(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 375 187 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.10.2011 Bulletin 2011/41

(21) Application number: **11001441.2**

(22) Date of filing: **21.02.2011**

(51) Int Cl.:
F25B 13/00 *(2006.01)* ***F25B 49/00*** *(2006.01)*
F25B 41/04 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **26.02.2010 JP 2010041386**

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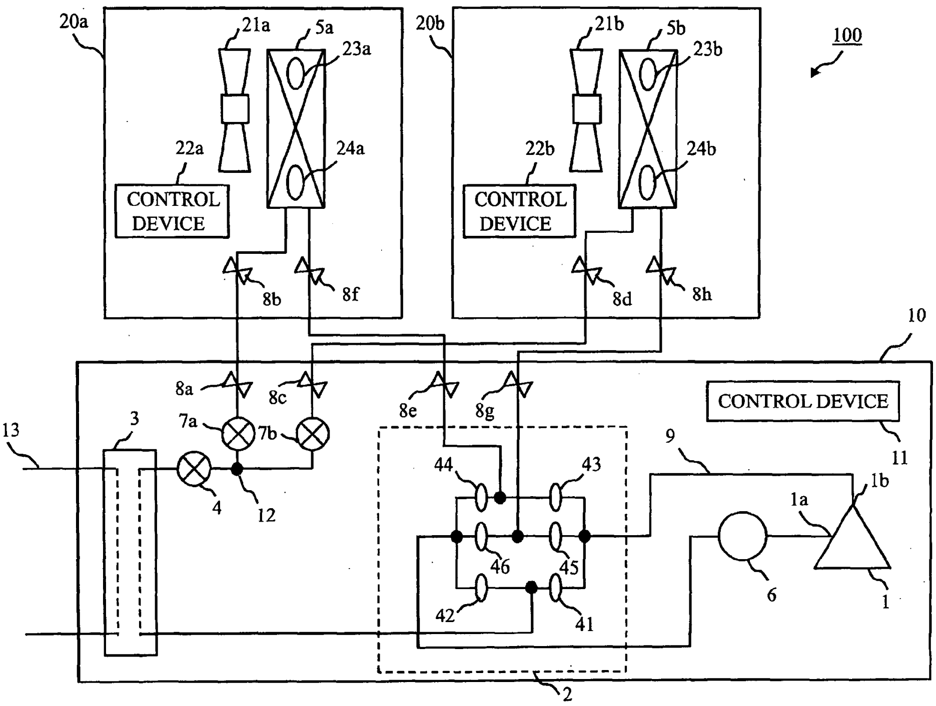
(54) Heat pump apparatus and operation control method of heat pump apparatus

(57) The present invention aims to prevent a refrigerant at a low temperature from being sent to a load-side heat exchanger during a defrost operation. At a time of a heat radiating operation, a switching mechanism 2 is controlled such that the refrigerant from a compressor 1 flows to a load-side heat exchanger 3, thereby causing the heat exchanger 3 to operate as a heat radiator and causing at least one of heat-source-side heat exchangers 5a and 5b to operate as an evaporator. At a time of the defrost operation of removing frost at the heat exchanger 5a, the switching mechanism 2 is controlled such that the refrigerant from the compressor 1 flows to the heat exchangers 3 and 5a, thereby causing the heat exchangers 3 and 5a to operate as heat radiators and causing the heat exchanger 5b to operate as an evaporator.

Fig. 1



EP 2 375 187 A2

Description

Technical Field

[0001] The present invention relates to a heat pump apparatus including a plurality of heat-source-side heat exchangers and an operation control method of the heat pump apparatus.

Background Art

[0002] In a heating operation using a heat pump apparatus, a temperature of a refrigerant flowing through a heat-source-side heat exchanger which serves as an evaporator is greatly reduced. For that reason, frost is attached to the heat-source-side heat exchanger. When the frost is attached, an air flow passage for heat exchange is blocked. Heat exchange capability of the heat-source-side heat exchanger is thereby degraded. As a result, heating capability of the heat pump apparatus is degraded.
A defrost operation for removing the frost attached to the heat-source-side heat exchanger is performed in order to prevent degradation of this heating capability. In the defrost operation, a flow direction of the refrigerant in a refrigerant circuit included in the heat pump apparatus is temporary reversed. In other words, the refrigerant is temporarily flown in the direction which is the same as in a cooling operation. With this arrangement, the heat-source-side heat exchanger with the frost attached thereto is temporarily operated as a condenser. The frost attached to the heat-source-side heat exchanger is thereby melted.

[0003] In the defrost operation, the heat-source-side heat exchanger which has operated as the evaporator during the heating operation operates as the condenser. In addition, a load-side heat exchanger which has operated as a condenser during the heating operation operates as an evaporator. In the defrost operation in particular, the frost attached to the heat-source-side heat exchanger is melted. The refrigerant of which the temperature has been reduced thereby flows into the load-side heat exchanger.
When the load-side heat exchanger is a heat exchanger which heat-exchanges the refrigerant flowing in the refrigerant circuit included in the heat pump apparatus and water flowing in a water circuit, the water flowing in the water circuit may be cooled to 0 °C or less to freeze up within the load-side heat exchanger. When the water freezes up within the load-side heat exchanger, the water circuit may be blocked and the load-side heat exchanger may be broken due to volume expansion by conversion of the water to ice.
When the load-side heat exchanger is an indoor heat exchanger in an air conditioner, and when the defrost operation is performed during the heating operation, a cool wind blows out from an indoor unit, though the heating operation is being performed. Accordingly, comfort of a user is thereby impaired.

[0004] Patent Document 1 describes provision of a bypass circuit for a refrigerant circuit so as to prevent flow of a low-temperature refrigerant into a load-side heat exchanger during a defrost operation.

[0005] Patent Document 2 describes shutting off of a refrigerant circuit for an indoor unit at a time of a defrost operation in order to prevent flow of a low-temperature refrigerant into the indoor unit during the defrost operation.

Related Art Documents

[0006]

[Patent Document 1] JP 05-019724 Y
[Patent Document 2] JP 58-102067 A

Disclosure of Invention

[0007] In the methods described in both of Patent Documents 1 and 2, the refrigerant is not circulated to the load-side heat exchanger during the defrost operation. For that reason, during the defrost operation, the heat-source-side heat exchanger operates as the condenser, but there is no heat exchanger which operates as an evaporator. Accordingly, the refrigerant cannot be completely evaporated. The refrigerant in a two-phase state or a liquid state is sucked into a compressor. As a result, a burden on the compressor is increased.
Further, in the methods described in both of Patent Documents 1 and 2, a heating operation is not performed during the defrost operation. For that reason, the heat pump apparatus alternates between the heating operation and the defrost operation. Accordingly, its takes time to obtain an effect of heating, so that electric power is wasted.
An object of the present invention is to prevent a low-temperature refrigerant from being sent to a load-side heat exchanger during a defrost operation, and also to continue a heating operation even during the defrost operation.

[0008] A heat pump apparatus of the present invention may include:

a refrigerant circuit that connects each side of a suction side and a discharge side of a compressor and a switching mechanism by a pipe, connects the switching mechanism and a first heat exchanger by a pipe, connects the first heat exchanger and a first pressure reduction mechanism by a pipe, connects the first pressure reduction mechanism and each second heat exchanger of a plurality of second heat exchangers by a pipe, and connects the each second heat exchanger and the switching mechanism by a pipe; and
a control unit which controls the switching mechanism at a time of a heat radiating operation such that

a refrigerant discharged from the compressor flows to the first heat exchanger, thereby causing the first heat exchanger to operate as a heat radiator and causing at least one of the plurality of second heat exchangers to operate as an evaporator for evaporating the refrigerant flown out from the first heat exchanger, and controls the switching mechanism at a time of a defrost operation of removing frost attached to one of the plurality of second heat exchangers which is a defrosting heat exchanger, such that the refrigerant discharged from the compressor flows to the first heat exchanger and the defrosting heat exchanger, thereby causing the first heat exchanger and the defrosting heat exchanger to operate as heat radiators and causing at least one of the remainder of the plurality of second heat exchangers excluding the defrosting heat exchanger to operate as an evaporator for evaporating the refrigerant flown out from the first heat exchanger and the defrosting heat exchanger.

