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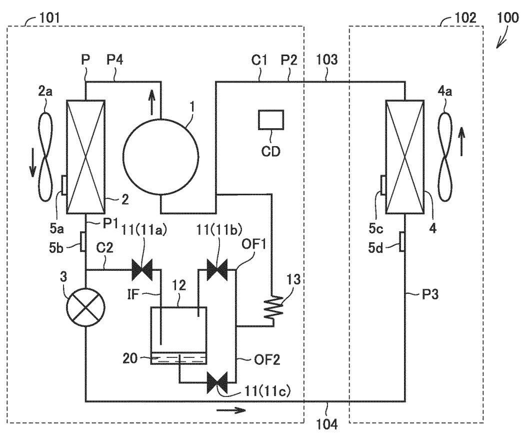
(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus (100) comprises a refrigerant circuit (C1) and a refrigerant storage circuit (C2). In the refrigerant circuit (C1), a compressor (1), an outdoor heat exchanger (2), an expansion valve (3), and an indoor heat exchanger (4) are connected together by a pipe (P). The pipe (P) has a first pipe portion (P1) and a second pipe portion (P2). The first pipe portion (P1) connects the outdoor heat exchanger (2) to the expansion valve (3). The second pipe portion (P2) connects the indoor heat exchanger (4) to the compressor (1). The refrigerant storage circuit (C2) has a storage container (12), an expander (13), and a valve device (11). The storage container (12) stores refrigerant. The expander (13) is located between the storage container (12) and the second pipe (P2). The valve device (11) is located between the first pipe (P1) and the expander (13). The valve device (11) is configured to open and close the refrigerant storage circuit (C2).

FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to a refrigeration cycle apparatus.

### BACKGROUND ART

**[0002]** Conventionally, an air conditioner has been known which includes a refrigerant circuit having a liquid receiver. In the refrigerant circuit of the air conditioner, refrigerant is stored into the liquid receiver in accordance with an operation state, thereby adjusting a degree of supercooling of the refrigerant. This leads to improved performance of refrigeration cycle.

**[0003]** For example, Japanese Patent Laying-Open No. 10-111047 (PTL 1) discloses an air conditioner including a refrigerant circuit having a liquid receiver (storage container). In the air conditioner described in this patent publication, refrigerant flows in the order of a refrigerant compressing device, a four-way valve, a condenser, a first expansion device, the liquid receiver (storage container), a second expansion device, an evaporator, and a four-way valve.

### CITATION LIST

### PATENT LITERATURE

**[0004]** PTL 1: Japanese Patent Laying-Open No. 10-111047

### SUMMARY OF INVENTION

### TECHNICAL PROBLEM

**[0005]** In the air conditioner described in the above patent publication, the refrigerant circuit includes the first expansion device and the second expansion device.

Therefore, the refrigerant circuit needs to control two expansion valves, thus resulting in decreased controllability of the expansion valves.

**[0006]** The present disclosure has been made in view of the above problems, and has an object to provide a refrigeration cycle apparatus to improve performance of refrigeration cycle using a storage container and improve controllability of an expansion valve.

### SOLUTION TO PROBLEM

**[0007]** A refrigeration cycle apparatus of the present disclosure comprises a refrigerant circuit and a refrigerant storage circuit. In the refrigerant circuit, a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger are connected together by a pipe. The refrigerant storage circuit is connected to the refrigerant circuit. The pipe has a first pipe portion and a second pipe portion. The first pipe portion connects the outdoor heat exchanger to the expansion valve. The second pipe portion connects the indoor heat exchanger to the compressor. The refrigerant storage circuit has a storage container, an expander, and a valve device. The storage container stores refrigerant. The expander is located between the storage container and the second pipe portion. The valve device is located between the first pipe portion and the expander. The valve device is configured to open and close the refrigerant storage circuit.

### ADVANTAGEOUS EFFECTS OF INVENTION

**[0008]** According to the refrigeration cycle apparatus of the present disclosure, the valve device is configured to open and close the refrigerant storage circuit having the storage container. Therefore, since the valve device opens and closes the refrigerant storage circuit to store the refrigerant into the storage container in accordance with an operating state, performance of refrigeration cycle can be improved. In the refrigerant circuit, the compressor, the outdoor heat exchanger, the expansion valve, and the indoor heat exchanger are connected together by the pipe. Therefore, with one expansion valve, controllability of the expansion valve can be improved.

### BRIEF DESCRIPTION OF DRAWINGS

**[0009]**

Fig. 1 is a refrigerant circuit diagram of a refrigeration cycle apparatus according to a first embodiment.

Fig. 2 is a functional block diagram of a controller of the refrigeration cycle apparatus according to the first embodiment.

Fig. 3 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the first embodiment in a high-load operation.

Fig. 4 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the first embodiment in a refrigerant storing operation.

Fig. 5 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the first embodiment in a refrigerant recovering operation.

Fig. 6 is a flowchart showing refrigerant amount adjustment of the refrigeration cycle apparatus according to the first embodiment.

Fig. 7 is a graph showing a relation between a refrigerant amount and a coefficient of performance in each of the refrigeration cycle apparatus according to the first embodiment and a comparative example.

Fig. 8 is a refrigerant circuit diagram of a modification of the refrigeration cycle apparatus according to the first embodiment.

Fig. 9 is a functional block diagram of a controller of the modification of the refrigeration cycle apparatus according to the first embodiment.

Fig. 10 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the first embodiment in a high-load operation.

Fig. 11 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the first embodiment in a refrigerant storing operation.

Fig. 12 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the first embodiment in a refrigerant recovering operation.

Fig. 13 is a refrigerant circuit diagram of a refrigeration cycle apparatus according to a second embodiment.

Fig. 14 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the second embodiment in a high-load operation.

Fig. 15 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the second embodiment in a refrigerant storing operation.

Fig. 16 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the second embodiment in a refrigerant recovering operation.

Fig. 17 is a refrigerant circuit diagram of a modification of the refrigeration cycle apparatus according to the second embodiment.

Fig. 18 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the second embodiment in a high-load operation.

Fig. 19 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the second embodiment in a refrigerant storing operation.

Fig. 20 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the second embodiment in a refrigerant recovering operation.

Fig. 21 is a refrigerant circuit diagram of a refrigeration cycle apparatus according to a third embodiment.

Fig. 22 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the third embodiment in a high-load operation.

Fig. 23 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the third embodiment in a refrigerant storing operation.

Fig. 24 is a refrigerant circuit diagram of the refrigeration cycle apparatus according to the third embodiment in a refrigerant recovering operation.

Fig. 25 is a refrigerant circuit diagram of a modification of the refrigeration cycle apparatus according to the third embodiment.

Fig. 26 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the third embodiment in a high-load operation.

Fig. 27 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the third embodiment in a refrigerant storing operation.

Fig. 28 is a refrigerant circuit diagram of the modification of the refrigeration cycle apparatus according to the third embodiment in a refrigerant recovering operation.

## DESCRIPTION OF EMBODIMENTS

**[0010]** Hereinafter, embodiments will be described based on figures. It should be noted that in the description below, the same or corresponding portions are denoted by the same reference characters and the same explanation will not be described repeatedly.

### First Embodiment.

**[0011]** A configuration of a refrigeration cycle apparatus 100 according to a first embodiment will be described with reference to Fig. 1. Examples of refrigeration cycle apparatus 100 includes an air conditioner, a refrigerator, and the like. In the first embodiment, an air conditioner will be described as an exemplary refrigeration cycle apparatus 100.

**[0012]** Refrigeration cycle apparatus 100 according to the first embodiment has a refrigerant circuit C1, a refrigerant storage circuit C2, a controller CD, a first blower apparatus 2a, a second blower apparatus 4a, a first temperature sensor 5a, a second temperature sensor 5b, a third temperature sensor 5c, and a fourth temperature sensor 5d.

**[0013]** Refrigerant circuit C1 includes a compressor 1, an outdoor heat exchanger (condenser) 2, an expansion valve 3, and an indoor heat exchanger (evaporator) 4. Refrigerant circuit C1 is configured to allow refrigerant to flow in the order of compressor 1, outdoor heat exchanger (condenser) 2, expansion valve 3, and indoor heat exchanger (evaporator) 4. Refrigerant circuit C1 is configured to circulate the refrigerant. The refrigerant circulates in refrigerant circuit C1 while changing its phase.

**[0014]** Compressor 1, outdoor heat exchanger (condenser) 2, expansion valve 3, and indoor heat exchanger (evaporator) 4 are connected together by a pipe P. Pipe P has a first pipe portion P1, a second pipe portion P2, a third pipe portion P3, and a fourth pipe portion P4. First pipe portion P1 connects outdoor heat exchanger (condenser) 2 to expansion valve 3. Second pipe portion P2 connects indoor heat exchanger (evaporator) 4 to compressor 1. Third pipe portion P3 connects expansion valve 3 to indoor heat exchanger (evaporator) 4. Fourth pipe portion P4 connects compressor 1 to outdoor heat exchanger (condenser) 2.

**[0015]** Compressor 1, outdoor heat exchanger 2, first blower apparatus 2a, expansion valve 3, first temperature sensor 5a, second temperature sensor 5b, and controller CD are accommodated in an outdoor unit 101. Indoor heat exchanger 4, second blower apparatus 4a, third temperature sensor 5c, and fourth temperature sensor 5d are accommodated in an indoor unit 102. Outdoor unit 101 and indoor unit 102 are connected together by a gas pipe 103 and a liquid pipe 104. It should be noted that portions of pipe P constitute gas pipe 103 and liquid pipe 104.

**[0016]** Controller CD is configured to control each device and the like of refrigeration cycle apparatus 100 by performing calculation, instruction and the like. Controller CD is electrically connected to compressor 1, expansion valve 3, first blower apparatus 2a, second blower apparatus 4a, and the like, and is configured to control operations thereof. Controller CD is electrically connected to each of first temperature sensor 5a, second temperature sensor 5b, third temperature sensor 5c, and fourth temperature sensor 5d, and is configured to control each device and the like based on signals detected by these sensors. Controller CD is constituted of, for example, a microcomputer. Controller CD includes a CPU (Central Processing Unit), a RAM (Random Access Memory), a ROM (Read Only Memory), and the like. The ROM stores a control program.

**[0017]** Compressor 1 is configured to compress the refrigerant. Compressor 1 is configured to compress the suctioned refrigerant and discharge the refrigerant. Compressor 1 may be variable in capacity. Compressor 1 may be configured to be changed in capacity by adjusting the rotation speed of compressor 1 based on an instruction from controller CD.

**[0018]** Outdoor heat exchanger 2 is configured to exchange heat between the refrigerant flowing inside outdoor heat exchanger 2 and air flowing outside outdoor heat exchanger 2. Outdoor heat exchanger 2 is configured to function as a condenser. Outdoor heat exchanger 2 is a fin-and-tube type heat exchanger having a plurality of fins and a heat transfer tube extending through the plurality of fins.

**[0019]** Expansion valve 3 is configured to expand the refrigerant condensed in outdoor heat exchanger 2 so as to reduce the pressure of the refrigerant. Expansion valve 3 is, for example, an electromagnetic valve. The electromagnetic valve is configured to adjust the flow rate of the refrigerant based on an instruction from controller CD.

**[0020]** Indoor heat exchanger 4 is configured to exchange heat between the refrigerant flowing inside indoor heat exchanger 4 and air flowing outside indoor heat exchanger 4. Indoor heat exchanger 4 is configured to function as an evaporator. Indoor heat exchanger 4 is a fin-and-tube type heat exchanger having a plurality of fins and a heat transfer tube extending through the plurality of fins.

**[0021]** First blower apparatus 2a is configured to blow outdoor air to outdoor heat exchanger 2. That is, first blower apparatus 2a is configured to supply air to outdoor heat exchanger 2. First blower apparatus 2a may be configured to adjust an amount of air flowing around outdoor heat exchanger 2 by adjusting the rotation speed of the fan of first blower apparatus 2a based on an instruction from controller CD, thereby adjusting an amount of heat exchanged between the refrigerant and the air.

**[0022]** Second blower apparatus 4a is configured to blow indoor air to indoor heat exchanger 4. That is, second blower apparatus 4a is configured to supply air to indoor heat exchanger 4. Second blower apparatus 4a may be configured to adjust an amount of air flowing around indoor heat exchanger 4 by adjusting the rotation speed of the fan of second blower apparatus 4a based on an instruction from controller CD, thereby adjusting an amount of heat exchanged between the refrigerant and the air.

**[0023]** First temperature sensor 5a is connected to outdoor heat exchanger 2. First temperature sensor 5a is configured to detect the temperature of the refrigerant flowing through outdoor heat exchanger 2. Second temperature sensor 5b is connected to first pipe portion P1. Second temperature sensor 5b is configured to detect the temperature of the refrigerant having flowed out from outdoor heat exchanger 2.

**[0024]** Third temperature sensor 5c is connected to indoor heat exchanger 4. Third temperature sensor 5c is configured to detect the temperature of the refrigerant flowing through indoor heat exchanger 4. Fourth temperature sensor 5d is connected to third pipe portion P3. Fourth temperature sensor 5d is configured to detect the temperature of the refrigerant flowing into indoor heat exchanger 4.

**[0025]** Refrigerant storage circuit C2 is configured to store the refrigerant. Refrigerant storage circuit C2 is connected to refrigerant circuit C1. Refrigerant storage circuit C2 has a valve device 11, a storage container 12, and an expander 13. In refrigerant storage circuit C2, valve device 11, storage container 12, and expander 13 are connected together by pipe P.

**[0026]** In refrigerant storage circuit C2, valve device 11 is located between first pipe portion P1 and expander 13. Valve device 11 is configured to open and close refrigerant storage circuit C2. Valve device 11 is configured to open and close refrigerant storage circuit C2 based on an instruction from controller CD. Valve device 11 is, for example, an electromagnetic valve. The electromagnetic valve is configured to adjust the flow rate of the refrigerant based on an instruction from controller CD.

**[0027]** Storage container 12 is configured to store the refrigerant. Storage container 12 is configured to discharge the refrigerant. That is, storage container 12 is configured to temporarily store the refrigerant and then discharge the refrigerant. Thus, storage container 12 is configured to receive and send the refrigerant.

**[0028]** In refrigerant storage circuit C2, expander 13 is located between storage container 12 and second pipe portion P2. Expander 13 is configured to expand the refrigerant having flowed out from storage container 12, thereby reducing the pressure of the refrigerant. Expander 13 is, for example, a capillary tube. The electromagnetic valve is configured to adjust the flow rate of the refrigerant based on an instruction from controller CD.

**[0029]** The refrigerant storage circuit has an inflow path IF, a first outflow path OF1, and a second outflow path

OF2. Inflow path IF is configured to allow the refrigerant to flow into storage container 12. Inflow path IF is connected to first pipe portion P1 and storage container 12. The flow inlet of inflow path IF is located inside storage container 12. The flow inlet of inflow path IF is located below the flow outlet of first outflow path OF1 and is located above the flow outlet of second outflow path OF2.

**[0030]** First outflow path OF1 is configured to allow the refrigerant in a gas state to flow out from storage container 12. First outflow path OF1 is connected to storage container 12 and expander 13. The discharge port of first outflow path OF1 is located inside storage container 12. The discharge port of first outflow path OF1 is located above the flow inlet of inflow path IF and second outflow path OF2.

**[0031]** Second outflow path OF2 is configured to allow the refrigerant in a liquid state to flow out from storage container 12. Second outflow path OF2 is connected to storage container 12 and expander 13. The discharge port of second outflow path OF2 is located inside storage container 12. The discharge port of second outflow path OF2 is located below inflow path IF and first outflow path OF1.

**[0032]** When storing the refrigerant into storage container 12, valve device 11 is configured to open inflow path IF and first outflow path OF1 and close second outflow path OF2. When recovering the refrigerant from storage container 12, valve device 11 is configured to close first outflow path OF1 and open second outflow path OF2.

**[0033]** Valve device 11 has a first valve 11a, a second valve 11b, and a third valve 11c. First valve 11a, second valve 11b, and third valve 11c are independently controllable. First valve 11a is configured to open and close inflow path IF. First valve 11a is connected to first pipe portion P1 and storage container 12 by pipe P. Second valve 11b is configured to open and close first outflow path OF1. Second valve 11b is connected to storage container 12 and expander 13 by pipe P. Third valve 11c is configured to open and close second outflow path OF2. Third valve 11c is connected to storage container 12 and expander 13 by pipe P.

**[0034]** When storing the refrigerant into storage container 12, first valve 11a is configured to open inflow path IF, second valve 11b is configured to open first outflow path OF1, and third valve 11c is configured to close second outflow path OF2. When recovering the refrigerant from storage container 12, second valve 11b is configured to close first outflow path OF1 and third valve 11c is configured to open second outflow path OF2.

**[0035]** Controller CD will be described in detail with reference to Fig. 2.

**[0036]** Controller CD has a control unit CD1, a compressor driving unit CD2, an expansion valve driving unit CD3, a blower apparatus driving unit CD4, a valve device driving unit CDS, and a temperature measuring unit CD6. Control unit CD1 is configured to control compressor driving unit CD2, expansion valve driving unit CD3, blower apparatus driving unit CD4, valve device driving unit CD5, and temperature measuring unit CD6. Compressor driving unit CD2 is configured to drive compressor 1 based on an instruction from control unit CD1. For example, compressor driving unit CD2 is configured to control the rotation speed of a motor of compressor 1 by controlling the frequency of AC current flowing through a motor of compressor 1.

**[0037]** Expansion valve driving unit CD3 is configured to drive expansion valve 3 based on an instruction from control unit CD1. For example, expansion valve driving unit CD3 is configured to control a degree of opening of expansion valve 3 by controlling a driving source such as a motor of expansion valve 3. Blower apparatus driving unit CD4 is configured to drive first blower apparatus 2a and second blower apparatus 4a based on an instruction from control unit CD1. For example, blower apparatus driving unit CD4 is configured to control the rotation speeds of the fans of first blower apparatus 2a and second blower apparatus 4a by controlling drive sources such as the motors of first blower apparatus 2a and second blower apparatus 4a.

**[0038]** Valve device driving unit CD5 is configured to drive valve device 11 based on an instruction from control unit CD1. For example, valve device driving unit CD5 is configured to control a degree of opening of valve device 11 by controlling a driving source such as a motor of valve device 11. Temperature measuring unit CD6 is configured to measure the temperature of the refrigerant based on signals from first to fourth temperature sensors 5a to 5d and transmit, to control unit CD1, a signal that is based on the temperature of the refrigerant.

