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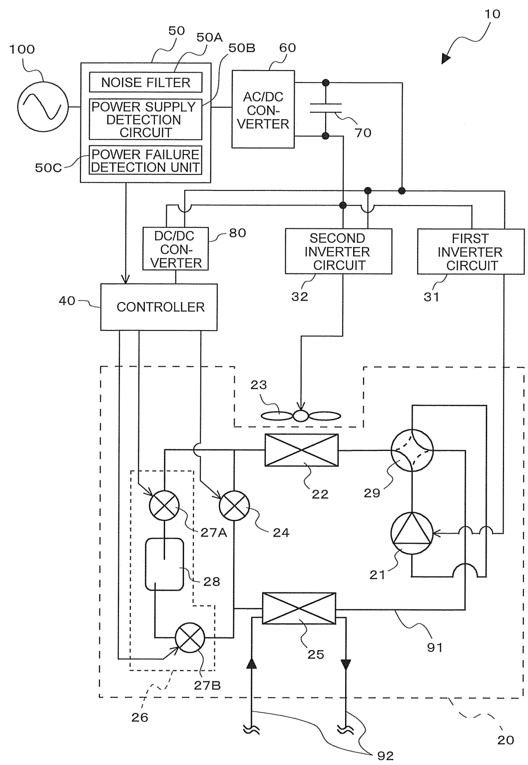
(54) HEAT SOURCE APPARATUS

(57) A heat source apparatus including: a compressor; an air-cooled heat exchanger; a load-side heat exchanger configured to exchange heat between a heat medium which flows through a load, and refrigerant; and a main expansion valve which is connected between the air-cooled heat exchanger and the load-side heat exchanger, and has a function of being fully closed when stoppage of power supply from a power supply source is detected, includes a refrigerant flow control circuit connected in parallel to the main expansion valve. The refrigerant flow control circuit includes a first sub-expansion valve configured to regulate a flow rate of the refrigerant, a refrigerant tank configured to store the refrigerant, and a second sub-expansion valve configured to regulate the flow rate of the refrigerant, which are connected in series with one another.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a heat source apparatus which is configured to cool or heat a heat medium to be supplied to a load.

Background Art

[0002] In the related art, there has been known an air-cooled heat pump chiller, for example, as a heat source apparatus which is configured to cool or heat water as a heat medium to produce cold water or hot water. A refrigerant circuit of the air-cooled heat pump chiller generally includes an expansion valve between an air-cooled heat exchanger and a water-cooled heat exchanger, and a refrigerant tank between the expansion valve and the water-cooled heat exchanger (see, for example, Patent Literature 1).

[0003] The water-cooled heat exchanger generally has efficiency of condensing refrigerant that is higher than that of the air-cooled heat exchanger, and hence requires an amount of refrigerant during a heating operation that is smaller than that during a cooling operation in the refrigerant circuit. Therefore, in order to store a surplus amount of refrigerant during the heating operation and hence regulate the amount of refrigerant circulating through the refrigerant circuit, the refrigerant tank is provided.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-247118

Summary of Invention

Technical Problem

[0005] However, when a power failure occurs, the related-art heat source apparatus is stopped entirely with the expansion valve being open. Therefore, when a power failure occurs during the heating operation, liquid refrigerant dwelling in the air-cooled heat exchanger flows into the water-cooled heat exchanger due to a pressure difference in the refrigerant circuit. Meanwhile, when a power failure occurs during the heating operation, liquid refrigerant dwelling in the refrigerant tank and the water-cooled heat exchanger flows into the air-cooled heat exchanger due to a pressure difference in the refrigerant circuit. Therefore, the structure of the related-art heat source apparatus disadvantageously contributes to a liquid backflow operation at the time of restarting after restoration of power.

[0006] The present invention has been made to solve the above-mentioned problem, and therefore has an object to provide a heat source apparatus for suppressing a liquid backflow operation at the time of restarting after restoration of power. Solution to Problem

[0007] According to one embodiment of the present invention, there is provided a heat source apparatus including: a compressor, which is configured to compress refrigerant; an air-cooled heat exchanger, which is configured to exchange heat between air and the refrigerant; a load-side heat exchanger, which is configured to exchange heat between a heat medium, which flows through a load, and the refrigerant; a main expansion valve, which is connected between the air-cooled heat exchanger and the load-side heat exchanger, and has a function of being fully closed when stoppage of power supply from a power supply source is detected; and a refrigerant flow control circuit, which is connected in parallel to the main expansion valve, and is configured to regulate a flow rate of the refrigerant by storing the refrigerant or causing outflow of the refrigerant, the refrigerant flow control circuit including a first sub-expansion valve configured to regulate the flow rate of the refrigerant, a refrigerant tank configured to store the refrigerant, and a second sub-expansion valve configured to regulate the flow rate of the refrigerant, which are connected in series with one another.

Advantageous Effects of Invention

[0008] According to the embodiment of the present invention, the main expansion valve which is connected between the air-cooled heat exchanger and the load-side heat exchanger, is configured to be fully closed when the stoppage of power supply from the power supply source is detected, and the refrigerant flow control circuit which is connected in parallel to the main expansion valve, is configured to regulate the flow rate of the refrigerant by storing the refrigerant or causing outflow of the refrigerant. As a result, liquid backflow, which occurs at the time of power failure and other such times due to a pressure difference in a refrigerant circuit, can be prevented, and hence the liquid backflow operation at the time of restarting after restoration of power can be suppressed.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a schematic diagram for illustrating an overall configuration of a heat source apparatus according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a block diagram for illustrating an internal configuration of a controller included in the heat source apparatus of Fig. 1.

[Fig. 3] Fig. 3 is a schematic diagram for illustrating a state of a refrigerant circuit included in the heat source apparatus of Fig. 1 during a cooling operation.

[Fig. 4] Fig. 4 is a schematic diagram for illustrating a state at the time when a power failure occurs during the cooling operation of Fig. 3.

[Fig. 5] Fig. 5 is a schematic diagram for illustrating a state of the refrigerant circuit included in the heat source apparatus of Fig. 1 during a heating operation.

[Fig. 6] Fig. 6 is a schematic diagram for illustrating a state at the time when a power failure occurs during the heating operation of Fig. 5.

[Fig. 7] Fig. 7 is a schematic diagram for illustrating a state of the refrigerant circuit included in the heat source apparatus of Fig. 1 during a defrosting operation.

[Fig. 8] Fig. 8 is a schematic diagram for illustrating a state at the time when a power failure occurs during the defrosting operation of Fig. 7.

[Fig. 9] Fig. 9 is a flow chart for illustrating operation of the heat source apparatus of Fig. 1.

Description of Embodiments

[Embodiment]

[0010] Fig. 1 is a schematic diagram for illustrating an overall configuration of a heat source apparatus according to an embodiment of the present invention. As illustrated in Fig. 1, a heat source apparatus 10 includes a refrigerant circuit 20, a first inverter circuit 31, a second inverter circuit 32, and a controller 40. The heat source apparatus 10 also includes a filter circuit 50, an AC/DC converter 60, a smoothing capacitor 70, and a DC/DC converter 80.

[0011] The heat source apparatus 10 in the embodiment includes the above-mentioned components in a casing (not shown) to be integrally formed, and is placed outdoors. In other words, the heat source apparatus 10 is a chiller unit configured to supply a cooled or heated heat medium to a load, and serves as an outdoor unit of a water heater, a floor heating system, an air-conditioning apparatus, or other such apparatus.

[0012] The refrigerant circuit 20 includes a compressor 21, an air-cooled heat exchanger 22, a main expansion valve 24, a load-side heat exchanger 25, a refrigerant flow control circuit 26, and a four-way valve 29. The refrigerant flow control circuit 26 is connected in parallel to the main expansion valve 24, and is configured to regulate a flow rate of refrigerant by storing the refrigerant or causing outflow of the refrigerant. The refrigerant flow control circuit 26 includes a first sub-expansion valve 27A configured to regulate the flow rate of the refrigerant, a refrigerant tank (high pressure receiver) 28 configured to store the refrigerant, and a second sub-expansion valve 27B configured to regulate the flow rate of the refrigerant, which are connected in series with one another.

