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

(11) EP 4 477 971 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.12.2024 Bulletin 2024/51

(21) Application number: **24180964.9**

(22) Date of filing: **10.06.2024**

(51) International Patent Classification (IPC):
F25B 40/02 *(2006.01)* ***F25B 49/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25B 40/02; F25B 49/02; F25B 2313/003; F25B 2313/004; F25B 2313/0272; F25B 2313/02741; F25B 2313/0314; F25B 2400/0411; F25B 2400/12; F25B 2400/13; F25B 2600/02; F25B 2600/13; F25B 2600/2513; F25B 2700/1931; F25B 2700/1933; (Cont.)

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **12.06.2023 JP 2023096279**

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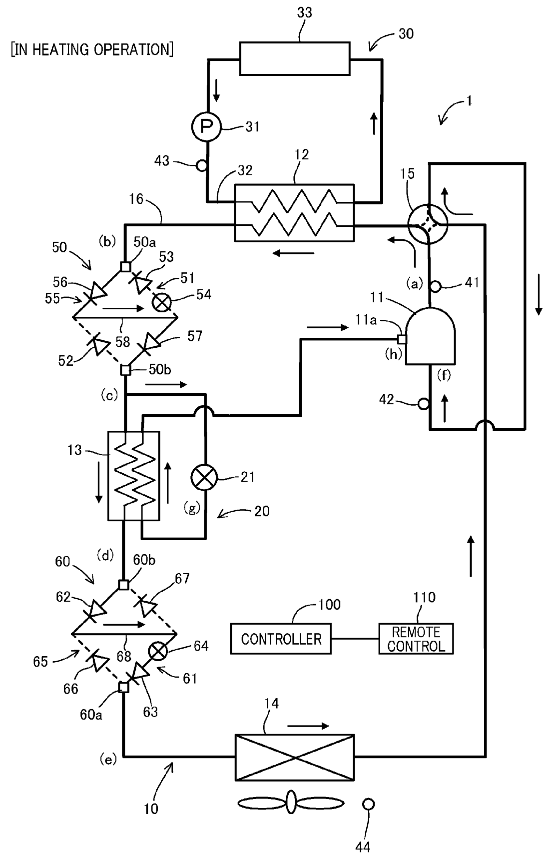
(54) REFRIGERATION CYCLE APPARATUS

(57) A refrigeration cycle apparatus 1 in the present disclosure includes a first channel switching circuit 50 provided between an economizer 13 and a use side heat exchanger 12, the first channel switching circuit being brought into a state in which a refrigerant flows through a first expansion valve 54 in a cooling-corresponding circulation state and brought into a state in which the refrigerant flows bypassing the first expansion valve in a heating-corresponding circulation state, and a second channel switching circuit 60 provided between the economizer and a heat source side heat exchanger 14, the second channel switching circuit being brought into a state in which the refrigerant flows through a second expansion valve 64 in the heating-corresponding circulation state and brought into a state in which the refrigerant flows bypassing the second expansion valve in the cooling-corresponding circulation state.

FIG.1



EP 4 477 971 A1

(52) Cooperative Patent Classification (CPC): (Cont.)
F25B 2700/2106; F25B 2700/21161;
F25B 2700/21171

Description

BACKGROUND OF THE INVENTION

Field of the Invention

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

Description of the Related Art

[0002] Japanese Patent No. 7017096 discloses an air conditioner including expansion valves provided on both sides of an economizer connected in the middle of a refrigerant circuit and an injection circuit to enable injection of a refrigerant to a compressor in both heating operation and cooling operation. This air conditioner includes a configuration that opens an injection valve provided in the injection circuit and performs injection when it is determined that a liquid refrigerant is accumulated in an intermediate receiver disposed between the two expansion valves.

[0003] The present disclosure provides a refrigeration cycle apparatus that can increase the effect of injection in both heating operation and cooling operation by performing, for each expansion valve provided on both sides of an economizer, switching between a channel that passes through the expansion valve and a channel that does not pass through the expansion valve using a simple configuration that does not use an actuator.

SUMMARY OF THE INVENTION

[0004] A refrigeration cycle apparatus in the present disclosure includes: a main refrigerant circuit through which a refrigerant flows, the main refrigerant circuit including a compressor having an injection port communicating with a compression chamber, a use side heat exchanger, an economizer, and a heat source side heat exchanger connected in order through a refrigerant pipe; a four-way valve provided between the compressor and the use side heat exchanger and between the compressor and the heat source side heat exchanger, the four-way valve being configured to switch between a heating-corresponding circulation state in which the refrigerant is discharged from the compressor to the use side heat exchanger to circulate the refrigerant in a direction from the compressor to the use side heat exchanger in the main refrigerant circuit and a cooling-corresponding circulation state in which the refrigerant is discharged from the compressor to the heat source side heat exchanger to circulate the refrigerant in a direction from the compressor to the heat source side heat exchanger in the main refrigerant circuit; a first channel switching circuit provided on the main refrigerant circuit between the economizer and the use side heat exchanger, the first channel switching circuit including a first channel that allows the refrigerant to flow through the main refrigerant circuit through a first expansion valve, and a second channel that allows the refrigerant to flow through the main refrigerant circuit bypassing the first expansion valve, the first channel switching circuit being brought into a state in which flow of the refrigerant through the second channel is blocked and the refrigerant flows through the first channel in the cooling-corresponding circulation state and brought into a state in which flow of the refrigerant through the first channel is blocked and the refrigerant flows through the second channel in the heating-corresponding circulation state by means of a refrigerant pressure whose application direction is switched in accordance with a refrigerant flowing direction in the main refrigerant circuit; a second channel switching circuit provided on the main refrigerant circuit between the economizer and the heat source side heat exchanger, the second channel switching circuit including a third channel that allows the refrigerant to flow through the main refrigerant circuit through a second expansion valve, and a fourth channel that allows the refrigerant to flow through the main refrigerant circuit bypassing the second expansion valve, the second channel switching circuit being brought into a state in which flow of the refrigerant through the third channel is blocked and the refrigerant flows through the fourth channel in the cooling-corresponding circulation state and brought into a state in which flow of the refrigerant through the fourth channel is blocked and the refrigerant flows through the third channel in the heating-corresponding circulation state by means of the refrigerant pressure whose application direction is switched in accordance with the refrigerant flowing direction in the main refrigerant circuit; a bypass refrigerant circuit branching off from the refrigerant pipe between the first channel switching circuit and the second channel switching circuit, the bypass refrigerant circuit communicating with the injection port of the compressor through a third expansion valve; and a controller configured to control operation of the four-way valve to switch between the cooling-corresponding circulation state and the heating-corresponding circulation state.

Advantageous Effects of Invention

[0005] The refrigeration cycle apparatus of the present disclosure can increase the effect of injection in both heating operation and cooling operation by performing, for each of the expansion valves provided on both sides of the economizer, switching between the channel that passes through the expansion valve and the channel that does not pass through the expansion valve using a simple configuration that does not use an actuator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is a configuration diagram showing a state in heating operation of a refrigeration cycle apparatus in an embodiment;

FIG. 2 is a configuration diagram showing a state in cooling operation of a refrigeration cycle apparatus in the embodiment;

FIG. 3 is a control block diagram of the refrigeration cycle apparatus in the embodiment;

FIG. 4 is a pressure-enthalpy chart (P-h chart) in cooling operation of the refrigeration cycle apparatus in the embodiment;

FIG. 5 is a flowchart of a control process at start of heating operation and cooling operation of the refrigeration cycle apparatus in the embodiment; and

FIG. 6 is another configuration diagram of a channel switching circuit of the refrigeration cycle apparatus in the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Knowledge and the like Underlying Present Disclosure)

[0007] At the time when the inventors conceived of the present disclosure, there was a technique in which, in a refrigeration cycle apparatus, expansion valves are provided on both a refrigerant pipe between an economizer and a use side heat exchanger and a refrigerant pipe between the economizer and a heat source side heat exchanger to enable injection operation to be performed in both heating operation and cooling operation.

