdoor expansion valve 9 is not incorporated in the outdoor bridge circuit 10, but is located between the liquid pipe 4 and one end of the outdoor bridge circuit 10.

**[0054]** In the indoor bridge circuit 315, the fixed throttle 31 located in series to the flow path provided with the check valve 16d is designed to have such a flow resistance as to reduce the pressure of high-pressure liquid refrigerant, having flowed out of the indoor heat exchanger 12 during heating operation, to a two-phase gas-liquid state. During heating operation, the refrigerant having been brought into a two-phase gas-liquid state by the fixed throttle 31 enters the outdoor unit 1 via the liquid pipe 4.

**[0055]** The refrigerant having entered the outdoor unit 1 is further reduced in pressure by the outdoor expansion valve 9, and thereafter enters an outdoor bridge circuit 310. At this time, the opening degree of the outdoor expansion valve 9 is controlled, for example, in such a manner that the temperature of gas discharged from the compressor 5 reaches its target value. That is, in the refrigeration cycle device 103 according to the present Embodiment 4, first the fixed throttle 31 located in the outdoor bridge circuit 315 reduces the pressure of refrigerant that flows through the liquid pipe 4 into a two-phase state, and further the outdoor expansion valve 9 reduces the pressure of this refrigerant to an appropriate level.

**[0056]** Since the indoor bridge circuit 315 is made up of only the check valves 16a, 16b, 16c, and 16d, and the fixed throttle 31, the indoor bridge circuit 315 does not need a power source or a signal for controlling the opening degree. Due to this configuration, it is unnecessary to connect electric wires to the indoor bridge circuit 315, so that the installation location is less limited, while the installation work is simplified.

**[0057]** The opening degree of the outdoor expansion valve 9 is controlled not only during cooling operation, but also during heating operation. Thus, when only the outdoor unit 1 is provided with a controller for the expansion valve, it is still possible to control the flow rate of refrigerant, and costs of the components such as an electric circuit can be reduced.

**[0058]** As described above, the refrigeration cycle device 103 according to Embodiment 4 can achieve the same effects as those obtained by the refrigeration cycle device 100 according to Embodiment 1. That is, the outdoor heat exchanger 7 and the indoor heat exchanger 12 can form a counter flow, and also change the refrigerant flowing through the liquid pipe 4 to low-density two-phase refrigerant not only during cooling, but also during heating.

**[0059]** The indoor bridge circuit 315 is made up of only mechanical components, so that electric wires are not needed and therefore costs of the installation work can be reduced.

**[0060]** The opening degree of the outdoor expansion valve 9 is controlled to adjust the flow rate of refrigerant not only during cooling operation, but also during heating operation. It is thus unnecessary to provide an expansion valve drive circuit on the indoor side, and accordingly costs of the electric components can be reduced.

**[0061]** The configurations described in the foregoing embodiments are examples of the present disclosure. Combining these configurations with other publicly known techniques is possible, and partial omissions and modifications of the configurations are possible without departing from the spirit of the present disclosure.

Reference Signs List

**[0062]** 1: outdoor unit, 2, 2a, 2b, 2c: indoor unit, 3: gas pipe, 4: liquid pipe, 5: compressor, 6: four-way valve, 7: outdoor heat exchanger, 8: outdoor fan, 9: outdoor expansion valve, 10, 110, 310: outdoor bridge circuit, 11a, 11b, 11c, 11d: outdoor check valve, 12, 12a, 12b, 12c: indoor heat exchanger, 13, 13a, 13b, 13c: indoor fan, 14: indoor expansion valve, 15, 115, 215, 315: indoor bridge circuit, 16a, 16b, 16c, 16d: indoor check valve, 17a: outdoor inlet header, 17b: outdoor outlet header, 18a: indoor inlet header, 18b: indoor outlet header, 20: rectifier, 21: rectification portion, 22a, 22b, 22c: opening-closing valve, 31: fixed throttle, 100, 101, 102, 103: refrigeration cycle device

