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(54) **AIR CONDITIONER**

(57) An air conditioning apparatus (1) is provided with a defrosting flow channel mechanism (26). The air conditioning apparatus (1) performs an air-warming defrost operation for evaporating refrigerant sent from an indoor heat exchanger (41) to an outdoor heat exchanger (23) while defrosting an arbitrarily selected heat exchange path, using the defrosting flow channel mechanism (26). In the air-warming defrost operation, the refrigerant sent from the indoor heat exchanger (41) to the outdoor heat exchanger (23) is first passed through the arbitrarily se-

lected heat exchange path from a gas-side end toward a liquid-side end of the arbitrarily selected heat exchange path by the defrosting flow channel mechanism (26), without flowing into a refrigerant flow diverter (64). Having passed through the arbitrarily selected heat exchange path, the refrigerant then flows through the refrigerant flow diverter (64) to be passed through other heat exchange paths other than the arbitrarily selected heat exchange path, from the liquid-side end toward the gas-side end of the other heat exchange paths.

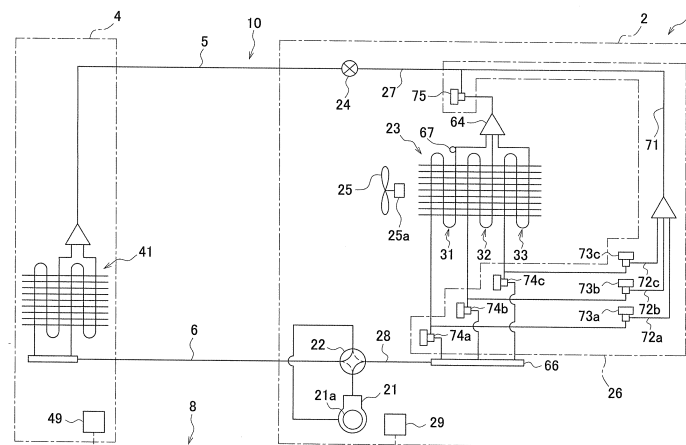


FIG. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus, and particularly relates to an air conditioning apparatus capable of performing an air-warming operation.

BACKGROUND ART

[0002] In the past there have been air conditioning apparatuses configured by sequentially connecting a compressor, an indoor heat exchanger, and an outdoor heat exchanger, and capable of performing an air-warming operation of circulating refrigerant in order through the compressor, the indoor heat exchanger, the outdoor heat exchanger, and the compressor. When frost forms on the outdoor heat exchanger in such an air conditioning apparatus, a reverse cycle defrosting operation is performed in which a switch is made by a four-way switching valve or the like so that the refrigerant is circulated in order through the compressor, the outdoor heat exchanger, the indoor heat exchanger, and the compressor to defrost the outdoor heat exchanger. Therefore, in this air conditioning apparatus, the air-warming operation is stopped during the reverse cycle defrosting operation, and the level of comfort in the room is compromised.

[0003] To improve circumstances when the air-warming operation is stopped during such a defrosting operation, air conditioning apparatuses have been proposed, such as those in Patent Literature 1 (Japanese Laid-open Patent Application No. 2000-274780) and Patent Literature 2 (Japanese Laid-open Patent Application No. 2001-059994), as defrosting systems for defrosting an outdoor heat exchanger while continuing an air-warming operation.

[0004] In the air conditioning apparatus of Patent Literature 1, electromagnetic valves are provided to each of the liquid-side ends of a plurality of heat exchange paths of the outdoor heat exchanger. When frost forms on the outdoor heat exchanger in the air conditioning apparatus, an operation for stopping the flow of refrigerant in a heat exchange path is performed by closing the electromagnetic valve of an arbitrarily selected heat exchange path. This operation makes it possible in this air conditioning apparatus to continue the air-warming operation by evaporating refrigerant in one heat exchange path while defrosting another arbitrarily selected heat exchange path by means of the heat of outdoor air.

[0005] In the air conditioning apparatus of Patent Literature 2, a bypass channel is provided for sending some of the refrigerant discharged from the compressor not to the indoor heat exchanger but to the liquid-side ends of the plurality of heat exchange paths of the outdoor heat exchanger. When frost forms on the outdoor heat exchanger in this air conditioning apparatus, an operation is performed for sending some of the refrigerant dis-

charged from the compressor through the bypass channel, not to the indoor heat exchanger, but to an arbitrarily selected heat exchange path of the outdoor heat exchanger. In this air conditioning apparatus, this operation makes it possible to continue the air-warming operation by evaporating refrigerant in one heat exchange path while defrosting another arbitrarily selected heat exchange path by means of the heat of the refrigerant sent through the bypass channel to the arbitrarily selected heat exchange path.