[0008] However, when the expansion valves are provided on both sides of the economizer, in both cooling operation and heating operation, a refrigerant is decompressed by the expansion valve and then divided into a main refrigerant circuit and a bypass refrigerant circuit for injection. Then, in the economizer, heat exchange is performed between the refrigerant flowing through the main refrigerant circuit and the refrigerant further decompressed by the expansion valve in the bypass circuit. Thus, compared to a case in which decompression by the expansion valve is not performed upstream of the economizer, the temperature difference between the refrigerant in the main refrigerant circuit and the refrigerant in the bypass circuit that exchange heat in the economizer decreases, which reduces the amount of heat exchange in the economizer and makes an energy saving effect obtained by performing injection operation insufficient, and the inventors have found this problem.

[0009] As means for solving the above problem, a configuration in which, for each of the expansion valves provided on both sides of the economizer, an actuator such as a three-way valve switches between a channel that allows the refrigerant to flow through the expansion valve and a channel that allows the refrigerant to flow bypassing the expansion valve may be provided, and control to bypass the expansion valve located on the upstream side of the economizer depending on cooling operation or heating operation may be performed. However, in this case, it is necessary to perform complicated control for bypassing the expansion valve by controlling the operation of the actuator, and the inventors have found this problem. Furthermore, for example, when a highly flammable refrigerant such as R290 is filled in, it is necessary to have a mold configuration to prevent a contact point of the actuator from being exposed in case of leakage of the refrigerant from the refrigerant circuit, which results in complicated component configuration of the actuator, and the inventors have found this problem.

[0010] The inventors have come to constitute the subject matter of the present disclosure to solve the above problems. Thus, the present disclosure provides a refrigeration cycle apparatus that can increase the effect of injection in both heating operation and cooling operation by performing, for each expansion valve provided on both sides of an economizer, switching between a channel that passes through the expansion valve and a channel that does not pass through the expansion valve using a simple configuration that does not use an actuator.

[0011] Hereinbelow, embodiments will be described in detail with reference to the drawings. Note that more details than necessary may be omitted. For example, detailed description of already well-known matters or repetitive description for substantially identical configurations may be omitted. This is to avoid making the following description unnecessarily redundant and facilitate the understanding of those skilled in the art.

[0012] Note that the accompanying drawings and the following description are provided to enable those skilled in the art to fully understand the present disclosure and are not intended to limit the subject matter described in the claims.

(Embodiment)

[0013] Hereinbelow, an embodiment will be described with reference to FIGS. 1 to 6.

[1. Configuration]

[0014] FIGS. 1 and 2 are configuration diagrams of a refrigeration cycle apparatus 1 according to the present embodiment. The refrigeration cycle apparatus 1 is a vapor compression refrigeration cycle apparatus and includes a main refrigerant circuit 10 and a bypass refrigerant circuit 20, and a controller 100. The refrigeration cycle apparatus 1 supports heating operation and cooling operation. A refrigerant flowing direction in heating operation is indicated by arrows in FIG. 1, and a refrigerant flowing direction in cooling operation is indicated by arrows in FIG. 2.

[0015] The main refrigerant circuit 10 includes a compressor 11 that compresses a refrigerant, a use side heat exchanger 12 that functions as a condenser (in heating operation) or an evaporator (in cooling operation), an economizer 13, and a heat source side heat exchanger 14 that functions as a condenser (in cooling operation) or an evaporator (in heating operation), the compressor 11, the use side heat exchanger 12, the economizer 13, and the heat source side heat exchanger 14 being connected in order through a refrigerant pipe 16. The main refrigerant circuit 10 is provided with a first channel switching circuit 50 between the use side heat exchanger 12 and the economizer 13 and provided with a second channel switching circuit 60 between the heat source side heat exchanger 14 and the economizer 13.

[0016] The main refrigerant circuit 10 is provided with a four-way valve 15 between the compressor 11 and the use side heat exchanger 12 and between the compressor 11 and the heat source side heat exchanger 14. The four-way valve 15 switches a direction in which the refrigerant discharged from the compressor 11 flows through the main refrigerant circuit 10. That is, the four-way valve 15 switches the direction in which the refrigerant discharged from the compressor 11 flows through the main refrigerant circuit 10 between a heating-corresponding circulation state indicated by arrows in FIG. 1 and a cooling-corresponding circulation state indicated by arrows in FIG. 2.

[0017] As shown in FIG. 1, in the heating-corresponding circulation state, in the main refrigerant circuit 10, the refrigerant flows through the compressor 11, the four-way valve 15, the use side heat exchanger 12, the first channel switching circuit 50, the economizer 13, the second channel switching circuit 60, the heat source side heat exchanger 14, the four-way valve 15, and the compressor 11 in this order. As shown in FIG. 2, in the cooling-corresponding circulation state, in the main refrigerant circuit 10, the refrigerant flows through the compressor 11, the four-way valve 15, the heat source side heat exchanger 14, the second channel switching circuit 60, the economizer 13, the first channel switching circuit 50, the use side heat exchanger 12, the four-way valve 15, and the compressor 11 in this order.

[0018] The first channel switching circuit 50 includes a first connection port 50a provided on the side corresponding to the use side heat exchanger 12, a second connection port 50b provided on the side corresponding to the economizer 13, and a first channel 51 and a second channel 55 connected in parallel between the first connection port 50a and the second connection port 50b. In the first channel 51, a first check valve 52 and a second check valve 53, and a first expansion valve 54 are connected in series when a direction through the first check valve 52 and the second check valve 53 from the second connection port 50b to the first connection port 50a is taken as the forward direction. In the second channel 55, a third check valve 56 and a fourth check valve 57 are connected in series when a direction from the first connection port 50a to the second connection port 50b is taken as the forward direction. Furthermore, a part of the first channel 51 between the first check valve 52 and the second check valve 53 and a part of the second channel 55 between the third check valve 56 and the fourth check valve 57 communicate with each other through a first communication passage 58.

[0019] Each of the first check valve 52, the second check valve 53, the third check valve 56, and the fourth check valve 57 includes a valve element that is brought into a closed state by the pressure of the refrigerant in the reverse direction (back pressure) to block the flow of the refrigerant. In the heating-corresponding circulation state, the first check valve 52 and the second check valve 53 are brought into a closed state, and the flow of the refrigerant through the first channel 51 through the first expansion valve 54 is thus blocked. In addition, the third check valve 56 and the fourth check valve 57 are maintained in an open state, and the second channel 55 allows the refrigerant to flow bypassing the first expansion valve 54. On the other hand, in the cooling-corresponding circulation state, the third check valve 56 and the fourth check valve 57 are brought into a closed state, and the flow of the refrigerant through the second channel 55 is thus blocked. In addition, the first check valve 52 and the second check valve 53 are maintained in an open state, and the first channel 51 allows the refrigerant to flow through the first expansion valve 54.

[0020] The second channel switching circuit 60 includes a third connection port 60a provided on the side corresponding to the heat source side heat exchanger 14, a fourth connection port 60b provided on the side corresponding to the economizer 13, and a third channel 61 and a fourth channel 65 connected in parallel between the third connection port 60a and the fourth connection port 60b. In the third channel 61, a fifth check valve 62 and a sixth check valve 63, and a second expansion valve 64 are connected in series when a direction through the fifth check valve 62 and the sixth check valve 63 from the fourth connection port 60b to the third connection port 60a is taken as the forward direction. In the fourth channel 65, a seventh check valve 66 and an eighth check valve 67 are connected in series when a direction from the third connection port 60a to the fourth connection port 60b is taken as the forward direction. Furthermore, a part of the third channel 61 between the fifth check valve 62 and the sixth check valve 63 and a part of the fourth channel 65 between the seventh check valve 66 and the eighth check valve 67 communicate with each other through a second communication passage 68.

[0021] Each of the fifth check valve 62, the sixth check valve 63, the seventh check valve 66, and the eighth check valve 67 includes a valve element that is brought into a closed state by the pressure of the refrigerant in the reverse direction (back pressure) to block the flow of the refrigerant. In the heating-corresponding circulation state, the seventh check valve 66 and the eighth check valve 67 are brought into a closed state, and the flow of the refrigerant through the fourth channel 65 is thus blocked. In addition, the fifth check valve 62 and the sixth check valve 63 are maintained in an open state, and the third channel 61 allows the refrigerant to flow through the second expansion valve 64. On the other hand, in the cooling-corresponding circulation state, the fifth check valve 62 and the sixth check valve 63 are brought into a closed state, and the flow of the refrigerant through the third channel 61 through the second expansion valve 64 is thus blocked. In addition, the seventh check valve 66 and the eighth check valve 67 are maintained in an open state, and the fourth channel 65 allows the refrigerant to flow bypassing the second expansion valve 64.