Advantageous Effect of Invention

[0009] In the heat pump apparatus of the present invention, one of the plurality of heat-source-side heat exchangers (second heat exchangers) from which frost is to be removed, which is the defrosting heat exchanger, is operated as a condenser, and the load-side heat exchanger (first heat exchanger) is also operated as a condenser, during the defrost operation. Then, in this heat pump apparatus, the other heat-source-side heat exchangers excluding the defrosting heat exchanger are operated as evaporators. With this arrangement, even during the defrost operation, the load-side heat exchanger may be operated as the condenser, and an effect of heating may be obtained.

Brief Description of Drawings

[0010]

Fig. 1 is a configuration diagram of a heat pump apparatus 100;
Fig. 2 is a configuration diagram of a switching device 2;
Fig. 3 is a diagram showing flows of a refrigerant during a heating operation;
Fig. 4 is a diagram showing flows of the refrigerant during a defrost operation A of removing frost attached to a heat exchanger 5a;
Fig. 5 is a diagram showing flows of the refrigerant during a defrost operation B of removing frost attached to a heat exchanger 5b;
Fig. 6 is a diagram showing flows of the refrigerant during a cooling operation; and
Fig. 7 is a table showing a control state of the switching device 2 in each operation state.

Description of Embodiment

First Embodiment.

[0011] Fig. 1 is a configuration diagram of a heat pump apparatus 100. In the heat pump apparatus 100, a suction side 1a of a compressor and a switching device 2 are connected by a pipe. A discharge side 1b of the compressor 1 and the switching device 2 are connected by a pipe. The switching device 2 and a heat exchanger 3 (first heat exchanger) are connected by a pipe. The heat exchanger 3 and a pressure reduction mechanism 4 (first pressure reduction mechanism) are connected by a pipe. The pressure reduction mechanism 4 and each of two heat exchangers 5a and 5b (second heat exchangers) are connected by a pipe. Each of two heat exchangers 5a and 5b and the switching device 2 are connected by a pipe. With this arrangement, a refrigerant circuit 9 is formed.
A liquid accumulating device 6 is provided in the course of a pipe connecting the suction side 1a of the compressor 1 and the switching device 2.
A pipe connected to the pressure reduction mechanism 4 is branched at a branch point 12 to be connected to each of the heat exchangers 5a and 5b. Pressure reduction mechanisms 7a and 7b (second pressure reduction mechanisms) are provided between the branch point 12 and the respective heat exchangers 5a and 5b.

[0012] Among the devices connected to the above-mentioned refrigerant circuit 9, the devices excluding the heat exchangers 5a and 5b are placed in a machine chamber 10 (first housing). The heat exchangers 5a and 5b are respectively placed in outdoor unit blower chambers 20a and 20b (second housings). That is, the devices including the compressor 1 and each of the heat exchangers 5a and 5b are placed in different housings.
The machine chamber 10 and the outdoor unit blower chambers 20a and 20b are connected through connection valves 8a, 8b, 8c, 8d, 8e, 8f, 8g, and 8h.

[0013] The housings of the heat pump apparatus 100 include control devices (control units) 11, 22a, and 22b, respectively. The control device 11 controls an operation of each of the compressor 1, the switching device 2, and the like placed in the machine chamber 10. The control device 22a controls an operation of a blower 21a and the like placed in the outdoor unit blower chamber 20a. The control device 22b controls an operation of a blower 21b and the like placed in the outdoor unit blower chamber 20b.
It is assumed herein that the control device is provided for each housing. One control device may control the devices in all of the housings. The control device, for example, is a computer such as a microcomputer.

[0014] Temperature detection sensors 23a and 24a are installed in the heat exchanger 5a. Temperature detection sensors 23b and 24b are installed in the heat exchanger 5b. The temperature detection sensors 23a and 23b respectively detect temperatures of a refrigerant in a two-phase state in the heat exchangers 5a and 5b. The temperature detection sensors 24a and 24b respectively detect temperatures of the refrigerant in a liquid state in the heat exchangers 5a and 5b.

[0015] The heat exchanger 3 is a plate type heat exchanger, for example. The heat exchanger 3 heat-exchanges the refrigerant circulating in the refrigerant circuit 9 with a liquid such as water circulating in a water circuit 13.

On the other hand, each of the heat exchangers 5a and 5b is a fin-and-tube type heat exchanger, for example. Each of the heat exchangers 5a and 5b heat-exchanges the refrigerant circulating in the refrigerant circuit 9 and a gas such as outdoor air sent from a corresponding one of the blowers 21 and 21b.

The heat exchanger 3 may be a heat exchanger for heat-exchanging the refrigerant circulating in the refrigerant circuit 9 and a gas such as air.

[0016] Fig. 2 is a diagram showing a configuration of the switching device 2.

The switching device 2 includes flow paths 31, 32, 33, 34, 35, and 36. The flow path 31 connects the pipe connected to the discharge side 1b of the compressor 1 and the pipe connected to the heat exchanger 3. The flow path 32 connects the pipe connected to the suction side 1a of the compressor 1 and the pipe connected to the heat exchanger 3. The flow path 33 (second flow path) connects the pipe connected to the discharge side 1b of the compressor 1 and the pipe connected to the heat exchanger 5a. The flow path 34 (first flow path) connects the pipe connected to the suction side 1a of the compressor 1 and the pipe connected to the heat exchanger 5a. The flow path 35 (second flow path) connects the pipe connected to the discharge side 1b of the compressor 1 and the pipe connected to the heat exchanger 5b.

The flow path 36 (first flow path) connects the pipe connected to the suction side 1a of the compressor 1 and the pipe connected to the heat exchanger 5b.

The flow path 31 includes an opening/closing mechanism 41, which is an electromagnetic valve or the like, in the course of the flow path 31. Similarly, the flow path 32 includes an opening/closing mechanism 42, which is an electromagnetic valve or the like, in the course of the flow path 32. Similarly, the flow path 33 includes an opening/closing mechanism 43 (second opening/closing mechanism), which is an electromagnetic valve or the like, in the course of the flow path 33. Similarly, the flow path 34 includes an opening/closing mechanism 44 (first opening/closing mechanism), which is an electromagnetic valve or the like, in the course of the flow path 34. Similarly, the flow path 35 includes an opening/closing mechanism 45 (second opening/closing mechanism), which is an electromagnetic valve or the like, in the course of the flow path 35. Similarly, the flow path 36 includes an opening/closing mechanism 46 (first opening/closing mechanism), which is an electromagnetic valve or the like, in the course of the flow path 46.

[0017] An operation of the heat pump apparatus 100 will be described.

The control device 11 controls the open/close mechanisms 41, 42, 43, 44, 45, and 46 included in the switching device 2 to be opened or closed, thereby making switching among a heating operation, a defrost operation, and a cooling operation.

[0018] First, the operation of the heat pump apparatus 100 at a time of the heating operation will be described. The heating operation herein refers to an operation of heating water flowing in the water circuit 13 by the heat exchanger 3. The heating operation includes a hot-water supply operation for supplying hot water as well as heating for heating indoor air.

Fig. 3 is a diagram showing flows of the refrigerant during the heating operation. Referring to Fig. 3, an arrow indicates a flow of the refrigerant. One of the opening/closing mechanisms included in the switching device 2 indicated by a blank ellipse shows that the opening/closing mechanism is opened. One of the opening/closing mechanisms included in the switching device 2 indicated by a black ellipse shows that the opening/closing mechanism is closed. That is, in the case of the heating operation, the control device 11 sets the opening/closing mechanisms 41, 44, and 46 to be opened, and sets the opening/closing mechanisms 42, 43, and 45 to be closed.

[0019] The refrigerant in a low-temperature and low-pressure gas-phase state is compressed into a high-temperature and high-pressure gas refrigerant by the compressor 1 and is then discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows into the switching device 2. The high-temperature and high-pressure gas refrigerant is guided to the heat exchanger 3.

The high-temperature and high-pressure gas refrigerant and the water circulating in the water circuit 13 are heat-exchanged at the heat exchanger 3. With this arrangement, the gas refrigerant condenses into a liquid refrigerant, and the water is heated into hot water. That is, the heat exchanger 3 operates as a condenser. The hot water generated by heat exchange with the refrigerant by the heat exchanger 3 is supplied to a heat radiator such as a radiator and a water heater not shown. Then, heating is performed, and the hot water is supplied.