SUMMARY OF THE INVENTION

[0006] However, in the defrosting system of Patent Literature 1, the frost (ice) does not melt when the temperature of the outdoor air is 0°C or less, and the system therefore has a problem in that the outdoor heat exchanger cannot be defrosted in weather conditions of an outside air temperature of 0°C or less in which a large air-warming load is required. Defrosting requires time to melt frost using outdoor air having a small difference in temperature with the frost, and as a result, only a short time is needed to perform only the air-warming operation, and the system has a problem in that the integral air-warming capability cannot be increased.

[0007] In the defrosting system in Patent Literature 2, because some of the refrigerant sent to the indoor heat exchanger and used in air warming is used to defrost the outdoor heat exchanger, the system has a problem in that the air-warming capability during defrosting is severely reduced.

[0008] An object of the present invention is to make defrosting of the outdoor heat exchanger possible with virtually no reduction in air-warming capability in an air conditioning apparatus capable of performing an air-warming operation.

[0009] An air conditioning apparatus according to a first aspect is configured by sequentially connecting a compressor for compressing refrigerant, an indoor heat exchanger for radiating the heat of the refrigerant compressed in the compressor, and an outdoor heat exchanger for evaporating the refrigerant heat-radiated in the indoor heat exchanger by heat exchange with outdoor air. This air conditioning apparatus is capable of performing an air-warming operation for circulating refrigerant in order through the compressor, the indoor heat exchanger, the outdoor heat exchanger, and the compressor. The outdoor heat exchanger has a plurality of heat exchange paths connected in parallel to each other. Liquid-side ends of the heat exchange paths are connected in parallel by a refrigerant flow diverter for branching the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the liquid-side ends of the heat exchange paths. On the premise of the configuration described above, the air conditioning apparatus is also provided with a defrosting flow channel mechanism for sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to a gas-side end of an arbitrary

trarily selected heat exchange path of the plurality of heat exchange paths, without channeling the refrigerant into the refrigerant flow diverter. In this air conditioning apparatus, the defrosting flow channel mechanism performs an air-warming defrost operation for evaporating the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger while defrosting the arbitrarily selected heat exchange path. In the air-warming defrost operation, the refrigerant sent from the outdoor heat exchanger to the indoor heat exchanger is not channeled into the refrigerant flow diverter by the defrosting flow channel mechanism, but is passed through the arbitrarily selected heat exchange path, from the gas-side end to the liquid-side end of the arbitrarily selected heat exchange path. The refrigerant passed through the arbitrarily selected heat exchange path then flows through the refrigerant flow diverter to be passed through another heat exchange path other than the arbitrarily selected heat exchange path, from the liquid-side end to the gas-side end of the other heat exchange path.

[0010] In this air conditioning apparatus, the entire outdoor heat exchanger can be defrosted by performing the air-warming defrost operation using the defrosting flow channel mechanism sequentially on the plurality of heat exchange paths. In the air-warming defrost operation, the total amount of refrigerant compressed in the compressor is sent to the indoor heat exchanger and used in air warming, after which defrosting can be performed by the heat of the refrigerant sent from the indoor heat exchanger to the outdoor heat exchanger. It is thereby possible to defrost the outdoor heat exchanger even in weather conditions having an outside air temperature of 0°C or less while achieving a high defrosting capability, with virtually no reduction in air-warming capability.

[0011] An air conditioning apparatus according to a second aspect is the air conditioning apparatus according to the first aspect, wherein the outdoor heat exchanger further has a subcooling path through which the refrigerant sent from the indoor heat exchanger to the outdoor heat exchanger passes before flowing into the refrigerant flow diverter. The defrosting flow channel mechanism is provided so as to be capable of sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths after the refrigerant has passed through the subcooling path.

[0012] In this air conditioning apparatus, because the refrigerant can be passed through to the subcooling path even during the air-warming defrost operation, drain water produced by defrosting the heat exchange path can be prevented from refreezing and can be quickly expelled from the bottom of the outdoor heat exchanger.

[0013] An air conditioning apparatus according to a third aspect is the air conditioning apparatus according to the first aspect, wherein the outdoor heat exchanger further has a subcooling path through which the refrigerant sent from the indoor heat exchanger to the outdoor

heat exchanger passes before flowing into the refrigerant flow diverter. The defrosting flow channel mechanism is provided so as to be capable of sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths without passing the refrigerant through the subcooling path.