[0022] The bypass refrigerant circuit 20 branches off from the refrigerant pipe 16 between the economizer 13 and the first channel switching circuit 50 and communicates with an injection port 11a provided in a compression chamber of the compressor 11. The third expansion valve 21 and the economizer 13 are connected, in this order from the upstream side, to the bypass refrigerant circuit 20. The third expansion valve 21 is an adjustable opening valve whose opening degree is changeable.

[0023] In heating operation, part of the high-pressure refrigerant passing through the use side heat exchanger 12 flows into the bypass refrigerant circuit 20. In cooling operation, part of the high-pressure refrigerant passing through the heat source side heat exchanger 14 flows into the bypass refrigerant circuit 20. Then, the refrigerant flowing into the bypass refrigerant circuit 20 is decompressed by the third expansion valve 21 to turn into a medium-pressure refrigerant, and the medium-pressure refrigerant exchanges heat with the high-pressure refrigerant flowing through the main refrigerant circuit 10 in the economizer 13 and is then injected into the compressor 11. The refrigerant injected into the compressor 11 merges with the refrigerant in the process of being compressed in the compression chamber of the compressor 11. The compressor 11 merges the injected refrigerant with the refrigerant in the process of being compressed and performs recompression.

[0024] A heating medium circuit 30 includes the use side heat exchanger 12, a feed pump 31, and an air conditioning terminal 33 that are connected through a heating medium pipe 32. Water or an antifreeze solution can be used as a heating medium flowing through the heating medium circuit 30. In the use side heat exchanger 12, heat exchange is performed between the refrigerant flowing through the main refrigerant circuit 10 and the heating medium flowing through the heating medium circuit 30. In heating operation, the heating medium flowing through the heating medium circuit 30 is heated by the use side heat exchanger 12, and the air conditioning terminal 33 functions as a heating terminal. In cooling operation, the heating medium flowing through the heating medium circuit 30 is cooled by the use side heat exchanger 12, and the air conditioning terminal 33 functions as a cooling terminal.

[0025] The refrigerant pipe 16 is provided with, on the discharge side of the compressor 11, a discharge pressure sensor 41 that detects the pressure of the refrigerant discharged from the compressor 11. The refrigerant pipe 16 is provided with, on the intake side of the compressor 11, an intake pressure sensor 42 that detects the pressure of the refrigerant drawn into the compressor 11. The heating medium pipe 32 is provided with, on the inlet side of the use side heat exchanger 12, a pre-heating temperature sensor 43 that detects the temperature of the heating medium near an inlet of the use side heat exchanger 12. An outside air temperature sensor 44 that detects the outside air temperature is provided near the heat source side heat exchanger 14.

[0026] The refrigeration cycle apparatus 1 includes the controller 100 that controls the operations of the compressor 11, the four-way valve 15, the third expansion valve 21, the feed pump 31, and the like to execute cooling operation and heating operation, and a remote control 110 for performing operations such as start and stop of heating operation and cooling operation, and settings of operating conditions. FIG. 3 is a control block diagram of the refrigeration cycle apparatus 1. Referring to FIG. 3, the controller 100 is connected to the discharge pressure sensor 41, the intake pressure sensor 42, the pre-heating temperature sensor 43, and the outside air temperature sensor 44, and detection signals of these sensors are input to the controller 100.

[0027] The controller 100 is also connected to the compressor 11, the four-way valve 15, the third expansion valve 21, and the feed pump 31, and the operations of these actuators are controlled by control signals output from the controller 100. Furthermore, the controller 100 is connected to the remote control 110. The remote control 110 includes a switch and a display unit, an operation signal of the switch is input to the controller 100, and the operating state of the refrigeration cycle apparatus 1 is displayed on the display unit of the remote control 110 in accordance with a display signal output from the controller 100.

[0028] The controller 100 includes a processor 101 and a memory 102, and a program 103 for controlling the refrigeration cycle apparatus 1 and control data 104 for determining control conditions for the compressor 11 and the third expansion valve 21 in heating operation and cooling operation are stored in the memory 102. The processor 101 reads and executes the program 103, thereby controlling the operation of the refrigeration cycle apparatus 1.

[0029] The operation of the refrigeration cycle apparatus 1 in the case of performing cooling operation will be described with reference to FIGS. 2 and 4. FIG. 4 is a pressure-enthalpy chart (P-h chart) in the case of performing injection of the refrigerant into the compressor 11. Points (a) to (h) in FIG. 4 correspond to positions (a) to (h) in FIG. 2, respectively.

[0030] First, the high-pressure refrigerant (a) discharged from the compressor 11 dissipates heat in the heat source side heat exchanger 14 and then flows through the main refrigerant circuit 10 through the fourth channel 65 of the second channel switching circuit 60 and the economizer 13, and part of the high-pressure refrigerant branches off toward the bypass refrigerant circuit 20 at (c). The high-pressure refrigerant flowing into the bypass refrigerant circuit 20 is decompressed by the third expansion valve 21 to a medium pressure, turning into the medium-pressure refrigerant (g), and the medium-pressure refrigerant exchanges heat with the high-pressure refrigerant flowing through the main refrigerant circuit 10 in the economizer 13.

[0031] In this manner, in the main refrigerant circuit 10, the high-pressure refrigerant that dissipates heat in the heat source side heat exchanger 14, and is cooled by the economizer 13 and thus has reduced enthalpy flows through the first channel 51 of the first channel switching circuit 50 and is brought into a state (b) decompressed by the first expansion valve 54. The degree of dryness of the refrigerant (b) decompressed by the first expansion valve 54 (the weight ratio of the vapor phase component to the entire refrigerant) decreases and the liquid component of the refrigerant increases in the use side heat exchanger 12, and the refrigerant evaporates in the use side heat exchanger 12 and returns to the intake side (f) of the compressor 11. On the other hand, the medium-pressure refrigerant (g) decompressed to the medium pressure by the third expansion valve 21 of the bypass refrigerant circuit 20 is heated in the economizer 13 by the high-pressure refrigerant flowing through the main refrigerant circuit 10 and thus has increased enthalpy, and, in this state, merges with the refrigerant in the process of being decompressed in the compressor 11 at (h) through the injection port 11a of the compressor 11.

[0032] As shown in FIG. 1, in heating operation, the refrigerant flowing direction in the main refrigerant circuit 10 is opposite to the direction in cooling operation, the refrigerant flows through the second channel 55 without being decompressed in the first channel switching circuit 50, and the refrigerant decompressed by the second expansion valve 64 flows through the third channel 61 in the second channel switching circuit 60.

[0033] As shown in FIG. 2, in cooling operation, the channel of the second channel switching circuit 60 is switched to the fourth channel 65. Thus, the high-pressure refrigerant flowing through the main refrigerant circuit 10 is prevented from being decompressed by the second expansion valve 64 of the third channel 61. Thus, it is possible to prevent a reduction in the amount of heat exchange in the economizer 13 caused by a decrease in the temperature difference between the refrigerant on the main refrigerant circuit 10 side and the refrigerant on the bypass refrigerant circuit 20 side in the economizer 13 caused by a decrease in the temperature of the high-pressure refrigerant due to the decompression. Similarly, also in heating operation, it is possible to prevent the high-pressure refrigerant from being decompressed by the first expansion valve 54 on the upstream side of the economizer 13 and prevent a reduction in the amount of heat exchange in the economizer 13.

[2. Control Process]

[0034] Following the flowchart shown in FIG. 5, a control process executed by the controller 100 when an operation for starting heating operation or cooling operation is performed using the remote control 110 is described.