The liquid refrigerant at a high pressure which has flown out from the heat exchanger 3 becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by the pressure reduction mechanism 4. The low-temperature and low-pressure gas-liquid two-phase refrigerant branches at the branch point 12 to flow into the heat exchanger 5a and the heat exchanger 5b. In this case, the refrigerant may be further pressure-reduced by each of the pressure reduction mechanisms 7a and 7b. The low-temperature and low-pressure gas-liquid two-phase refrigerant and the outdoor air are heat-exchanged by each of the heat exchangers 5a and 5b. The refrigerant evaporates into a low-pressure gas refrigerant. That is, each of the heat exchangers 5a and 5b operates as an evaporator.

The low-pressure gas refrigerant flows into the switching device 2 through each of the heat exchangers 5a and 5b. The low-pressure gas refrigerant is guided to a liquid accumulating device 6 through the switching device 2. Then, the low-pressure gas refrigerant is sucked into the compressor 1 through the liquid accumulating device 6 and is then compressed into a high-temperature and high-pressure gas state.

[0020] When the low-temperature and low-pressure gas-liquid two-phase refrigerant and the outdoor air are heat-exchanged by each of the heat exchangers 5a and 5b, and when the temperature of the refrigerant is low, vapor in the air condenses and then freezes. Frost is thereby attached to the heat exchangers 5a and 5b.

[0021] Next, the operation of the heat pump apparatus 100 at a time of the defrost operation will be described. The defrost operation refers to an operation of removing frost attached to at least one of the heat exchangers 5a and 5b.

First, the operation of removing the frost attached to the heat exchanger 5a will be described.

Fig. 4 is a diagram showing flows of the refrigerant during a defrost operation A of removing the frost attached to the heat exchanger 5a. Referring to Fig. 4, an arrow shows a flow of the refrigerant. Referring to Fig. 4, one of the opening/closing mechanisms included in the switching device 2 indicated by a blank ellipse shows that the opening/closing mechanism is opened. One of the opening/closing mechanisms included in the switching device 2 indicated by a black ellipse shows that the opening/closing mechanism is closed. That is, in the operation of removing the frost attached to the heat exchanger 5a, the control device 11 sets the opening/closing mechanisms 41, 43, and 46 to be opened, and sets the opening/closing mechanisms 42, 44, and 45 to be closed.

[0022] The refrigerant in a low-temperature and low-pressure gas-phase state is compressed into a high-temperature and high-pressure gas refrigerant by the compressor 1 and is then discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows into the switching device 2. The high-temperature and high-pressure gas refrigerant is guided to each of the heat exchanger 3 and the heat exchanger 5a through the switching device 2.

The high-temperature and high-pressure gas refrigerant which has flown into the heat exchanger 3 and the water circulating in the water circuit 13 are heat-exchanged at the heat exchanger 3. The gas refrigerant condenses into a liquid refrigerant, and the water is heated into hot water. That is, the heat exchanger 3 operates as the condenser. The hot water generated by heat exchange with the refrigerant at the heat exchanger 3 is supplied to the heat radiator such as the radiator and the water heater not shown, as at the time of the heating operation. Then, heating is performed, and the hot water is supplied. This means that the heating and the supply of the hot water are continuously performed even during the defrost operation A. The liquid refrigerant at a high pressure which has flown out from the heat exchanger 3 becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by the pressure reduction mechanism 4. The low-temperature and low-pressure gas-liquid two-phase refrigerant flows into the heat exchanger 5b through the branch point 12. In this case, the refrigerant may be further pressure-reduced by the pressure reduction mechanism 7b.

On the other hand, the high-temperature and high-pressure gas refrigerant which has flown into the heat exchanger 5a condenses into a liquid refrigerant by the heat exchanger 5a. In this case, condensation heat is discharged to the outdoor air, and the frost attached to the heat exchanger 5a melts by the discharged condensation heat. That is, the heat exchanger 5a also operates as a condenser. Then, the liquid refrigerant at a high pressure which has flown out from the heat exchanger 5a becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by the pressure reduction mechanism 7a. The low-temperature and low-pressure gas-liquid two-phase refrigerant flows into the heat exchanger 5b through the branch point 12. In this case, the refrigerant may be further pressure-reduced by the pressure reduction mechanism 7b.

The low-temperature and low-pressure gas-liquid two-phase refrigerant and the outdoor air are heat-exchanged at the heat exchanger 5b, and the refrigerant evaporates into a low-pressure gas refrigerant. That is, the heat exchanger 5b operates as an evaporator.

The low-pressure gas refrigerant flows into the switching device 2 from the heat exchanger 5b. The low-pressure gas refrigerant is guided to the liquid accumulating device 6 through the switching device 2. Then, the low-pressure gas refrigerant is sucked into the compressor 1 through the liquid accumulating device 6, and is then compressed into a high-temperature and high-pressure gas-phase state.

[0023] Next, the operation of removing the frost attached to the heat exchanger 5b will be described.

Fig. 5 is a diagram showing flows of the refrigerant during a defrost operation B of removing the frost attached to the heat exchanger 5b. Referring to Fig. 5, an arrow shows a flow of the refrigerant. Referring to Fig. 5, one of the opening/closing mechanisms included in the switching device 2 indicated by a blank ellipse shows that the opening/closing mechanism is opened. One of the opening/closing mechanisms included in the switching device 2 indicated by a black ellipse shows that the opening/closing mechanism is closed. That is, in the operation of removing the frost attached to the heat exchanger 5b, the control device 11 sets the opening/closing mechanisms 41, 44, and 45 to be opened, and sets the opening/closing mechanisms 42, 43, and 46 to be closed.

[0024] The refrigerant in a low-temperature and low-pressure gas-phase state is compressed into a high-temperature and high-pressure gas refrigerant by the compressor 1 and is then discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows into the switching device 2. The high-temperature and high-pressure gas refrigerant is guided to each of the heat exchanger 3 and the heat exchanger 5b through the switching device 2.

The high-temperature and high-pressure gas refrigerant which has flown into the heat exchanger 3 and the water circulating in the water circuit 13 are heat-exchanged at the heat exchanger 3. The gas refrigerant condenses into a liquid refrigerant, and the water is heated into hot water. That is, the heat exchanger 3 operates as the condenser. The hot water generated by heat exchange with the refrigerant at the heat exchanger 3 is supplied to the heat radiator such as the radiator and the water heater not shown, as at the time of the heating operation. Then, heating is performed, and the hot water is supplied. This means that the heating and the supply of the hot water are continuously performed even during the defrost operation B. The liquid refrigerant at a high pressure which has flown out from the heat exchanger 3 becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by the pressure reduction mechanism 4. The low-temperature and low-pressure gas-liquid two-phase refrigerant flows into the heat exchanger 5a through the branch point 12. In this case, the refrigerant may be further pressure-reduced by the pressure reduction mechanism 7b.

On the other hand, the high-temperature and high-pressure gas refrigerant which has flown into the heat exchanger 5b condenses into a liquid refrigerant by the heat exchanger 5b. In this case, condensation heat is discharged to the outdoor air, and the frost attached to the heat exchanger 5b melts by the discharged condensation heat. That is, the heat exchanger 5b also operates as a condenser. Then, the liquid refrigerant at a high pressure which has flown out from the heat exchanger 5b becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by the pressure reduction mechanism 7b. The low-temperature and low-pressure gas-liquid two-phase refrigerant flows into the heat exchanger 5a through the branch point 12. In this case, the refrigerant may be further pressure-reduced by the pressure reduction mechanism 7a.

The low-temperature and low-pressure gas-liquid two-phase refrigerant and the outdoor air are heat-exchanged at the heat exchanger 5a, and the refrigerant evaporates into a low-pressure gas refrigerant. That is, the heat exchanger 5a operates as an evaporator.

The low-pressure gas refrigerant flows into the switching device 2 from the heat exchanger 5a. The low-pressure gas refrigerant is guided to the liquid accumulating device 6 through the switching device 2. Then, the low-pressure gas refrigerant is sucked into the compressor 1 through the liquid accumulating device 6, and is then compressed into a high-temperature and high-pressure gas-phase state.

[0025] Next, the operation of the heat pump apparatus 100 at a time of the cooling operation will be described. The cooling operation herein refers to an operation of cooling the water flowing in the water circuit 13 by the heat exchanger 3. The cooling operation includes a cool water supply operation of supplying cool water as well as cooling for cooling the indoor air.