[0014] In this air conditioning apparatus, because the heat exchange path can be defrosted without passing the refrigerant through the subcooling path during the air-warming defrost operation, the heat of the refrigerant can be used solely for defrosting the heat exchange path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a schematic configuration diagram of the air conditioning apparatus according to the first embodiment of the present invention;

FIG. 2 is a plan view of an outdoor unit (excluding the depiction of a top plate);

FIG. 3 is a diagram schematically depicting the outdoor heat exchanger of the first embodiment and the surrounding structure;

FIG. 4 is a control block diagram of the air conditioning apparatus;

FIG. 5 is a diagram showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation of the first embodiment;

FIG. 6 is a flowchart of the air-warming defrost operation;

FIG. 7 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation of the first embodiment;

FIG. 8 is a pressure-enthalpy graph depicting the refrigeration cycle during the air-warming defrost operation of the first embodiment;

FIG. 9 is a pressure-enthalpy graph depicting the refrigeration cycle during a conventional (Patent Literature 2) defrost operation;

FIG. 10 is a flowchart of the air-warming defrost operation according to Modification 1 of the first embodiment;

FIG. 11 is a schematic configuration diagram of the air conditioning apparatus according to Modification 2 of the first embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 12 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 2 of the first embodiment;

FIG. 13 is a schematic configuration diagram of the air conditioning apparatus according to Modification

3 of the first embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 14 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 3 of the first embodiment;

FIG. 15 is a schematic configuration diagram of the air conditioning apparatus according to Modification 4 of the first embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 16 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 4 of the first embodiment;

FIG. 17 is a schematic configuration diagram of the air conditioning apparatus according to Modification 5 of the first embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 18 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 5 of the first embodiment;

FIG. 19 is a schematic configuration diagram of the air conditioning apparatus according to Modification 6 of the first embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 20 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 6 of the first embodiment;

FIG. 21 is a schematic configuration diagram of the air conditioning apparatus according to the second embodiment of the present invention;

FIG. 22 is a diagram schematically depicting the outdoor heat exchanger of the second embodiment and the surrounding structure;

FIG. 23 is a diagram showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation of the second embodiment;

FIG. 24 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation of the second embodiment;

FIG. 25 is a pressure-enthalpy graph depicting the refrigeration cycle during the air-warming defrost operation of the second embodiment;

FIG. 26 is a schematic configuration diagram of the air conditioning apparatus according to Modification 2 of the second embodiment, showing the flow of

refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 27 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 2 of the second embodiment;

FIG. 28 is a schematic configuration diagram of the air conditioning apparatus according to Modification 3 of the second embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 29 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 3 of the second embodiment;

FIG. 30 is a schematic configuration diagram of the air conditioning apparatus according to Modification 4 of the second embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 31 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 4 of the second embodiment;

FIG. 32 is a schematic configuration diagram of the air conditioning apparatus according to Modification 5 of the second embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 33 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 5 of the second embodiment;

FIG. 34 is a schematic configuration diagram of the air conditioning apparatus according to Modification 6 of the second embodiment, showing the flow of refrigerant in the air conditioning apparatus during the air-warming operation;

FIG. 35 is a diagram showing the flow of refrigerant (when the first heat exchange path is being defrosted) in the air conditioning apparatus during the air-warming defrost operation in Modification 6 of the second embodiment; and

FIG. 37 is a schematic configuration diagram of an air conditioning apparatus according to another embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0016] Embodiments of the air conditioning apparatus according to the present invention are described below based on the drawings.

<First Embodiment>

(Overall configuration)

[0017] FIG. 1 is a schematic configuration diagram of the air conditioning apparatus 1 according to the first embodiment of the present invention. The air conditioning apparatus 1 is capable of performing an air-warming operation, and a split type apparatus is employed herein. The air conditioning apparatus 1 has primarily an outdoor unit 2, an indoor unit 4, and a liquid refrigerant communication tube 5 and a gas refrigerant communication tube 6 connecting the outdoor unit 2 and the indoor unit 4. By being connected via the liquid refrigerant communication tube 5 and the gas refrigerant communication tube 6, the outdoor unit 2 and the indoor unit 4 constitute a refrigerant circuit 10 for performing a vapor compression type refrigeration cycle.

(Indoor unit)

[0018] The indoor unit 4, which is installed indoors, constitutes part of the refrigerant circuit 10. The indoor unit 4 has primarily an indoor heat exchanger 41.

[0019] The indoor heat exchanger 41 is a heat exchanger which functions as an evaporator of refrigerant and cools the air in the room during an air-cooling operation, and functions as a heat radiator of refrigerant and heats the air in the room during the air-warming operation. A cross fin type fin-and-tube heat exchanger configured from a heat transfer tube and numerous fins is employed herein as the indoor heat exchanger 41. The liquid side of the indoor heat exchanger 41 is connected to the liquid refrigerant communication tube 5, and the gas side is connected to the gas refrigerant communication tube 6.

[0020] The indoor unit 4 has an indoor controller 49 for controlling the actions of the components constituting the indoor unit 4. The indoor controller 49 has a microcomputer, a memory, and other components for controlling the indoor unit 4, and can exchange control signals and the like with an outdoor controller 29 (described hereinafter) of the outdoor unit 2.