[0013] In other words, the refrigerant circuit 20 includes the compressor 21, the air-cooled heat exchanger 22, the main expansion valve 24, the load-side heat exchanger 25, the first sub-expansion valve 27A, the second sub-expansion valve 27B, the refrigerant tank 28, and the four-way valve 29, which are connected by refrigerant pipes 91. The refrigerant pipes 91 of the refrigerant circuit 20 are configured to allow the refrigerant to circulate therethrough. Moreover, a fan 23 configured to facilitate heat exchange is provided together with the air-cooled heat exchanger 22.

[0014] The compressor 21 includes a compressor motor (not shown) which is driven by the first inverter circuit 31, and is configured to compress the refrigerant. The air-cooled heat exchanger 22 is formed of a fin-and-tube heat exchanger, for example, and is configured to exchange heat between outside air (air) as the heat medium and the refrigerant.

[0015] The fan 23 includes a fan motor (not shown) which is driven by the second inverter circuit 32, and is rotated with the fan motor as a power source to send air to the air-cooled heat exchanger 22. The fan 23 is configured to facilitate the heat exchange between the outside air and the refrigerant in the air-cooled heat exchanger 22.

[0016] The main expansion valve 24 is formed of an electronic expansion valve, for example, and is configured to reduce a pressure of high-pressure refrigerant that flows thereinto from the air-cooled heat exchanger 22. The main expansion valve 24 is in a state of being open in all operation states: a cooling operation, a heating operation, and a defrosting operation. The main expansion valve 24 has a function of being fully closed when power supply from a power supply source 100 is stopped (at the time of power failure).

[0017] Each of the first sub-expansion valve 27A and the second sub-expansion valve 27B is formed of an electronic expansion valve, for example, and is configured to regulate the flow rate of the refrigerant flowing through the refrigerant flow control circuit 26. Each of the first sub-expansion valve 27A and the second sub-expansion valve 27B has a function of being fully closed. More specifically, when a power failure (stoppage of power supply from power supply source 100) occurs during the heating operation, the first sub-expansion valve 27A which is located on the air-cooled heat exchanger 22 side, is changed to a state of being fully closed, and when a power failure occurs during the defrosting operation, the second sub-expansion valve 27B which is located on the load-side heat exchanger 25 side, is changed to a state of being fully closed.

[0018] The refrigerant tank 28 is configured to store a surplus amount of refrigerant during the heating operation and other such times, and hence regulate an amount of refrigerant circulating through the refrigerant circuit 20.

[0019] The four-way valve 29 is configured to switch a passage of the refrigerant, and includes four pipes for forming a passage corresponding to an operational state. In other words, each of the compressor 21, the air-cooled heat exchanger 22, and the load-side heat exchanger 25 is connected to any one of the four pipes of the four-way valve 29 depending on the operational state. More specifically, during the cooling operation or the defrosting operation, the four-way valve 29 is switched such that gas refrigerant discharged from the compressor 21 flows to the air-cooled heat exchanger 22 (see the solid line in Fig. 1). Meanwhile, during the heating operation, the four-way valve 29 is switched such that the gas refrigerant discharged from the compressor 21 flows to the load-side heat exchanger 25 (see the broken line in Fig. 1).

[0020] The load-side heat exchanger 25 is configured to exchange heat between a heat medium flowing through the load and the refrigerant. The load-side heat exchanger 25 serves as an evaporator during the cooling operation and the defrosting operation, and serves as a condenser during the heating operation.

[0021] During the cooling operation, heat refrigerant that has flowed into the load-side heat exchanger 25 from the load through pipes 92 is cooled through heat exchange with the refrigerant circulating through the refrigerant pipes 91, and is supplied to the load side. During the heating operation, heat refrigerant that has flowed into the load-side heat exchanger 25 from the load through the pipes 92 is heated through heat exchange with the refrigerant circulating through the refrigerant pipes 91, and is supplied to the load side.

[0022] The first inverter circuit 31 is configured to generate a voltage for driving the compressor 21, and supply the generated voltage to the compressor motor. The second inverter circuit 32 is configured to generate a voltage for driving the fan 23, and supply the generated voltage to the fan motor.

[0023] The filter circuit 50 includes a noise filter 50A, a power supply detection circuit 50B, and a power failure detection unit 50C. The noise filter 50A is configured to remove noise superimposed on a voltage (current) supplied from the power supply source 100 which is formed of a commercial power supply, for example. The power supply detection circuit 50B is configured to detect power supplied from the power supply source 100 as the power source through comparison with a predetermined voltage, which is set in advance. The power failure detection unit 50C is configured to monitor a state of power supply from the power supply source 100 at all times to detect the stoppage of power supply from the power supply source 100 (power failure). The power failure detection unit 50C may be incorporated in the power supply detection circuit 50B, or may be provided outside the filter circuit 50.

[0024] The AC/DC converter 60 is configured to convert an AC voltage, which is supplied from the power supply source 100, into a DC voltage. The smoothing capacitor 70 is configured to smooth the DC voltage output from the AC/DC converter 60. The DC/DC converter 80 is configured to generate a DC voltage suitable for operation of the controller 40 based on the DC voltage input from the AC/DC converter 60 via the smoothing capacitor 70.

[0025] Fig. 2 is a block diagram for illustrating an internal configuration of the controller 40 included in the heat source apparatus 10. As illustrated in Fig. 2, the controller 40 includes an operational state identification unit 40A, a storage unit 40B, and a valve control unit 40C.

[0026] The operational state identification unit 40A has a function of determining whether or not the heat source apparatus 10 is in operation. The operational state identification unit 40A is also configured to identify, when the heat source apparatus 10 is in operation, which of the operational states: the cooling operation, the heating operation, and the defrosting operation the heat source apparatus 10 is in, and record operation type information, which indicates the identified operational state, in the storage unit 40B.

[0027] The operational state identification unit 40A further has a function of monitoring the operational state of the heat source apparatus 10 at all times or every predetermined time that has been set to update the operation type information in the storage unit 40B. In other words, the operational state identification unit 40A has a function of changing, when detecting a change of the operational state, the operation type information in the storage unit 40B. For example, the operational state identification unit 40A detects a situation of switching between the heating operation and the defrosting operation as occasion arises to identify the operational state, and updates the operation type information in the storage unit 40B based on the identified operational state.

[0028] The storage unit 40B is configured to store data used by the controller 40 in various arithmetic operations and other such operations, operation results, and other such data. For example, in the storage unit 40B, the operation type information is recorded by the operational state identification unit 40A, and the recorded operation type information is read by the valve control unit 40C. The storage unit 40B may be formed of a hard disk drive (HDD), a flash memory, or other such storage device. The storage unit 40B may be provided outside the controller 40.

[0029] The valve control unit 40C is configured to change the main expansion valve 24 to a state of being fully closed when the power failure is detected by the power failure detection unit 50C during the cooling operation, in which the load-side heat exchanger 25 serves as the evaporator. Moreover, the valve control unit 40C is configured to change each of the main expansion valve 24 and the first sub-expansion valve 27A to the state of being fully closed when the power failure is detected by the power failure detection unit 50C during the heating operation, in which the load-side heat exchanger 25 serves as the condenser. Further, the valve control unit 40C is configured to change each of the main expansion valve 24 and the second sub-expansion valve 27B to the state of being fully closed when the power failure is detected by the power failure detection unit 50C during the defrosting operation, in which the load-side heat exchanger 25 serves as the evaporator to remove frost attached to the air-cooled heat exchanger 22.

[0030] Moreover, the valve control unit 40C is configured to, when the power failure is detected by the power failure detection unit 50C, access the storage unit 40B to check the operation type information recorded by the operational state identification unit 40A, in order to identify the operational state before the power failure.

[0031] The valve control unit 40C is configured to operate using power stored in the smoothing capacitor 70 (residual charge of the smoothing capacitor 70) when the power failure occurs.

[0032] The operational state identification unit 40A and the valve control unit 40C may be implemented by hardware, for example, a circuit device configured to implement those functions, or may be implemented by software executed on a DSP or other such microcomputer, or a CPU or other such arithmetic unit, for example.