Fig. 6 is a diagram showing flows of the refrigerant during the cooling operation. Referring to Fig. 6, an arrow shows a flow of the refrigerant. Referring to Fig. 6, one of the opening/closing mechanisms included in the switching device 2 indicated by a blank ellipse shows that the opening/closing mechanism is opened. One of the opening/closing mechanisms included in the switching device 2 indicated by a black ellipse shows that the opening/closing mechanism is closed. That is, in the cooling operation, the control device 11 sets the opening/closing mechanisms 42, 43, and 45 to be opened, and sets the opening/closing mechanisms 41, 44, and 46 to be closed.

[0026] The refrigerant in a low-temperature and low-pressure gas-phase state is compressed into a high-temperature and high-pressure gas refrigerant by the compressor 1 and is then discharged from the compressor 1. The high-temperature and high-pressure gas refrigerant discharged from the compressor 1 flows into the switching device 2. The high-temperature and high-pressure gas refrigerant is guided to each of the heat exchanger 5a and the heat exchanger 5b through the switching device 2.

The high-temperature and high-pressure gas refrigerant and the outdoor air are heat-exchanged by each of the heat exchangers 5a and 5b.

The gas refrigerant thereby condenses into a liquid refrigerant. That is, each of the heat exchangers 5a and 5b operates as a condenser.

The liquid refrigerant at a high pressure which has flown out from each of the heat exchangers 5a and 5b becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant by a corresponding one of the pressure reduction mechanisms 7a and 7b. The low-temperature and low-pressure gas-liquid two-phase refrigerant flows into the heat exchanger 3. In this case, the refrigerant may be further pressure-reduced by the pressure reduction mechanism 4. The low-temperature and low-pressure gas-liquid two-phase refrigerant and the water circulating in the water circuit 13 are heat-exchanged at the heat exchanger 3. Then, the refrigerant evaporates into a low-pressure gas refrigerant. The water is cooled into cold water. This means that the heat exchanger 3 operates as an evaporator. The cold water generated by heat exchange with the refrigerant at the heat exchanger 3 is supplied to a heat absorber and a cold water supplier not shown. Then, cooling is performed, and the cold water is supplied.

The low-pressure gas refrigerant flows into the switching device 2 from the heat exchanger 3. The low-pressure gas refrigerant is guided to the liquid accumulating device 6 through the switching device 2. Then, the low-pressure gas refrigerant is sucked into the compressor 1 through the liquid accumulating device 6 and is then compressed into a high-temperature and high-pressure gas-phase state.

[0027] Fig. 7 is a table showing a control state of the switching device 2 in each operation state. As described above, each of the opening/closing mechanisms 41, 42, 43, 44, 45, and 46 included in the switching device 2 is controlled to be opened or closed according to each operating state. Details of opening/closing control are as described above. Thus, description of the opening/closing control will be omitted.

[0028] Next, a start condition of the defrost operation will be described.

In the heat pump apparatus 100, by continuously performing the heating cooperation, frost is gradually attached to each of the heat exchangers 5a and 5b used as the evaporator. Thus, heating capability is degraded. Then, the control device 22a obtains temperatures of the refrigerant detected by the temperature detection sensors 23a and 24a and transfers the detected temperatures to the control device 11. The control device 22b obtains temperatures of the refrigerant detected by the temperature detection sensors 23b and 24b and transfers the detected temperatures to the control device 11. The control device 11 determines a state of the frost attached to each of the heat exchangers 5a and 5b by the transferred temperatures of the refrigerant. When the temperature of the refrigerant detected by each of the temperature detection sensors 24a and 24b continues to be -7°C or less for five minutes, the control device 11 determines that the frost of a predetermined amount or more has been attached. The control unit therefore causes the defrost operation to be started.

[0029] The control device 11 determines whether or not to individually start the defrost operation for each of the heat exchangers 5a and 5b.

That is, when only the heat exchanger 5a satisfies the start condition of the defrost operation, the control device 11 causes the defrost operation A of removing the frost attached to the heat exchanger 5a to be started. On the contrary, when only the heat exchanger 5b satisfies the start condition of the defrost operation, the control device 11 causes the defrost operation B of removing the frost attached to the head exchanger 5b to be started.

When both of the heat exchangers 5a and 5b satisfy the start condition of the defrost operation at the same time, the control unit 11 causes the defrost operation A and the defrost operation B to be performed in a predetermined order. The order of the control may be arbitrarily determined.

[0030] Next, a description will be directed to a method of controlling the pressure reduction mechanisms 4, 7a, and 7b.

The outdoor unit blower chambers 20a and 20b are the different housings and may be disposed in positions having different distances from the machine chamber 10. In this case, it is desirable to adjust pressures of the refrigerant to be sent to the outdoor unit blower chambers 20a and 20b according to the distances from the machine chamber 10 to the outdoor unit blower chambers 20a and 20b. Then, opening degrees of the pressure reduction mechanisms 4, 7a, and 7b may be adjusted according to the distances from the machine chamber 10 to the outdoor unit blower chambers 20a and 20b.

In the case of the heating operation, for example, the refrigerant which has flown out from the heat exchanger 3 is pressure-reduced by the pressure reduction mechanisms 4, 7a, and 7b. By adjusting the opening degrees of the pressure reduction mechanisms 7a and 7b according to the distances from the machine chamber 10 to the outdoor unit blower chambers 20a and 20b in this case, the pressures of the refrigerant which will flow into both of the heat exchangers 5a and 5b may be set to be appropriate.

[0031] The opening degrees of the pressure reduction mechanisms 4, 7a, and 7b may be adjusted based on degrees of supercooling and degrees of superheating of the heat exchangers 5a and 5b as well as the distances from the machine chamber 10 to the outdoor unit blower chambers 20a and 20b.

In the case of the cooling operation, a degree of supercooling of the heat exchanger 5a can be computed from temperatures of the temperature detection sensors 23a and 24a installed in the heat exchanger 5a. Similarly, a degree of supercooling of the heat exchanger 5b can be computed from temperatures of the temperature detection sensors 23b and 24b installed in the heat exchanger 5b. The degree of supercooling may be adjusted by a flow amount of the refrigerant. Further, by operating the heat pump apparatus 100 so that the degrees of supercooling are constant, the heat pump apparatus 100 may obtain stable performance. Then, the opening degrees of the pressure reduction mechanisms 4, 7a and 7b may be controlled such that the degrees of supercooling are constant (such as 7°C).

Likewise, in the case of the heating operation, a degree of superheating of the heat exchanger 5a can be computed from temperatures of the temperature detection sensors 23a and 24a installed in the heat exchanger 5a. A degree of superheating of the heat exchanger 5b can be computed from temperatures of the temperature detection sensors 23b and 24b installed in the heat exchanger 5b. The degree of superheating may be adjusted by a flow amount of the refrigerant. Further, by operating the heat pump apparatus so that the degrees of superheating are constant, the heat pump apparatus 100 may obtain stable performance. Then, the opening degrees of the pressure reduction mechanisms 4, 7a and 7b may be controlled such that the degrees of superheating are constant (such as 5°C).

[0032] As described above, the heat pump apparatus 100 causes the heat exchanger 3, which is a load-side heat exchanger, to operate as the condenser during the defrost operation as well. For that reason, the water does not freeze inside the heat exchanger 3, which is the load-side heat exchanger, during the defrost operation. Further, heating and hot water supply may be continued during the defrost operation as well. For that reason, wasteful power consumption may be prevented without impairing comfort of a user.

[0033] Further, in the heat pump apparatus 100, the machine chamber 10 including the compressor 1 is set to be placed in the housing different from those of the outdoor unit blower chamber 20a including the heat exchanger 5a and the outdoor unit blower chamber 20b including the heat exchanger 5b. For that reason, the machine chamber 10, the outdoor unit blower chamber 20a, and the outdoor unit blower chamber 20b may be respectively installed in different locations.

Each of the compressor 1 and the blowers 21a and 21b placed in the outdoor unit blower chambers 20a and 20b generates operation noise. Generally, when there are two sound sources having an identical sound pressure, the sound pressure increases by approximately 3 dB. Accordingly, when the compressor 1 and the blowers 21a and 21b are installed close to one another, a sound pressure increase occurs. However, by respectively disposing the machine chamber 10 and the outdoor unit blower chambers 20a and 20b in different locations, the sound pressure increase may be prevented. Noise as a whole may be reduced.