**[0039]** Next, operations of refrigeration cycle apparatus 100 according to the first embodiment will be described.

**[0040]** Referring to Fig. 1, the following describes an operation of refrigeration cycle apparatus 100 according to the first embodiment during a low-load operation in a cooling operation. It should be noted that in Fig. 1, valve device 11 is painted in black to indicate that valve device 11 is in a closed state. In the below-described figures, valve device 11 painted in black indicates the closed state.

**[0041]** The refrigerant having flowed into compressor 1 is compressed by compressor 1 to become high-temperature and high-pressure gas refrigerant, which is then discharged from compressor 1. The high-temperature and high-pressure gas refrigerant flows into outdoor heat exchanger 2, is condensed by outdoor heat exchanger 2 to become liquid refrigerant, which then flows out from outdoor heat exchanger 2. The liquid refrigerant flows into expansion valve 3, is reduced in pressure by expansion valve 3 to become low-pressure gas-liquid two-phase refrigerant, which then flows out from expansion valve 3. The low-pressure gas-liquid two-phase refrigerant flows into indoor heat exchanger 4, is evaporated by indoor heat exchanger 4 to become gas refrigerant, which then flows out from indoor heat exchanger 4. The gas refrigerant flows into compressor 1. In this way, the refrigerant circulates in refrigerant circuit C1.

**[0042]** Valve device 11 closes refrigerant storage circuit C2. Specifically, all of first valve 11a, second valve 11b, and third valve 11c close refrigerant storage circuit C2. Therefore, the liquid refrigerant having flowed out from outdoor heat exchanger 2 does not flow into storage container 12 of refrigerant storage circuit C2. Further, refrigerant 20 stored in storage container 12 does not flow into refrigerant circuit C1.

**[0043]** In refrigeration cycle apparatus 100, the low-load operation and high-load operation are performed, the low-load operation being an operation in which the rotation speed of compressor 1 is low, the high-load operation being an operation in which the rotation speed of compressor 1 is high. A refrigerant amount with which performance of refrigeration cycle is maximum in the high-load operation is smaller than that in the low-load operation. Accordingly, the amount of the refrigerant flowing through refrigerant circuit C1 during the low-load operation is larger than that during the high-load operation, and the amount of refrigerant 20 stored in storage container 12 of refrigerant storage circuit C2 during the low-load operation is smaller than that during the high-load operation.

**[0044]** Referring to Fig. 3, the following describes an operation of refrigeration cycle apparatus 100 according to the first embodiment during the high-load operation in the cooling operation. The refrigerant circulates in refrigerant circuit C1 in the same manner as in the low-load operation. Valve device 11 closes refrigerant storage circuit C2 in the same manner as in the low-load operation. The amount of the refrigerant flowing through refrigerant circuit C1 during the high-load operation is smaller than that during the low-load operation, and the amount of refrigerant 20 stored in storage container 12 of refrigerant storage circuit C2 during the high-load operation is larger than that during the low-load operation.

**[0045]** Referring to Fig. 4, the following describes an operation (refrigerant storing operation) of storing the refrigerant into storage container 12. When storing the refrigerant into storage container 12, valve device 11 opens inflow path IF and first outflow path OF1 and closes second outflow path OF2. Specifically, when storing the refrigerant into storage container 12, first valve 11a opens inflow path IF, second valve 11b opens first outflow path OF1, and third valve 11c closes second outflow path OF2. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into storage container 12 of refrigerant storage circuit C2 via inflow path IF, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12. By performing the high-load operation with the refrigerant being stored in storage container 12 through the refrigerant storing operation, the performance of the refrigeration cycle is improved in the high-load operation.

**[0046]** Referring to Fig. 5, the following describes an operation of refrigeration cycle apparatus 100 during an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. When recovering the refrigerant from storage container 12, valve device 11 closes first outflow path OF1 and opens second outflow path OF2. Valve device 11 opens inflow path IF. Specifically, when recovering the refrigerant from storage container 12, second valve 11b closes first outflow path OF1 and third valve 11c opens second outflow path OF2. Further, first valve 11a opens inflow path IF. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into storage container 12 of refrigerant storage circuit C2 via inflow path IF, and flows out from second outflow path OF2. The refrigerant is recovered to refrigerant circuit C1. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered. By performing the low-load operation with the refrigerant being recovered from storage container 12 through the refrigerant recovering operation, the performance of the refrigeration cycle is improved in the low-load operation.

**[0047]** It should be noted that in the refrigerant recovering operation, the amount of liquid refrigerant flowing out from storage container 12 should be larger than the amount of liquid refrigerant flowing into storage container 12. In the refrigerant recovering operation, for example, the amount of liquid refrigerant flowing into storage container 12 may be reduced by stopping the rotation of the fan of first blower apparatus 2a or the like.

**[0048]** Next, refrigerant amount adjustment in refrigeration cycle apparatus 100 according to the first embodiment will be described with reference to Figs. 1, 2, and 6. In this refrigerant amount adjustment, the refrigerant amount is adjusted based on a degree of supercooling (subcooling).

**[0049]** Referring mainly to Fig. 6, when the refrigerant amount adjustment is started (step S1), a subcooling (SC) is calculated (step S2). In the cooling operation, the subcooling (SC) is calculated by control unit CD1 in accordance with a difference between the temperature of the refrigerant detected by first temperature sensor 5a and the temperature of the refrigerant detected by second temperature sensor 5b. It should be noted that in a below-described heating operation, the subcooling (SC) is calculated in accordance with a difference between the temperature of the refrigerant detected by third temperature sensor 5c and the temperature of the refrigerant detected by fourth temperature sensor 5d. Further, a target subcooling (SC) is calculated (step S3). The target subcooling (SC) is calculated by control unit CD1 in accordance with the rotation speed of compressor 1 and the outdoor air temperature.

**[0050]** Next, control unit CD1 determines whether or not the subcooling (SC) is smaller than a target SC-$\alpha$ obtained by providing a margin to the target subcooling (SC) on the low temperature side (step S4). When the subcooling (SC) is smaller than target SC-a, the refrigerant recovering operation is performed (step S5). When the subcooling (SC) is smaller than target SC-a, it is determined that the refrigerant amount is insufficient.

**[0051]** When the subcooling (SC) is not smaller than target SC-$\alpha$, control unit CD1 determines whether or not the subcooling (SC) is larger than a target SC+$\alpha$ obtained by providing a margin to the target subcooling (SC) on the high temperature side (step S6). When the subcooling (SC) is larger than target SC+$\alpha$, the refrigerant storing operation is performed (step S7). When the subcooling (SC) is larger than target SC+$\alpha$, it is determined that the refrigerant amount is excessive.

**[0052]** When the subcooling (SC) is not larger than target SC+$\alpha$, control unit CD1 determines whether or not the subcooling (SC) is larger than target SC-$\alpha$ and smaller than target SC+$\alpha$ (step S8). When the subcooling (SC) is larger than target SC-$\alpha$ and is not smaller than target SC+$\alpha$, the subcooling (SC) is calculated again. When the subcooling (SC) is larger than target SC-$\alpha$ and is smaller than target SC+$\alpha$, the refrigerant amount adjustment is ended (step S9).

**[0053]** Next, function and effect of refrigeration cycle apparatus 100 according to the first embodiment will be described in comparison with a comparative example.

**[0054]** Referring to Fig. 7, the following describes a relation between the refrigerant amount and a coefficient of performance (COP) in each of refrigeration cycle apparatus 100 according to the first embodiment and the comparative example. In refrigeration cycle apparatus 100 according to the first embodiment, the refrigerant amount is different between the low-load operation and the high-load operation, with the result that the coefficient of performance (COP) can be improved. In the comparative example, the refrigerant amount is unchanged between the low-load operation and the high-load operation, with the result that it is difficult to improve the coefficient of performance (COP) in both the low-load operation and the high-load operation.

**[0055]** According to refrigeration cycle apparatus 100 of the first embodiment, valve device 11 is configured to open and close refrigerant storage circuit C2 having storage container 12. Therefore, since valve device 11 opens and closes refrigerant storage circuit C2 to store the refrigerant into storage container 12 in accordance with the operation state, the performance of the refrigeration cycle can be improved. In refrigerant circuit C1, compressor 1, outdoor heat exchanger 2, expansion valve 3, and indoor heat exchanger 4 are connected together by pipe P. Therefore, with one expansion valve 3, controllability of expansion valve 3 can be improved.

**[0056]** According to refrigeration cycle apparatus 100 of the first embodiment, when storing the refrigerant into storage container 12, first valve 11a opens inflow path IF, second valve 11b opens first outflow path OF1, and third valve 11c closes second outflow path OF2. When recovering the refrigerant from storage container 12, second valve 11b closes first outflow path OF1 and third valve 11c opens second outflow path OF2. Therefore, the amount of refrigerant flowing through refrigerant circuit C1 can be adjusted.

**[0057]** Next, a modification of refrigeration cycle apparatus 100 according to the first embodiment will be described. The modification of refrigeration cycle apparatus 100 according to the first embodiment has the same configuration, operation, function and effect as those of refrigeration cycle apparatus 100 according to the first embodiment unless otherwise described particularly.

**[0058]** Referring to Fig. 8, in the modification of refrigeration cycle apparatus 100 according to the first embodiment, refrigerant circuit C1 has a four-way valve 6. Refrigerant circuit C1 is configured to allow the refrigerant to flow in the order of compressor 1, four-way valve 6, the condenser (outdoor heat exchanger 2 or indoor heat exchanger 4), expansion valve 3, the evaporator (indoor heat exchanger 4 or outdoor heat exchanger 2) and four-way valve 6. Further, refrigerant storage circuit C2 has a first check valve 14a and a second check valve 14b.

**[0059]** In the modification of refrigeration cycle apparatus 100 according to the first embodiment, outdoor heat exchanger 2 is configured to function as a condenser in the cooling operation and function as an evaporator in the heating operation. Indoor heat exchanger 4 is configured to function as an evaporator in the cooling operation and function as a condenser in the heating operation.

**[0060]** Four-way valve 6 is connected to compressor 1, outdoor heat exchanger 2, and indoor heat exchanger 4. Four-way valve 6 is configured to switch the flow of the refrigerant so as to allow the refrigerant to flow from compressor 1 to outdoor heat exchanger 2 in the cooling operation and allow the refrigerant to flow from compressor 1 to indoor heat exchanger 4 in the heating operation.

**[0061]** In refrigerant storage circuit C2, first check valve 14a and second check valve 14b are located in parallel with valve device 11. In refrigerant storage circuit C2, first check valve 14a is located at pipe P branched from between outdoor heat exchanger 2 and expansion valve 3. In refrigerant storage circuit C2, second check valve 14b is located at pipe P branched from between indoor heat exchanger 4 and expansion valve 3. Each of first check valve 14a and second check valve 14b is configured to allow the refrigerant to flow toward valve device 11 and avoid the refrigerant from flowing opposite to valve device 11.

**[0062]** Referring to Fig. 9, in the modification of refrigeration cycle apparatus 100 according to the first embodiment, controller CD has a four-way valve driving unit CD7. Four-way valve driving unit CD7 is configured to drive four-way valve 6 based on an instruction from control unit CD1. For example, four-way valve driving unit CD7 is configured to control switching of four-way valve 6 by controlling a driving source such as a motor of four-way valve 6.

**[0063]** Next, operations of the modification of refrigeration cycle apparatus 100 according to the first embodiment will be described with reference to Figs. 8 and 10 to 12. In the figures, solid arrows indicate flow of the refrigerant in the cooling operation, and broken arrows indicate flow of the refrigerant in the heating operation.

**[0064]** Referring to Fig. 8, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the first embodiment during the low-load operation in the cooling operation.

**[0065]** The modification of refrigeration cycle apparatus 100 according to the first embodiment can selectively perform the cooling operation and the heating operation. In the cooling operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, outdoor heat exchanger (condenser) 2, expansion valve 3, indoor heat exchanger (evaporator) 4, and four-way valve 6.

**[0066]** Referring to Fig. 10, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the first embodiment during the high-load operation in the cooling operation. During the high-load operation, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0067]** Referring to Fig. 11, the following describes an operation (refrigerant storing operation) of storing refrigerant into storage container 12. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12 through first valve 11a, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12.

**[0068]** Referring to Fig. 12, the following describes an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12 through first valve 11a, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0069]** Referring to Fig. 8, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the first embodiment during the low-load operation in the heating operation.

**[0070]** In the heating operation, the high-temperature and high-pressure gas refrigerant discharged from compressor 1 flows into indoor heat exchanger (condenser) 4, is condensed by indoor heat exchanger 4 to become liquid refrigerant, which then flows out from indoor heat exchanger 4. The liquid refrigerant flows into expansion valve 3, is reduced in pressure by expansion valve 3 to become low-pressure gas-liquid two-phase refrigerant, which then flows out from expansion valve 3. The low-pressure gas-liquid two-phase refrigerant flows into outdoor heat exchanger (evaporator) 2, is evaporated by outdoor heat exchanger 2 to become gas refrigerant, which then flows out from outdoor heat exchanger 2. The gas refrigerant flows into compressor 1 through four-way valve 6. In this way, the refrigerant circulates in refrigerant circuit C1. That is, in the heating operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, indoor heat exchanger (condenser) 4, expansion valve 3, outdoor heat exchanger (evaporator) 2, and four-way valve 6.

**[0071]** Referring to Fig. 10, during the high-load operation in the heating operation of the modification of refrigeration cycle apparatus 100 according to the first embodiment, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0072]** Referring to Fig. 11, in the operation (refrigerant storing operation) of storing the refrigerant into storage container 12, part of the liquid refrigerant having flowed out from indoor heat exchanger (evaporator) 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12 through first valve 11a, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12.

**[0073]** Referring to Fig. 12, in the operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2, part of the liquid refrigerant having flowed out from indoor heat exchanger 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12 through first valve 11a, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0074]** According to the modification of refrigeration cycle apparatus 100 of the first embodiment, four-way valve 6 is configured to switch the flow of the refrigerant so as to allow the refrigerant to flow from compressor 1 to outdoor heat exchanger 2 in the cooling operation and allow the refrigerant to flow from compressor 1 to indoor heat exchanger 4 in the heating operation. Therefore, the refrigerant can be stored into storage container 12 in both the cooling operation and the heating operation. For this reason, in both the cooling operation and the heating operation, the performance of the refrigeration cycle can be improved by storage container 12 and the controllability of expansion valve 3 can be improved.

**[0075]** In the modification of refrigeration cycle apparatus 100 according to the first embodiment, with first check valve 14a or second check valve 14b, the liquid refrigerant having flowed out from outdoor heat exchanger 2 or indoor heat exchanger 4 functioning as a condenser can be prevented from flowing into compressor 1 without being reduced in pressure by expansion valve 3.

Second Embodiment.

**[0076]** A refrigeration cycle apparatus 100 according to a second embodiment has the same configuration, operation, function and effect as those of refrigeration cycle apparatus 100 according to the first embodiment unless otherwise described particularly.

**[0077]** Referring to Fig. 13, in refrigeration cycle apparatus 100 according to the second embodiment, valve device 11 is a three-way valve 11d. In refrigerant storage circuit C2, three-way valve 11d is located among first outflow path OF1, second outflow path OF2, and expander 13. Three-way valve 11d is configured to make switching as to whether to allow the refrigerant to flow from first outflow path OF1 to expander 13 or allow the refrigerant to flow from second outflow path OF2 to expander 13.

**[0078]** When storing the refrigerant into storage container 12, three-way valve 11d is configured to connect first outflow path OF1 to expander 13. When recovering the refrigerant from storage container 12, three-way valve 11d is configured to connect second outflow path OF2 to expander 13.

**[0079]** Next, operations of refrigeration cycle apparatus 100 according to the second embodiment will be described.

**[0080]** Referring to Fig. 13, the following describes an operation of refrigeration cycle apparatus 100 according to the second embodiment during the low-load operation in the cooling operation. The refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, outdoor heat exchanger (condenser) 2, expansion valve 3, and indoor heat exchanger (evaporator) 4. Valve device 11 closes refrigerant storage circuit C2. Specifically, three-way valve 11d closes refrigerant storage circuit C2. Therefore, the refrigerant stored in storage container 12 does not flow into refrigerant circuit C1.

**[0081]** Referring to Fig. 14, the following describes an operation of refrigeration cycle apparatus 100 according to the second embodiment during the high-load operation in the cooling operation. During the high-load operation, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation. Three-way valve 11d closes refrigerant storage circuit C2 in the same manner as in the low-load operation. The amount of the refrigerant flowing through refrigerant circuit C 1 during the high-load operation is smaller than that during the low-load operation, and the amount of refrigerant 20 stored in storage container 12 of refrigerant storage circuit C2 during the high-load operation is larger than that during the low-load operation.

**[0082]** Referring to Fig. 15, the following describes an operation (refrigerant storing operation) of storing the refrigerant into storage container 12. When storing the refrigerant into storage container 12, three-way valve 11d connects first outflow path OF1 to expander 13. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into storage container 12 of refrigerant storage circuit C2 via inflow path IF, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1 to expander 13. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12.

**[0083]** Referring to Fig. 16, the following describes an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. When recovering the refrigerant from storage container 12, three-way valve 11d connects second outflow path OF2 to expander 13. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into storage container 12 of refrigerant storage circuit C2 via inflow path IF, and flows out to expander 13 via second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0084]** Next, function and effect of refrigeration cycle apparatus 100 according to the second embodiment will be described.

**[0085]** According to refrigeration cycle apparatus 100 of the second embodiment, when storing the refrigerant into storage container 12, three-way valve 11d connects first outflow path OF1 to expander 13. When recovering the refrigerant from storage container 12, three-way valve 11d connects second outflow path OF2 to expander 13. Therefore, refrigerant storage circuit C2 can be opened and closed by one three-way valve 11d. Therefore, the number of driving circuits for driving valves can be reduced as compared with the case where valve device 11 has three valves. Therefore, cost of refrigeration cycle apparatus 100 can be reduced.

**[0086]** Next, a modification of refrigeration cycle apparatus 100 according to the second embodiment will be described. The modification of refrigeration cycle apparatus 100 according to the second embodiment has the same configuration, operation, function and effect as those of refrigeration cycle apparatus 100 according to the second embodiment unless otherwise described particularly.