[0033] Incidentally, in the embodiment, water is adopted as the heat medium flowing through the load. In other words, the heat source apparatus 10 includes a water-cooled heat exchanger as the load-side heat exchanger 25. The water-cooled heat exchanger has heat exchange efficiency that is higher than that of the air-cooled heat exchanger, and hence may have a volume that is smaller than that of the air-cooled heat exchanger. Therefore, in the embodiment, the load-side heat exchanger 25, which has a volume that is smaller than that of the air-cooled heat exchanger 22, is adopted to downsize the heat source apparatus 10. This leads to a situation in which the amount of refrigerant stored in the load-side heat exchanger 25 is smaller than that of the air-cooled heat exchanger 22.

[0034] Moreover, as described above, the heat source apparatus 10 is integrally formed and placed outdoors, with the result that the refrigerant pipe 91 that connects the load-side heat exchanger 25 to the compressor 21, and the refrigerant pipe 91 that connects the load-side heat exchanger 25 to the main expansion valve 24 and the second sub-expansion valve 27B are shorter than those in the structure in which the load-side heat exchanger 25 is placed indoors. Therefore, the heat source apparatus 10 has an amount of refrigerant that can be stored in the refrigerant pipes 91 that is smaller than that in the structure in which the load-side heat exchanger 25 is placed indoors.

[0035] Under the above-mentioned circumstances, in the heat source apparatus 10, the main expansion valve 24 is changed to the state of being fully closed, and the first sub-expansion valve 27A maintains the state of being fully closed when the power failure occurs during the cooling operation, with the result that an inflow path of the high-pressure refrigerant to the load-side heat exchanger 25 side can be blocked.

[0036] Meanwhile, in the heat source apparatus 10, each of the main expansion valve 24 and the first sub-expansion valve 27A is changed to the state of being fully closed when the power failure occurs during the heating operation, with the result that an inflow path of the high-pressure refrigerant to the air-cooled heat exchanger 22 side can be blocked. At that time, the second sub-expansion valve 27B is in a state of being open, and hence this allows the refrigerant dwelling in the load-side heat exchanger 25 to escape to the refrigerant tank 28, with the result that outflow of the refrigerant to the compressor 21 side can be further suppressed.

[0037] Further, in the heat source apparatus 10, each of the main expansion valve 24 and the second sub-expansion valve 27B is changed to the state of being fully closed when the power failure occurs during the defrosting operation, with the result that an inflow path of the high-pressure refrigerant to the load-side heat exchanger 25 side can be blocked. At that time, the first sub-expansion valve 27A is in a state of being open, and hence this allows the refrigerant dwelling in the air-cooled heat exchanger 22 to escape to the refrigerant tank 28, with the result that outflow of the refrigerant to the compressor 21 side can be further suppressed.

[0038] In other words, the heat source apparatus 10 adopts the water-cooled heat exchanger as the load-side heat exchanger 25, and even when serving as an outdoor unit, can prevent liquid backflow, which occurs at the time of a power failure and other such times due to a pressure difference in the refrigerant circuit, and hence can suppress a liquid backflow operation at the time of restarting after restoration of power.

[0039] Next, referring to Fig. 3 to Fig. 8, a description is given of open/close states of the main expansion valve 24, the first sub-expansion valve 27A, and the second sub-expansion valve 27B at the time when the power failure occurs during each of the operational states (cooling operation, heating operation, and defrosting operation).

(During Cooling Operation)

[0040] Fig. 3 is a schematic diagram for illustrating a state of the refrigerant circuit 20 included in the heat source apparatus 10 during the cooling operation. Fig. 4 is a schematic diagram for illustrating a state at the time when the power failure occurs during the cooling operation of Fig. 3.

[0041] The refrigerant circuit 20 during the cooling operation regulates the flow rate of the refrigerant with the main expansion valve 24. In other words, as illustrated in Fig. 3, the main expansion valve 24 is in the state of being open. Moreover, the first sub-expansion valve 27A is in the state of being closed (fully closed), and the second sub-expansion valve 27B is in the state of being open.

[0042] During the cooling operation, the refrigerant that has been compressed in and discharged from the compressor 21 passes through the four-way valve 29, then passes through the air-cooled heat exchanger 22, the main expansion valve 24, and the load-side heat exchanger 25 in the stated order, and passes through the four-way valve 29 again to be suctioned by the compressor 21. In other words, the air-cooled heat exchanger 22 serves as a condenser, and the load-side heat exchanger 25 serves as the evaporator.

[0043] Moreover, the refrigerant circulating through the refrigerant circuit 20 is in a high-pressure state on the air-cooled heat exchanger 22 side of the main expansion valve 24, and in a low-pressure state on the load-side heat exchanger 25 side of the main expansion valve 24. Therefore, when the power failure occurs during the cooling operation, a pressure difference between the air-cooled heat exchanger 22 side and the load-side heat exchanger 25 side causes liquid refrigerant dwelling in the air-cooled heat exchanger 22 to flow into the load-side heat exchanger 25 via the main expansion valve 24.

[0044] Under the above-mentioned circumstances, the heat source apparatus 10 according to the embodiment is configured such that, when the power failure occurs during the cooling operation, as illustrated in Fig. 4, the open/close state of the main expansion valve 24 is changed from the open state to the closed (fully closed) state. Therefore, the flow of the liquid refrigerant dwelling in the air-cooled heat exchanger 22 to the load-side heat exchanger 25 side can be stopped, and hence the liquid backflow operation at the time of restarting after restoration of power can be suppressed. The heat source apparatus 10 is configured such that, even when the power failure occurs during the cooling operation, the open/close states of the first sub-expansion valve 27A and the second sub-expansion valve 27B are not changed.

(During Heating Operation)

[0045] Fig. 5 is a schematic diagram for illustrating a state of the refrigerant circuit 20 included in the heat source apparatus 10 during the heating operation. Fig. 6 is a schematic diagram for illustrating a state at the time when the power failure occurs during the heating operation of Fig. 5.

[0046] The refrigerant circuit 20 during the heating operation regulates the refrigerant with the main expansion valve 24, the first sub-expansion valve 27A, and the second sub-expansion valve 27B. In other words, as illustrated in Fig. 5, the main expansion valve 24 is in the state of being open. Moreover, the first sub-expansion valve 27A is in a state of being open (slightly open), and the second sub-expansion valve 27B is in the state of being open.

[0047] During the heating operation, the refrigerant that has been compressed in and discharged from the compressor 21 passes through the four-way valve 29, then passes through the load-side heat exchanger 25, the main expansion valve 24, the refrigerant flow control circuit 26, and the air-cooled heat exchanger 22 in the stated order, and passes through the four-way valve 29 again to be suctioned by the compressor 21. In other words, the air-cooled heat exchanger 22 serves as an evaporator, and the load-side heat exchanger 25 serves as the condenser.

[0048] Moreover, the refrigerant circulating through the refrigerant circuit 20 is in a high-pressure state on the load-side heat exchanger 25 side of the main expansion valve 24, and in a low-pressure state on the air-cooled heat exchanger 22 side via the main expansion valve 24. As illustrated in Fig. 5, a surplus amount of refrigerant is stored in the refrigerant tank 28. Therefore, when the power failure occurs during the heating operation, a pressure difference between the air-cooled heat exchanger 22 side and the load-side heat exchanger 25 side causes liquid refrigerant dwelling in the load-side heat exchanger 25 and the refrigerant tank 28 to flow into the air-cooled heat exchanger 22 via the main expansion valve 24 and the first sub-expansion valve 27A.

[0049] Under the above-mentioned circumstances, the heat source apparatus 10 according to the embodiment is configured such that, when the power failure occurs during the heating operation, the main expansion valve 24 is changed from the state of being open to the state of being closed (fully closed), and the first sub-expansion valve 27A is changed from the state of being open (slightly open) to the state of being closed (fully closed) as illustrated in Fig. 6. Therefore, the flow of the liquid refrigerant dwelling in the load-side heat exchanger 25 and the refrigerant tank 28 to the air-cooled heat exchanger 22 side can be stopped, and hence the liquid backflow operation at the time of restarting after restoration of power can be suppressed. The heat source apparatus 10 is configured such that, even when the power failure occurs during the heating operation, the open/close state of the second sub-expansion valve 27B is not changed.