## Claims

**1.** A refrigeration cycle device comprising:

an outdoor unit including a compressor, a four-way valve, an outdoor heat exchanger, and an outdoor expansion valve, the four-way valve being configured to switch between cooling operation and heating operation;

an indoor unit including an indoor heat exchanger and an indoor expansion valve; and

a gas pipe and a liquid pipe configured to connect the outdoor unit and the indoor unit to form a refrigerant circuit, the refrigerant circuit being filled with refrigerant, wherein

the refrigeration cycle device comprises at least either one of

a first bridge circuit accommodated in the outdoor unit, the first bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through the outdoor heat exchanger in a same direction both during the cooling operation and during the heating operation, a flow path opening-closing unit of the plurality of flow path opening-closing units, installed in a flow path connecting the liquid pipe and an outlet side of the outdoor heat exchanger, being the outdoor expansion valve, and

a second bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through the indoor heat exchanger in a same direction both during the cooling operation and during the heating operation, a flow path opening-closing unit of the plurality of flow path opening-closing units, installed in a flow path connecting the liquid pipe and an outlet side of the indoor heat exchanger, being the indoor expansion valve.

**2.** The refrigeration cycle device of claim 1, wherein the first bridge circuit includes a first check valve located in series to the outdoor expansion valve and configured to stop the refrigerant from flowing through the outdoor expansion valve during the heating operation.

**3.** The refrigeration cycle device of claim 1, wherein the second bridge circuit includes a second check valve located in series to the indoor expansion valve and configured to stop the refrigerant from flowing through the indoor expansion valve during the cooling operation.

**4.** The refrigeration cycle device of any one of claims 1 to 3, wherein the second bridge circuit includes a rectification unit on an upstream side of the indoor expansion valve, the rectification unit being configured to allow the refrigerant to flow in a uniform state.

**5.** A refrigeration cycle device comprising:

an outdoor unit including a compressor, a four-way valve, an outdoor heat exchanger, and an outdoor expansion valve, the four-way valve being configured to switch between cooling operation and heating operation;

a plurality of indoor units each including an indoor heat exchanger and a solenoid valve; a first bridge circuit accommodated in the outdoor unit, the first bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through the outdoor heat exchanger in a same direction both during the cooling operation and during the heat-

ing operation, a flow path opening-closing unit of the plurality of flow path opening-closing units, installed in a flow path connecting the liquid pipe and an outlet side of the outdoor heat exchanger, being the outdoor expansion valve;
a second bridge circuit to which each of the plurality of indoor units is connected in parallel, the second bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through each of the plurality of indoor units in a same direction both during the cooling operation and during the heating operation, the second bridge circuit including an indoor expansion valve in a flow path connecting the liquid pipe and an outlet side of each of the plurality of indoor units; and
a gas pipe and a liquid pipe configured to connect the outdoor unit and the second bridge circuit to form a refrigerant circuit, the refrigerant circuit being filled with refrigerant.