**[0087]** Referring to Fig. 17, in a modification of refrigeration cycle apparatus 100 according to the second embodiment, refrigerant circuit C1 has a four-way valve 6. Refrigerant circuit C1 is configured to allow the refrigerant to flow in the order of compressor 1, four-way valve 6, the condenser (outdoor heat exchanger 2 or indoor heat exchanger 4), expansion valve 3, the evaporator (indoor heat exchanger 4 or outdoor heat exchanger 2) and four-way valve 6. Refrigerant storage circuit C2 has a first check valve 14a and a second check valve 14b.

**[0088]** Next, operations of the modification of refrigeration cycle apparatus 100 according to the second embodiment will be described with reference to Figs. 17 to 20. In the figures, solid arrows indicate flow of the refrigerant in the cooling operation, and broken arrows indicate flow of the refrigerant in the heating operation.

**[0089]** Referring to Fig. 17, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the low-load operation in the cooling operation. The modification of refrigeration cycle apparatus 100 according to the second embodiment can selectively perform the cooling operation and the heating operation. In the cooling operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, outdoor heat exchanger (condenser) 2, expansion valve 3, indoor heat exchanger (evaporator) 4, and four-way valve 6.

**[0090]** Referring to Fig. 18, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the high-load operation in the cooling operation. During the high-load operation, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0091]** Referring to Fig. 19, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the operation (refrigerant storing operation) of storing refrigerant into storage container 12. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored in storage container 12.

**[0092]** Referring to Fig. 20, the following describes an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0093]** Referring to Fig. 17, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the low-load operation in the heating operation. In the heating operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, indoor heat exchanger (condenser) 4, expansion valve 3, outdoor heat exchanger (evaporator) 2, and four-way valve 6.

**[0094]** Referring to Fig. 18, during the high-load operation in the heating operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0095]** Referring to Fig. 19, in the operation (refrigerant storing operation) of storing the refrigerant into storage container 12, part of the liquid refrigerant having flowed out from indoor heat exchanger (evaporator) 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12.

**[0096]** Referring to Fig. 20, in the operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2, part of the liquid refrigerant having flowed out from indoor heat exchanger 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0097]** According to the modification of refrigeration cycle apparatus 100 of the second embodiment, four-way valve 6 is configured to switch the flow of the refrigerant so as to allow the refrigerant to flow from compressor 1 to outdoor heat exchanger 2 in the cooling operation and allow the refrigerant to flow from compressor 1 to indoor heat exchanger 4 in the heating operation. Therefore, the refrigerant can be stored into storage container 12 in both the cooling operation and the heating operation. For this reason, in both the cooling operation and the heating operation, the performance of the refrigeration cycle can be improved by storage container 12 and the controllability of expansion valve 3 can be improved.

Third Embodiment.

**[0098]** A refrigeration cycle apparatus 100 according to the third embodiment has the same configuration, operation, function and effect as those of refrigeration cycle apparatus 100 according to the first embodiment unless otherwise described particularly.

**[0099]** Referring to Fig. 21, in refrigeration cycle apparatus 100 according to the third embodiment, valve device 11 is a five-way valve 11e. In refrigerant storage circuit C2, five-way valve 110e is located among first pipe portion P1, storage container 12, and expander 13. Five-way valve 11e is configured to make switching as to whether to allow the refrigerant to flow from first pipe portion P1 to storage container 12 or allow the refrigerant to flow from storage container 12 to expander 13. Five-way valve 11e forms portions of inflow path IF, first outflow path OF1, and second outflow path OF2.

**[0100]** When storing the refrigerant into storage container 12, five-way valve 11e is configured to connect first pipe portion P1 to storage container 12 so as to form inflow path IF and connect storage container 12 to expander 13 so as to form first outflow path OF1. When recovering the refrigerant from storage container 12, five-way valve 11e is configured to connect storage container 12 to expander 13 so as to form second outflow path OF2.

**[0101]** Next, operations of refrigeration cycle apparatus 100 according to the third embodiment will be described.

**[0102]** Referring to Fig. 21, the following describes an operation of refrigeration cycle apparatus 100 according to the third embodiment during the low-load operation in the cooling operation. The refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, outdoor heat exchanger (condenser) 2, expansion valve 3, and indoor heat exchanger (evaporator) 4. Valve device 11 closes refrigerant storage circuit C2. Specifically, five-way valve 11e closes refrigerant storage circuit C2. Therefore, the refrigerant stored in storage container 12 does not flow into refrigerant circuit C1.

**[0103]** Referring to Fig. 22, the following describes an operation of refrigeration cycle apparatus 100 according to the third embodiment during the high-load operation in the cooling operation. During the high-load operation, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation. Five-way valve 11e closes refrigerant storage circuit C2 in the same manner as in the low-load operation. The amount of the refrigerant flowing through refrigerant circuit C1 during the high-load operation is smaller than that during the low-load operation, and the amount of refrigerant 20 stored in storage container 12 of refrigerant storage circuit C2 during the high-load operation is larger than that during the low-load operation.

**[0104]** Referring to Fig. 23, the following describes an operation of refrigeration cycle apparatus 100 according to the third embodiment during an operation (refrigerant storing operation) of storing refrigerant into storage container 12. When storing the refrigerant into storage container 12, five-way valve 11e connects first pipe portion P1 to storage container 12 so as to form inflow path IF, and connects storage container 12 to expander 13 so as to form first outflow path OF1. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into storage container 12 via inflow path IF, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1 to expander 13. In this way, in the refrigerant storing operation, the liquid refrigerant is stored into storage container 12.

**[0105]** Referring to Fig. 24, the following describes an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. When recovering the refrigerant from the storage container 12, five-way valve 11e is configured to connect storage container 12 to expander 13 so as to form second outflow path OF2. The liquid refrigerant stored in storage container 12 flows out from second outflow path OF2 to expander 13. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0106]** Next, function and effect of refrigeration cycle apparatus 100 according to the third embodiment will be described.

**[0107]** According to refrigeration cycle apparatus 100 of the third embodiment, when storing the refrigerant into storage container 12, five-way valve 11e connects first pipe portion P1 to storage container 12 so as to form inflow path IF and connects storage container 12 to expander 13 so as to form first outflow path OF1. When recovering the refrigerant from storage container 12, five-way valve 11e connects storage container 12 to expander 13 so as to form second outflow path OF2. Therefore, refrigerant storage circuit C2 can be opened and closed by one five-way valve 11e. Therefore, the number of driving circuits for driving valves can be reduced as compared with the case where valve device 11 has three valves. Therefore, cost can be reduced.

**[0108]** Next, a modification of refrigeration cycle apparatus 100 according to the third embodiment will be described. The modification of refrigeration cycle apparatus 100 according to the third embodiment has the same configuration, operation, function and effect as those of refrigeration cycle apparatus 100 according to the third embodiment unless otherwise described particularly.

**[0109]** Referring to Fig. 25, in the modification of refrigeration cycle apparatus 100 according to the third embodiment, refrigerant circuit C1 has a four-way valve 6. Refrigerant circuit C1 is configured to allow the refrigerant to flow in the order of compressor 1, four-way valve 6, the condenser (outdoor heat exchanger 2 or indoor heat exchanger 4), expansion valve 3, the evaporator (indoor heat exchanger 4 or outdoor heat exchanger 2) and four-way valve 6. Refrigerant storage circuit C2 has a first check valve 14a and a second check valve 14b.

**[0110]** Next, operations of the modification of refrigeration cycle apparatus 100 according to the third embodiment will be described with reference to Figs. 25 to 28. In the figures, solid arrows indicate flow of the refrigerant in the cooling operation, and broken arrows indicate flow of the refrigerant in the heating operation.

**[0111]** Referring to Fig. 25, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the third embodiment during the low-load operation in the cooling operation. The modification of refrigeration cycle apparatus 100 according to the third embodiment can selectively perform the cooling operation and the heating operation. In the cooling operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, outdoor heat exchanger (condenser) 2, expansion valve 3, indoor heat exchanger (evaporator) 4, and four-way valve 6.

**[0112]** Referring to Fig. 26, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the third embodiment during the high-load operation in the cooling operation. During the high-load operation, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0113]** Referring to Fig. 27, the following describes an operation (refrigerant storing operation) of storing refrigerant into storage container 12. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored in storage container 12.

**[0114]** Referring to Fig. 28, the following describes an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2. Part of the liquid refrigerant having flowed out from outdoor heat exchanger 2 flows into refrigerant storage circuit C2 via first pipe portion P1. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through first check valve 14a, flows into storage container 12, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0115]** Referring to Fig. 25, the following describes an operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment during the low-load operation in the heating operation. In the heating operation, the refrigerant circulates in refrigerant circuit C1 in the order of compressor 1, four-way valve 6, indoor heat exchanger (condenser) 4, expansion valve 3, outdoor heat exchanger (evaporator) 2, and four-way valve 6.

**[0116]** Referring to Fig. 26, during the high-load operation in the heating operation of the modification of refrigeration cycle apparatus 100 according to the second embodiment, the refrigerant circulates in refrigerant circuit C1 in the same manner as during the low-load operation.

**[0117]** Referring to Fig. 27, in the operation of the modification of refrigeration cycle apparatus 100 according to the third embodiment during the operation (refrigerant storing operation) of storing the refrigerant into storage container 12, part of the liquid refrigerant having flowed out from indoor heat exchanger (evaporator) 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12, and is stored into storage container 12. The gas refrigerant flows out from first outflow path OF1. In this way, in the refrigerant storing operation, the liquid refrigerant is stored in storage container 12.

**[0118]** Referring to Fig. 28, in an operation (refrigerant recovering operation) of recovering the refrigerant stored in storage container 12 of refrigerant storage circuit C2, part of the liquid refrigerant having flowed out from indoor heat exchanger 4 flows into refrigerant storage circuit C2 via first pipe portion P1 connecting indoor heat exchanger (evaporator) 4 to expansion valve 3. The liquid refrigerant having flowed into refrigerant storage circuit C2 passes through second check valve 14b, flows into storage container 12, and flows out from second outflow path OF2. In this way, in the refrigerant recovering operation, the liquid refrigerant stored in storage container 12 is recovered.

**[0119]** According to the modification of refrigeration cycle apparatus 100 of the third embodiment, four-way valve 6 is configured to switch the flow of the refrigerant so as to allow the refrigerant to flow from compressor 1 to outdoor heat exchanger 2 in the cooling operation and allow the refrigerant to flow from compressor 1 to indoor heat exchanger 4 in the heating operation. Therefore, the refrigerant can be stored in storage container 12 in both the cooling operation and the heating operation. For this reason, in both the cooling operation and the heating operation, the performance of the refrigeration cycle can be improved by storage container 12 and the controllability of expansion valve 3 can be improved.

**[0120]** The embodiments disclosed herein are illustrative and non-restrictive in any respect. The scope of the present disclosure is defined by the terms of the claims, rather than the embodiments described above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

**[0121]** 1: compressor; 2: outdoor heat exchanger; 2a: first blower apparatus; 3: expansion valve; 4: indoor heat exchanger; 4a: second blower apparatus; 5a: first temperature sensor; 5b: second temperature sensor; 5c: third temperature sensor; 5d: fourth temperature sensor; 6: four-way valve; 11: valve device; 11a: first valve; 11b: second valve; 11c: third valve; 11d: three-way valve; 11e: five-way valve; 12: storage container; 13: expander; 14a: first check valve; 14b: second check valve; 100: refrigeration cycle apparatus; 101: outdoor unit; 102: indoor unit; C1: refrigerant circuit; C2: refrigerant storage circuit; CD: controller; CD1: control unit; CD2: compressor driving unit; CD3: expansion valve driving unit; CD4: blower apparatus driving unit; CD5: valve device driving unit; CD6: temperature measuring unit; CD7: four-way valve driving unit; IF: inflow path; OF1: first outflow path; OF2: second outflow path; P: pipe; P1: first pipe portion; P2: second pipe portion; P3: third pipe portion; P4: fourth pipe portion.

## Claims

1. A refrigeration cycle apparatus comprising:

   a refrigerant circuit having a compressor, a condenser, an expansion valve, and an evaporator that are connected together by a pipe; and
   a refrigerant storage circuit connected to the refrigerant circuit,
   the pipe having a first pipe portion connecting the condenser to the expansion valve, and a second pipe portion connecting the evaporator to the compressor,
   the refrigerant storage circuit having:

      a storage container configured to store refrigerant;
      an expander located between the storage container and the second pipe portion; and
      a valve device located between the first pipe portion and the expander,

   the valve device being configured to open and close the refrigerant storage circuit.

2. The refrigeration cycle apparatus according to claim 1, wherein

   the refrigerant storage circuit has an inflow path through which the refrigerant flows into the storage container, a first outflow path through which the refrigerant in a gas state flows out from the storage container, and a second outflow path through which the refrigerant in a liquid state flows out from the storage container,
   when storing the refrigerant into the storage container, the valve device is configured to open the inflow path and the first outflow path and close the second outflow path, and
   when recovering the refrigerant from the storage container, the valve device is configured to close the first outflow path and open the second outflow path.

3. The refrigeration cycle apparatus according to claim 2, wherein

   the valve device has a first valve, a second valve, and a third valve,
   the first valve is configured to open and close the inflow path,
   the second valve is configured to open and close the first outflow path,
   the third valve is configured to open and close the second outflow path,
   when storing the refrigerant into the storage container, the first valve is configured to open the inflow path, the second valve is configured to open the first outflow path, and the third valve is configured to close the second outflow path, and
   when recovering the refrigerant from the storage container, the second valve is configured to close the first outflow path and the third valve is configured to open the second outflow path.

4. The refrigeration cycle apparatus according to claim 2, wherein

   the valve device is a three-way valve,
   the three-way valve is located among the first outflow path, the second outflow path, and the expander,
   when storing the refrigerant into the storage container, the three-way valve is configured to connect the first outflow path to the expander, and
   when recovering the refrigerant from the storage container, the three-way valve is configured to connect the second outflow path to the expander.

5. The refrigeration cycle apparatus according to claim 2, wherein

   the valve device is a five-way valve,
   the five-way valve is located among the first pipe portion, the storage container, and the expander, and forms portions of the inflow path, the first outflow path, and the second outflow path,
   when storing the refrigerant into the storage container, the five-way valve is configured to connect the first pipe portion to the storage container so as to form the inflow path, and connect the storage container to the expander so as to form the first outflow path, and
   when recovering the refrigerant from the storage container, the five-way valve is configured to connect the storage container to the expander so as to form the second outflow path.

6. The refrigeration cycle apparatus according to any one of claims 1 to 5, wherein

   the refrigerant circuit has:

      an outdoor heat exchanger functioning as the condenser in a cooling operation and functioning as the evaporator in a heating operation;
      an indoor heat exchanger functioning as the

evaporator in the cooling operation and functioning as the condenser in the heating operation; and
a four-way valve connected to the compressor, the outdoor heat exchanger, and the indoor heat exchanger, and

the four-way valve is configured to switch flow of the refrigerant so as to allow the refrigerant to flow from the compressor to the outdoor heat exchanger in the cooling operation and allow the refrigerant to flow from the compressor to the indoor heat exchanger in the heating operation.

FIG.1

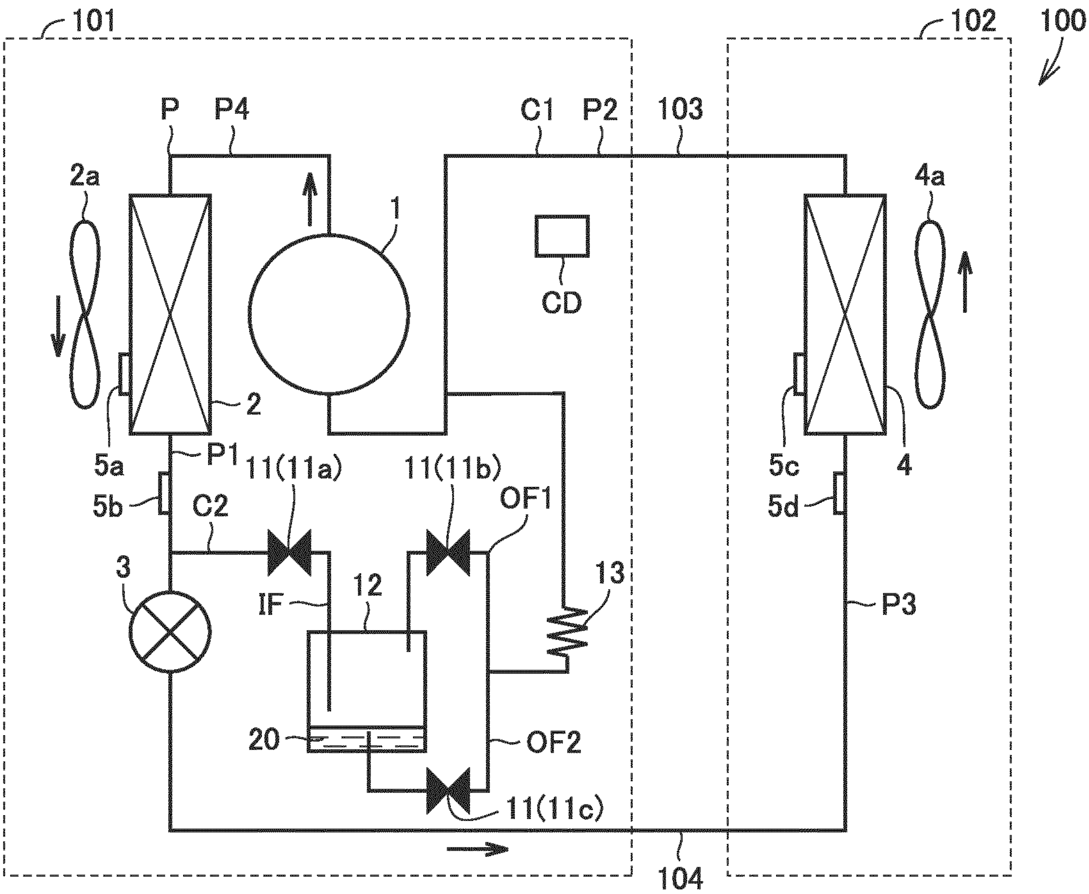

101
102
100
P
P4
C1
P2
103
2a
1
4a
CD
2
5a
P1
5c
4
11(11a)
11(11b)
5b
C2
OF1
5d
3
12
13
IF
P3
20
OF2
11(11c)
104