(During Defrosting Operation)

[0050] Fig. 7 is a schematic diagram for illustrating a state of the refrigerant circuit 20 included in the heat source apparatus 10 during the defrosting operation. Fig. 8 is a schematic diagram for illustrating a state at the time when a power failure occurs during the defrosting operation of Fig. 7. When the heat source apparatus 10 performs the heating operation, the air-cooled heat exchanger 22 has its surface frosted. Therefore, during the heating operation, in order to melt the frost on the surface of the air-cooled heat exchanger 22, the heat source apparatus 10 periodically performs the defrosting operation for a predetermined time period.

[0051] The refrigerant circuit 20 in the defrosting operation regulates the refrigerant with the main expansion valve 24, the first sub-expansion valve 27A, and the second sub-expansion valve 27B. In other words, as illustrated in Fig. 7, the main expansion valve 24 is in the state of being open. Moreover, the first sub-expansion valve 27A is in the state of being open (slightly open), and the second sub-expansion valve 27B is in the state of being open.

[0052] During the defrosting operation, the refrigerant that has been compressed in and discharged from the compressor 21 passes through the four-way valve 29, then passes through the air-cooled heat exchanger 22, the main expansion valve 24, the refrigerant flow control circuit 26, and the load-side heat exchanger 25 in the stated order, and passes through the four-way valve 29 again to be suctioned by the compressor 21. In other words, the air-cooled heat exchanger 22 serves as the condenser, and the load-side heat exchanger 25 serves as the evaporator.

[0053] Moreover, the refrigerant circulating through the refrigerant circuit 20 has a pressure that is higher on the air-cooled heat exchanger 22 side of the main expansion valve 24 than on the load-side heat exchanger 25 side of the main expansion valve 24. Therefore, when the power failure occurs during the defrosting operation, a pressure difference between the air-cooled heat exchanger 22 side and the load-side heat exchanger 25 side causes liquid refrigerant dwelling in the air-cooled heat exchanger 22 and the refrigerant tank 28 to flow into the load-side heat exchanger 25 via the main expansion valve 24 and the second sub-expansion valve 27B.

[0054] Under the above-mentioned circumstances, the heat source apparatus 10 according to the embodiment is configured such that, when the power failure occurs during the cooling operation, the main expansion valve 24 is changed from the state of being open to the state of being closed (fully closed), and the second sub-expansion valve 27B is changed from the state of being open to the state of being closed (fully closed) as illustrated in Fig. 8. Therefore, the flow of the liquid refrigerant dwelling in the air-cooled heat exchanger 22 and the refrigerant tank 28 to the load-side heat exchanger 25 side can be stopped, and hence the liquid backflow operation at the time of restarting after restoration of power can be suppressed. The heat source apparatus 10 is configured such that, even when the power failure occurs during the defrosting operation, the open/close state of the first sub-expansion valve 27A is not changed.

[0055] Fig. 9 is a flow chart for illustrating operation of the heat source apparatus 10. Referring to Fig. 9, a description is given of operational state identification processing which is performed by the operational state identification unit 40A, and valve control which is performed by the valve control unit 40C.

(Operational State Identification Processing)

[0056] The operational state identification unit 40A determines whether or not the heat source apparatus 10 is in operation (Fig. 9: Step S101). When the operational state identification unit 40A determines that the heat source apparatus 10 is not in operation (Fig. 9: Step S101/NO), the controller 40 ends the operation while maintaining the open/close states of the main expansion valve 24, the first sub-expansion valve 27A, and the second sub-expansion valve 27B.

[0057] Meanwhile, when determining that the heat source apparatus 10 is in operation (Fig. 9: Step S101/YES), the operational state identification unit 40A determines whether or not the heat source apparatus 10 is in the cooling operation (Fig. 9: Step S102).

[0058] When determining that the heat source apparatus 10 is in the cooling operation (Fig. 9: Step S102/YES), the operational state identification unit 40A records, in the storage unit 40B, that the heat source apparatus 10 is in the cooling operation as the operation type information (Fig. 9: Step S103). Meanwhile, when determining that the heat source apparatus 10 is not in the cooling operation (Fig. 9: Step S102/NO), the operational state identification unit 40A determines whether or not the heat source apparatus 10 is in the heating operation (Fig. 9: Step S104).

[0059] When determining that the heat source apparatus 10 is in the heating operation (Fig. 9: Step S104/YES), the operational state identification unit 40A records, in the storage unit 40B, that the heat source apparatus 10 is in the heating operation as the operation type information (Fig. 9: Step S105). Meanwhile, when determining that the heat source apparatus 10 is not in the heating operation (Fig. 9: Step S104/NO), the operational state identification unit 40A records, in the storage unit 40B, that the heat source apparatus 10 is in the defrosting operation as the operation type information (Fig. 9: Step S106).

[0060] The operational state identification unit 40A executes the processing of Steps S101 to S106 described above at all times or every predetermined time that has been set to identify the operational state of the heat source apparatus 10, and updates the operation type information in the storage unit 40B based on the identified operational state.

[0061] The operational state identification processing described above in Steps S101 to S106 generates a state in which the operation type information indicating the operational state of the heat source apparatus 10 is recorded in the storage unit 40B. Therefore, when the stoppage of power supply from the power supply source 100 (power failure) occurs, the valve control unit 40C may use the power stored in the smoothing capacitor 70 to perform valve control corresponding to the operational state before the power failure.

(Valve Control)

[0062] When the stoppage of power supply from the power supply source 100 is detected by the power failure detection unit 50C, the valve control unit 40C uses the power stored in the smoothing capacitor 70 to access the storage unit 40B, thereby checking the operation type information indicating the operational state before the power failure, which is recorded in the storage unit 40B (Fig. 9: Step S108).

[0063] When the storage unit 40B stores the operation type information indicating the cooling operation, the valve control unit 40C determines that the heat source apparatus 10 was in the cooling operation before the power failure, and uses the power stored in the smoothing capacitor 70 to change the main expansion valve 24 from the state of being open to the state of being closed (fully closed) (Fig. 9: Step S109).

[0064] When the storage unit 40B stores the operation type information indicating the heating operation, the valve control unit 40C determines that the heat source apparatus 10 was in the heating operation before the power failure, and uses the power stored in the smoothing capacitor 70 to change the main expansion valve 24 from the state of being open to the state of being closed (fully closed), and change the first sub-expansion valve 27Afrom the state of being open (slightly open) to the state of being closed (fully closed) (Fig. 9: Step S110).

[0065] When the storage unit 40B stores the operation type information indicating the heating operation, the valve control unit 40C determines that the heat source apparatus 10 was in the heating operation before the power failure, and uses the power stored in the smoothing capacitor 70 to change the main expansion valve 24 from the state of being open to the state of being closed (fully closed), and change the second sub-expansion valve 27B from the state of being open to the state of being closed (fully closed) (Fig. 9: Step S111).

[0066] As described above, immediately after the power failure occurs, the valve control unit 40C uses the power stored in the smoothing capacitor 70 to change the main expansion valve 24 to the state of being fully closed. Therefore, according to the heat source apparatus 10, the movement of the refrigerant between the air-cooled heat exchanger 22 and the load-side heat exchanger 25 can be suppressed.

[0067] Moreover, the valve control unit 40C further changes the first sub-expansion valve 27A to the state of being fully closed immediately after the power failure during the heating operation, and further changes the second sub-expansion valve 27B to the state of being fully closed immediately after the power failure during the defrosting operation. Therefore, according to the heat source apparatus 10, outflow of liquid refrigerant dwelling in the air-cooled heat exchanger 22 or the load-side heat exchanger 25 can be prevented more effectively.