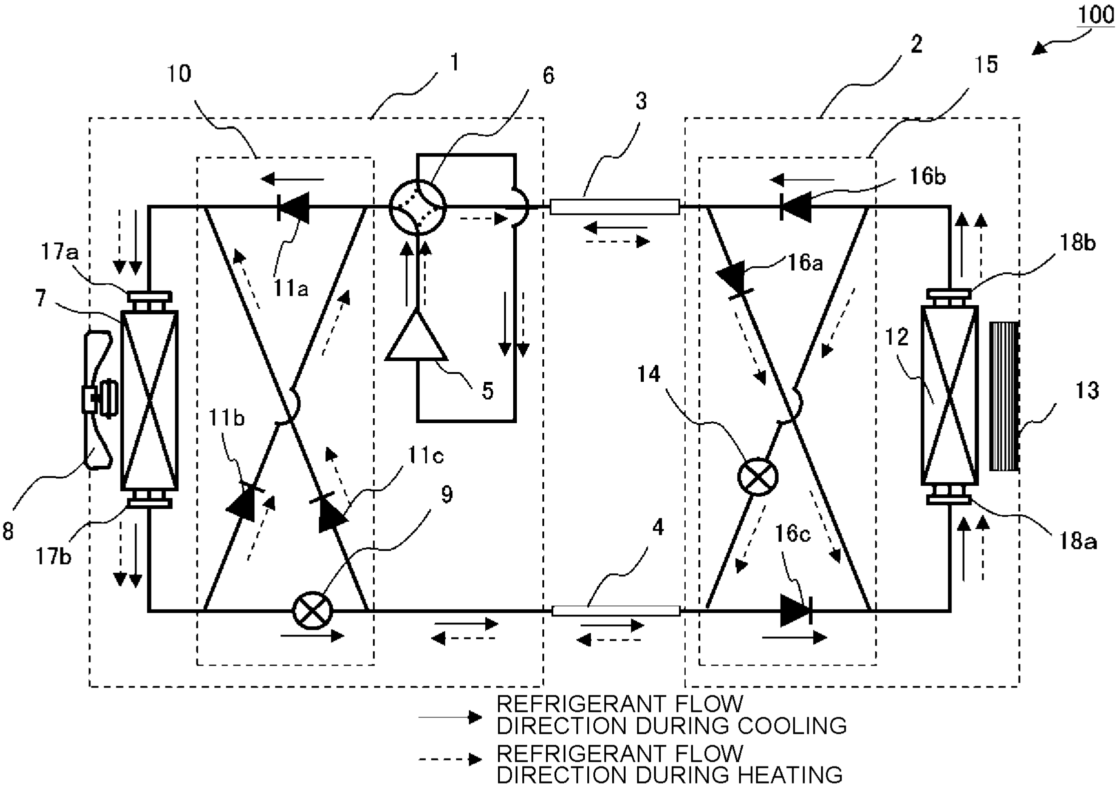
**6.** A refrigeration cycle device comprising:

an outdoor unit including a compressor, a four-way valve, an outdoor heat exchanger, and an outdoor expansion valve, the four-way valve being configured to switch between cooling operation and heating operation;
an indoor unit including an indoor heat exchanger; and
a gas pipe and a liquid pipe configured to connect the outdoor unit and the indoor unit to form a refrigerant circuit, the refrigerant circuit being filled with refrigerant, wherein
the refrigeration cycle device comprises:

a first bridge circuit accommodated in the outdoor unit, the first bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through the outdoor heat exchanger in a same direction both during the cooling operation and during the heating operation; and
a second bridge circuit having a configuration including a plurality of flow path opening-closing units to allow the refrigerant to flow through the indoor unit in a same direction both during the cooling operation and during the heating operation, the second bridge circuit including a fixed throttle located in series to a flow path opening-closing unit of the plurality of flow path opening-closing units, the flow path opening-closing unit being installed in a flow path connecting the liquid pipe and an outlet side of the indoor unit.

**7.** The refrigeration cycle device of any one of claims 1 to 6, wherein the refrigerant is a non-azeotropic refrigerant mixture made up of two or more types of refrigerants with different boiling points.

FIG. 1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2
3
4
5
6
7
8
9
10
11a
11b
11c
12
13
14
15
16a
16b
16c
17a
17b
18a
18b
REFRIGERANT FLOW DIRECTION DURING COOLING
REFRIGERANT FLOW DIRECTION DURING HEATING