FIG.2

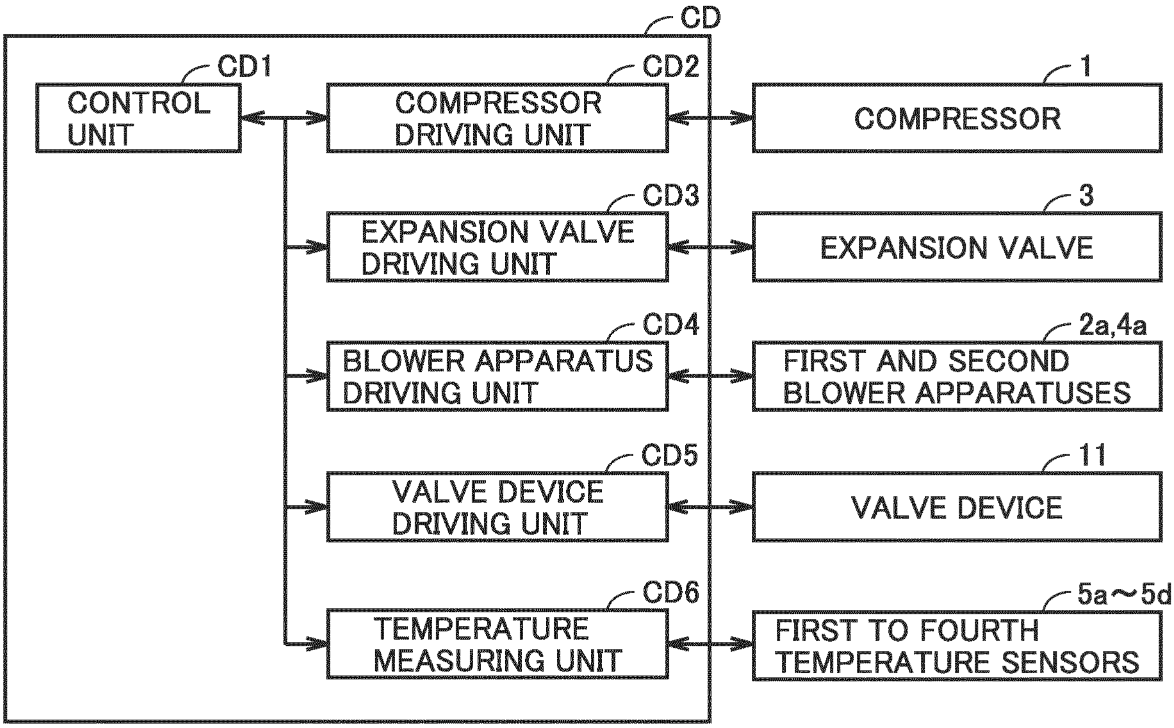

CD
CD1
CONTROL UNIT
CD2
COMPRESSOR DRIVING UNIT
CD3
EXPANSION VALVE DRIVING UNIT
CD4
BLOWER APPARATUS DRIVING UNIT
CD5
VALVE DEVICE DRIVING UNIT
CD6
TEMPERATURE MEASURING UNIT
1
COMPRESSOR
3
EXPANSION VALVE
2a,4a
FIRST AND SECOND BLOWER APPARATUSES
11
VALVE DEVICE
5a～5d
FIRST TO FOURTH TEMPERATURE SENSORS

FIG.3

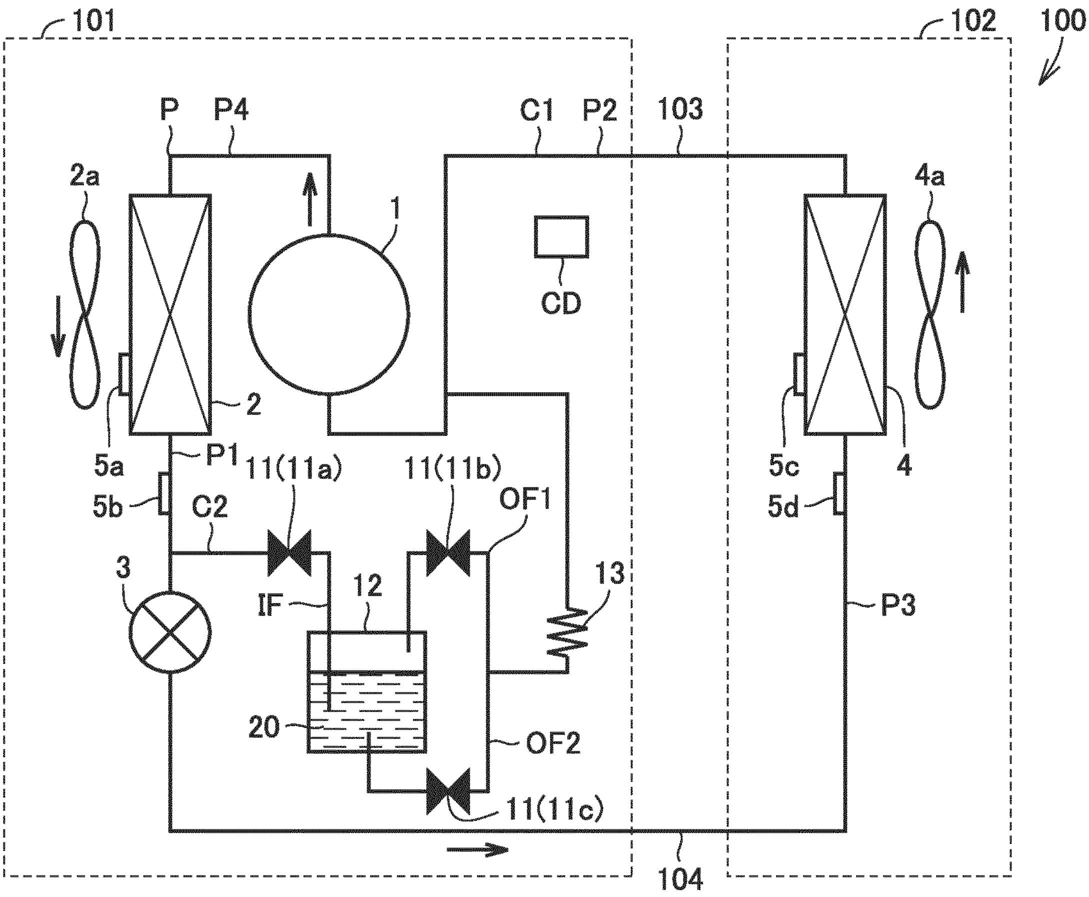
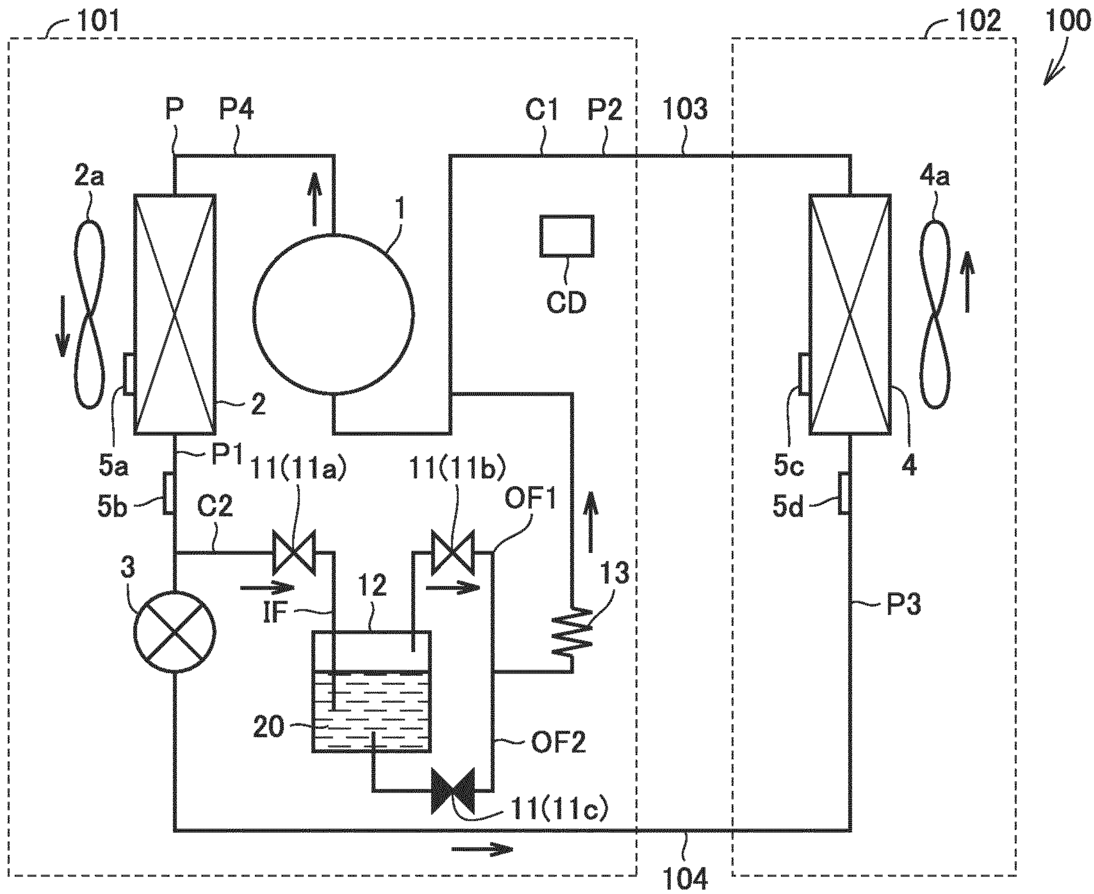

101
102
100
P
P4
C1
P2
103
2a
1
4a
CD
2
5a
P1
11(11a)
11(11b)
5c
4
5b
C2
OF1
5d
3
12
13
IF
P3
20
OF2
11(11c)
104

FIG.4



101
102
100
P
P4
C1
P2
103
2a
1
4a
CD
2
5a
P1
11(11a)
11(11b)
5c
4
5b
C2
OF1
5d
3
12
13
IF
P3
20
OF2
11(11c)
104

FIG.5

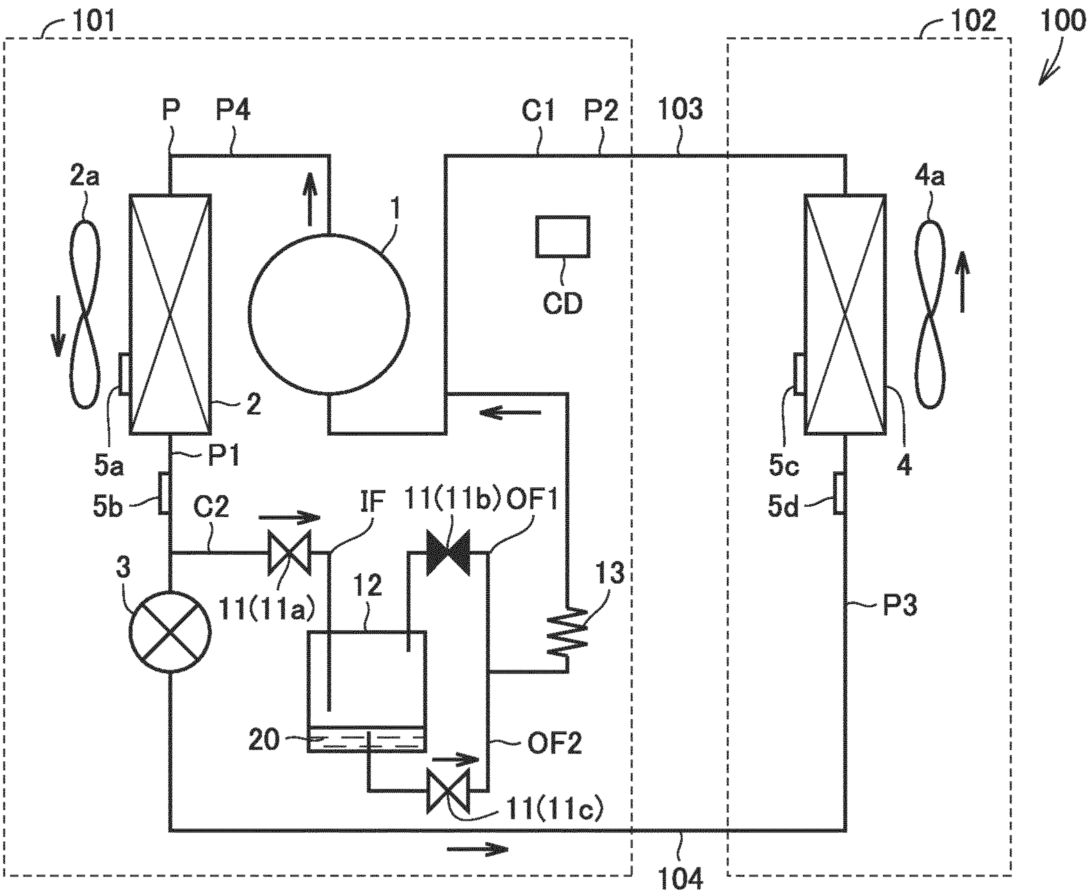

101
102
100
P
P4
C1
P2
103
2a
1
4a
CD
2
5a
P1
5c
4
5b
C2
IF
11(11b)
OF1
5d
3
11(11a)
12
13
P3
20
OF2
11(11c)
104

FIG.6

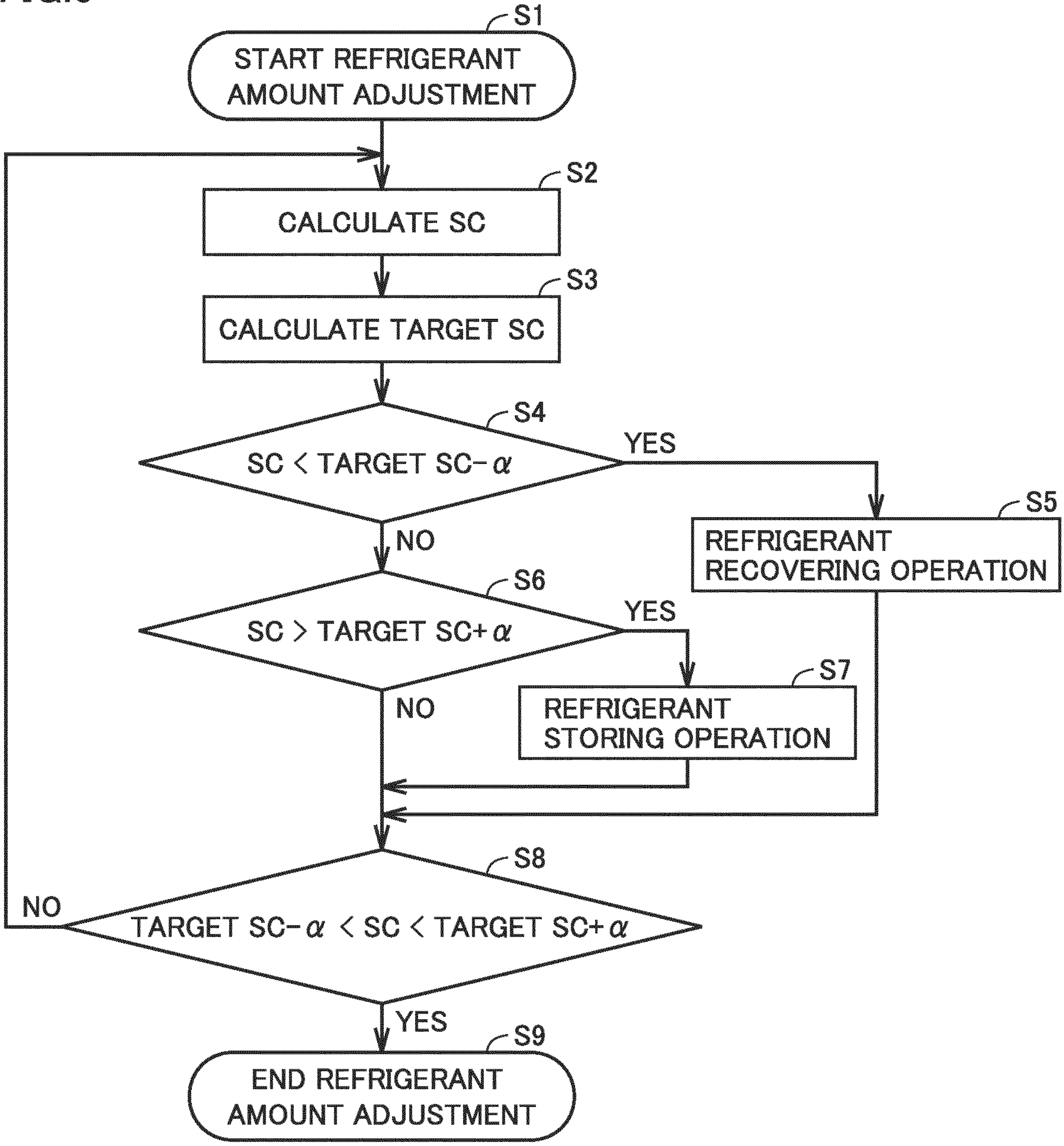

S1
START REFRIGERANT AMOUNT ADJUSTMENT
S2
CALCULATE SC
S3
CALCULATE TARGET SC
S4
SC < TARGET SC− α
YES
NO
S5
REFRIGERANT RECOVERING OPERATION
S6
SC > TARGET SC+ α
YES
NO
S7
REFRIGERANT STORING OPERATION
S8
TARGET SC− α < SC < TARGET SC+ α
NO
YES
S9
END REFRIGERANT AMOUNT ADJUSTMENT