When all the devices are placed in one housing, the size of the housing is increased. However, by dividing the devices into a plurality of groups and respectively disposing the groups in a plurality of housings, the size of each housing may be reduced. This offers a broader range of selection of installation locations.

Further, it is not necessary to dispose the machine chamber 10 outdoors. Thus, durability of the machine chamber 10 may be improved, which prevents aging degradation. Alternatively, all the devices may be placed in one housing.

[0034] Assume that a required load, which is an amount of heat necessary for bringing a temperature of the water to a predetermined temperature at the heat exchanger 3, is small. Then, one of the blower 21a of the outdoor unit blower chamber 20a and the blower 21b of the outdoor unit blower chamber 20b may be stopped. Further, the control device 11 may control the switching device 2 and the pressure reduction mechanisms 7a and 7b so that the refrigerant does not flow into one of the outdoor unit blower chambers 20a and 20b in which the blower has been stopped. With this arrangement, power consumption may be reduced.

[0035] In the above description, the heat exchanger 3 is set to heat-exchange the refrigerant circulating in the refrigerant circuit 9 and the liquid such as the water circulating in the water circuit 13. The heat exchanger 3, however, may heat-exchange the refrigerant circulating in the refrigerant circuit 9 and a gas such as air.

[0036] In the above description, the number of the heat-source-side heat exchangers is two, which are the heat exchangers 5a and 5b. The heat pump apparatus 100, however, may include three or more heat-source-side heat exchangers.

Claims

1. A heat pump apparatus (100) comprising:

a refrigerant circuit (9) that connects each side of a suction side (1a) and a discharge side (1b) of a compressor (1) and a switching mechanism (2) by a pipe, connects the switching mechanism (2) and a first heat exchanger (3) by a pipe, connects the first heat exchanger (3) and a first pressure reduction mechanism (4) by a pipe, connects the first pressure reduction mechanism (4) and each second heat exchanger of a plurality of second heat exchangers (5a, 5b) by a pipe, and connects the each second heat exchanger and the switching mechanism (2) by a pipe; and

a control unit (11) which controls the switching mechanism at a time of a heat radiating operation such that a refrigerant discharged from the compressor flows to the first heat exchanger, thereby causing the first heat exchanger to operate as a heat radiator and causing at least one of the plurality of second heat exchangers to operate as an evaporator for evaporating the refrigerant flown out from the first heat exchanger, and controls the switching mechanism at a time of a defrost operation of removing frost attached to one of the plurality of second heat exchangers which is a defrosting heat exchanger, such that the refrigerant discharged from the compressor flows to the first heat exchanger and the defrosting heat exchanger, thereby causing the first heat exchanger and the defrosting heat exchanger to operate as heat radiators and causing at least one of the remainder of the plurality of second heat exchangers excluding the defrosting heat exchanger to operate as an evaporator for evaporating the refrigerant flown out from the first heat exchanger and the defrosting heat exchanger.

2. The heat pump apparatus (100) according to claim 1, wherein the switching mechanism includes:

a plurality of first flow paths which connect the pipe connected to the suction side of the compressor and pipes each connected to the each second heat exchanger, each first flow path of the plurality of first flow paths including a first opening/closing mechanism (43, 45) in the course thereof; and

a plurality of second flow paths which connect the pipe connected to the discharge side of the compressor and the pipes each connected to the each second heat exchanger, each second flow path of the plurality of second flow paths including a second opening/closing mechanism (44, 46) in the course thereof;

wherein the control unit opens the first opening/closing mechanism provided on at least one of the plurality of first flow paths, and closes the remainder of the first opening/closing mechanisms and the remainderof second opening/closing mechanisms at the time of the heat radiating operation,; and
wherein the control unit opens the second opening/closing mechanism provided on the second flow path that connects the pipe connected to the discharge side of the compressor and the pipe connected to the defrosting heat exchanger, opens the first opening/closing mechanism provided on at least one of the plurality of first flow paths excluding the first flow path that connects the pipe connected to the suction side of the compressor and the pipe connected to the defrosting heat exchanger, and closes the remainder of the first and second opening/closing mechanisms at the time of the defrost operation.

3. The heat pump apparatus (100) according to claim 1, wherein the first pressure reduction mechanism is connected to the each second heat exchanger by the pipe branched from a pipe connected to the first pressure mechanism at a branch point (12); and
wherein the refrigerant circuit includes a second pressure reduction mechanism (7a, 7b) in the course of the pipe between the branch point and the each second heat exchanger.

4. The heat pump apparatus (100) according to claim 1, further comprising:

a first housing with at least the compressor placed therein; and
a plurality of second housings each with one of the plurality of second heat exchangers placed therein, a number of the plurality of second housings being the same as a number of the plurality of second heat exchangers.

5. The heat pump apparatus (100) according to claim 4, wherein the each second heat exchanger is a heat exchanger for heat-exchanging the refrigerant and a gas; and
wherein each second housing of the plurality of second housings includes a blower (21a, 21b) for sending the gas to the second heat exchanger placed in the second housing.

6. The heat pump apparatus (100) according to claim 5, wherein the control unit causes an operation of the blower included in at least one of the plurality of second housings to be stopped when a required load is lower than a predetermined load at the first heat exchanger, the required load being an amount of heat necessary for bringing a temperature of a fluid to be heat-exchanged by the refrigerant flowing in the refrigerant circuit to a predetermined temperature.

7. The heat pump apparatus (100) according to claim 1, wherein the first heat exchanger is a heat exchanger for heat-exchanging the refrigerant and water.

8. An operation control method of a heat pump apparatus (100) which includes a refrigerant circuit (9) that connects each side of a suction side (1a) and a discharge side (1b) of a compressor (1) and a switching mechanism (2) by a pipe, connects the switching mechanism (2) and a first heat exchanger (3) by a pipe, connects the first heat exchanger (3) and a first pressure reduction mechanism (4) by a pipe, connects the first pressure reduction mechanism (4) and each second heat exchanger of a plurality of second heat exchangers (5a, 5b) by a pipe, and connects the each second heat exchanger and the switching mechanism (2) by a pipe,
the operation control method of the heat pump apparatus (100) comprising:

controlling the switching mechanism at a time of a heat radiating operation such that a refrigerant discharged from the compressor flows to the first heat exchanger, thereby causing the first heat exchanger to operate as a heat radiator and causing at least one of the plurality of second heat exchangers to operate as an evaporator, and
controlling the switching mechanism at a time of a defrost operation of removing frost attached to one of the plurality of second heat exchangers which is a defrosting heat exchanger, such that the refrigerant discharged from the compressor flows to the first heat exchanger and the defrosting heat exchanger, thereby causing the first heat exchanger and the defrosting heat exchanger to operate as heat radiators and causing at least one of the remainder of the plurality of second heat exchangers excluding the defrosting heat exchanger to operate as an evaporator.