(Outdoor unit)

[0021] The outdoor unit 2, which is installed outdoors, constitutes part of the refrigerant circuit 10. The outdoor unit 2 has primarily a compressor 21, a four-way switching valve 22, an outdoor heat exchanger 23, an expansion valve 24, an outdoor fan 25, and a defrosting flow channel mechanism 26. In the structure (a so-called trunk structure) employed for the outdoor unit 2 herein, the interior of a substantially rectangular box-shaped unit casing 51 is divided into an air-blower chamber S1 and a machinery chamber S2 by a partitioning plate 58 extending vertically, as shown in FIG. 2. FIG. 2 is a plan view of the outdoor unit 2 (excluding the depiction of a

top plate). Primarily in the outdoor unit 2, various instruments 21 to 26 and the like are accommodated inside the substantially rectangular box-shaped unit casing 51.

[0022] The unit casing 51 has primarily a bottom plate 52, a top plate, a left front plate 54, a right front plate 56, a right side plate 57, and the partitioning plate 58. The bottom plate 52 is a horizontally long substantially rectangular plate-shaped member constituting the bottom surface portion of the unit casing 51. The bottom plate 52 is designed so as to also function as a drain pan for receiving drain water flowing down from the outdoor heat exchanger 23. The top plate, though not shown in FIG. 2, is a horizontally long substantially rectangular plate-shaped member constituting the top surface portion of the outdoor unit 2. The left front plate 54 is primarily a plate-shaped member constituting the left front surface portion and the left side surface portion of the unit casing 51. Formed in the left front plate 54 is an intake port 55a for air drawn into the unit casing 51 by the outdoor fan 25. The left front plate 54 is also provided with a blowout port 54a for blowing out air taken into the interior from the back surface side and left surface side of the unit casing 51 by the outdoor fan 25. The right front plate 56 is primarily a plate-shaped member constituting the right front surface portion and the front part of the right side surface of the unit casing 51. The right side plate 57 is primarily a plate-shaped member constituting the rear part of the right side surface and the right back surface portion of the unit casing 51. Between the rear end of the left front plate 54 and the back surface side end of the right side plate 57 with respect to the left-right direction, an intake port 55b is formed for air drawn into the unit casing 51 by the outdoor fan 25. The partitioning plate 58 is a plate-shaped member extending vertically and disposed on the bottom plate 52, and is disposed so as to partition the internal space of the unit casing 51 into two left and right spaces (i.e. the air-blower chamber S1 and the machinery chamber S2).

[0023] The compressor 21 is a compressor for drawing in low-pressure gas refrigerant in the refrigeration cycle, compressing the refrigerant into a high-pressure gas refrigerant in the refrigeration cycle, and then discharging the refrigerant. The compressor 21 herein is a hermetically sealed compressor in which a positive displacement compression element (not shown), such as a rotary or scroll element accommodated in a casing (not shown), is driven by a compressor motor 21 a similarly accommodated in the casing. The intake side and discharge side of the compressor 21 are connected to the four-way switching valve 22. The compressor 21 is disposed in the machinery chamber S2.

[0024] The four-way switching valve 22 is a valve for switching the direction of refrigerant flow during a switch between the air-cooling operation and the air-warming operation. During the air-cooling operation, the four-way switching valve 22 is capable of connecting the discharge side of the compressor 21 and the gas side of the outdoor heat exchanger 23, and also connecting the gas refrigerant

erant communication tube 6 and the intake side of the compressor 21 (refer to the solid lines of the four-way switching valve 22 in FIG. 1). During the air-warming operation, the four-way switching valve 22 is capable of connecting the discharge side of the compressor 21 and the gas refrigerant communication tube 6, and also connecting the gas side of the outdoor heat exchanger 23 and the intake side of the compressor 21 (refer to the dashed lines of the four-way switching valve 22 in FIG. 1). The four-way switching valve 22 is connected to the gas refrigerant communication tube 6, the intake side and discharge side of the compressor 21, and the gas side of the outdoor heat exchanger 23. Though not shown in FIG. 2, the four-way switching valve 22 is disposed in the machinery chamber S2.

[0025] The outdoor heat exchanger 23 is a heat exchanger which functions as a heat radiator of refrigerant during the air-cooling operation and functions as an evaporator of refrigerant during the air-warming operation. The outdoor heat exchanger 23 herein is a cross fin type fin-and-tube heat exchanger configured from a heat transfer tube and numerous fins. The liquid side of the outdoor heat exchanger 23 is connected to the expansion valve 24 via a liquid refrigerant tube 27, and the gas side is connected to the four-way switching valve 22 via a gas refrigerant tube 28.