FIG.7

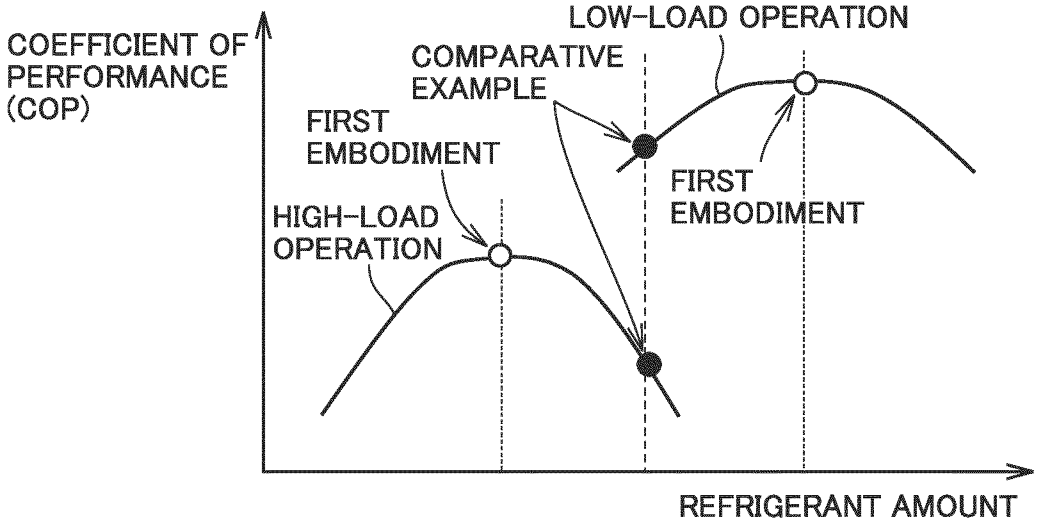

COEFFICIENT OF PERFORMANCE (COP)
LOW-LOAD OPERATION
COMPARATIVE EXAMPLE
FIRST EMBODIMENT
HIGH-LOAD OPERATION
FIRST EMBODIMENT
REFRIGERANT AMOUNT

FIG.8

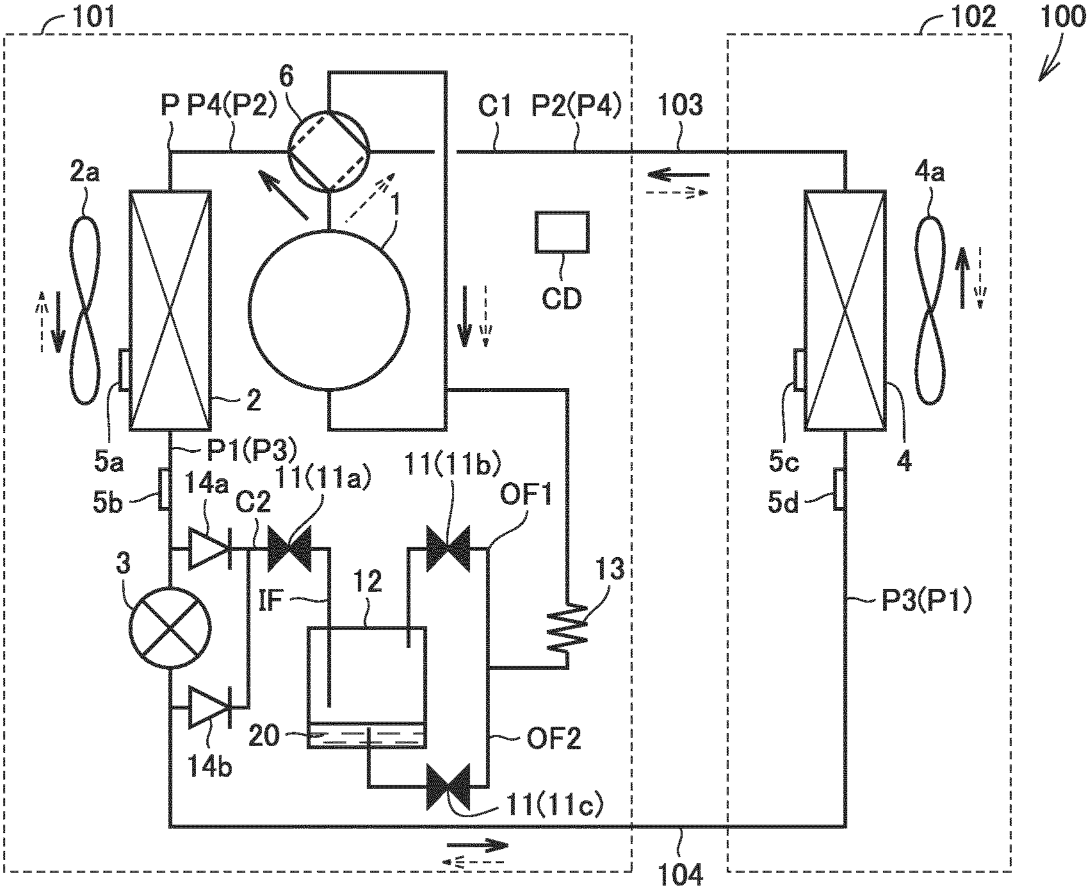
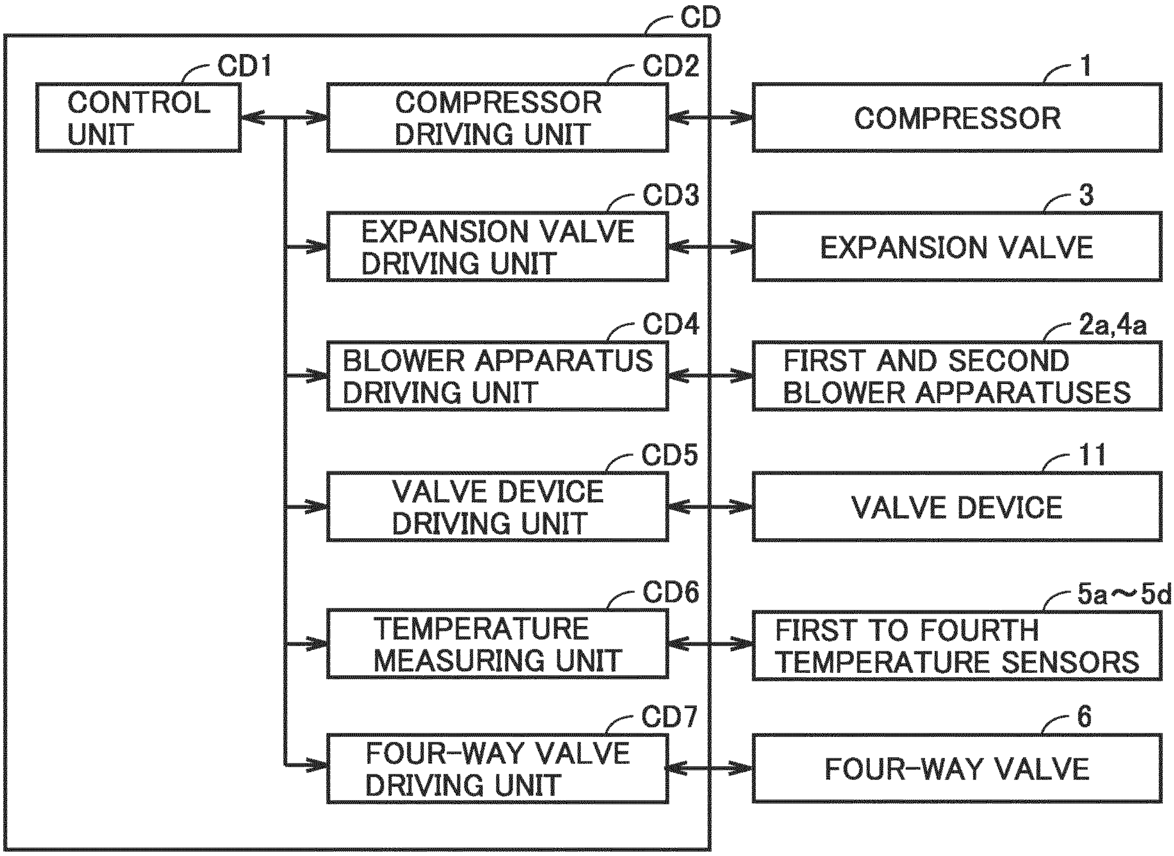

101
102
100
6
P
P4(P2)
C1
P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
5c
4
5b
14a
11(11a)
11(11b)
OF1
5d
C2
3
IF
12
13
P3(P1)
20
OF2
14b
11(11c)
104

FIG.9


CD
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CONTROL UNIT
CD2
COMPRESSOR DRIVING UNIT
1
COMPRESSOR
CD3
EXPANSION VALVE DRIVING UNIT
3
EXPANSION VALVE
CD4
BLOWER APPARATUS DRIVING UNIT
2a,4a
FIRST AND SECOND BLOWER APPARATUSES
CD5
VALVE DEVICE DRIVING UNIT
11
VALVE DEVICE
CD6
TEMPERATURE MEASURING UNIT
5a～5d
FIRST TO FOURTH TEMPERATURE SENSORS
CD7
FOUR-WAY VALVE DRIVING UNIT
6
FOUR-WAY VALVE

FIG.10

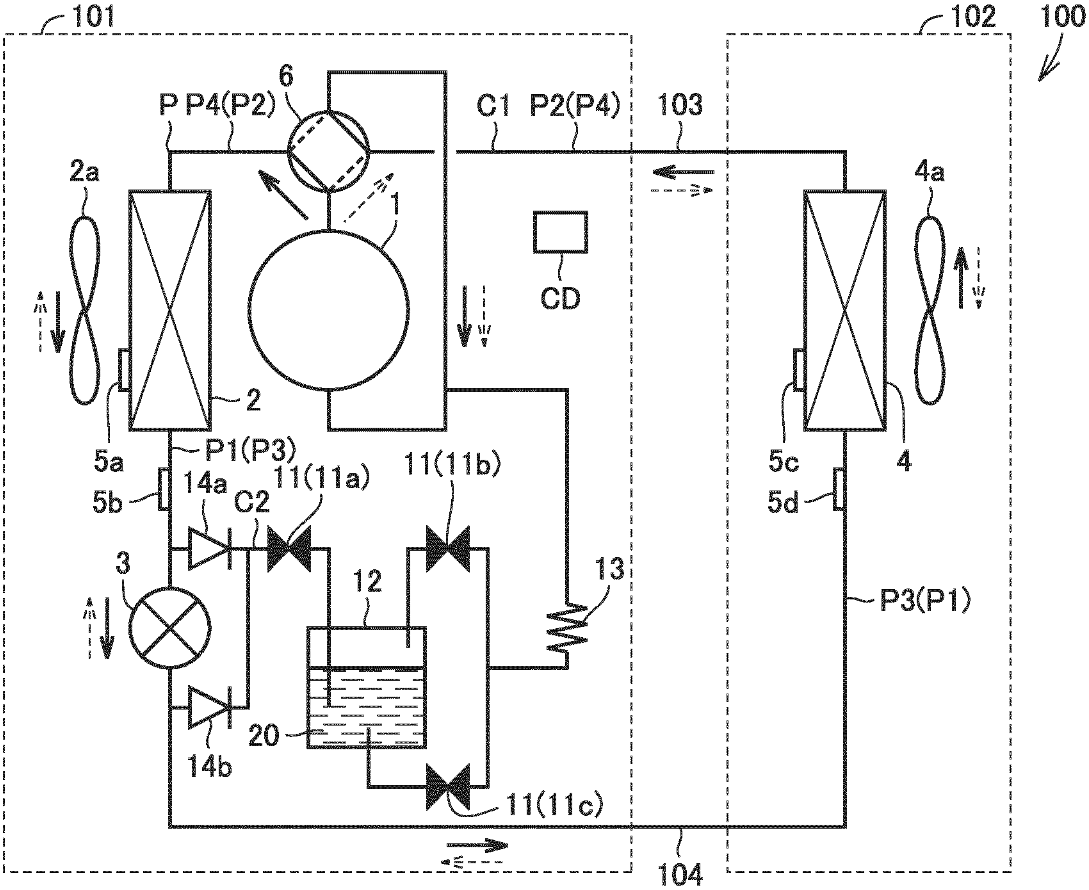
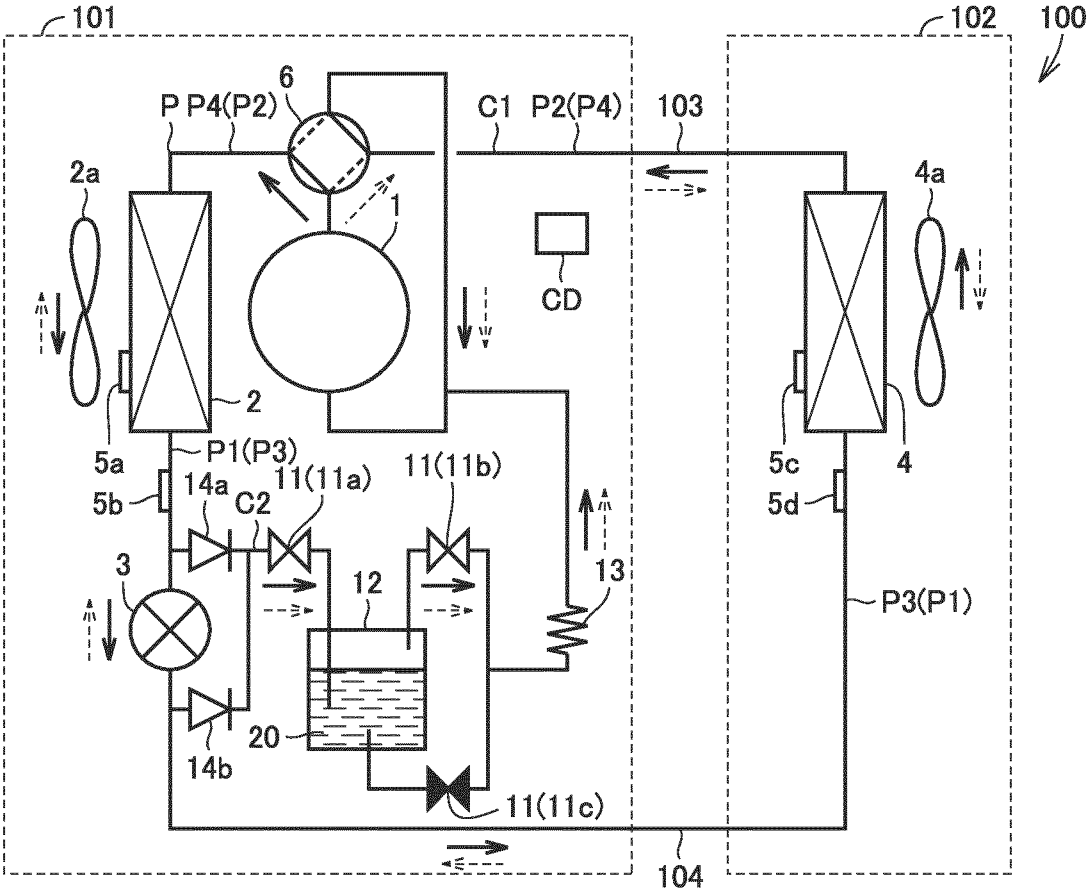

101
102
100
6
P P4(P2)
C1 P2(P4)
103
2a
4a
1
CD
2
5a
P1(P3)
5c
4
5b
14a
11(11a)
11(11b)
C2
5d
3
12
13
P3(P1)
20
14b
11(11c)
104

FIG.11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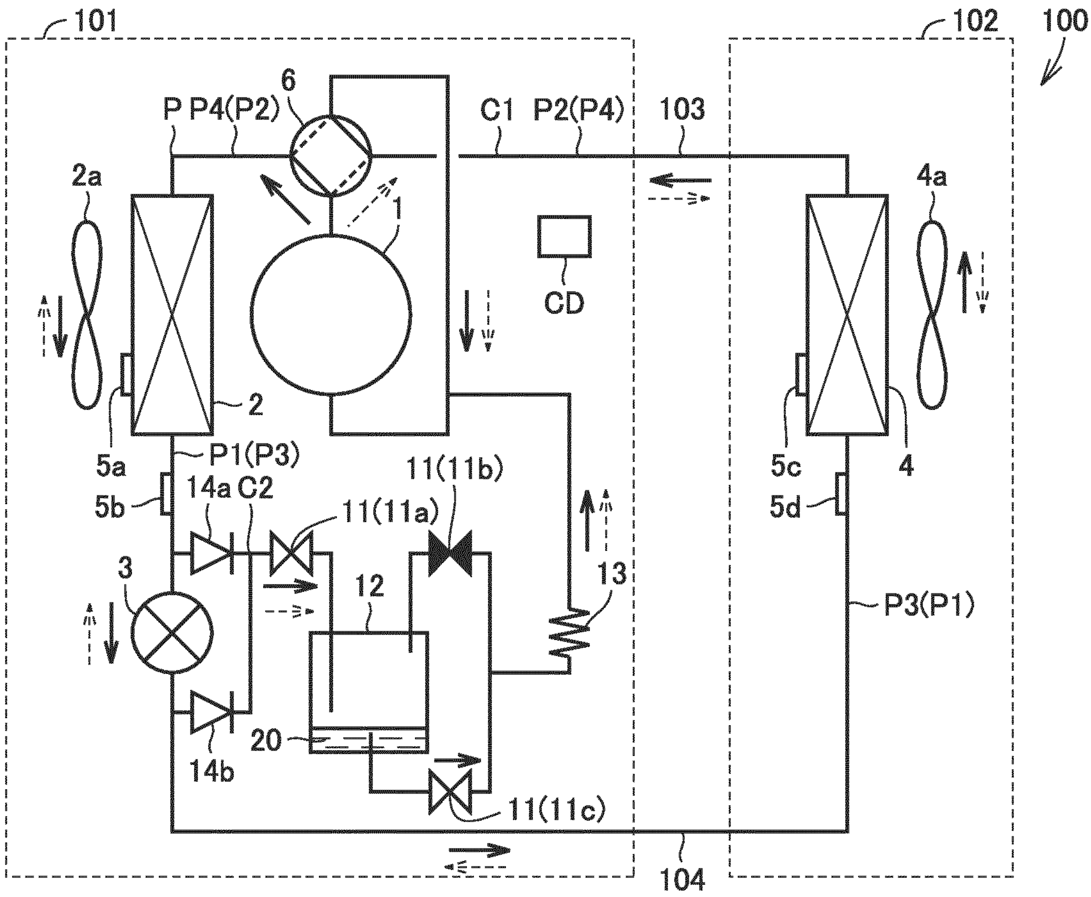
C1
P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
5c
4
5b
14a
11(11a)
11(11b)
5d
C2
3
12
13
P3(P1)
20
14b
11(11c)
104