FIG. 2

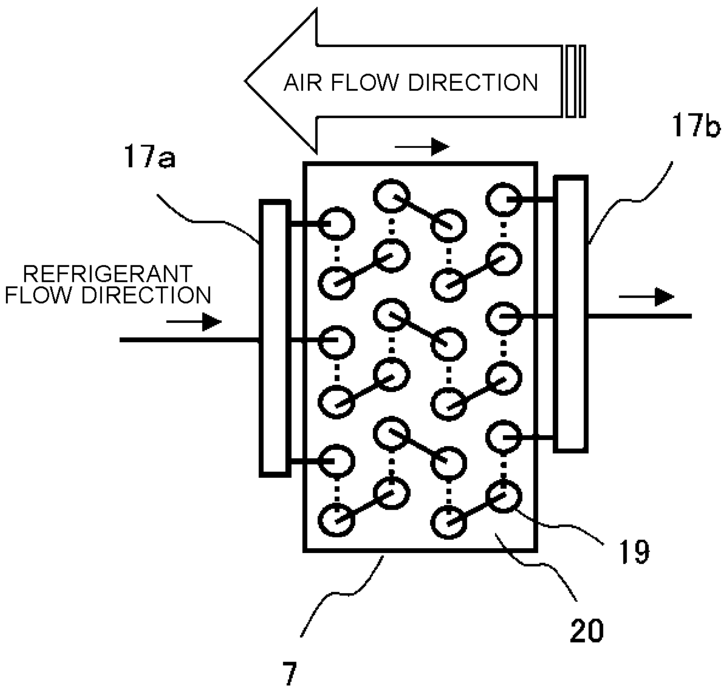
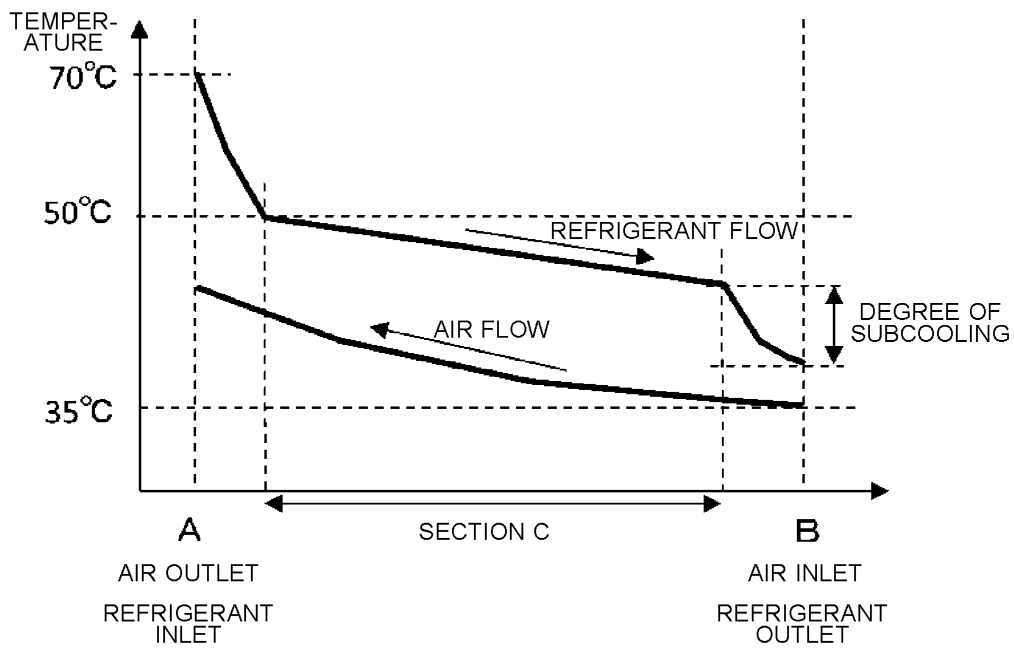

AIR FLOW DIRECTION
17a
17b
REFRIGERANT FLOW DIRECTION
19
20
7

FIG. 3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DEGREE OF
SUBCOOLING
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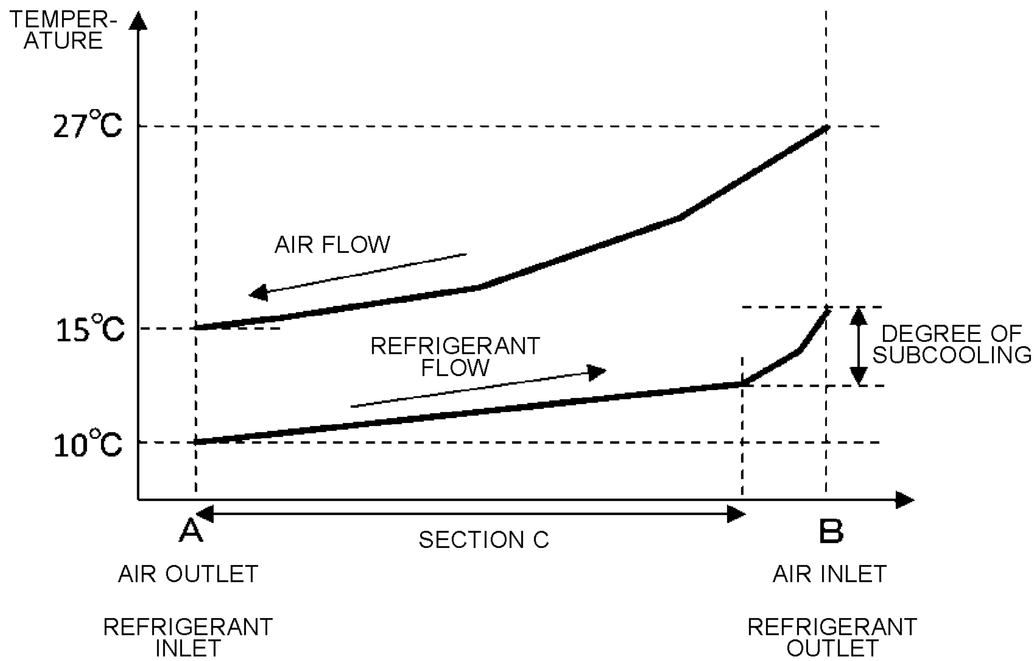
B
AIR OUTLET
REFRIGERANT
INLET
AIR INLET
REFRIGERANT
OUTLET