[0026] More specifically, the outdoor heat exchanger 23 has numerous fins 61, and numerous heat transfer tubes 62 attached in a state of passing through the fins 61 in the plate thickness direction (see FIG. 2). In this outdoor heat exchanger 23, the heat transfer tubes 62 are assorted in a plural system (three in this case) in the up-down direction, forming a first heat exchange path 31, a second heat exchange path 32, and a third heat exchange path 33 which are independent of each other, as shown in FIG. 3. FIG. 3 is a diagram schematically depicting the outdoor heat exchanger 23 and the surrounding structure. The liquid-side ends of the first through third heat exchange paths 31 to 33 are connected to a refrigerant flow diverter 64 via first through third capillary tubes 63a to 63c, respectively. The refrigerant flow diverter 64 is a tube member for converging the first through third capillary tubes 63a to 63c connected to the liquid-side ends of the first through third heat exchange paths 31 to 33, and the refrigerant flow diverter is connected to the liquid refrigerant tube 27. The gas-side ends of the first through third heat exchange paths 31 to 33 are connected to a header 66 via first through third header communication tubes 65a to 65c, respectively. The header 66 is a tube member for converging the first through third header communication tubes 65a to 65c connected to the gas-side ends of the first through third heat exchange paths 31 to 33, and the header is connected to the gas refrigerant tube 28. Thus, the plurality (three in this case) of heat exchange paths 31 to 33 constituting the outdoor heat exchanger 23 are connected in parallel to each other via the refrigerant flow diverter 64 and the header 66. During the air-cooling operation, all of the heat exchange

paths 31 to 33 function as heat radiators of refrigerant, and during the air-warming operation, all of the heat exchange paths 31 to 33 function as evaporators of refrigerant. The outdoor heat exchanger 23 (i.e. the heat exchange paths 31 to 33) has an L shape running from the left side surface along the back surface of the unit casing 51. The tube members 63a to 63c, 64, 65a to 65c, and 66 connecting the heat exchange paths 31 to 33, though not shown in FIG. 2, are disposed in a space on the right end side of the outdoor heat exchanger 23, i.e. in the machinery chamber S2.

[0027] The expansion valve 24 is an electric expansion valve capable of depressurizing the high-pressure liquid refrigerant heat-radiated in the outdoor heat exchanger 23 during the air-cooling operation before the refrigerant is sent to the indoor heat exchanger 41, and depressurizing the high-pressure liquid refrigerant heat-radiated in the indoor heat exchanger 41 during the air-warming operation before the refrigerant is sent to the outdoor heat exchanger 23. The expansion valve 24 is provided to the liquid refrigerant tube 27, one end thereof is connected to the liquid refrigerant communication tube 5, and the other end is connected to the outdoor heat exchanger 23. Though not shown in FIG. 2, the expansion valve 24 is disposed in the machinery chamber S2.

[0028] The outdoor fan 25 is an air blower for drawing outdoor air into the outdoor unit 2, supplying the outdoor air to the outdoor heat exchanger 23, and then expelling the air out of the unit. The outdoor fan 25 herein is a propeller fan driven by an outdoor fan motor 25a. The outdoor fan 25 is disposed in the front side of the outdoor heat exchanger 23 in the air-blower chamber S1. When the outdoor fan 25 is driven air is taken into the interior through the intake ports 55a, 55b in the back surface and left side surface of the unit casing 51, the air is passed through the outdoor heat exchanger 23, and the air is then blown out of the unit casing 51 from the blowout port 54a in the front surface of the unit casing 51. The outdoor heat exchanger 23 is thereby a heat exchanger for either radiating the heat of the refrigerant using the outdoor air as a cooling source, or evaporating the refrigerant using the outdoor air as a heating source.

[0029] The defrosting flow channel mechanism 26 is a mechanism for sending the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 to the gas-side end of an arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33, without channeling the refrigerant to the refrigerant flow diverter 64. The defrosting flow channel mechanism 26 is provided in order to perform an air-warming defrost operation, described hereinafter. The air-warming defrost operation is an operation for evaporating the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 while defrosting the arbitrarily selected heat exchange path of the heat exchange paths 31 to 33 constituting the outdoor heat exchanger 23. The defrosting flow channel mechanism 26 has primarily a heat exchange path supply tube 71, a plurality (three in

this case) of heat exchange path branching tubes 72a to 72c, a plurality (three in this case) of branching-tube-side heat exchange path selection valves 73a to 73c, a plurality (three in this case) of header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75. Though not shown in FIG. 2, the defrosting flow channel mechanism 26 (i.e. the refrigerant tubes and valves 71, 72a to 72c, 73a to 73c, 74a to 74c, and 75) is disposed in the machinery chamber S2.

[0030] The heat exchange path supply tube 71 is a refrigerant tube for causing the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 to branch from the liquid refrigerant tube 27 before the refrigerant flows into the refrigerant flow diverter 64. One end of the heat exchange path supply tube 71 is connected to the portion of the liquid refrigerant tube 27 that is between the expansion valve 24 and the refrigerant flow diverter 64, and the other end is connected to the heat exchange path branching tubes 72a to 72c.

[0031] The first through third heat exchange path branching tubes 72a to 72c are refrigerant tubes for supplying the refrigerant flowing through the heat exchange path supply tube 71 to the gas-side ends of the first through third heat exchange paths 31 to 33. The first through third heat exchange path branching tubes 72a to 72c are connected at one end to the heat exchange path supply tube 71, and connected at the other end to the first through third header communication tubes 65a to 65c, respectively.