FIG.12



101
102
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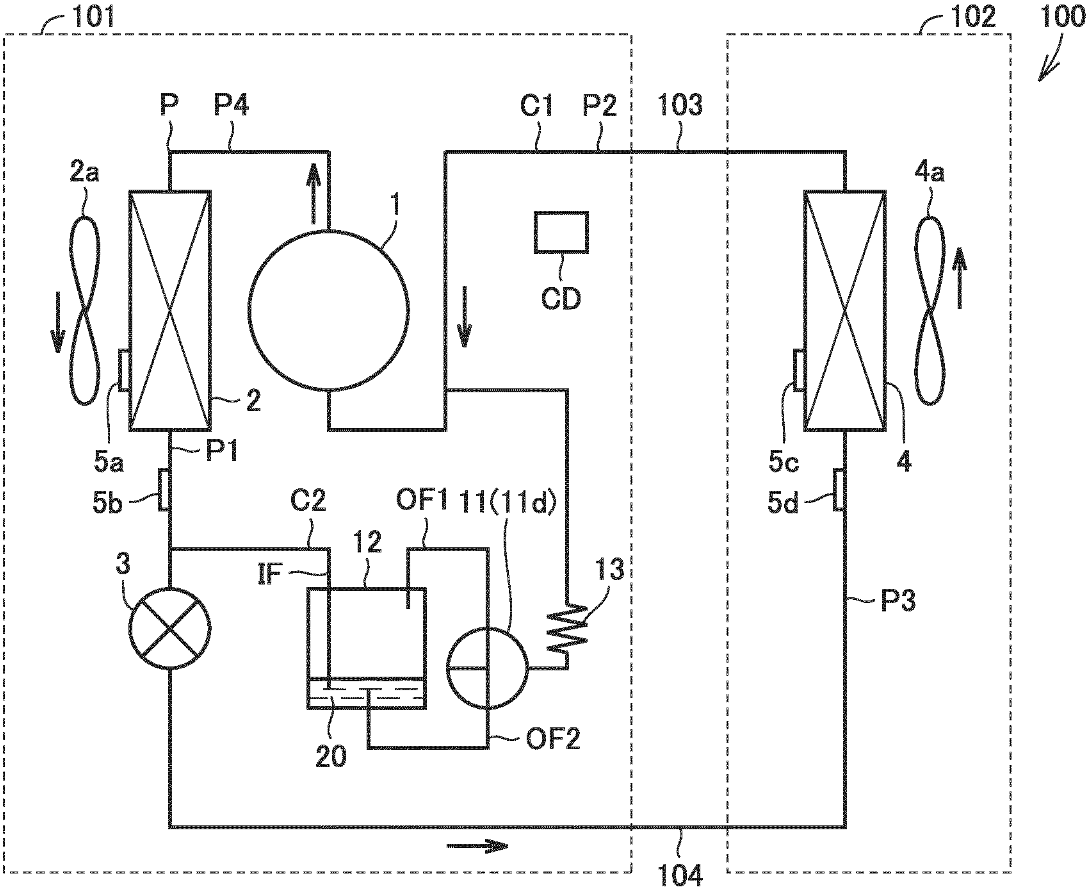
6
P
P4(P2)
C1
P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
5c
4
5b
14a
C2
11(11b)
5d
11(11a)
3
12
13
P3(P1)
20
14b
11(11c)
104

FIG.13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P4
C1
P2
103
2a
1
4a
CD
2
5a
P1
5c
4
5b
5d
C2
OF1
11(11d)
12
3
IF
13
P3
20
OF2
104

FIG.14

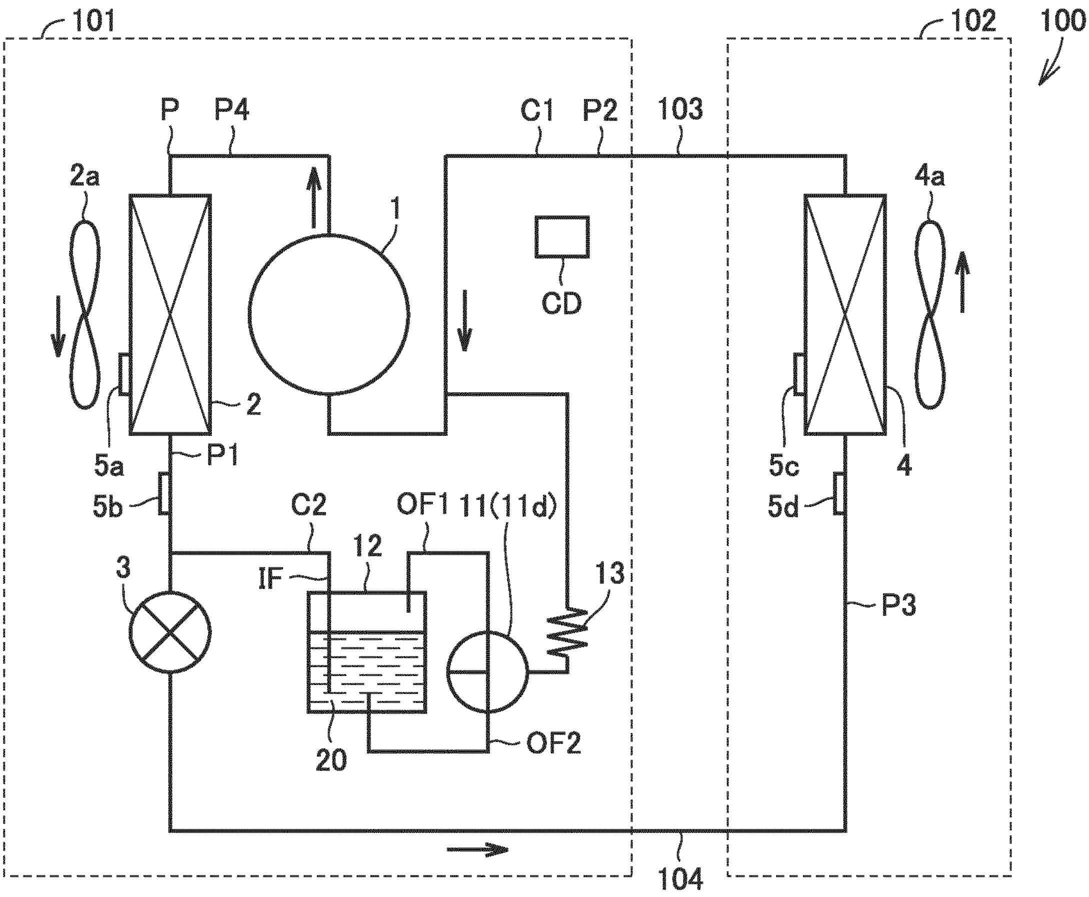
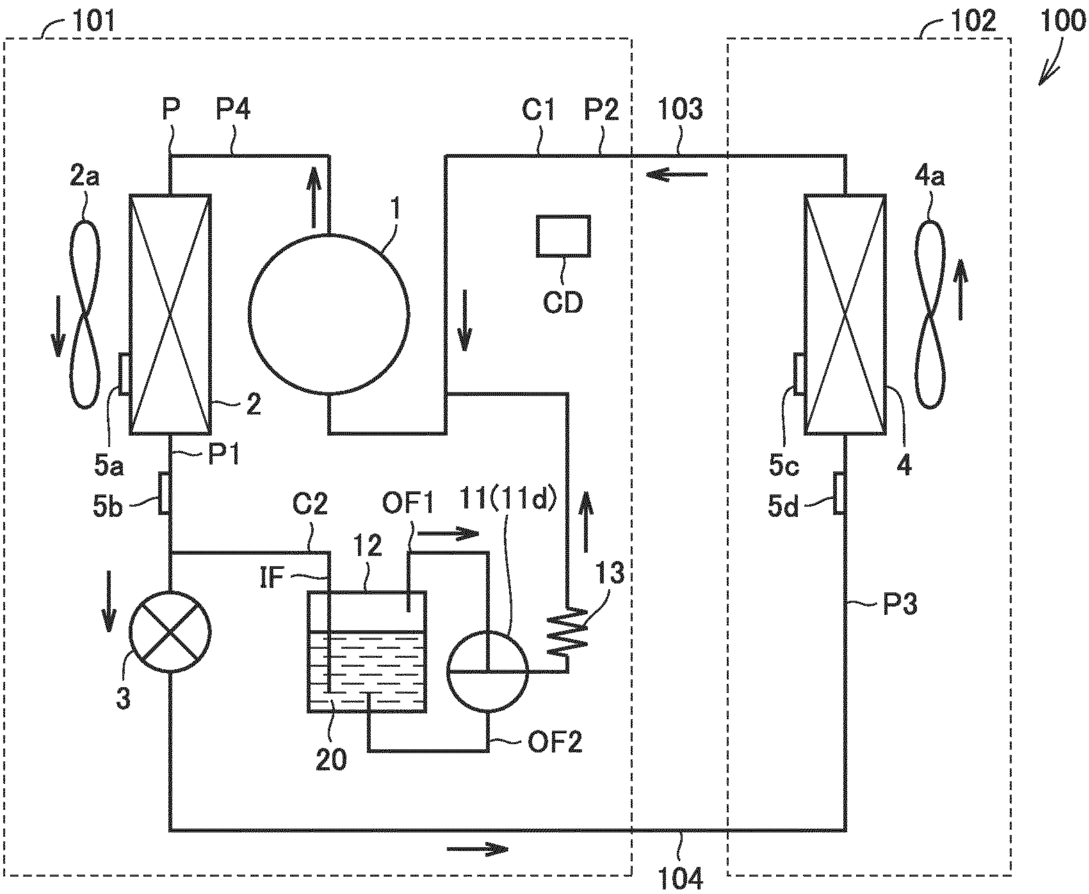

101
102
100
P
P4
C1
P2
103
2a
4a
1
CD
2
5a
P1
5c
4
5b
C2
OF1
11(11d)
5d
12
3
IF
13
P3
20
OF2
104

FIG.15



101
102
100
P
P4
C1
P2
103
2a
4a
1
CD
2
5a
P1
5c
4
5b
5d
C2
OF1
11(11d)
12
IF
13
P3
3
20
OF2
104

FIG.16

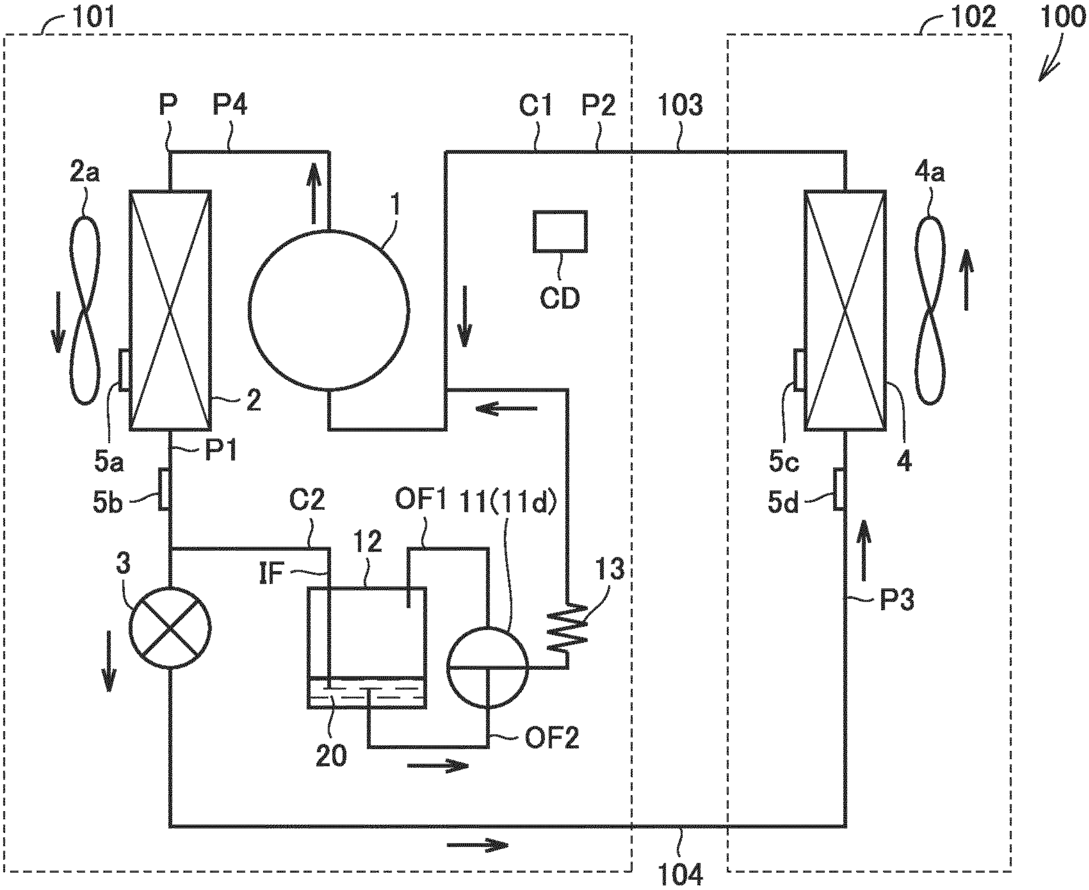

101
102
100
P
P4
C1
P2
103
2a
4a
1
CD
2
5a
P1
5c
4
5b
C2
OF1
11(11d)
5d
12
3
IF
13
P3
20
OF2
104

FIG.17

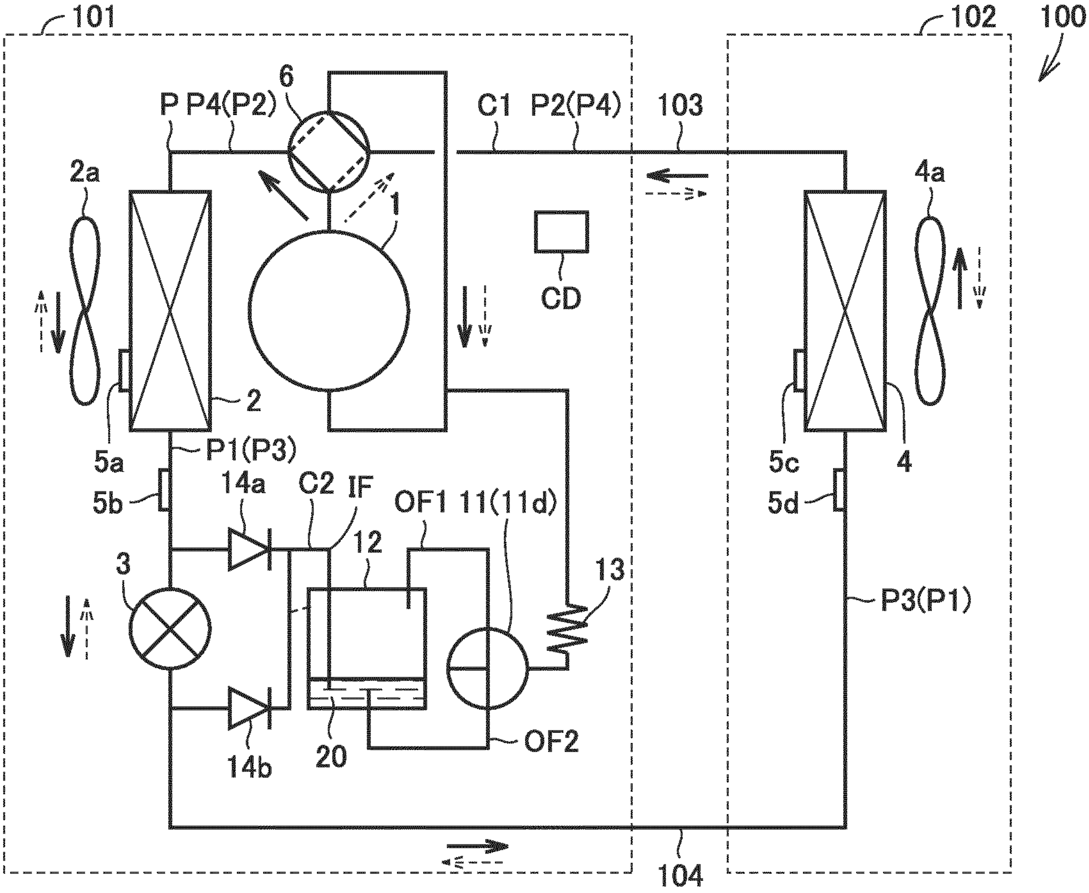

101
102
100
6
P P4(P2)
C1 P2(P4)
103
2a
1
4a
CD
2
P1(P3)
5a
5c
4
5b
14a
C2 IF
OF1 11(11d)
5d
12
3
13
P3(P1)
20
OF2
14b
104

FIG.18

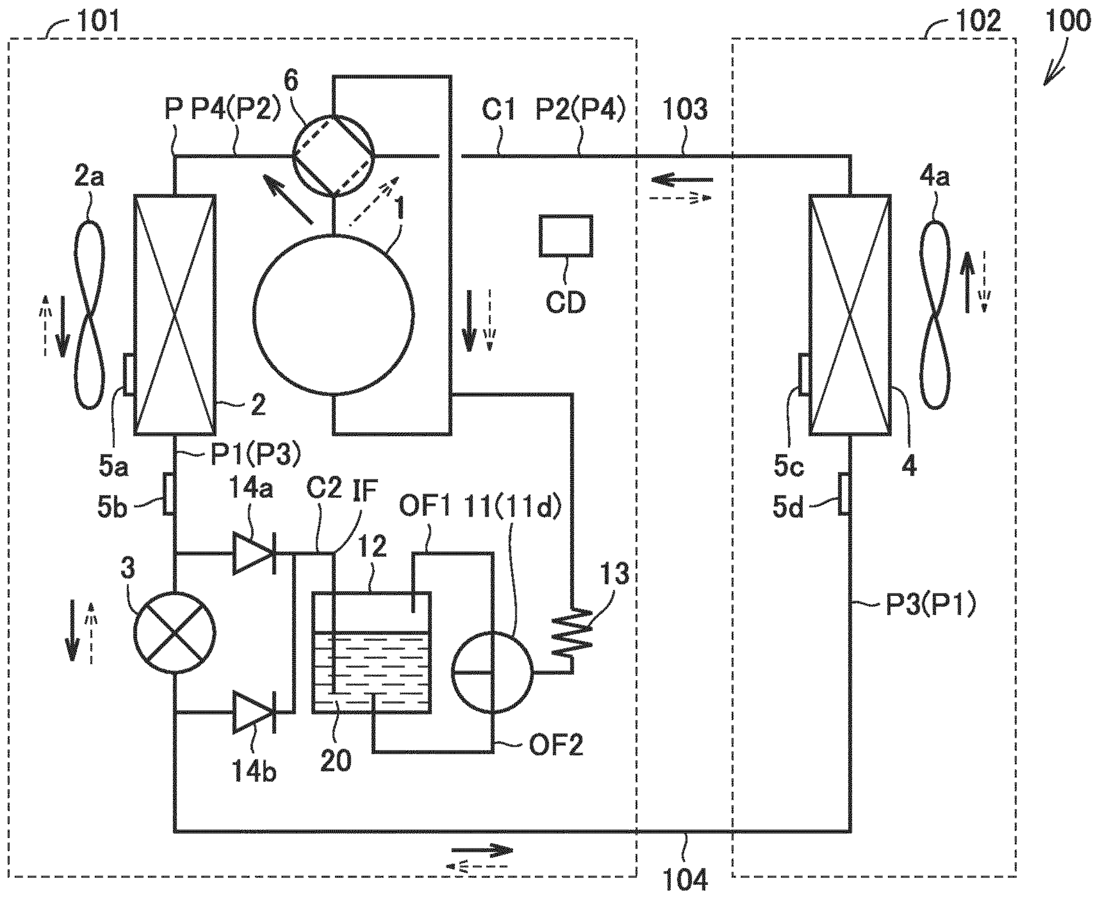

101
102
100
6
P P4(P2)
C1 P2(P4)
103
2a
4a
1
CD
2
5a
P1(P3)
5c
4
5b
5d
14a
C2 IF
OF1 11(11d)
12
3
13
P3(P1)
14b
20
OF2
104