[0035] Through a loop process of step S1 and step S10 of FIG. 5, the controller 100 determines whether or not an operation for starting the heating operation is performed using the remote control 110 in step S1 and determines whether or not an operation for starting the cooling operation is performed using the remote control 110 in step S10. The controller 100 advances the process from step S1 to step S2 when recognizing the operation for starting heating operation using the remote control 110 and advances the process from step S10 to step S11 when recognizing the operation for starting cooling operation using the remote control 110.

[0036] Steps S2 and S3 are processes corresponding to heating operation. In step S2, the controller 100 controls the four-way valve 15 to the heating-corresponding circulation state in which the refrigerant discharged from the compressor 11 flows in the direction from the compressor 11 to the use side heat exchanger 12 as shown in FIG. 1. Accordingly, as shown in FIG. 1, the use side heat exchanger 12 functions as a condenser, and the heat source side heat exchanger 14 functions as an evaporator.

[0037] In the following step S3, the controller 100 starts the compressor 11 to start heating operation. The controller 100 controls the operating frequency of the compressor 11, the opening degree of the third expansion valve 21, and the operating frequency of the feed pump 31 in accordance with detection signals of the discharge pressure sensor 41, the intake pressure sensor 42, the pre-heating temperature sensor 43, and the outside air temperature sensor 44, and a heating temperature set by the remote control 110, based on a heating operation control map stored in the control data 104.

[0038] Steps S11 and S12 are processes corresponding to cooling operation. In step S11, the controller 100 controls the four-way valve 15 to the cooling-corresponding circulation state in which the refrigerant discharged from the compressor 11 flows in the direction from the compressor 11 to the heat source side heat exchanger 14 as shown in FIG. 2. Accordingly, as shown in FIG. 2, the heat source side heat exchanger 14 functions as a condenser, and the use side heat exchanger 12 functions as an evaporator.

[0039] In the following step S12, the controller 100 starts the compressor 11 to start cooling operation. The controller 100 controls the operating frequency of the compressor 11, the opening degree of the third expansion valve 21, and the operating frequency of the feed pump 31 in accordance with detection signals of the discharge pressure sensor 41, the intake pressure sensor 42, the pre-heating temperature sensor 43, and the outside air temperature sensor 44, and a cooling temperature set by the remote control 110, based on a cooling operation control map stored in the control data 104.

[0040] Through the process of the flowchart shown in FIG. 4, simple control in which the four-way valve 15 switches between the heating-corresponding circulation state and the cooling-corresponding circulation state switches the channel for the refrigerant in the first channel switching circuit 50 and the second channel switching circuit 60 by means of the refrigerant pressure whose application direction is switched in accordance with the refrigerant flowing direction in the main refrigerant circuit 10. Thus, without providing an actuator such as a three-way valve for bypassing the first expansion valve 54 (in heating operation) or the second expansion valve 64 (in cooling operation) located on the upstream side of the economizer 13, it is possible to prevent a reduction in the amount of heat exchange in the economizer 13 caused by the refrigerant being decompressed on the upstream side of the economizer 13.

[0041] In the configuration that bypasses the expansion valve using an actuator such as a three-way valve, when a highly flammable refrigerant such as R290 is used as the refrigerant filled in the main refrigerant circuit 10 and the bypass refrigerant circuit 20, it is necessary to have a mold configuration to prevent a contact point of the actuator from being exposed in case of leakage of the refrigerant from the main refrigerant circuit 10 or the bypass refrigerant circuit 20. However, such a measure is not required.

[3. Effects and the like]

[0042] As described above, in the present embodiment, the refrigeration cycle apparatus 1 includes the four-way valve 15 that switches the refrigerant flowing direction in the main refrigerant circuit 10 between the heating-corresponding circulation state and the cooling-corresponding circulation state, the first channel switching circuit 50 that allows the refrigerant to flow bypassing the first expansion valve 54 located on the upstream side of the economizer 13 in the heating-corresponding circulation state and allows the refrigerant to flow through the first expansion valve 54 located on the downstream side of the economizer 13 in the cooling-corresponding circulation state in accordance with the direction of the refrigerant flowing pressure, the second channel switching circuit 60 that allows the refrigerant to flow bypassing the second expansion valve 64 located on the upstream side of the economizer 13 in the cooling-corresponding circulation state and allows the refrigerant to flow through the second expansion valve 64 located on the downstream side of the economizer 13 in the heating-corresponding circulation state in accordance with the direction of the refrigerant flowing pressure, the bypass refrigerant circuit 20, and the controller 100. The controller 100 controls the operation of the four-way valve 15 to switch between the heating-corresponding circulation state and the cooling-corresponding circulation state.

[0043] In the refrigeration cycle apparatus 1, for the first expansion valve 54 and the second expansion valve 64 provided on both sides of the economizer 13, switching between the channel that passes through the first expansion valve 54 and the channel that bypasses the first expansion valve 54 and switching between the channel that passes through the second expansion valve 64 and the channel that bypasses the second expansion valve 64 are achieved by the simple configuration that does not use an actuator, thereby increasing the effect of injection in both heating operation and cooling operation.

(Other Embodiments)

[0044] As above, the embodiment has been described as an example of the technique disclosed in the present application. However, the technique in the present disclosure is not limited thereto and also applicable to embodiments with changes, replacements, additions, omissions, and the like.

[0045] Although, in the above embodiment, each of the first channel switching circuit 50 and the second channel switching circuit 60 is formed from the bridge circuit using the four check valves as shown in FIGS. 1 and 2, another configuration may switch the channel in accordance with the direction of the refrigerant flowing pressure. For example, as shown in FIG. 6, a channel switching circuit 200 including two check valves 211 and 221 connected in parallel with their forward directions opposite to each other may be used.

[0046] In the channel switching circuit 200, a channel 210 and a channel 220 are connected in parallel between a first connection port 200a and a second connection port 200b, the channel 210 including the check valve 211 and an expansion valve 212 that are connected in series when a direction from the first connection port 200a to the second connection port 200b is taken as the forward direction of the check valve 211, the channel 220 including the check valve 221 connected in the forward direction, which is a direction from the second connection port 200b to the first connection port 200a.

[0047] In the channel switching circuit 200, as shown in S1, when the refrigerant flows in the direction from the first connection port 200a to the second connection port 200b, the flow of the refrigerant toward the channel 220 is blocked by the check valve 221, and the channel 210 allows the refrigerant to flow through the expansion valve 212. As shown in S2, when the refrigerant flows in the direction from the second connection port 200b to the first connection port 200a, the flow of the refrigerant toward the channel 210 is blocked by the check valve 211, and the channel 220 allows the refrigerant to flow bypassing the expansion valve 212. The first channel switching circuit or the second channel switching circuit of the present disclosure may be formed by using a valve of type other than the check valve, such as a pressure responsive valve.

[0048] Although, in the above embodiment, the first expansion valve 54 and the second expansion valve 64 are always in an open state, an on-off valve switchable between open and closed states may be used as the first expansion valve 54 and the second expansion valve 64. In this case, as shown in FIGS. 1 and 2, the controller 100 controls opening and closing of the first expansion valve 54 and the second expansion valve 64. In the heating operation shown in FIG. 1, by controlling the first expansion valve 54 to a closed state (fully-closed state), even if the blockage of the flow of the refrigerant performed by the first check valve 52 and the second check valve 53 may become insufficient due to low refrigerant flowing pressure, it is possible to reliably prevent the refrigerant from flowing to the first expansion valve 54 and being decompressed. In the cooling operation shown in FIG. 2, by controlling the second expansion valve 64 to a closed state (fully-closed state), even if the blockage of the flow of the refrigerant performed by the fifth check valve 62 and the sixth check valve 63 may become insufficient due to low refrigerant flowing pressure, it is possible to reliably prevent the refrigerant from flowing to the second expansion valve 64 and being decompressed.