FIG. 4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FLOW
DEGREE OF
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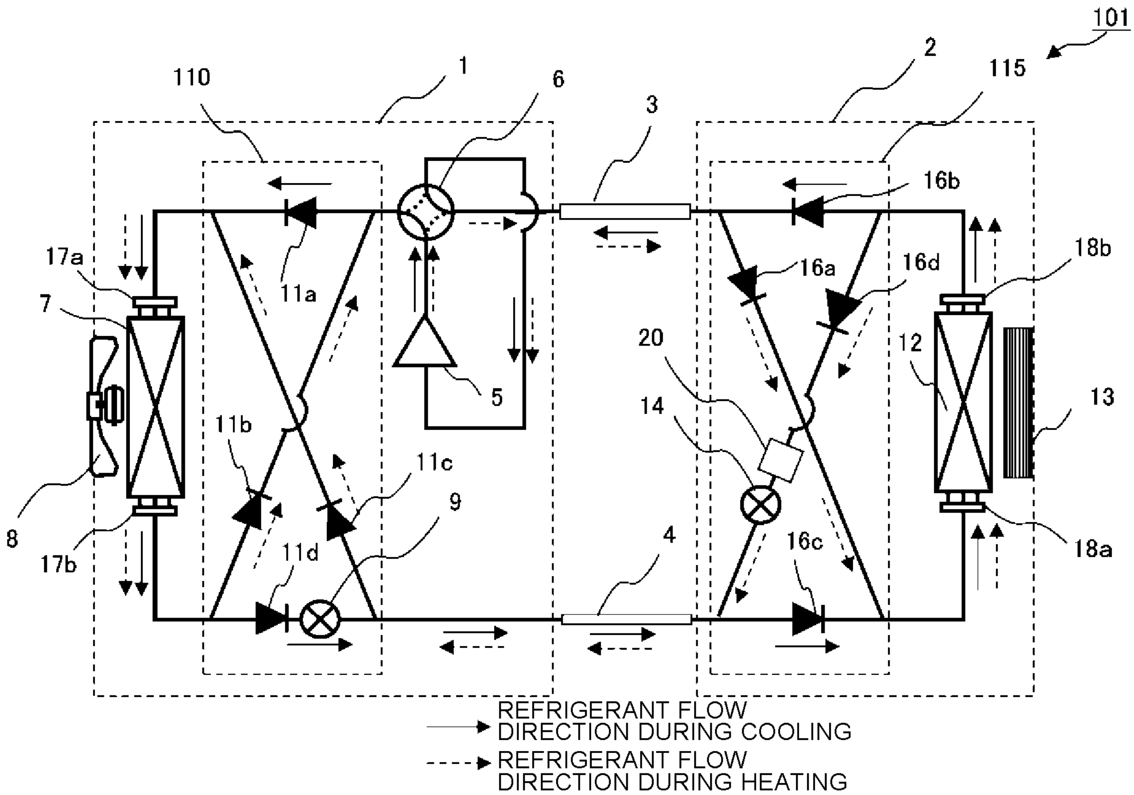
INLET
AIR INLET
REFRIGERANT
OUTLET