[0068] In other words, according to the heat source apparatus 10 of the embodiment, the main expansion valve 24, which is connected between the air-cooled heat exchanger 22 and the load-side heat exchanger 25, is fully closed when the stoppage of power supply from the power supply source 100 is detected, and the refrigerant flow control circuit 26, which is connected in parallel to the main expansion valve 24, regulates the flow rate of the refrigerant by storing the refrigerant or causing outflow of the refrigerant. Therefore, according to the heat source apparatus 10, the liquid backflow, which occurs at the time of power failure and other such times due to the pressure difference in the refrigerant circuit 20, can be prevented, and hence the liquid backflow operation at the time of restarting after restoration of power can be suppressed.

[0069] The embodiment is a preferred specific example of the heat source apparatus, and a technical scope of the present invention is not limited to those aspects. For example, in the embodiment, there has been exemplified the case in which the valve control unit 30 operates using the power stored in the smoothing capacitor 70 at the time of power failure. However, the present invention is not limited thereto, and the valve control unit 30 may use power stored in another capacitor or other such element on a substrate on which the controller 40 is provided. In addition, the valve control unit 30 may use power stored in a capacitor or other such element forming the DC/DC converter 80 at the time of power failure. Alternatively, there may be adopted a configuration in which the heat source apparatus 10 includes an auxiliary power supply device configured to provide power at the time of power failure, and in which the valve control unit 30 operates using the power supplied from the auxiliary power supply device at the time of power failure.

[0070] Moreover, in the embodiment, there has been described the case in which the heat medium to exchange heat with the refrigerant in the load-side heat exchanger 25 is water. However, the present invention is not limited thereto, and brine or other such material may be adopted as the heat medium. Further, the heat source apparatus 10 may perform the cooling operation or the heating operation and the defrosting operation. When the heat source apparatus 10 is configured to perform only the cooling operation, the four-way valve 29 is not required. Reference Signs List

[0071] 10 heat source apparatus 20 refrigerant circuit 21 compressor 22 air-cooled heat exchanger 23 fan 24 main expansion valve 25 load-side heat exchanger 26 refrigerant flow control circuit 27A first sub-expansion valve 27B second sub-expansion valve 28 refrigerant tank 29 four-way valve 31 first inverter circuit 32 second inverter circuit 40 controller 40A operational state identification unit 40B storage unit 40C valve control unit 50 filter circuit 50A noise filter 50B power supply detection circuit 50C power failure detection unit 60 AC/DC converter 70 smoothing capacitor 80 DC/DC converter 91 refrigerant pipe 92 pipe

100 power supply source

Claims

1. A heat source apparatus comprising:

a compressor configured to compress refrigerant;
an air-cooled heat exchanger configured to exchange heat between air and the refrigerant;
a load-side heat exchanger configured to exchange heat between a heat medium flowing through a load, and the refrigerant;
a main expansion valve connected between the

air-cooled heat exchanger and the load-side heat exchanger, and having a function of being fully closed when stoppage of power supply from a power supply source is detected; and
a refrigerant flow control circuit connected in parallel to the main expansion valve, and configured to regulate a flow rate of the refrigerant by storing the refrigerant or causing outflow of the refrigerant,
the refrigerant flow control circuit comprising a first sub-expansion valve configured to regulate the flow rate of the refrigerant, a refrigerant tank configured to store the refrigerant, and a second sub-expansion valve configured to regulate the flow rate of the refrigerant, which are connected in series with one another.

2. The heat source apparatus of claim 1, further comprising:

a power failure detection unit configured to detect the stoppage of power supply from the power supply source; and
a valve control unit configured to control to change the main expansion valve to a state of being fully closed when the stoppage of power supply is detected by the power failure detection unit.

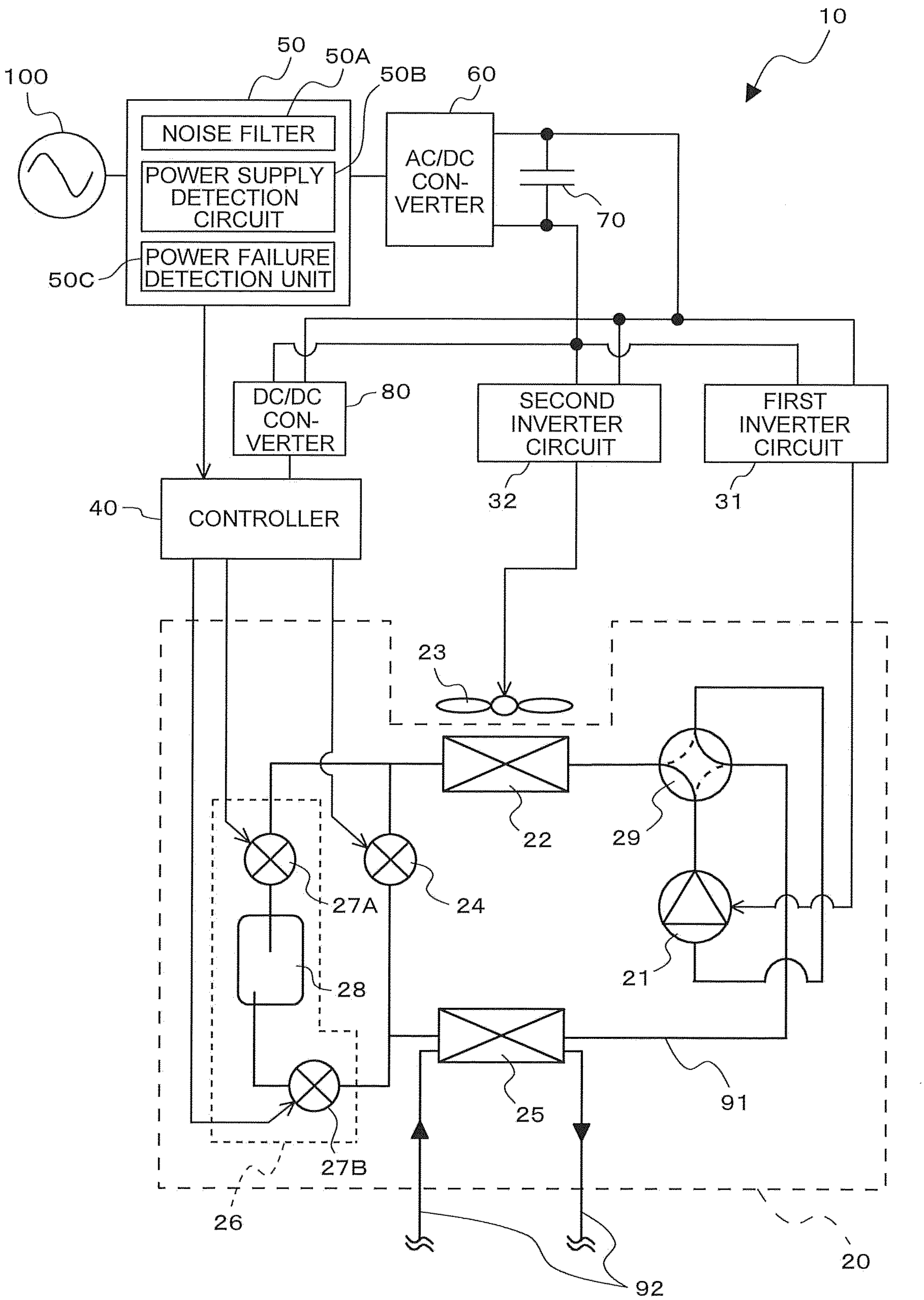
3. The heat source apparatus of claim 2, wherein the valve control unit is configured to control to further change the first sub-expansion valve to a state of being fully closed when the stoppage of power supply is detected by the power failure detection unit during a heating operation in which the load-side heat exchanger serves as a condenser.

4. The heat source apparatus of claim 2 or 3, wherein the valve control unit is configured to control to further change the second sub-expansion valve to a state of being fully closed when the stoppage of power supply is detected by the power failure detection unit during a defrosting operation in which the load-side heat exchanger serves as an evaporator.

5. The heat source apparatus of any one of claims 2 to 4, further comprising:

an AC/DC converter configured to convert an AC voltage, that is supplied from the power supply source, into a DC voltage; and
a smoothing capacitor configured to smooth the DC voltage output from the AC/DC converter,
wherein the valve control unit is configured to operate using a residual charge of the smoothing capacitor.