FIG.19

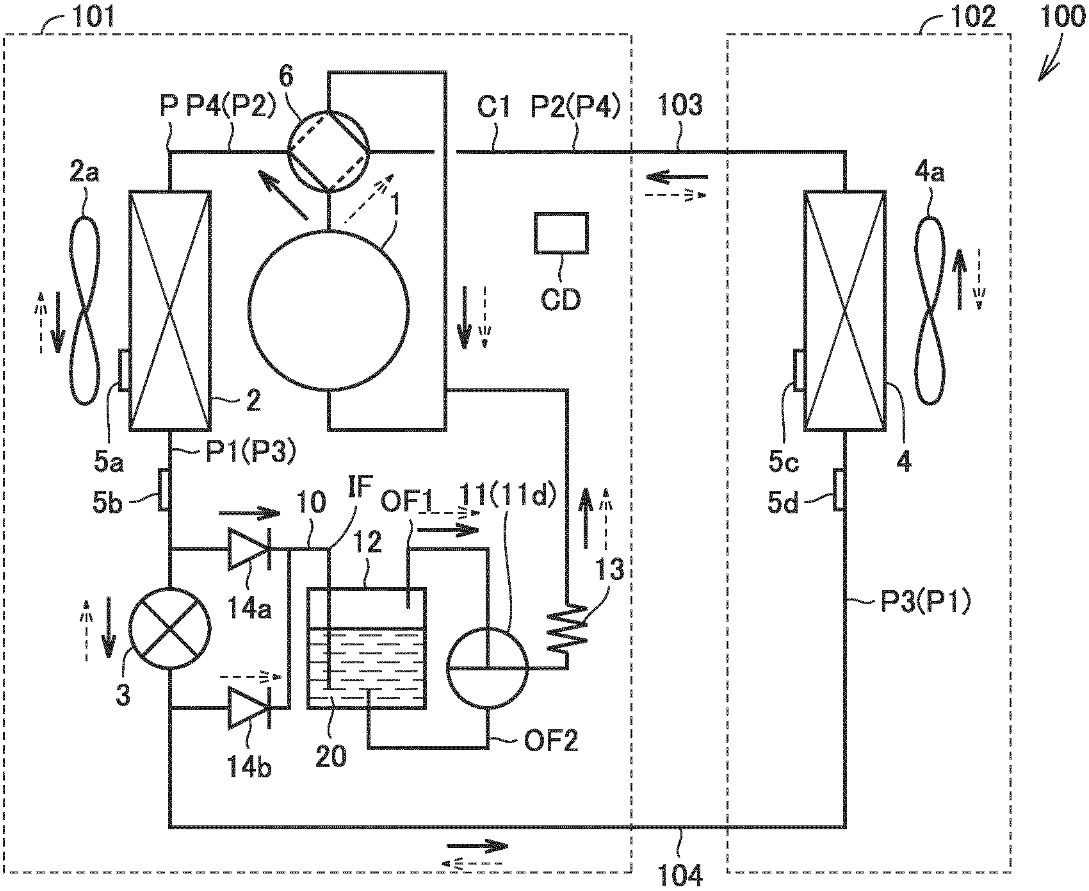
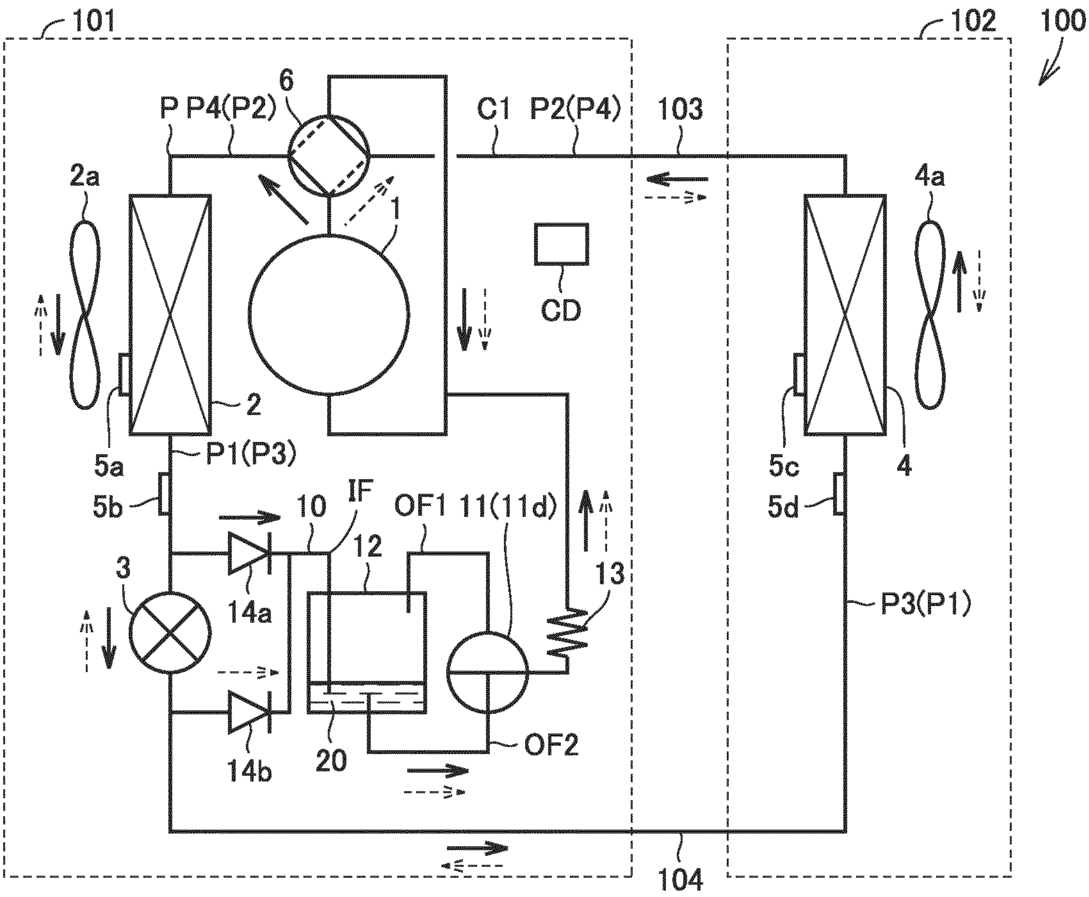

101
102
100
6
P P4(P2)
C1 P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
5c
4
5b
10
IF
OF1
11(11d)
5d
12
13
14a
P3(P1)
3
14b
20
OF2
104

FIG.20


101
102
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6
P P4(P2)
C1 P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
5c
4
5b
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IF
OF1 11(11d)
5d
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12
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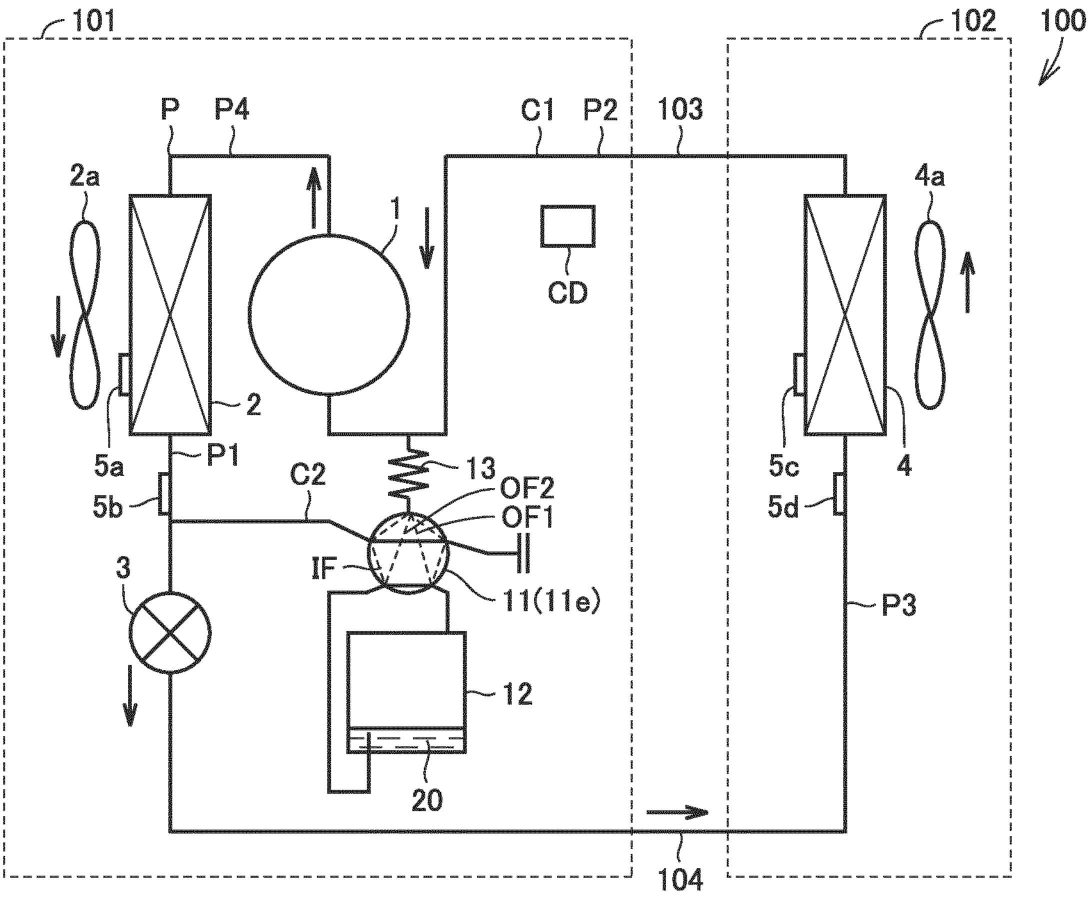
14a
P3(P1)
14b
20
OF2
104

FIG.21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P2
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5a
P1
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5c
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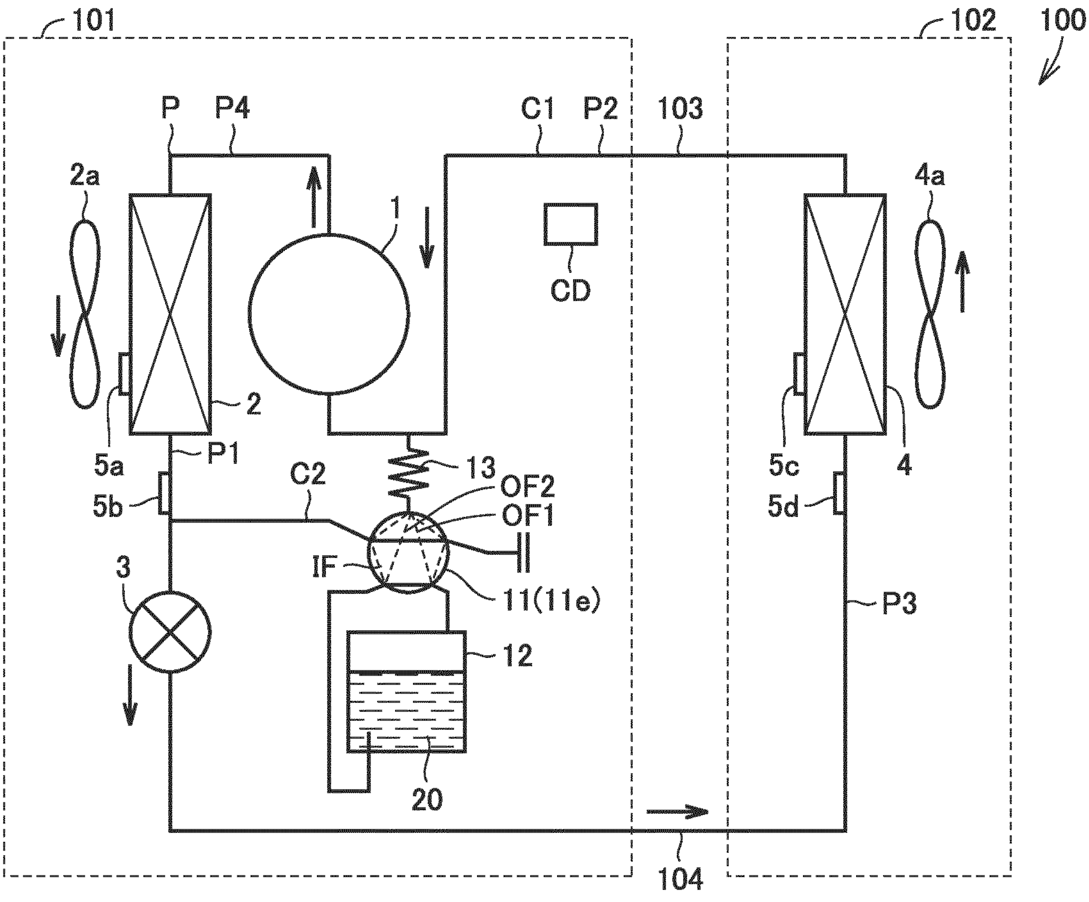
C2
OF2
5b
OF1
5d
3
IF
11(11e)
P3
12
20
104

FIG.22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C1
P2
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2a
1
4a
CD
2
5a
P1
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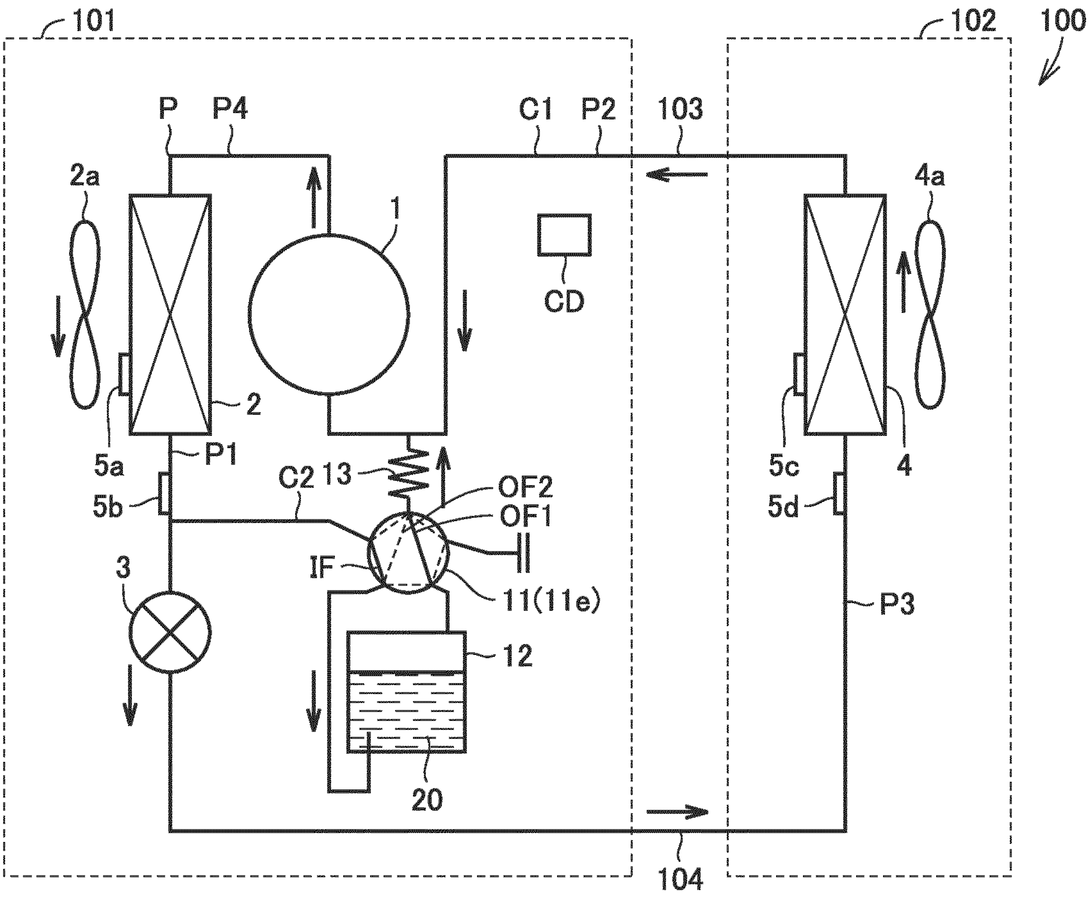
5c
4
5b
C2
OF2
OF1
5d
IF
3
11(11e)
P3
12
20
104