FIG. 5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115
110
1
6
3
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17a
16a
16d
18b
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11a
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12
13
5
14
11b
11c
9
8
17b
11d
4
16c
18a
REFRIGERANT FLOW DIRECTION DURING COOLING
REFRIGERANT FLOW DIRECTION DURING HEATING

FIG. 6

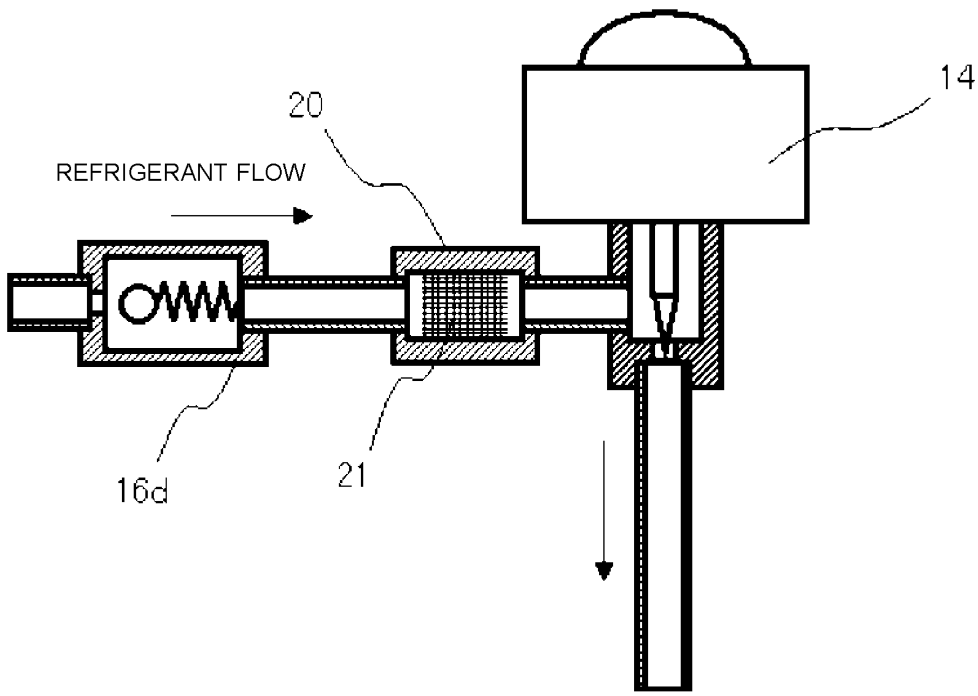
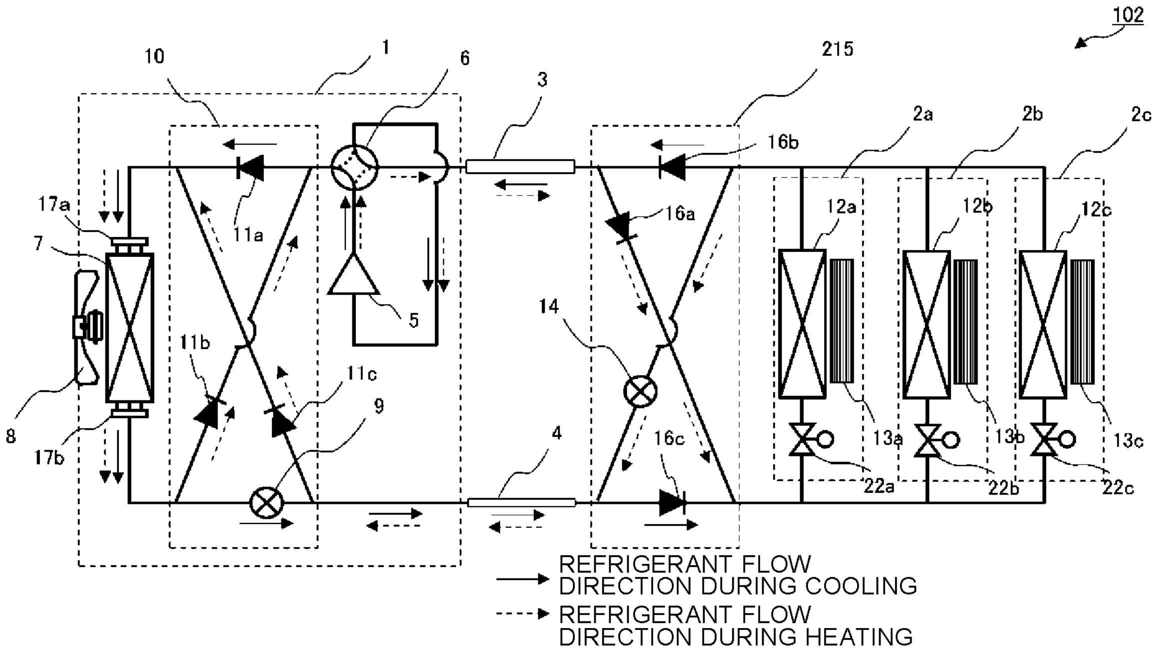