Fig. 1

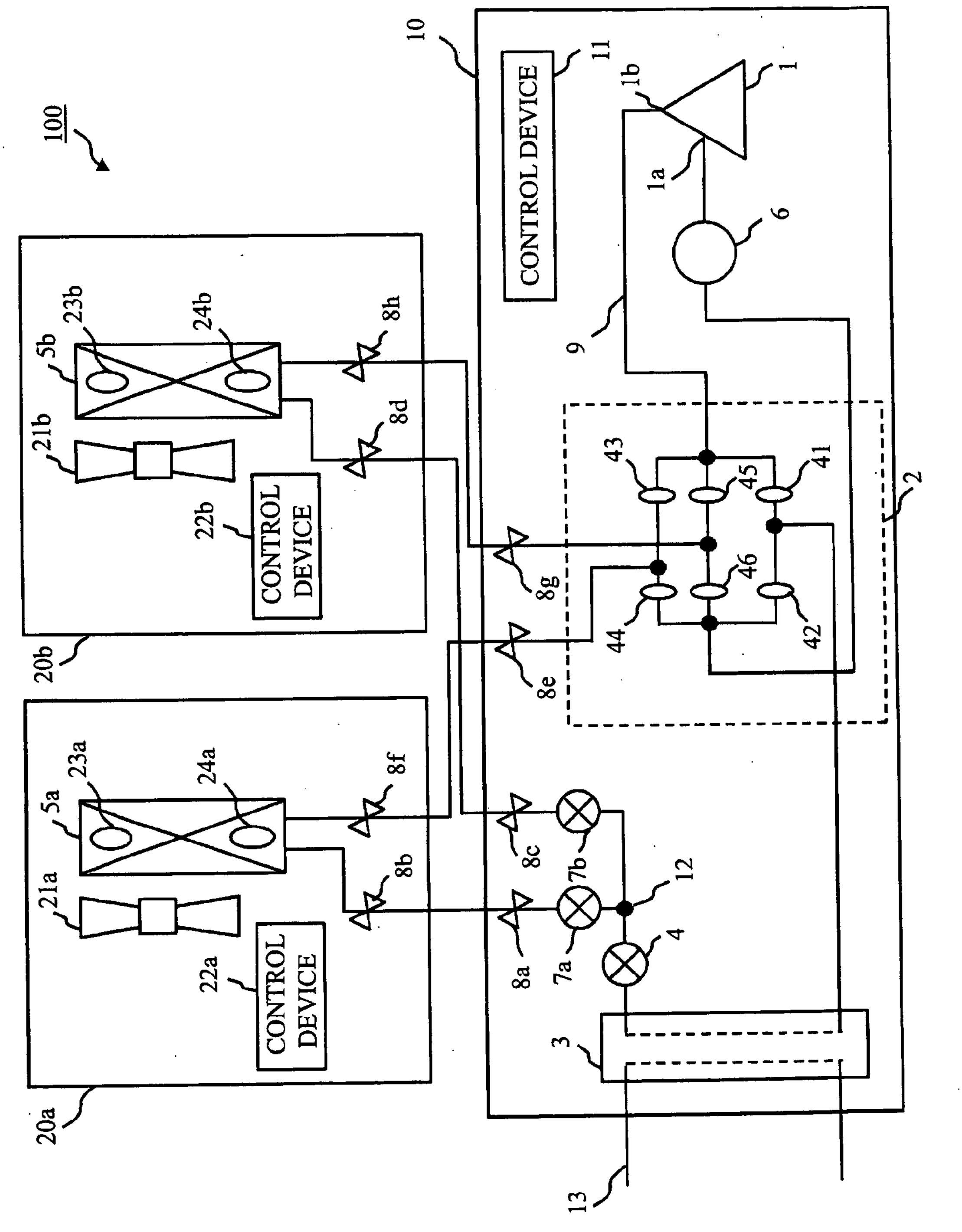
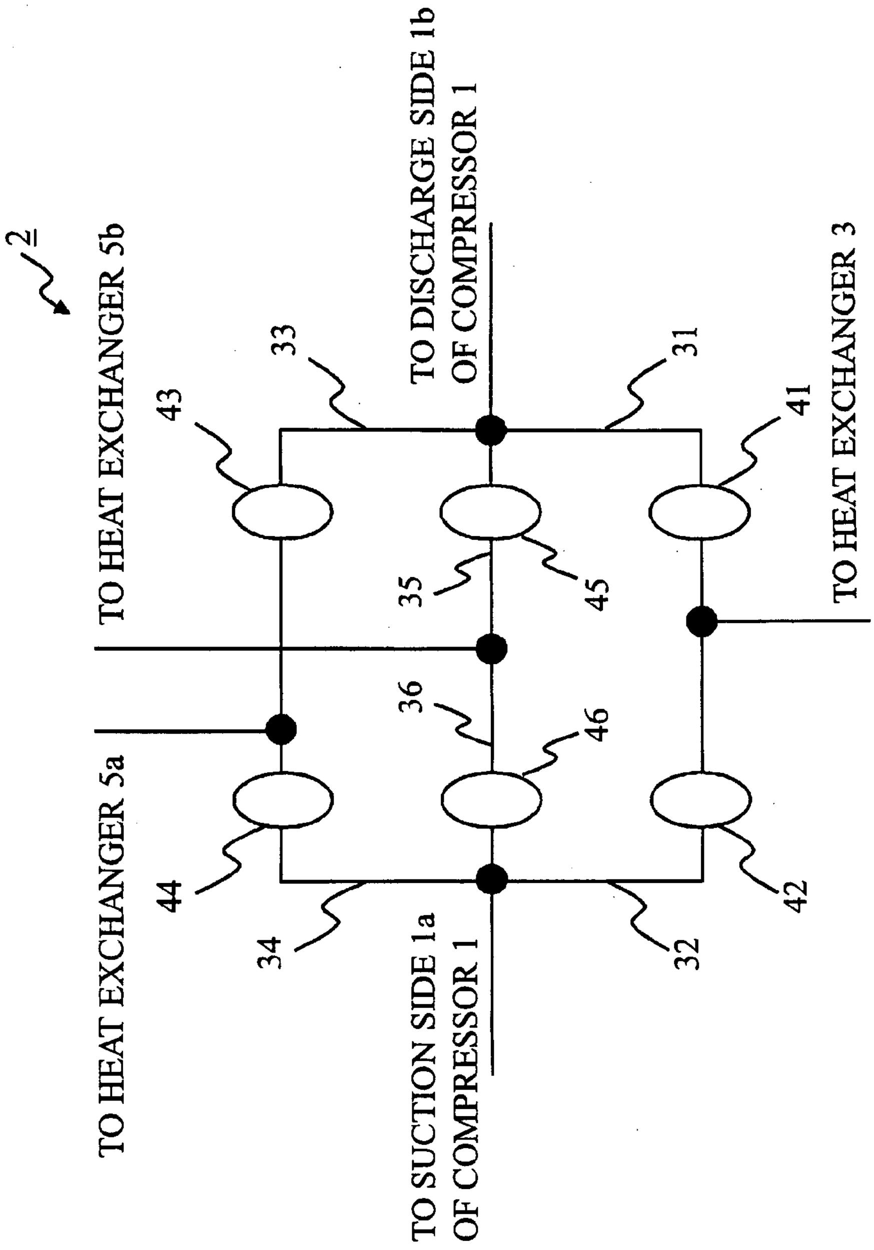

100
10
11
CONTROL DEVICE
1
1a
1b
6
9
2
41
42
43
44
45
46
20b
5b
21b
22b
23b
24b
CONTROL DEVICE
8d
8h
8g
8e
20a
5a
21a
22a
23a
24a
CONTROL DEVICE
8f
8b
8c
8a
7a
7b
4
12
3
13

Fig. 2


2
TO HEAT EXCHANGER 5b
TO DISCHARGE SIDE 1b
OF COMPRESSOR 1
TO HEAT EXCHANGER 3
TO HEAT EXCHANGER 5a
TO SUCTION SIDE 1a
OF COMPRESSOR 1
31
32
33
34
35
36
41
42
43
44
45
46