[0032] The first through third branching-tube-side heat exchange path selection valves 73a to 73c, together with the first through third header-side heat exchange path selection valves 74a to 74c, are electromagnetic valves for selecting which heat exchange path gas-side end of the heat exchange paths 31 to 33 the refrigerant flowing through the heat exchange path supply tube 71 will be sent to. The first through third branching-tube-side heat exchange path selection valves 73a to 73c are provided to the first through third heat exchange path branching tubes 72a to 72c, respectively. The first through third branching-tube-side heat exchange path selection valves 73a to 73c are all designed to be closed during both the air-cooling operation and the air-warming operation. During the air-warming defrost operation, of the first through third branching-tube-side heat exchange path selection valves 73a to 73c, the branching-tube-side heat exchange path selection valve corresponding to the heat exchange path being defrosted is opened, while the branching-tube-side heat exchange path selection valves corresponding to the other heat exchange paths are closed.

[0033] The first through third header-side heat exchange path selection valves 74a to 74c, together with the first through third branching-tube-side heat exchange path selection valves 73a to 73c, are electromagnetic valves for selecting which heat exchange path gas-side end of the heat exchange paths 31 to 33 the refrigerant flowing through the heat exchange path supply tube 71

will be sent to. The first through third header-side heat exchange path selection valves 74a to 74c are provided to respective portions of the first through third header communication tubes 65a to 65c that are between the header 66 and the positions where the other ends of the first through third heat exchange path branching tubes 72a to 72c are connected. The first through third header-side heat exchange path selection valves 74a to 74c are all designed to be open during both the air-cooling operation and the air-warming operation. During the air-warming defrost operation, of the first through third header-side heat exchange path selection valves 74a to 74c, the header-side heat exchange path selection valve corresponding to the heat exchange path being defrosted is closed, while the header-side heat exchange path selection valves corresponding to the other heat exchange paths are open.

[0034] The diverter-tube-side selection valve 75 is an electromagnetic valve for selecting whether or not the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 will be made to branch from the liquid refrigerant tube 27 before flowing into the refrigerant flow diverter 64. The diverter-tube-side selection valve 75 is provided to a portion in the liquid refrigerant tube 27 that is between the refrigerant flow diverter 64 and the position where the heat exchange path supply tube 71 branches. The diverter-tube-side selection valve 75 is designed so as to be open during both the air-cooling operation and the air-warming operation. The diverter-tube-side selection valve 75 is also designed so as to be closed during the air-warming defrost operation.

[0035] The outdoor unit 2 is also provided with an outdoor heat exchange temperature sensor 67 for detecting the saturation temperature T_{sat} of refrigerant flowing through the outdoor heat exchanger 23. The outdoor heat exchange temperature sensor 67 herein is provided in proximity to the liquid-side end of the first heat exchange path 31 of the outdoor heat exchanger 23.

[0036] The outdoor unit 2 also has the outdoor controller 29 for controlling the actions of the components constituting the outdoor unit 2. The outdoor controller 29 has a microcomputer, a memory, and the like for controlling the outdoor unit 2, and the outdoor controller is capable of exchanging control signals and the like with the indoor controller 49 of the indoor unit 4.

[0037] A controller 8 for performing operation controls and the like for the air conditioning apparatus 1 is configured by the outdoor controller 29 and the indoor controller 49 (see FIGS. 1 and 4). FIG. 4 is a control block diagram of the air conditioning apparatus 1.

(Action)

[0038] Next is a description of the action of the air conditioning apparatus 1 having the configuration described above. The controls of the various instruments, the various processes, and the like needed to perform the following action are performed by the controller 8.

[0039] The operations of the air conditioning apparatus 1 include the air-cooling operation for cooling the air in the room, the air-warming operation for only warming the air in the room, and the air-warming defrost operation for both defrosting the outdoor heat exchanger 23 and warming the air in the room. The actions during these operations are described below using FIGS. 5 to 8. FIG. 5 is a diagram showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 6 is a flowchart of the air-warming defrost operation. FIG. 7 is a diagram showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming defrost operation (when the first heat exchange path 31 is being defrosted). FIG. 8 is pressure-enthalpy graph depicting the refrigeration cycle during the air-warming defrost operation.

-Air-cooling operation-

[0040] The air-cooling operation is an operation for circulating refrigerant in order through the compressor 21, the outdoor heat exchanger 23, the indoor heat exchanger 41, and the compressor 21. In the air-cooling operation, the outdoor heat exchanger 23 functions as a heat radiator of refrigerant and the indoor heat exchanger 41 functions as an evaporator of refrigerant, thereby cooling the indoor air.