[0049] It is only required that the controller in the present disclosure be one that can control the apparatus in the present disclosure. In describing the subject matter of the invention, one that controls the apparatus of the present disclosure may be described as control means or a control unit, or described with similar wording, in addition to the controller. The controller can be implemented in various modes. For example, a processor may be used as the controller. Using the processor as the controller makes it possible to execute various processes by the processor reading a program from a storage medium in which the program is stored and executing the program. Thus, processing details can be changed by changing the program stored in the storage medium, and flexibility of changing control details can thus be increased. Examples of the processor include a central processing unit (CPU) and a micro-processing unit (MPU). Examples of the storage medium include a hard disk, a flash memory, and an optical disk. Wired logic that cannot be reprogrammed may be used as the controller. Using the wired logic as the controller is effective in improving the processing speed. An application specific integrated circuit (ASIC) is an example of the wired logic. The controller may be implemented by a combination of the processor and the wired logic. Implementing the controller by the combination of the processor and the wired logic makes it possible to improve the processing speed while increasing the flexibility of software design. The controller and a circuit having a function different from the function of the controller may be constituted of a single semiconductor device. An A/D or D/A conversion circuit is an example of the circuit having different function. The controller may be constituted of a single semiconductor device or may include multiple semiconductor devices. When the controller includes multiple semiconductor devices, the control operations described in the claims may be achieved by semiconductor devices different from each other. Furthermore, the controller may have a configuration including a semiconductor device, and a passive component such as a resistor or a capacitor.

[0050] Since the embodiments described above are intended to exemplify the technique in the present disclosure, various changes, replacements, additions, omissions, and the like can be made within the scope of the claims or a scope equivalent thereto.

Industrial Applicability

[0051] The present disclosure is applicable to a use, in a refrigeration cycle apparatus that performs injection of a refrigerant to a compressor, for increasing the effect of the injection in both heating operation and cooling operation by performing, for each of the expansion valves provided on both sides of an economizer, switching between a channel that passes through the expansion valve and a channel that does not pass through the expansion valve using a simple configuration that does not use an actuator.

Reference Signs List

[0052]

1	refrigeration cycle apparatus
10	main refrigerant circuit
11	compressor
12	use side heat exchanger
13	economizer
14	heat source side heat exchanger
15	four-way valve
16	refrigerant pipe
20	bypass refrigerant circuit
21	third expansion valve
30	heating medium circuit
31	feed pump
32	heating medium pipe
33	air conditioning terminal
41	discharge pressure sensor
42	intake pressure sensor
43	pre-heating temperature sensor
44	outside air temperature sensor
50	first channel switching circuit
51	first channel
52	first check valve
53	second check valve
54	first expansion valve
55	second channel
56	third check valve
57	fourth check valve
58	first communication passage
60	second channel switching circuit
61	third channel
62	fifth check valve
63	sixth check valve
64	second expansion valve
65	fourth channel

66 seventh check valve
67 eighth check valve
68 second communication passage
100 controller
101 processor
102 memory
103 program
104 control data
110 remote control

Claims

1. A refrigeration cycle apparatus **characterized by** comprising:

a main refrigerant circuit (50) through which a refrigerant flows, the main refrigerant circuit including a compressor (11) having an injection port (11a) communicating with a compression chamber, a use side heat exchanger (12), an economizer (13), and a heat source side heat exchanger (14) connected in order through a refrigerant pipe (16);
a four-way valve (15) provided between the compressor and the use side heat exchanger and between the compressor and the heat source side heat exchanger, the four-way valve being configured to switch between a heating-corresponding circulation state in which the refrigerant is discharged from the compressor to the use side heat exchanger to circulate the refrigerant in a direction from the compressor to the use side heat exchanger in the main refrigerant circuit and a cooling-corresponding circulation state in which the refrigerant is discharged from the compressor to the heat source side heat exchanger to circulate the refrigerant in a direction from the compressor to the heat source side heat exchanger in the main refrigerant circuit;
a first channel switching circuit (50) provided on the main refrigerant circuit between the economizer and the use side heat exchanger, the first channel switching circuit including a first channel (51) that allows the refrigerant to flow through the main refrigerant circuit through a first expansion valve (54), and a second channel (55) that allows the refrigerant to flow through the main refrigerant circuit bypassing the first expansion valve, the first channel switching circuit being brought into a state in which flow of the refrigerant through the second channel is blocked and the refrigerant flows through the first channel in the cooling-corresponding circulation state and brought into a state in which flow of the refrigerant through the first channel is blocked and the refrigerant flows through the second channel in the heating-corresponding circulation state by means of a refrigerant pressure whose application direction is switched in accordance with a refrigerant flowing direction in the main refrigerant circuit;
a second channel switching circuit (60) provided on the main refrigerant circuit between the economizer and the heat source side heat exchanger, the second channel switching circuit including a third channel (61) that allows the refrigerant to flow through the main refrigerant circuit through a second expansion valve (64), and a fourth channel (65) that allows the refrigerant to flow through the main refrigerant circuit bypassing the second expansion valve, the second channel switching circuit being brought into a state in which flow of the refrigerant through the third channel is blocked and the refrigerant flows through the fourth channel in the cooling-corresponding circulation state and brought into a state in which flow of the refrigerant through the fourth channel is blocked and the refrigerant flows through the third channel in the heating-corresponding circulation state by means of the refrigerant pressure whose application direction is switched in accordance with the refrigerant flowing direction in the main refrigerant circuit;
a bypass refrigerant circuit (20) branching off from the refrigerant pipe between the first channel switching circuit and the second channel switching circuit, the bypass refrigerant circuit communicating with the injection port of the compressor through a third expansion valve (21); and
a controller (100) configured to control operation of the four-way valve to switch between the cooling-corresponding circulation state and the heating-corresponding circulation state.

2. The refrigeration cycle apparatus according to claim 1, wherein each of the first channel switching circuit and the second channel switching circuit includes a check valve (52) configured to block flow of the refrigerant in a reverse direction using a valve element to be closed by back pressure.

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

the first channel switching circuit is connected to the refrigerant pipe through a first connection port (50a) provided on a side corresponding to the use side heat exchanger and a second connection port (50b) provided on a side corresponding to the economizer, the first channel and the second channel allow the first connection port and the second connection port to communicate with each other, the first channel includes a first check valve (52) and a second check valve (53) that are connected in series with the first expansion valve when a direction from the second connection port to the first connection port is taken as the forward direction, the second channel includes a third check (56) valve and a fourth check valve (57) that are connected in series when a direction from the first connection port to the second connection port is taken as the forward direction, and a part of the first channel between the first check valve and the second check valve communicates with a part of the second channel between the third check valve and the fourth check valve, and

the second channel switching circuit is connected to the refrigerant pipe through a third connection port (60a) provided on a side corresponding to the heat source side heat exchanger and a fourth connection port (60b) provided on a side corresponding to the economizer, the third channel and the fourth channel allow the third connection port and the fourth connection port to communicate with each other, the third channel includes a fifth check valve (62) and a sixth check valve (63) that are connected in series with the second expansion valve when a direction from the fourth connection port to the third connection port is taken as the forward direction, the fourth channel includes a seventh check valve (66) and an eighth check valve (67) that are connected in series when a direction from the third connection port to the fourth connection port is taken as the forward direction, and a part of the third channel between the fifth check valve and the sixth check valve communicates with a part of the fourth channel between the seventh check valve and the eighth check valve.

4. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein the refrigerant is a highly flammable refrigerant.

5. The refrigeration cycle apparatus according to any one of claims 1 to 3, wherein

each of the first expansion valve and the second expansion valve is an on-off valve switchable between an open state and a closed state, and the controller switches the second expansion valve to a closed state when the four-way valve creates the cooling-corresponding circulation state and switches the first expansion valve to a closed state when the four-way valve creates the heating-corresponding circulation state.