FIG. 1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100
50
50A
50B
60
NOISE FILTER
POWER SUPPLY DETECTION CIRCUIT
POWER FAILURE DETECTION UNIT
50C
AC/DC CON-VERTER
70
DC/DC CON-VERTER
80
SECOND INVERTER CIRCUIT
FIRST INVERTER CIRCUIT
32
31
40
CONTROLLER
23
22
29
27A
24
28
21
25
91
27B
26
20
92

FIG. 2

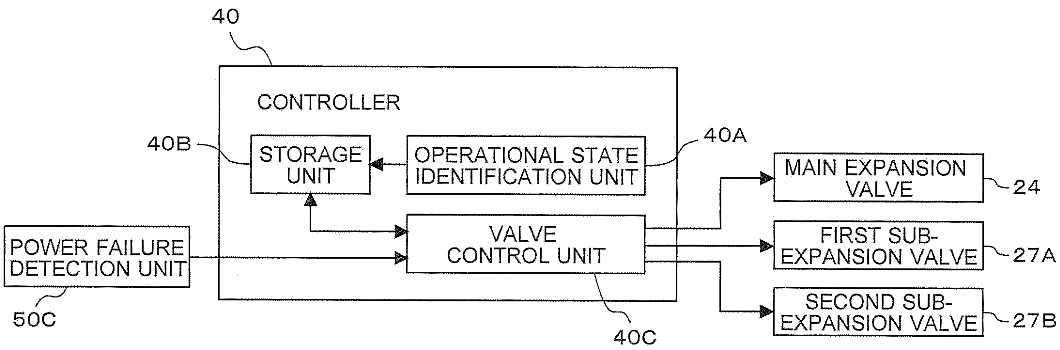
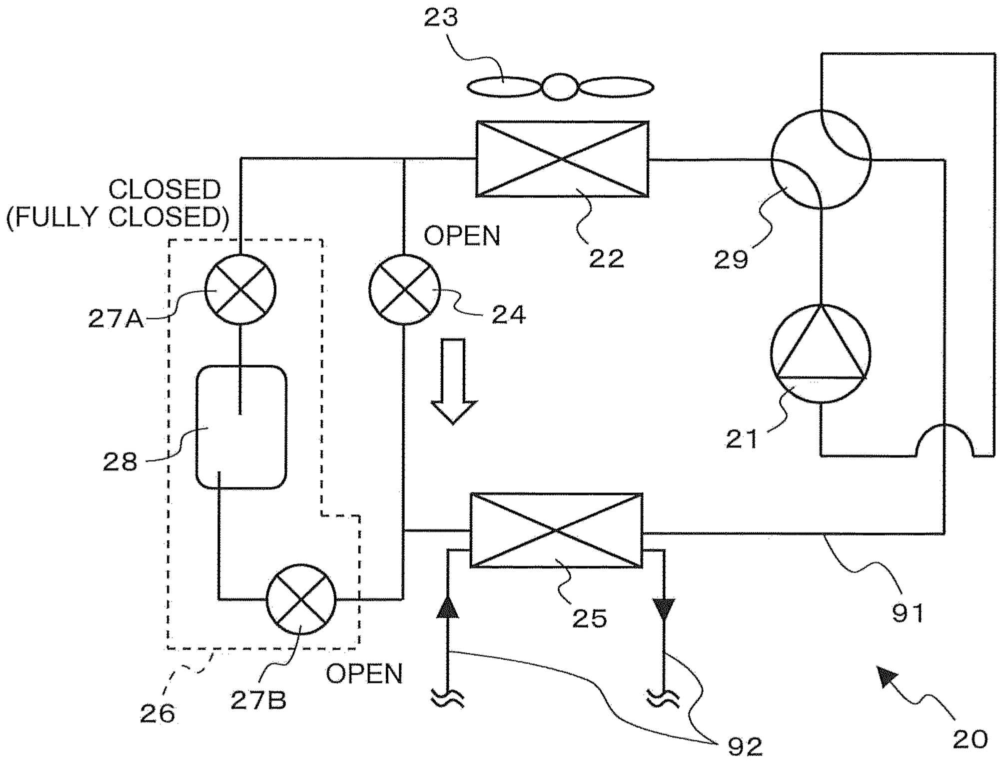

40
CONTROLLER
40B
STORAGE UNIT
OPERATIONAL STATE IDENTIFICATION UNIT
40A
MAIN EXPANSION VALVE
24
VALVE CONTROL UNIT
POWER FAILURE DETECTION UNIT
FIRST SUB-EXPANSION VALVE
27A
SECOND SUB-EXPANSION VALVE
27B
50C
40C

FIG. 3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(FULLY CLOSED)
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27A
24
28
21
25
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26
27B
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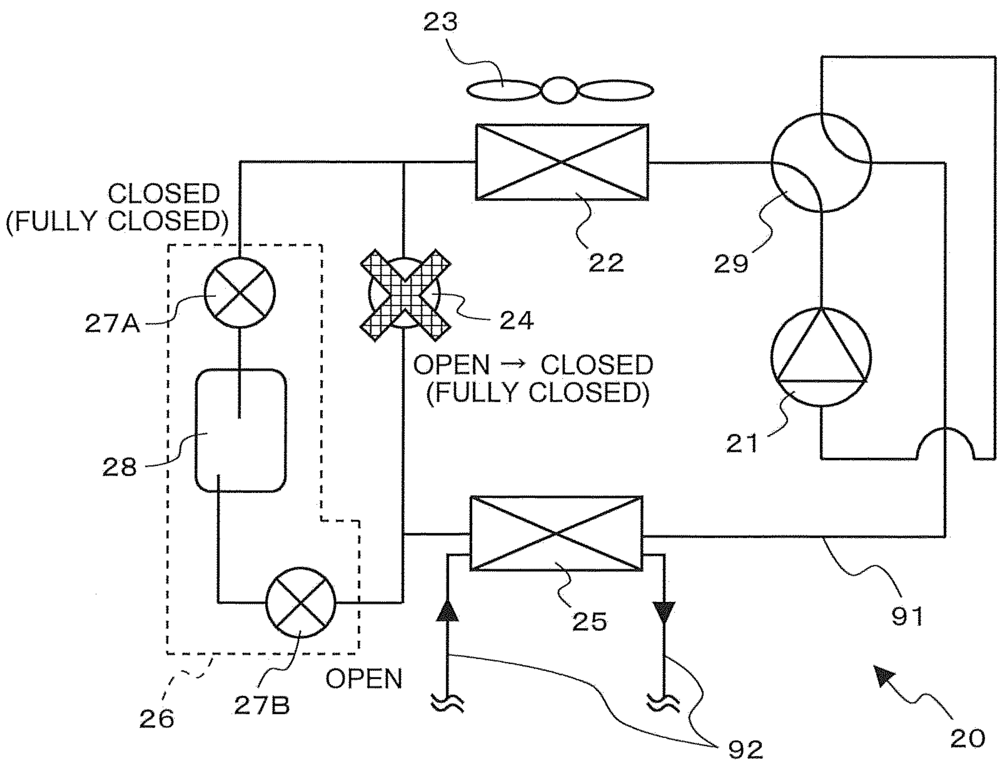
92
20