FIG.23


101
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P4
C1
P2
103
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4a
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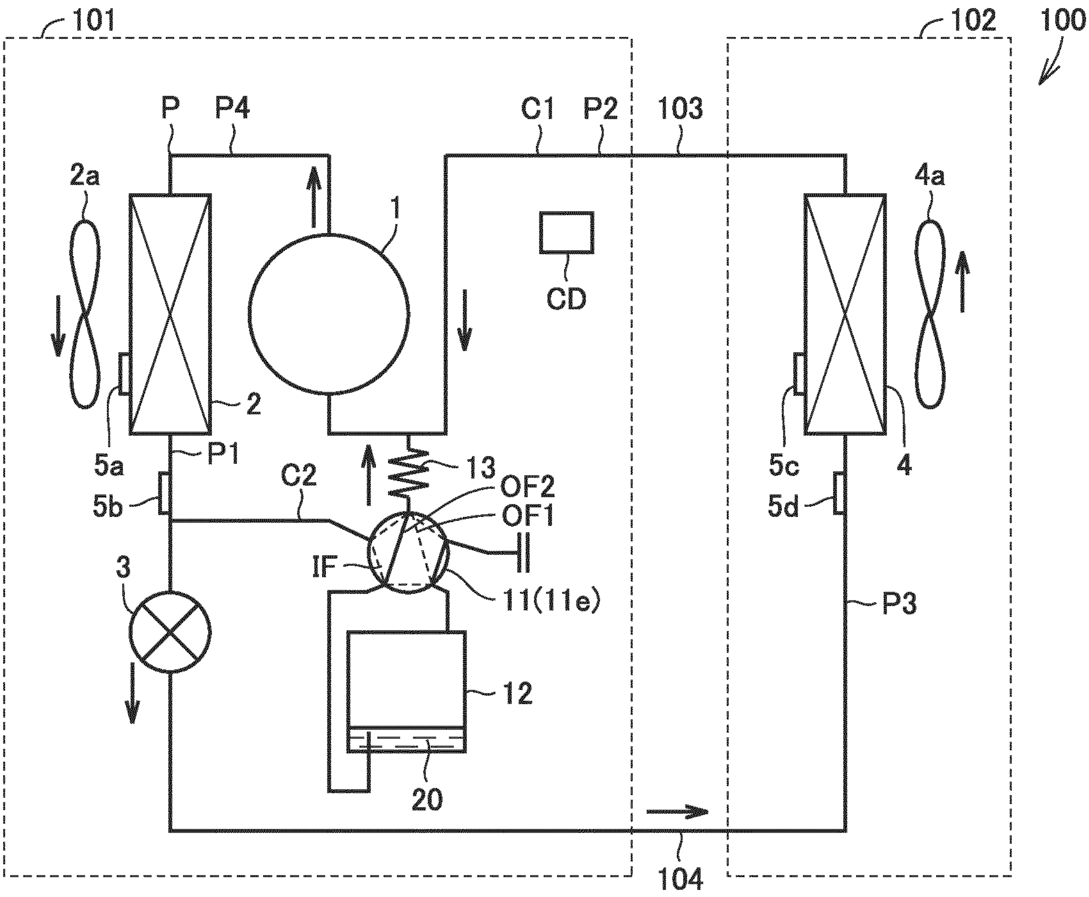
CD
2
5a
P1
5c
4
C2
13
OF2
OF1
5b
5d
3
IF
11(11e)
P3
12
20
104

FIG.24


101
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P4
C1
P2
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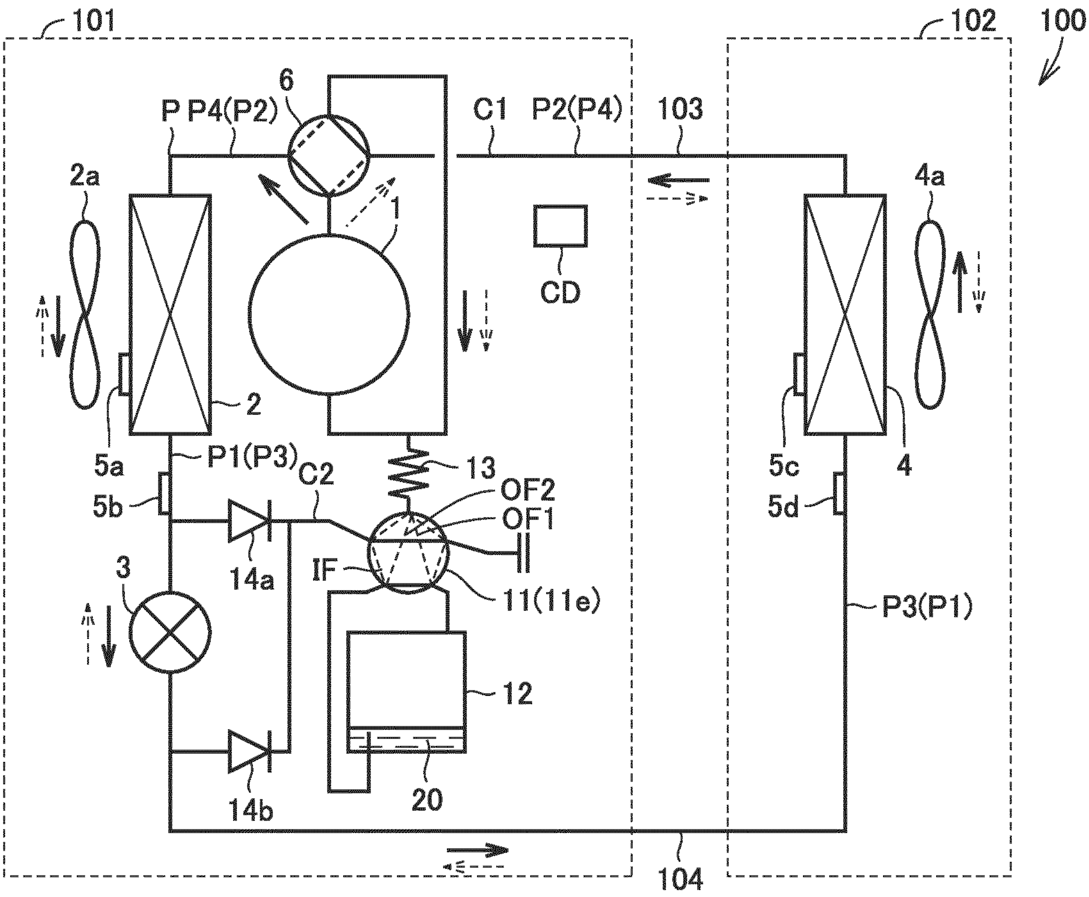
2a
4a
1
CD
2
5a
P1
5c
4
13
5b
C2
OF2
OF1
5d
IF
3
11(11e)
P3
12
20
104

FIG.25


101
102
100
6
P P4(P2)
C1
P2(P4)
103
2a
4a
1
CD
2
5a
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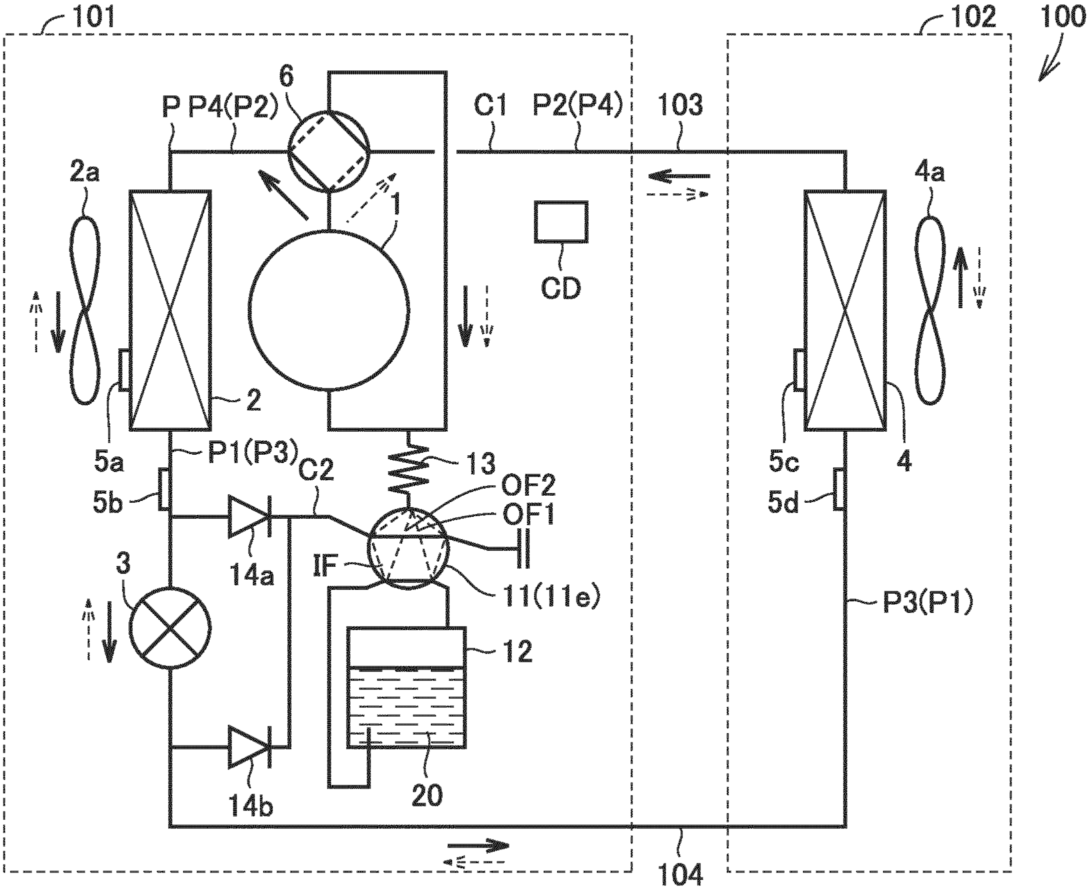
C2
13
OF2
OF1
5c
4
5b
5d
3
14a
IF
11(11e)
P3(P1)
12
14b
20
104

FIG.26


101
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P
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C1
P2(P4)
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2a
1
4a
CD
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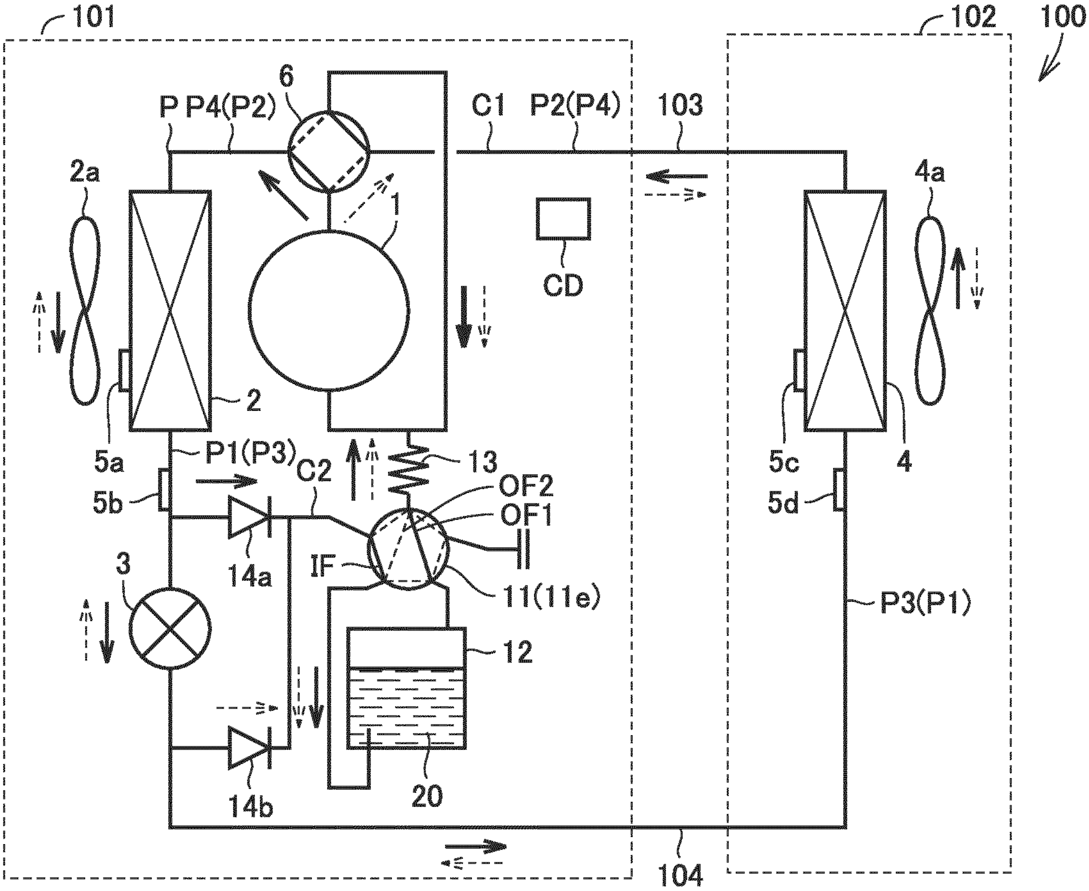
5a
5c
4
P1(P3)
C2
13
OF2
OF1
5b
5d
14a
3
IF
11(11e)
P3(P1)
12
14b
20
104

FIG.27


101
102
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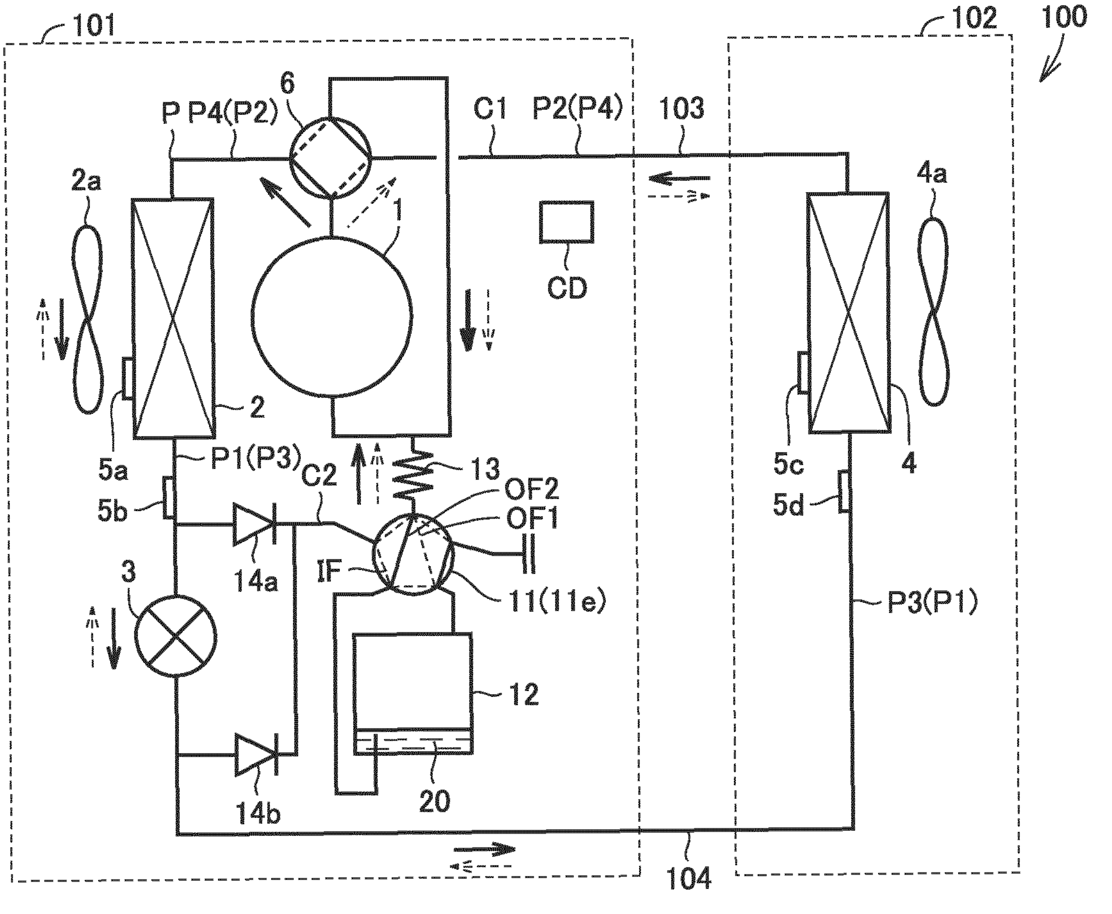
P P4(P2)
C1
P2(P4)
103
2a
1
4a
CD
2
5a
P1(P3)
C2
13
5c
4
5b
OF2
OF1
5d
14a
IF
11(11e)
3
P3(P1)
12
20
14b
104

FIG.28


101
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C1
P2(P4)
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4a
CD
2
5a
5c
4
P1(P3)
C2
13
5a
5b
OF2
OF1
5d
IF
11(11e)
3
14a
P3(P1)
12
20
14b
104

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2020/018843

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F25B13/00(2006.01)i, F25B1/00(2006.01)i
FI: F25B1/00 385Z, F25B13/00 P

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

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. |
|---|---|---|
| X<br>Y | WO 2008/093718 A1 (DAIKIN INDUSTRIES, LTD.) 07 August 2008, paragraphs [0031]-[0055], [0065], [0066], fig. 1, 2 | 1, 6<br>2-6 |
| X<br>Y | JP 2012-207823 A (FUJITSU GENERAL LTD.) 25 October 2012, paragraphs [0021]-[0024], [0042]-[0044], [0052]-[0057], [0061], [0063], [0064], fig. 1, 2, 5, 6, 8, 9 | 1, 6<br>2-6 |
| Y | JP 2010-127531 A (MITSUBISHI ELECTRIC CORP.) 10 June 2010, paragraphs [0026]-[0029], fig. 4 | 2-6 |

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

☒ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 27.07.2020 | 04.08.2020 |

| 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. |

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

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

International application No.
PCT/JP2020/018843

| Patent Documents referred to in the Report | Publication Date | Patent Family | Publication Date |
|---|---|---|---|
| WO 2008/093718 A1 | 07.08.2008 | US 2010/0089085 A1<br>paragraphs [0049]-[0074], [0084], [0085], fig. 1, 2<br>EP 2128543 A1<br>CN 101595351 A<br>AU 2008210830 A<br>KR 10-2009-0115174 A<br>JP 2008-185295 A | |
| JP 2012-207823 A | 25.10.2012 | (Family: none) | |
| JP 2010-127531 A | 10.06.2010 | (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 10111047 A **[0003] [0004]**