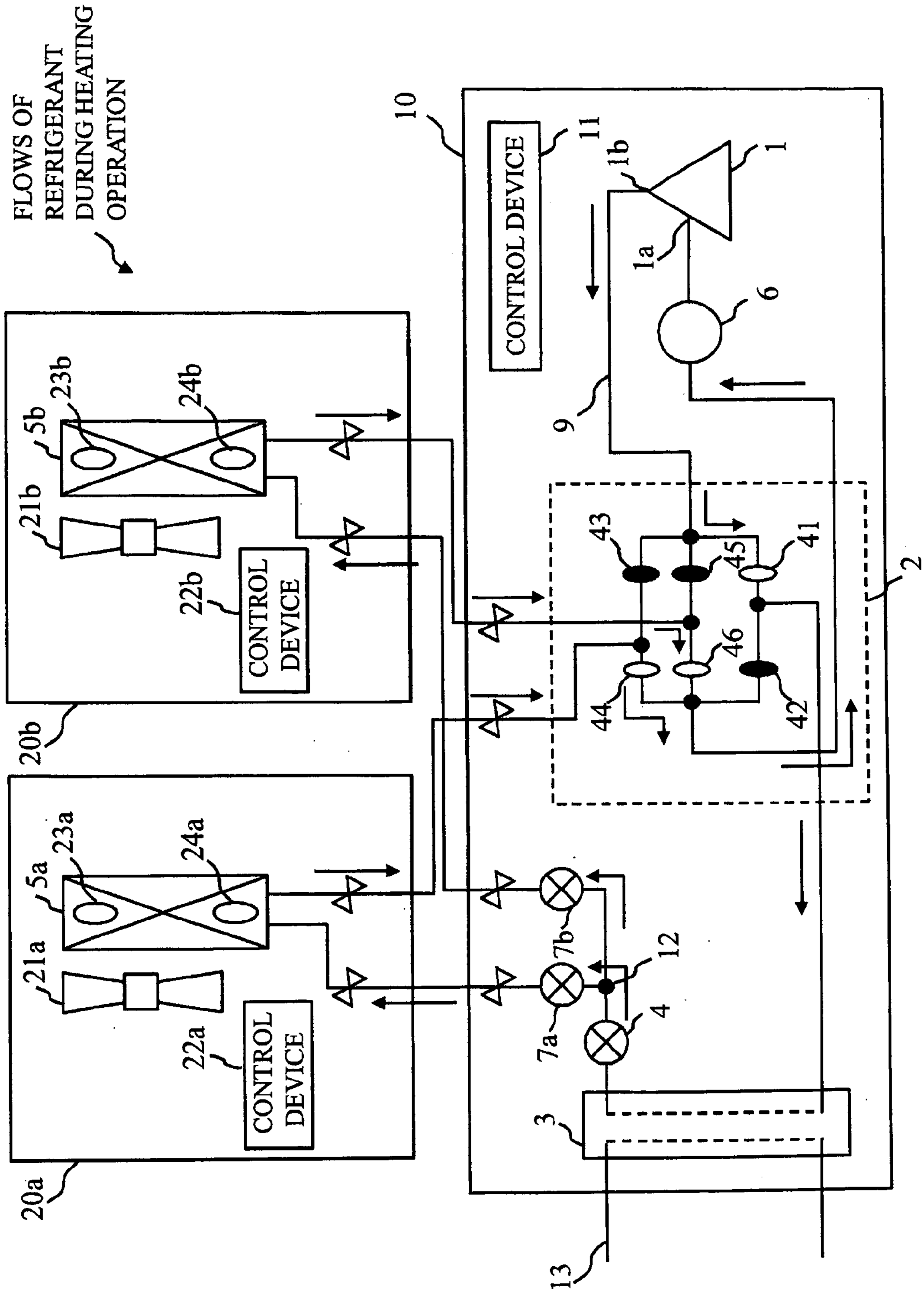

FLOWS OF REFRIGERANT DURING HEATING OPERATION
CONTROL DEVICE
CONTROL DEVICE
CONTROL DEVICE
10
11
1b
1
1a
6
9
43
45
41
2
46
44
42
12
4
7a
7b
3
13
20a
20b
5a
5b
21a
21b
22a
22b
23a
23b
24a
24b

Fig. 3

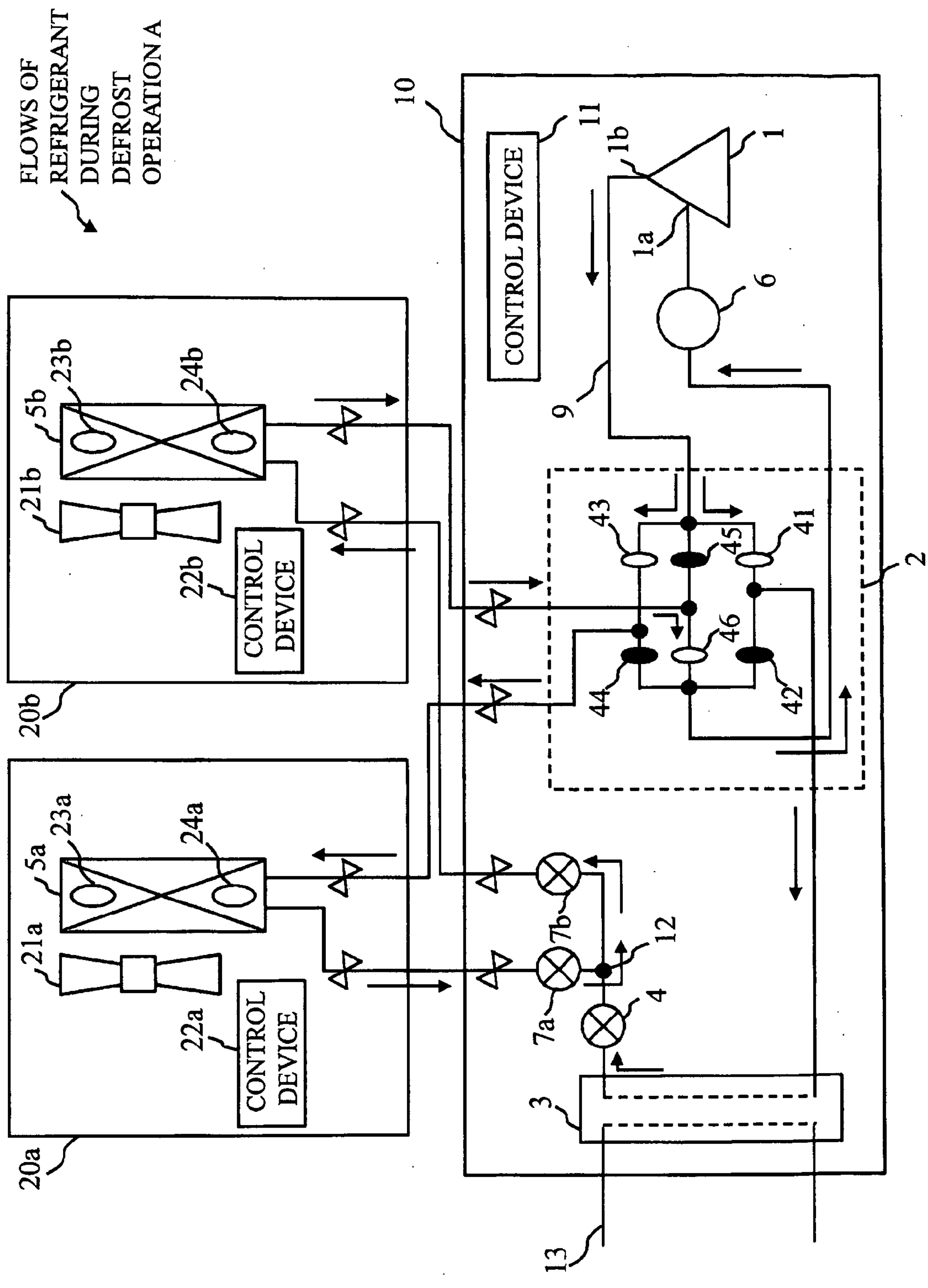

FLOWS OF REFRIGERANT DURING DEFROST OPERATION A
CONTROL DEVICE
CONTROL DEVICE
CONTROL DEVICE
10
11
1
1b
1a
6
9
43
45
41
46
44
42
2
20a
20b
21a
21b
22a
22b
23a
23b
24a
24b
5a
5b
3
4
7a
7b
12
13