14
20
REFRIGERANT FLOW
16d
21

FIG. 7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10
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6
3
215
2a
2b
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16b
17a
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16a
12a
12b
12c
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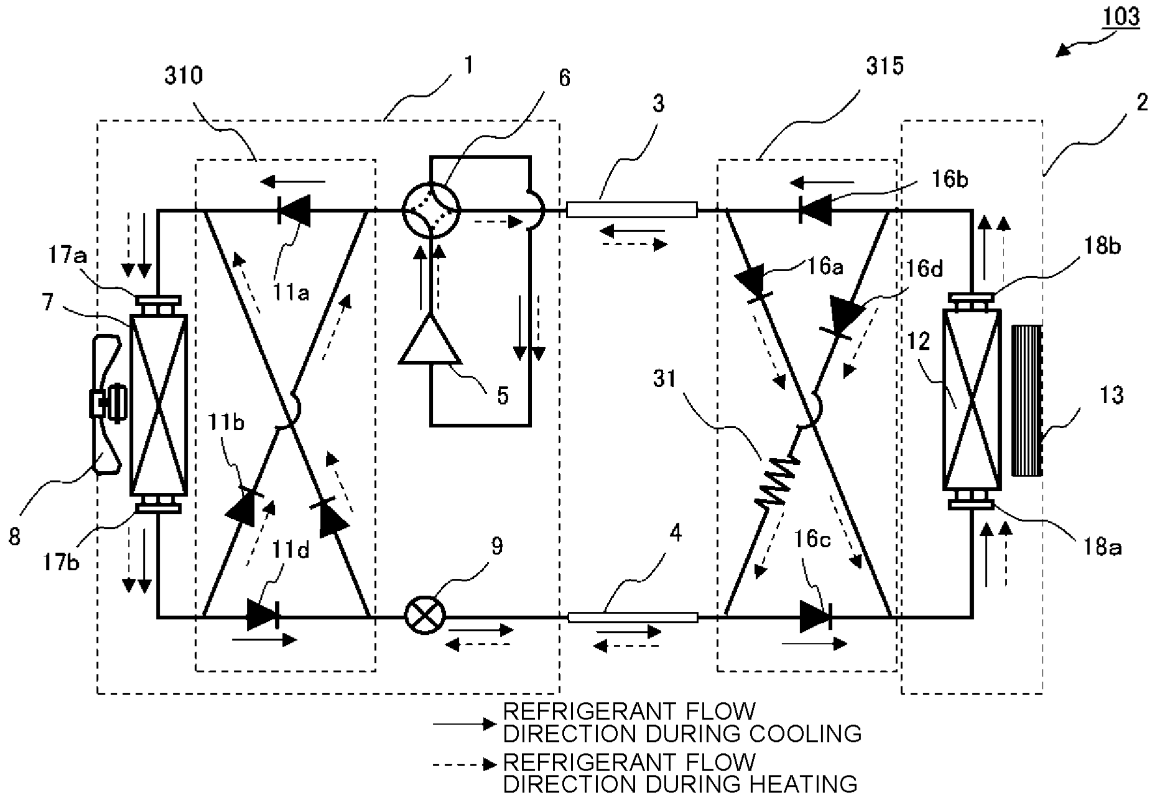
14
11b
11c
9
8
17b
4
16c
13a
13b
13c
22a
22b
22c
REFRIGERANT FLOW DIRECTION DURING COOLING
REFRIGERANT FLOW DIRECTION DURING HEATING