FIG. 4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(FULLY CLOSED)
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27A
24
OPEN → CLOSED
(FULLY CLOSED)
28
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25
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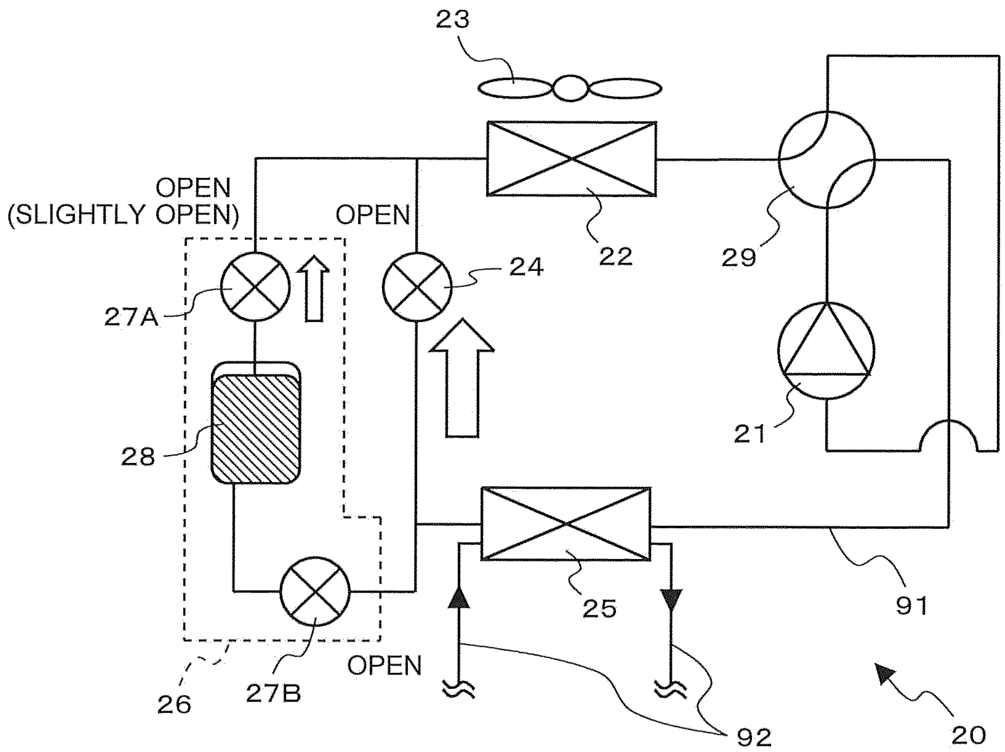
26
27B
OPEN
92
20

FIG. 5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22
29
27A
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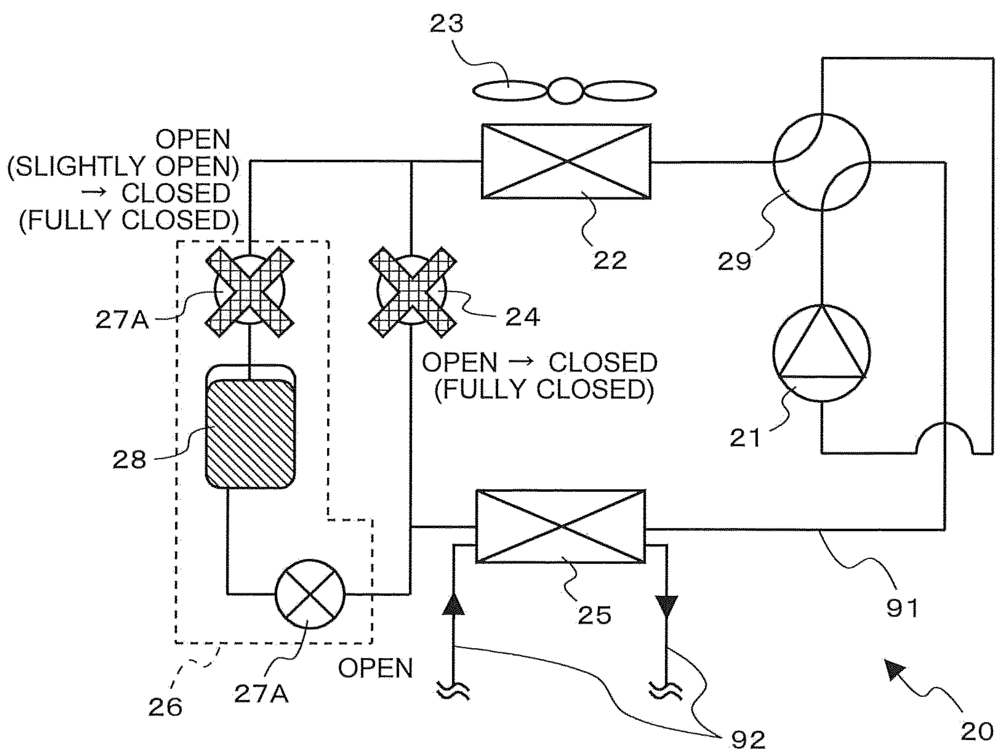
21
25
91
OPEN
26
27B
92
20

FIG. 6


23
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(SLIGHTLY OPEN)
→ CLOSED
(FULLY CLOSED)
22
29
27A
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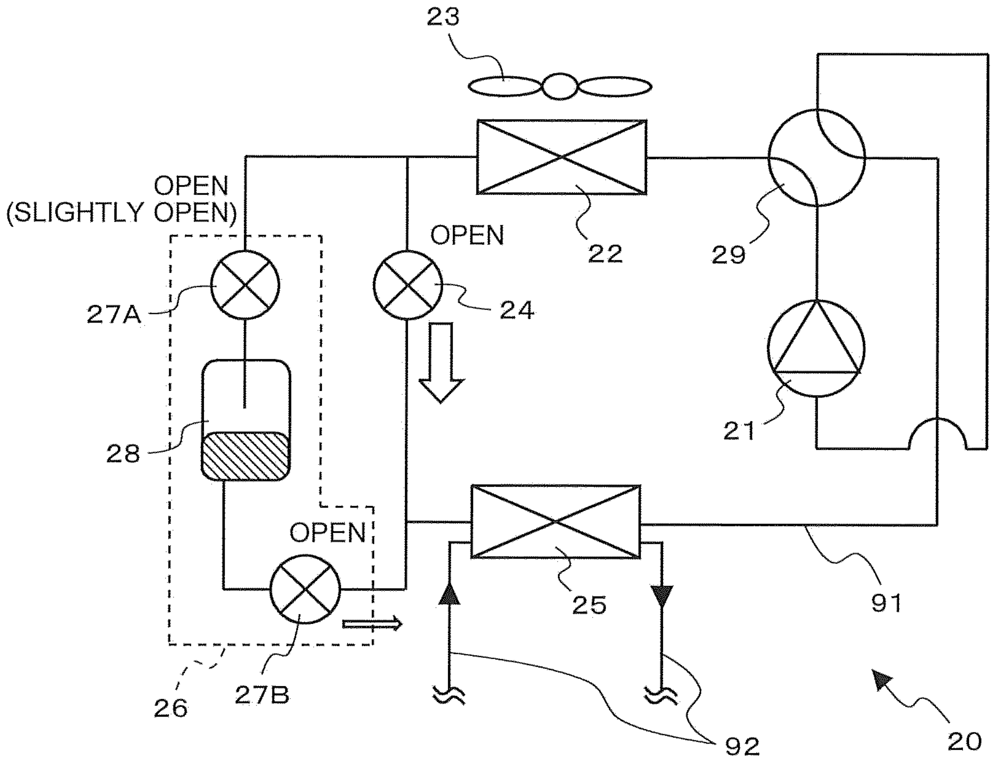
OPEN → CLOSED
(FULLY CLOSED)
28
21
25
91
OPEN
26
27A
92
20