[0041] In the air-cooling operation, the four-way switching valve 22 is switched so as to create a state in which the outdoor heat exchanger 23 functions as a heat radiator of refrigerant and the indoor heat exchanger 41 functions as an evaporator of refrigerant (i.e. the state shown by the solid lines of the four-way switching valve 22 in FIG. 1). This is also a state in which the first through third branching-tube-side heat exchange path selection valves 73a to 73c are all closed, the first through third header-side heat exchange path selection valves 74a to 74c are all open, and the diverter-tube-side selection valve 75 is open. Specifically, this is a state in which refrigerant does not flow to the heat exchange path supply tube 71 or the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 26.

[0042] In the refrigerant circuit 10 in this state, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 to the outdoor heat exchanger 23. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22, the gas refrigerant tube 28, the header 66, the header communication tubes 65a to 65c, and the header-side heat exchange path selection valves 74a to 74c to the gas-side ends of the heat exchange paths 31 to 33 of the outdoor heat exchanger 23. The high-pressure refrigerant sent to the gas-side ends of the heat exchange paths 31 to 33 undergoes heat ex-

change in the heat exchange paths 31 to 33 with the outdoor air supplied by the outdoor fan 25, and the refrigerant radiates heat. The high-pressure refrigerant that has radiated heat in the heat exchange paths 31 to 33 is sent from the liquid-side ends of the heat exchange paths 31 to 33 through the capillary tubes 63a to 63c, the refrigerant flow diverter 64, the liquid refrigerant tube 27, and the diverter-tube-side selection valve 75 to the expansion valve 24. The refrigerant sent to the expansion valve 24 is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant depressurized in the expansion valve 24 is sent through the liquid refrigerant communication tube 5 to the indoor heat exchanger 41. The low-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with the indoor air in the indoor heat exchanger 41, and the refrigerant evaporates. The low-pressure refrigerant evaporated in the indoor heat exchanger 41 is drawn through the gas refrigerant communication tube 6 and the four-way switching valve 22 back into the compressor 21.

-Air-warming operation-

[0043] The air-warming operation is an operation for circulating refrigerant in order through the compressor 21, the indoor heat exchanger 41, the outdoor heat exchanger 23, and the compressor 21. In the air-warming operation, the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 23 functions as an evaporator of refrigerant, thereby heating the indoor air.

[0044] In the air-warming operation, the four-way switching valve 22 is switched so as to create a state in which the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 23 functions as an evaporator of refrigerant (i.e. the state shown by the dashed lines of the four-way switching valve 22 in FIGS. 1 and 5). This is also a state in which the first through third branching-tube-side heat exchange path selection valves 73a to 73c are all closed, the first through third header-side heat exchange path selection valves 74a to 74c are all open, and the diverter-tube-side selection valve 75 is open. Specifically, this is a state in which refrigerant does not flow to the heat exchange path supply tube 71 or the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 26.

[0045] In the refrigerant circuit 10 in this state, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 and through the gas refrigerant communication tube 6 to the indoor heat exchanger 41. The high-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with the indoor air in the indoor heat exchanger

41, and the refrigerant radiates heat. The high-pressure refrigerant that has radiated heat in the indoor heat exchanger 41 is sent through the liquid refrigerant communication tube 5 to the expansion valve 24 and depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant depressurized in the expansion valve 24 is sent to the outdoor heat exchanger 23. The low-pressure refrigerant depressurized in the expansion valve 24 is sent through the liquid refrigerant tube 27, the diverter-tube-side selection valve 75, the refrigerant flow diverter 64, and the capillary tubes 63a to 63c to the liquid-side ends of the heat exchange paths 31 to 33 of the outdoor heat exchanger 23. The low-pressure refrigerant sent to the liquid-side ends of the heat exchange paths 31 to 33 undergoes heat exchange with the outdoor air supplied by the outdoor fan 25 in the heat exchange paths 31 to 33, and the refrigerant evaporates. The low-pressure refrigerant evaporated in the heat exchange paths 31 to 33 is drawn from the gas-side ends of the heat exchange paths 31 to 33, through the header communication tubes 65a to 65c, the header-side heat exchange path selection valves 74a to 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, back into the compressor 21.

-Air-warming defrost operation-

[0046] The air-warming defrost operation is an operation in which the outdoor heat exchanger 23 is defrosted by the defrosting flow channel mechanism 26 while refrigerant is circulated in order through the compressor 21, the indoor heat exchanger 41, the outdoor heat exchanger 23, and the compressor 21, similar to the air-warming operation. In the air-warming defrost operation, the indoor heat exchanger 41 functions as a heat radiator of refrigerant, any one of the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 23 functions as a heat radiator of refrigerant, and the remaining heat exchange paths 31 to 33 function as evaporators of refrigerant. The indoor air is thereby heated while the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 23 are sequentially defrosted.