Fig. 4

Fig. 5

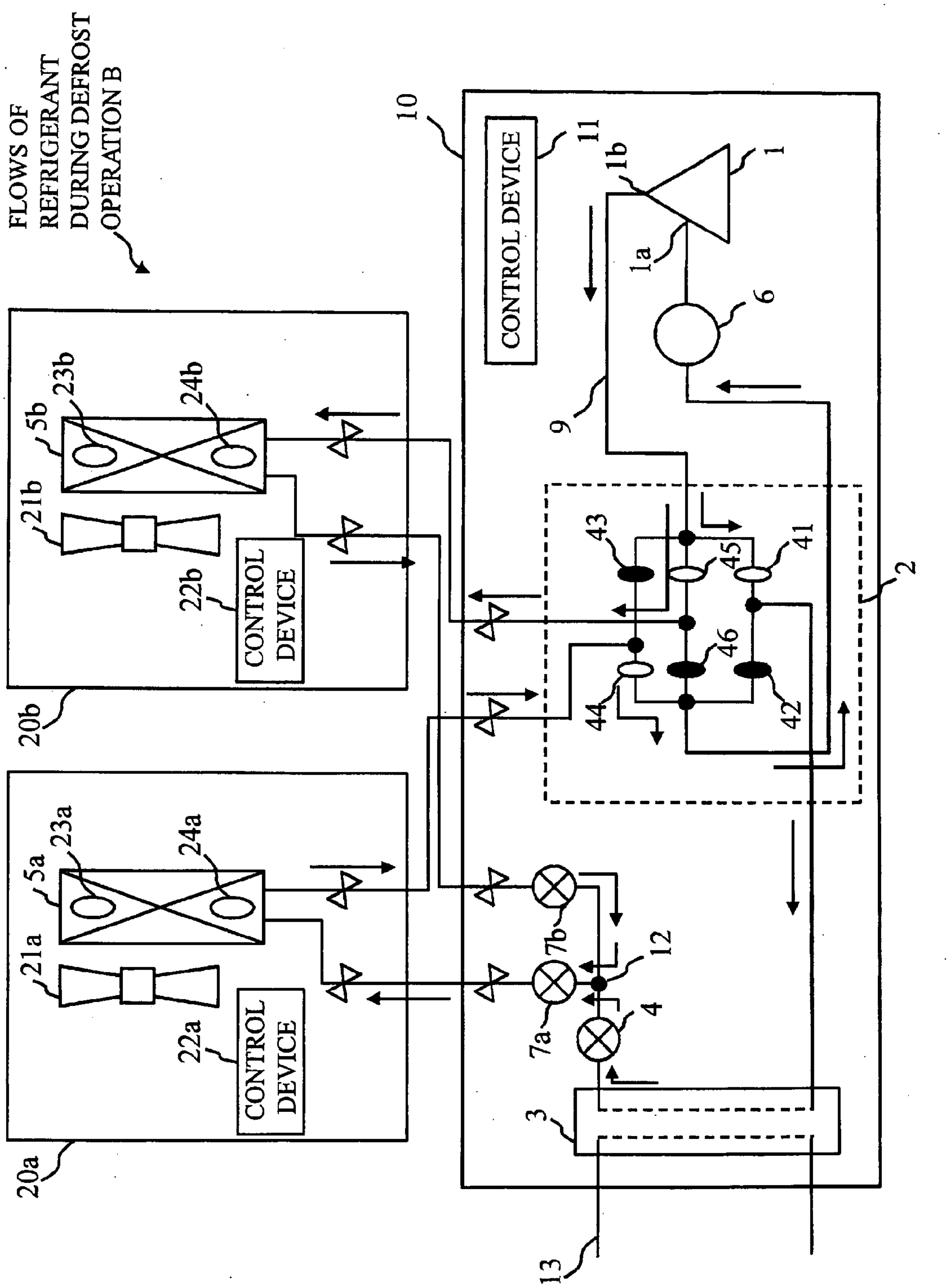

FLOWS OF REFRIGERANT DURING DEFROST OPERATION B
CONTROL DEVICE
CONTROL DEVICE
CONTROL DEVICE
1
1a
1b
2
3
4
5a
5b
6
7a
7b
9
10
11
12
13
20a
20b
21a
21b
22a
22b
23a
23b
24a
24b
41
42
43
44
45
46

Fig. 6

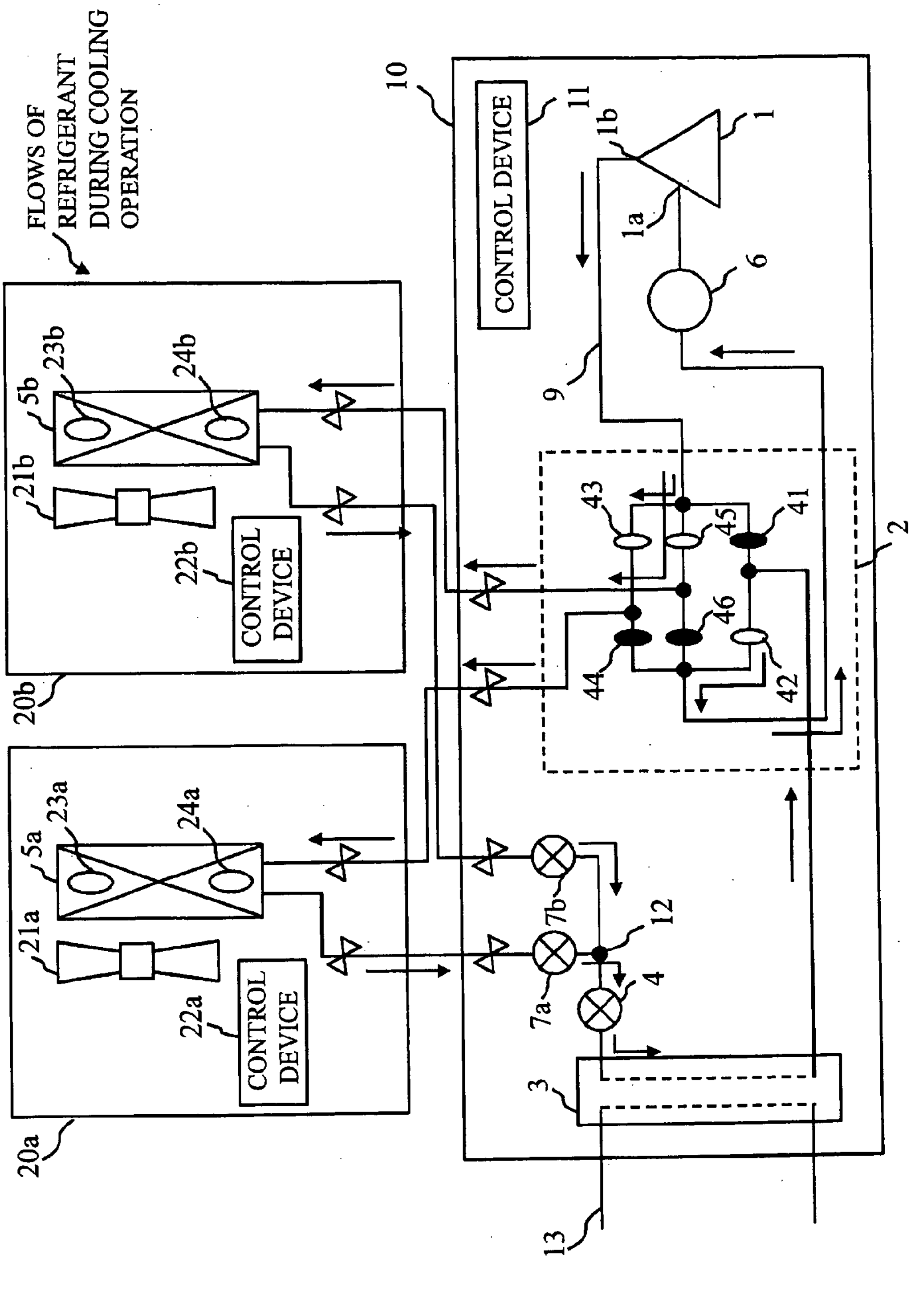
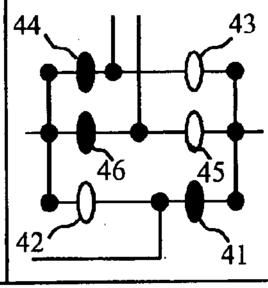
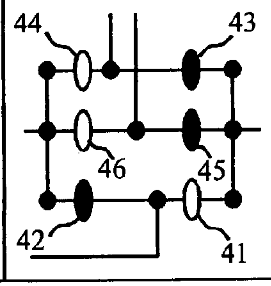
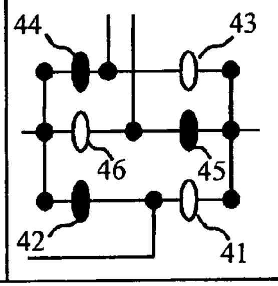
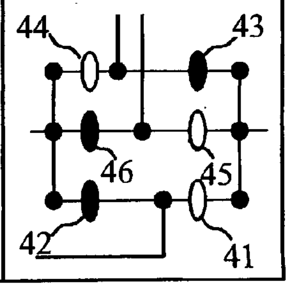

FLOWS OF
REFRIGERANT
DURING COOLING
OPERATION
CONTROL DEVICE
CONTROL DEVICE
CONTROL DEVICE
10
11
1
1a
1b
6
9
2
3
4
5a
5b
7a
7b
12
13
20a
20b
21a
21b
22a
22b
23a
23b
24a
24b
41
42
43
44
45
46

Fig. 7

OPENING/CLOSING MECHANISM	COOLING	HEATING	DEFROSTING A	DEFROSTING B
41	CLOSED	OPENED	OPENED	OPENED
42	OPENED	CLOSED	CLOSED	CLOSED
43	OPENED	CLOSED	OPENED	CLOSED
44	CLOSED	OPENED	CLOSED	OPENED
45	OPENED	CLOSED	CLOSED	OPENED
46	CLOSED	OPENED	OPENED	CLOSED
 : CLOSED : OPENED				

REFERENCES CITED IN THE DESCRIPTION

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