FIG.1

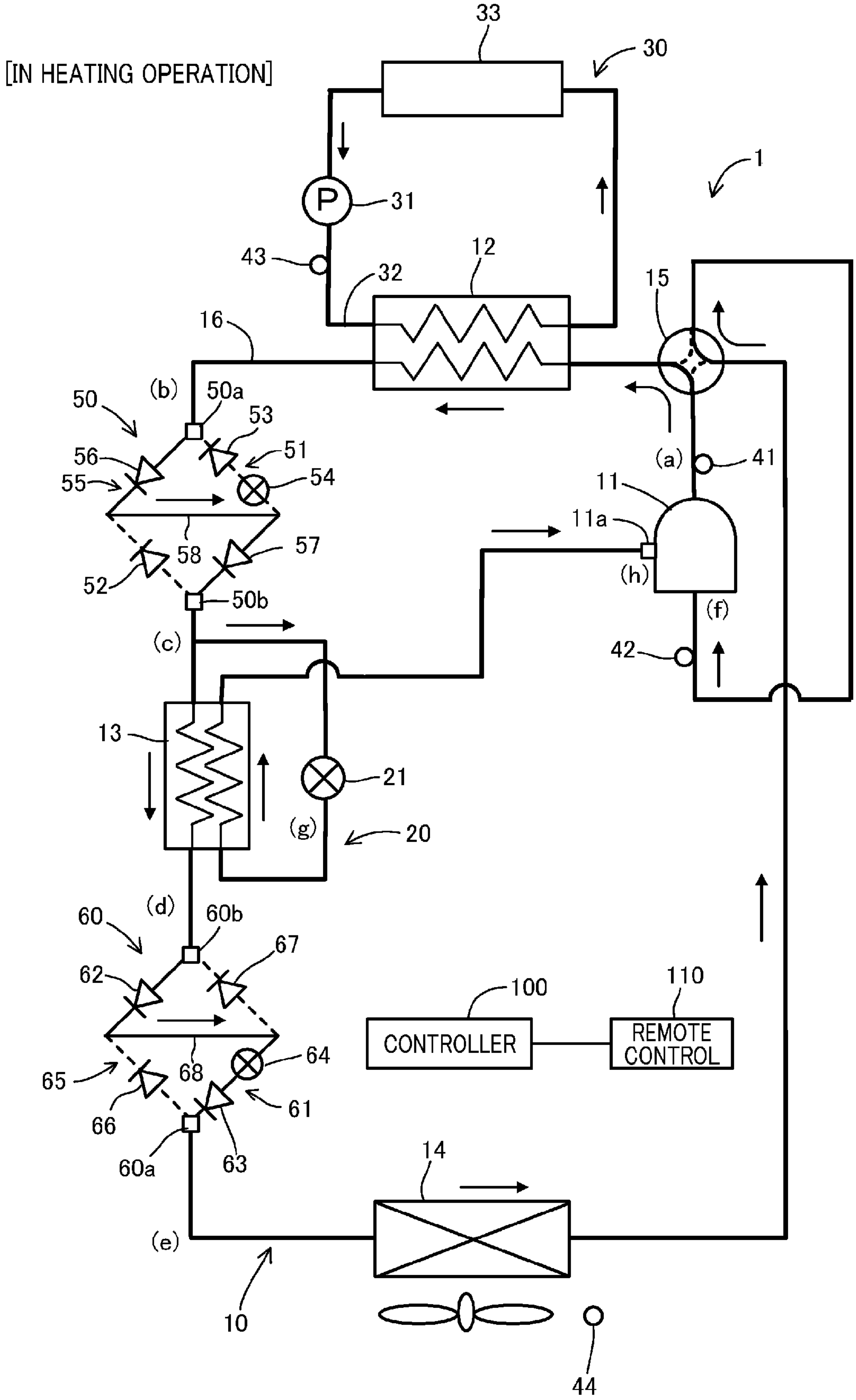

[IN HEATING OPERATION]
33
30
1
P
31
43
32
12
15
16
(b)
50a
50
53
51
56
55
54
(a)
41
11
11a
58
57
52
(h)
50b
(f)
(c)
42
13
21
(g)
20
(d)
60b
60
67
62
100
110
CONTROLLER
REMOTE CONTROL
68
64
65
66
61
60a
63
14
(e)
10
44

FIG.2

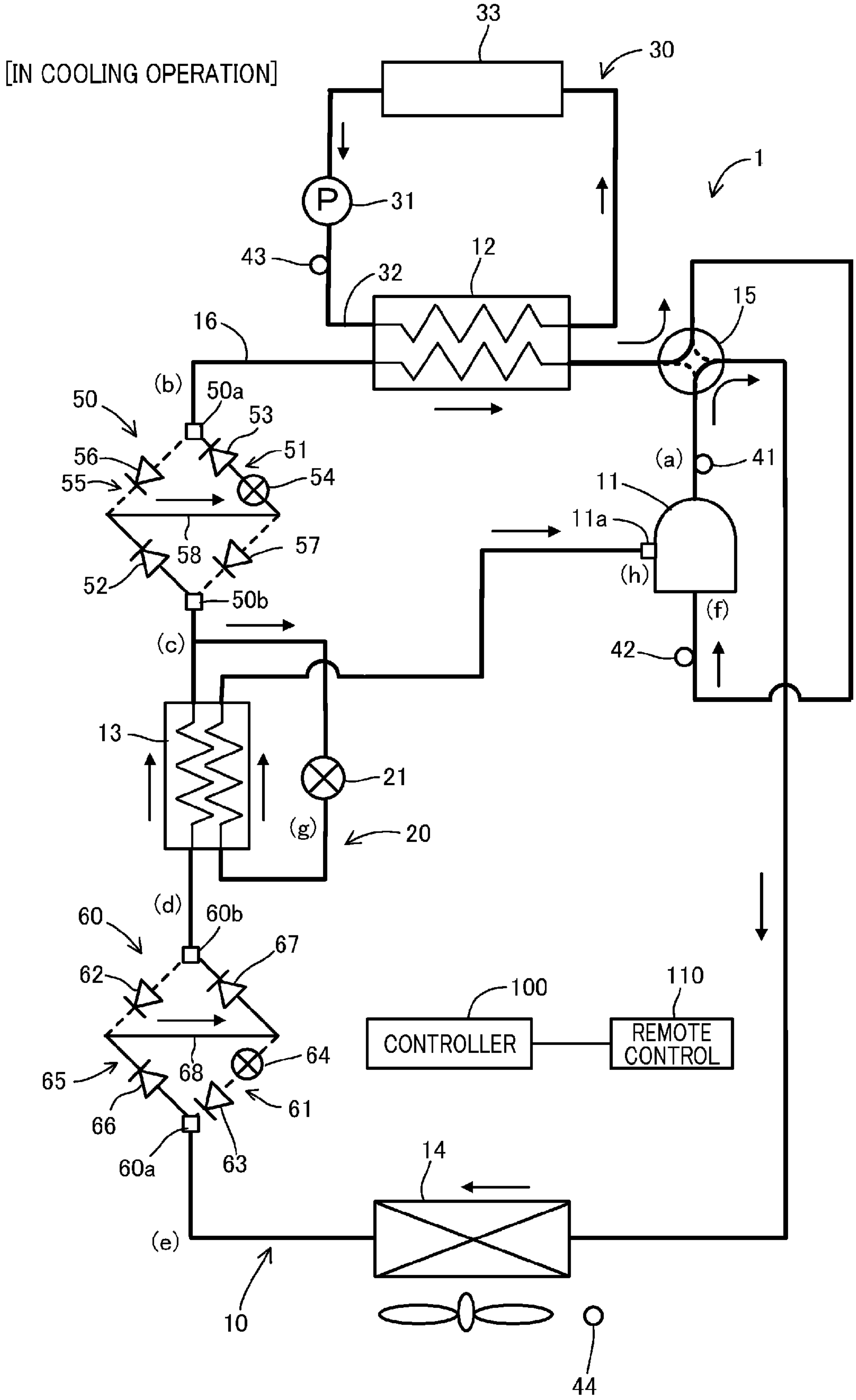

[IN COOLING OPERATION]
33
30
1
P
31
43
32
12
15
16
(b)
50a
50
53
56
51
55
54
(a)
41
11
11a
58
57
52
(h)
50b
(f)
(c)
42
13
21
(g)
20
(d)
60b
60
67
62
100
110
CONTROLLER
REMOTE CONTROL
64
68
65
61
66
60a
63
14
(e)
10
44