FIG. 7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(SLIGHTLY OPEN)
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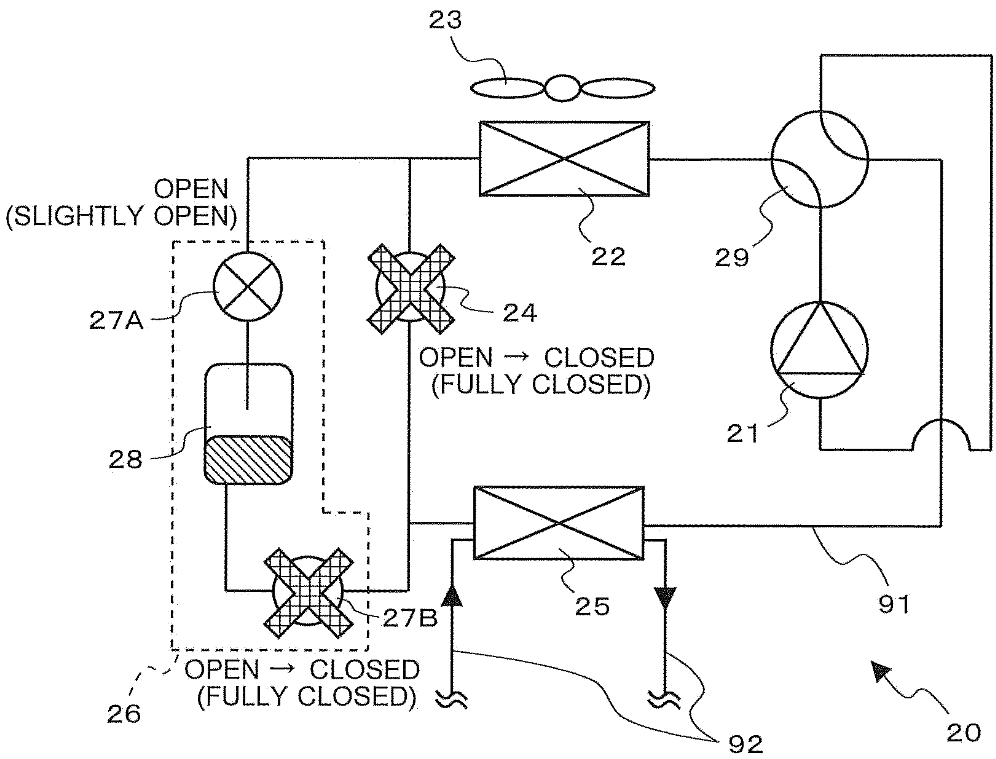
27A
24
28
21
OPEN
25
91
26
27B
92
20

FIG. 8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(SLIGHTLY OPEN)
22
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27A
24
OPEN → CLOSED
(FULLY CLOSED)
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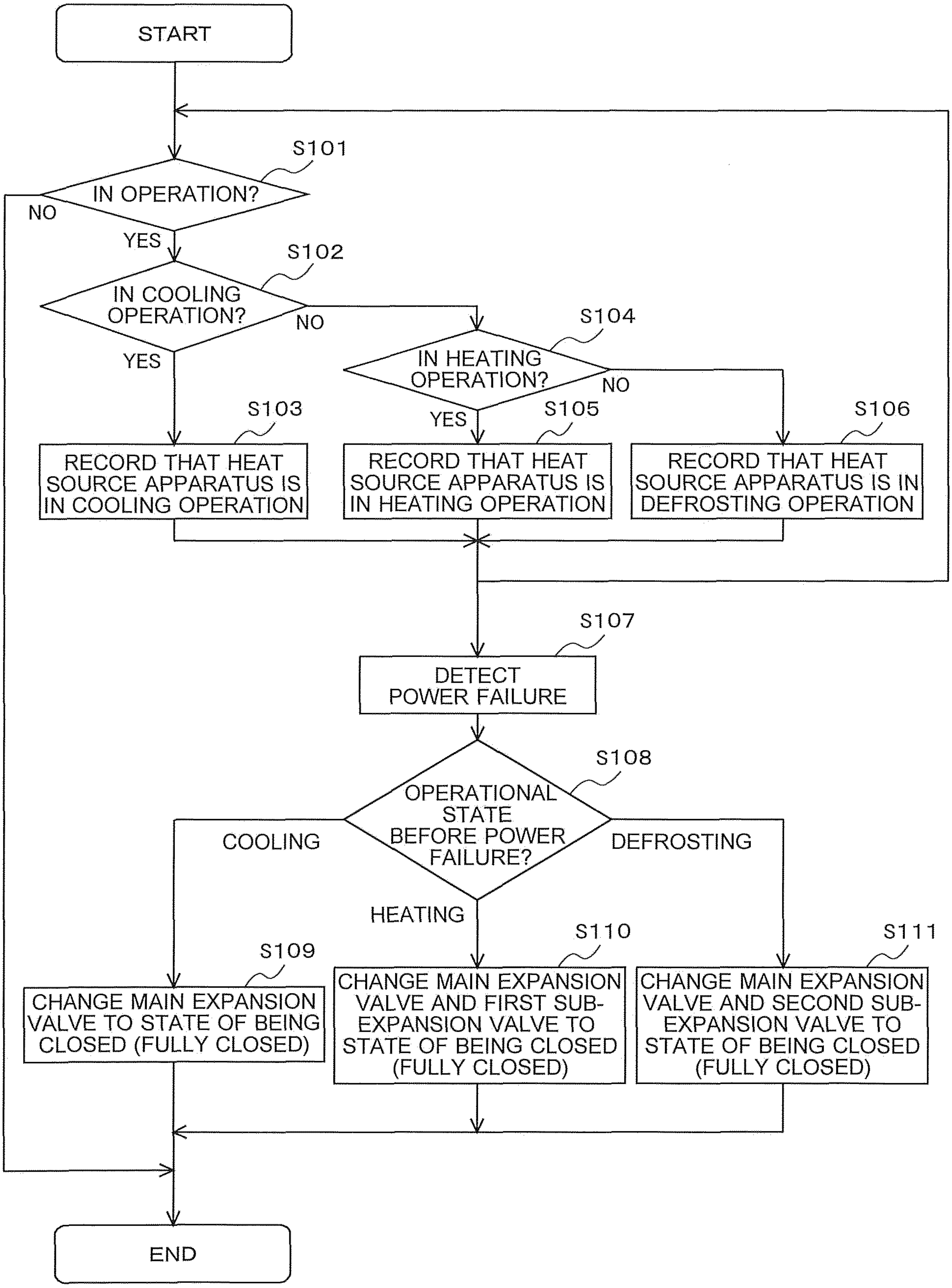
21
25
91
27B
OPEN → CLOSED
(FULLY CLOSED)
26
92
20

FIG. 9


START
S101
IN OPERATION?
NO
YES
S102
IN COOLING OPERATION?
NO
YES
S104
IN HEATING OPERATION?
NO
YES
S103
RECORD THAT HEAT SOURCE APPARATUS IS IN COOLING OPERATION
S105
RECORD THAT HEAT SOURCE APPARATUS IS IN HEATING OPERATION
S106
RECORD THAT HEAT SOURCE APPARATUS IS IN DEFROSTING OPERATION
S107
DETECT POWER FAILURE
S108
OPERATIONAL STATE BEFORE POWER FAILURE?
COOLING
HEATING
DEFROSTING
S109
CHANGE MAIN EXPANSION VALVE TO STATE OF BEING CLOSED (FULLY CLOSED)
S110
CHANGE MAIN EXPANSION VALVE AND FIRST SUB-EXPANSION VALVE TO STATE OF BEING CLOSED (FULLY CLOSED)
S111
CHANGE MAIN EXPANSION VALVE AND SECOND SUB-EXPANSION VALVE TO STATE OF BEING CLOSED (FULLY CLOSED)
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/068247

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F25B41/04*(2006.01)i, *F25B43/00*(2006.01)i, *F25B49/02* (2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00, F25B41/04, F25B43/00, F25B49/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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.
Y	JP 2014-119161 A (Sharp Corp.), 30 June 2014 (30.06.2014), paragraphs [0031] to [0066]; fig. 1 to 4 & WO 2014/092152 A	1-5
Y	JP 8-200858 A (Toyo Engineering Works, Ltd.), 06 August 1996 (06.08.1996), paragraph [0022]; fig. 1 (Family: none)	1-5
Y	JP 4-270863 A (Sanyo Electric Co., Ltd.), 28 September 1992 (28.09.1992), paragraphs [0013] to [0016]; fig. 1 (Family: none)	1-5

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 September 2015 (11.09.15)	29 September 2015 (29.09.15)

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

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/068247

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-121333 A (Hitachi, Ltd.), 12 May 2005 (12.05.2005), paragraphs [0020] to [0045]; fig. 1 (Family: none)	1-5
Y	JP 2009-156531 A (Mitsubishi Electric Corp.), 16 July 2009 (16.07.2009), paragraph [0026]; fig. 1 (Family: none)	3-5
Y	JP 2015-94574 A (Daikin Industries, Ltd.), 18 May 2015 (18.05.2015), paragraph [0066]; fig. 2 (Family: none)	3-5
Y	JP 63-46348 A (Daikin Industries, Ltd.), 27 February 1988 (27.02.1988), page 2, lower left column, line 19 to page 4, upper left column, line 4; figures (Family: none)	5

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2012247118 A **[0004]**