FIG. 8


103
310
1
6
3
315
2
16b
17a
7
11a
16a
16d
18b
12
5
31
13
11b
11d
9
4
16c
8
17b
18a
REFRIGERANT FLOW DIRECTION DURING COOLING
REFRIGERANT FLOW DIRECTION DURING HEATING

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/042432

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B13/00(2006.01)i
FI: F25B13/00S, F25B13/00A, F25B13/00P

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. F25B13/00

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

| | |
|---|---|
| Published examined utility model applications of Japan | 1922-1996 |
| Published unexamined utility model applications of Japan | 1971-2020 |
| Registered utility model specifications of Japan | 1996-2020 |
| Published registered utility model applications of Japan | 1994-2020 |

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. |
|---|---|---|
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| Y<br>A | JP 07-190528 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 28 July 1995 (1995-07-28), paragraphs [0001], [0026]-[0031], fig. 3 | 1-4, 6-7<br>5 |
| Y | JP 2000-274856 A (MITSUBISHI ELECTRIC CORPORATION) 06 October 2000 (2000-10-06), paragraphs [0020], [0028]-[0034], fig. 2 | 1-4, 7 |
| Y | JP 03-170753 A (MITSUBISHI ELECTRIC CORPORATION) 24 July 1991 (1991-07-24), page 3, upper right column, line 5 to page 4, upper right column, line 18, fig. 1 | 1-4, 7 |

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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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 |
|---|---|
| 17 December 2020 | 28 December 2020 |

| 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. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2020/042432

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| Y | JP 2006-098020 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 13 April 2006 (2006-04-13), paragraphs [0002], [0003] | 4 |
| Y | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 123297/1989 (Laid-open No. 067863/1991) (SHARP CORPORATION) 03 July 1991 (1991-07-03), specification, page 6, line 1 to page 10, line 4, fig. 1, 2 | 6-7 |
| Y | JP 43-029014 Y1 (HITACHI, LTD.) 28 November 1968 (1968-11-28), page 2, left column, lines 12-31, fig. 2 | 6-7 |
| A | JP 06-257874 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 16 September 1994 (1994-09-16), paragraphs [0014]-[0020], fig. 3 | 1-7 |
| A | JP 09-280680 A (DAIKIN INDUSTRIES, LTD.) 31 October 1997 (1997-10-31), entire text, all drawings | 1-7 |
| A | JP 10-073334 A (SANYO ELECTRIC CO., LTD.) 17 March 1998 (1998-03-17), entire text, all drawings | 1-7 |
| A | JP 10-318619 A (MITSUBISHI ELECTRIC CORPORATION) 04 December 1998 (1998-12-04), fig. 1 | 1-7 |
| A | JP 07-098166 A (TOSHIBA CORPORATION) 11 April 1995 (1995-04-11), fig. 5 | 1-7 |
| A | JP 08-334274 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 17 December 1996 (1996-12-17), fig. 4 | 5 |

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

International application No.
PCT/JP2020/042432

| | | |
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| JP 07-190528 A | 28 July 1995 | (Family: none) |
| JP 2000-274856 A | 06 October 2000 | (Family: none) |
| JP 03-170753 A | 24 July 1991 | (Family: none) |
| JP 2003-314930 A | 06 November 2003 | (Family: none) |
| JP 2006-098020 A | 13 April 2006 | (Family: none) |
| JP 03-067863 U1 | 03 July 1991 | (Family: none) |
| JP 43-029014 Y1 | 28 November 1968 | (Family: none) |
| JP 06-257874 A | 16 September 1994 | (Family: none) |
| JP 09-280680 A | 31 October 1997 | (Family: none) |
| JP 10-073334 A | 17 March 1998 | (Family: none) |
| JP 10-318619 A | 04 December 1998 | (Family: none) |
| JP 07-098166 A | 11 April 1995 | (Family: none) |
| JP 08-334274 A | 17 December 1996 | (Family: none) |

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