FIG.3

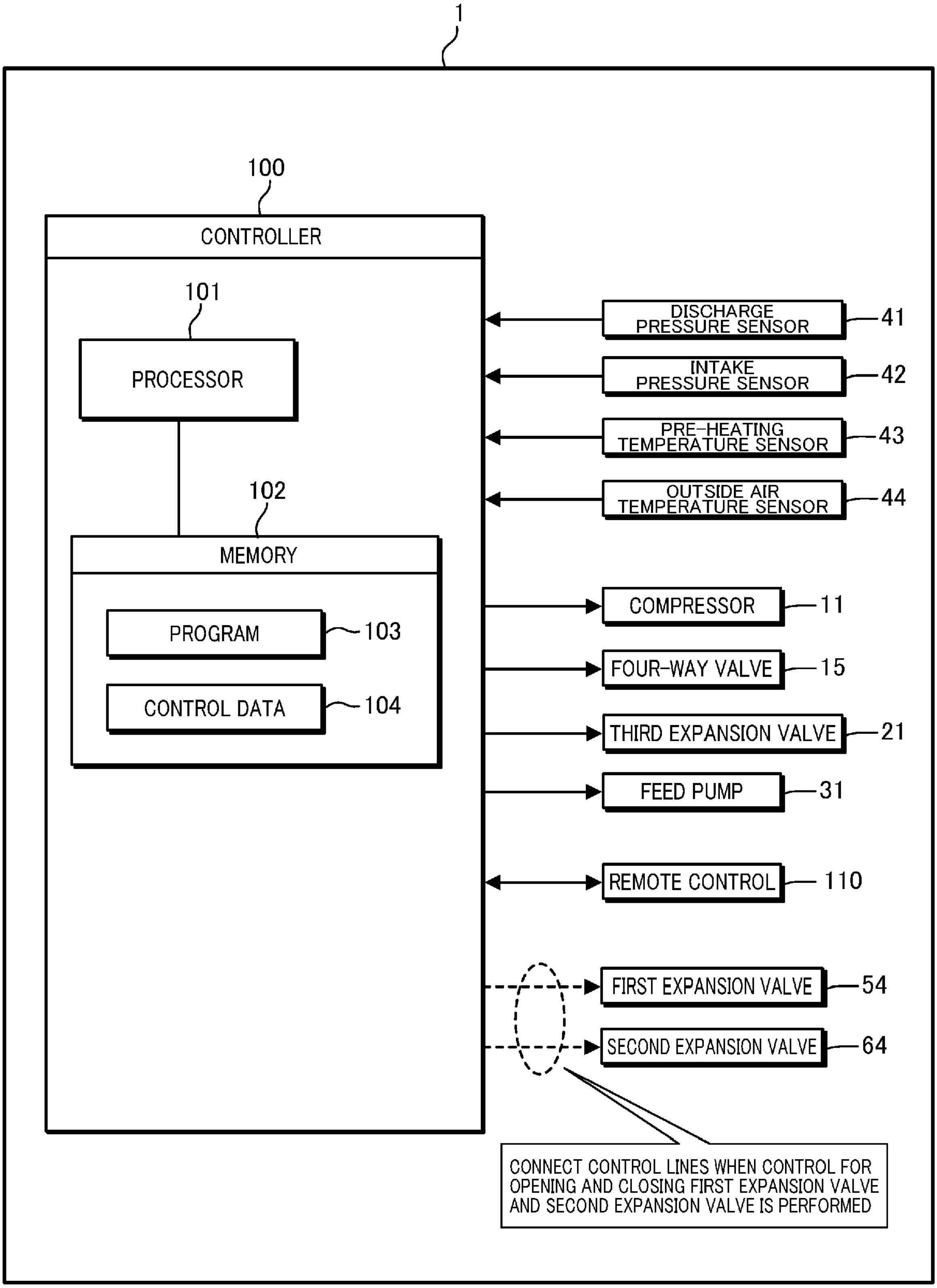

1
100
CONTROLLER
101
PROCESSOR
102
MEMORY
PROGRAM
103
CONTROL DATA
104
DISCHARGE PRESSURE SENSOR
41
INTAKE PRESSURE SENSOR
42
PRE-HEATING TEMPERATURE SENSOR
43
OUTSIDE AIR TEMPERATURE SENSOR
44
COMPRESSOR
11
FOUR-WAY VALVE
15
THIRD EXPANSION VALVE
21
FEED PUMP
31
REMOTE CONTROL
110
FIRST EXPANSION VALVE
54
SECOND EXPANSION VALVE
64
CONNECT CONTROL LINES WHEN CONTROL FOR OPENING AND CLOSING FIRST EXPANSION VALVE AND SECOND EXPANSION VALVE IS PERFORMED

FIG.4

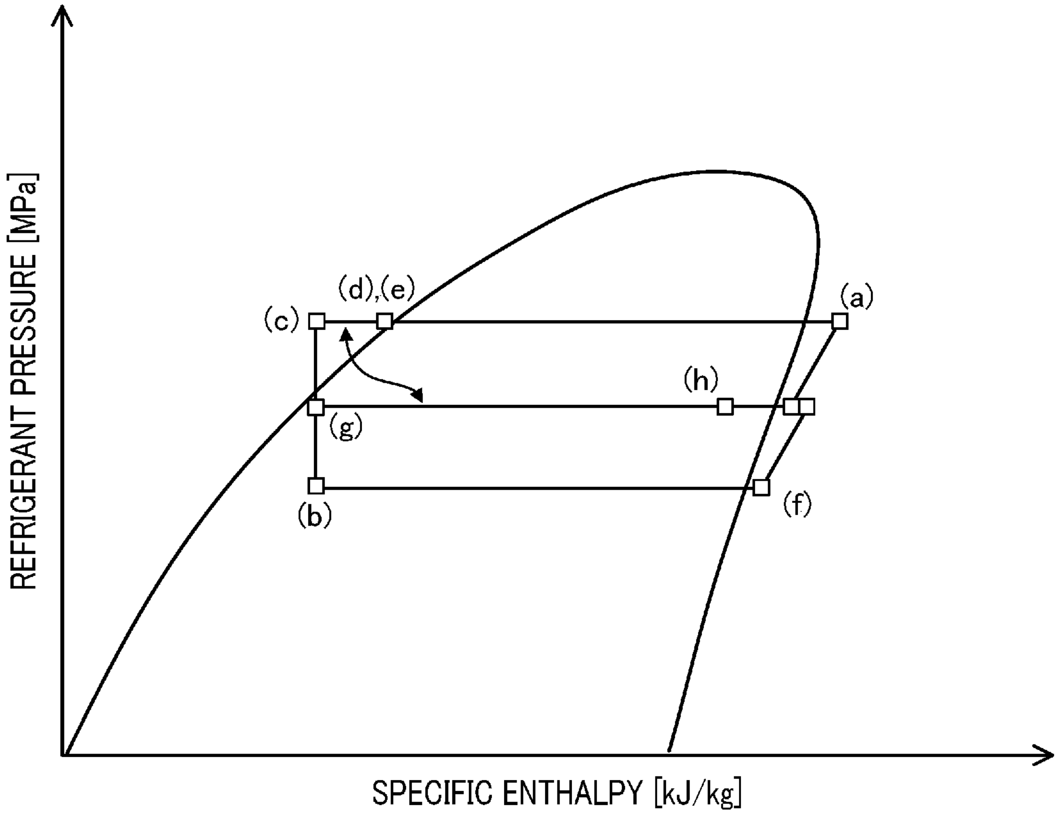

REFRIGERANT PRESSURE [MPa]
(d),(e)
(c)
(a)
(h)
(g)
(b)
(f)
SPECIFIC ENTHALPY [kJ/kg]

FIG.5

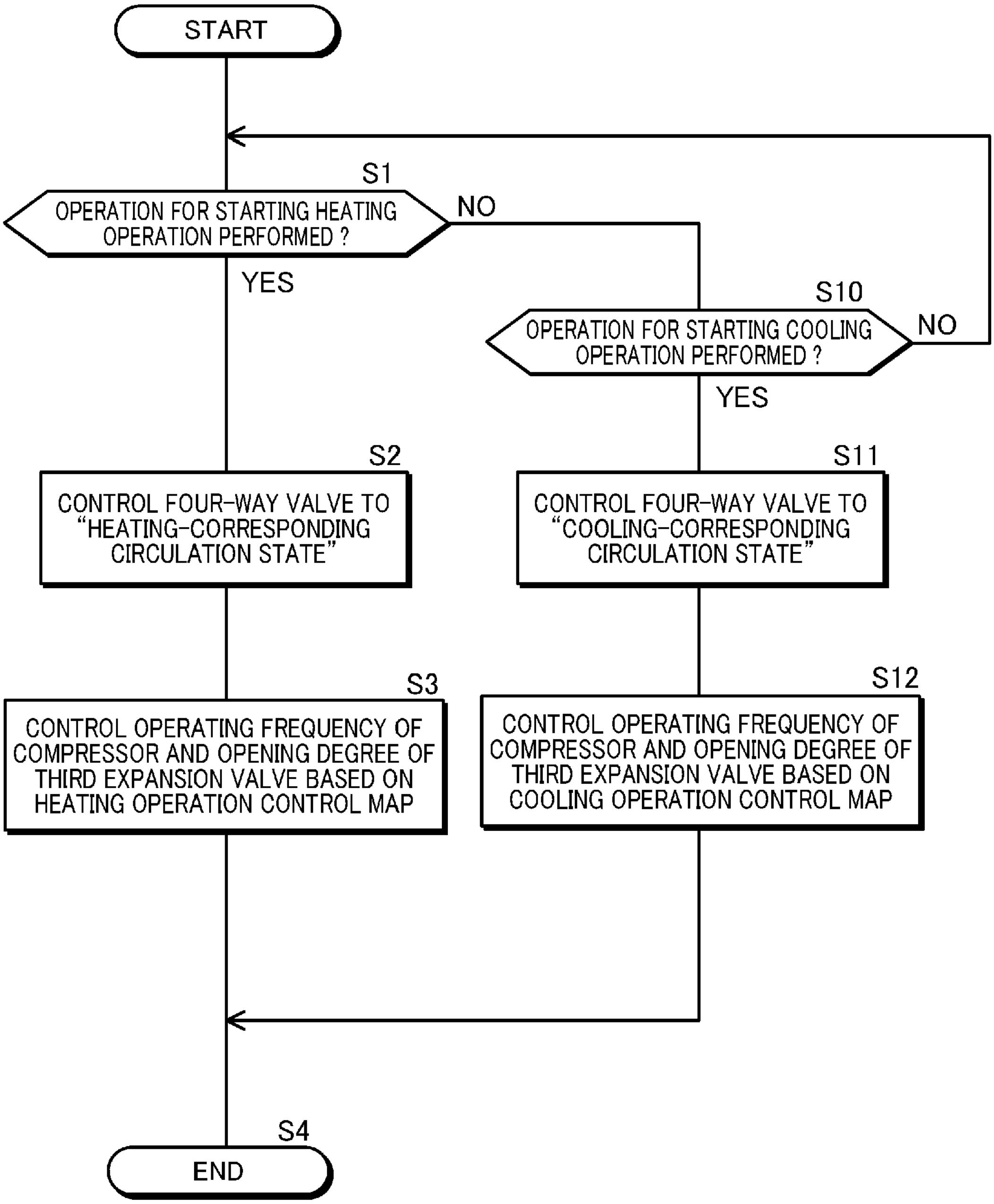
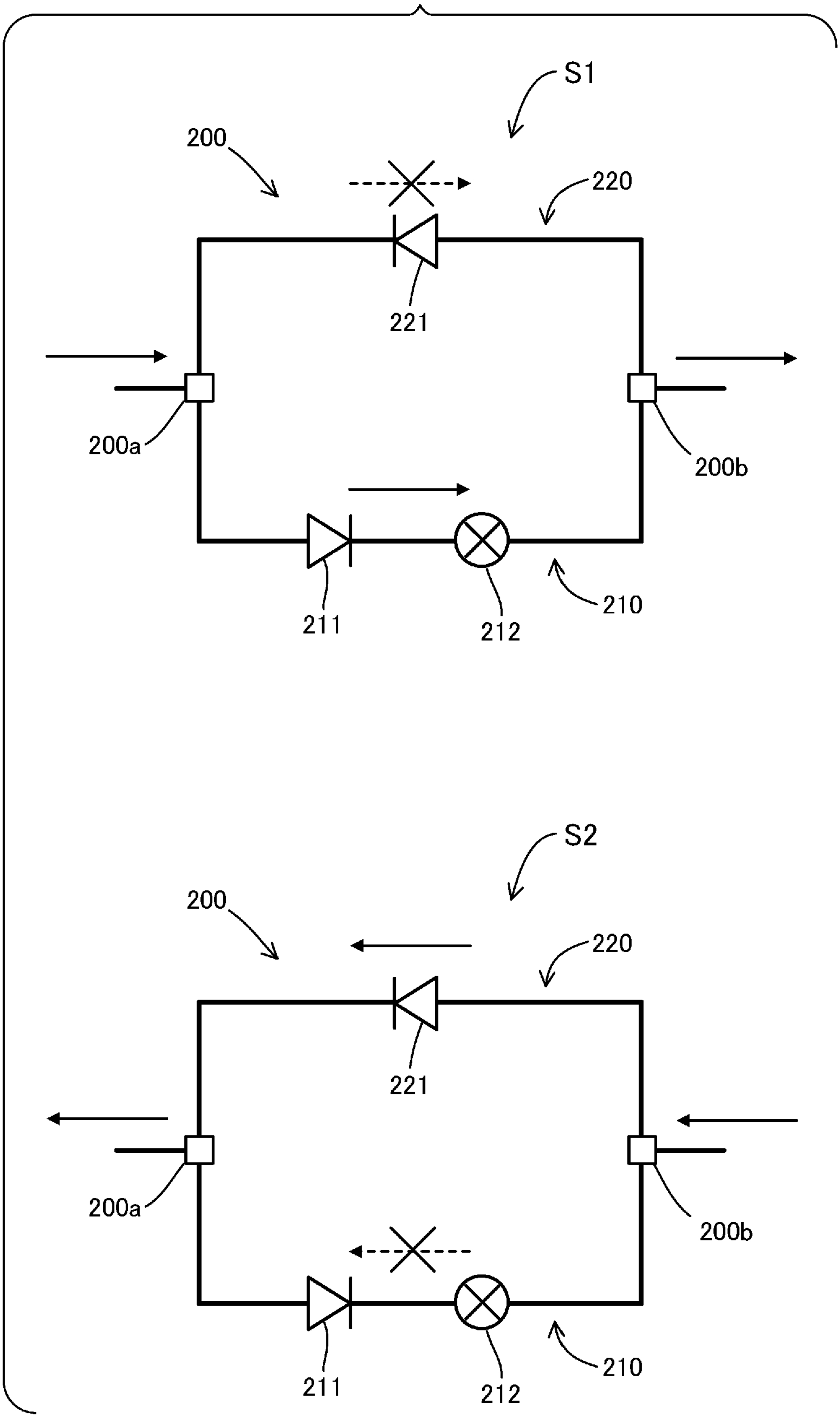

START
S1
OPERATION FOR STARTING HEATING OPERATION PERFORMED ?
NO
YES
S10
OPERATION FOR STARTING COOLING OPERATION PERFORMED ?
NO
YES
S2
CONTROL FOUR-WAY VALVE TO "HEATING-CORRESPONDING CIRCULATION STATE"
S11
CONTROL FOUR-WAY VALVE TO "COOLING-CORRESPONDING CIRCULATION STATE"
S3
CONTROL OPERATING FREQUENCY OF COMPRESSOR AND OPENING DEGREE OF THIRD EXPANSION VALVE BASED ON HEATING OPERATION CONTROL MAP
S12
CONTROL OPERATING FREQUENCY OF COMPRESSOR AND OPENING DEGREE OF THIRD EXPANSION VALVE BASED ON COOLING OPERATION CONTROL MAP
S4
END

FIG.6


S1
200
220
221
200a
200b
211
212
210
S2
200
220
221
200a
200b
211
212
210

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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 0964

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X	US 2020/200441 A1 (NAGAMATSU SHINICHIRO [JP] ET AL) 25 June 2020 (2020-06-25) * paragraphs [0021], [0068] - [0075]; figure 4 * -----	1-5	INV. F25B40/02 F25B49/02
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			TECHNICAL FIELDS SEARCHED (IPC)
			F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 September 2024	Amous, Moez

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EPO FORM 1503 03.82 (P04C01)

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19-09-2024

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		WO 2020003590 A1	02-01-2020

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