[0047] The switched state of the four-way switching valve 22 in the air-warming defrost operation is the same as during the air-warming operation. Specifically, the four-way switching valve 22 goes into a state in which the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 23 functions as an evaporator of refrigerant (i.e. the state shown by the dashed lines of the four-way switching valve 22 in FIGS. 1 and 7). To sequentially defrost the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 23, the selection valves 73a to 73c, 74a to 74c, and 75 are switched to different opened and closed states during the air-cooling operation and during the air-warming operation. Specifically, the state in the air-warming defrost operation is such that refrigerant flows to the

heat exchange path supply tube 71 and the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 26. The action during the air-warming defrost operation is described below in detail, including the procedure from the start to the end of the air-warming defrost operation.

[0048] First, in step S1, a determination is made as to whether or not the amount of frost formed in the outdoor heat exchanger 23 has been increased by the air-warming operation and defrosting is required. This determination of whether or not defrosting is required could be made based on the continuation time of the air-warming operation or the temperature of the outdoor heat exchanger 23, but in this case the determination is made based on the saturation temperature T_{sat} detected by the outdoor heat exchange temperature sensor 67. Specifically, when the saturation temperature T_{sat} is equal to or less than a predetermined temperature T_m , it is determined that defrosting of the outdoor heat exchanger 23 is required. When it is determined that defrosting of the outdoor heat exchanger 23 is required in step S1, the sequence transitions to the process of step S2.

[0049] Next, in steps S2 to S7, the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 23 are sequentially defrosted. Defrosting of the first through third heat exchange paths 31 to 33 may essentially be arbitrarily selected, but taking into account the flow of drain water produced by defrosting and expelled to the bottom plate 52 of the unit casing 51, defrosting is preferably performed from the top of the outdoor heat exchanger 23 toward the bottom. Therefore, defrosting herein is performed in order of the first heat exchange path 31, the second heat exchange path 32, and the third heat exchange path 33.

[0050] Defrosting of the first heat exchange path 31 (step S2) is performed by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 26. Specifically, the valves are switched to a state in which the first branching-tube-side heat exchange path selection valve 73a is opened, the second and third branching-tube-side heat exchange path selection valves 73b, 73c are closed, the first header-side heat exchange path selection valve 74a is closed, the second and third header-side heat exchange path selection valves 74b, 74c are opened, and the diverter-tube-side selection valve 75 is closed. Because the air-warming operation is performed until prior to the start of the defrosting of the first heat exchange path 31, a switching action is performed for opening the first branching-tube-side heat exchange path selection valve 73a, closing the first header-side heat exchange path selection valve 74a, and closing the diverter-tube-side selection valve 75. Refrigerant thereby flows to the heat exchange path supply tube 71 and the first heat exchange path branching tube 72a of the defrosting flow channel mechanism 26.

[0051] In the refrigerant circuit 10 in this state, low-pressure refrigerant in the refrigeration cycle (see point

A in FIGS. 7 and 8) is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged (see point B in FIGS. 7 and 8). The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 and through the gas refrigerant communication tube 6 to the indoor heat exchanger 41. The high-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air in the indoor heat exchanger 41, and the refrigerant radiates heat (see point C in FIGS. 7 and 8). So far the process has been identical to the air-warming operation. The high-pressure refrigerant heat-radiated in the indoor heat exchanger 41 is sent through the liquid refrigerant communication tube 5 to the expansion valve 24, and depressurized to a pressure between the high pressure and low pressure in the refrigeration cycle (referred to below as the intermediate pressure) (see point D in FIGS. 7 and 8). The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent to the outdoor heat exchanger 23. The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent from the liquid refrigerant tube 27 to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is sent through the first heat exchange path branching tube 72a, the first branching-tube-side heat exchange path selection valve 73a, and the first header communication tube 65a to the gas-side end of the first heat exchange path 31 of the outdoor heat exchanger 23. Thus, all of the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 is sent to the gas-side end of the first heat exchange path 31 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the first heat exchange path 31 passes through the first heat exchange path 31 from the gas-side end toward the liquid-side end of the first heat exchange path 31, and melts the frost adhering to the first heat exchange path 31 of the outdoor heat exchanger 23 (see point E in FIGS. 7 and 8). The first heat exchange path 31 of the outdoor heat exchanger 23 is thereby defrosted. The intermediate pressure refrigerant passing through the first heat exchange path 31 is then sent from the liquid-side end of the first heat exchange path 31, through the first capillary tube 63a, to the refrigerant flow diverter 64. Because intermediate pressure refrigerant flows through the first capillary tube 63a at a greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure (i.e. the pressure at point E in FIGS. 7 and 8) and the low pressure in the refrigeration cycle (see point F in FIGS. 7 and 8). The low-pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is

branched to the second and third capillary tubes 63b, 63c and sent to the liquid-side ends of the second and third heat exchange paths 32, 33. At this time, due to passing through the second and third capillary tubes 63b, 63c, the refrigerant is depressurized to a low pressure in the refrigeration cycle (see point G in FIGS. 7 and 8). The low-pressure refrigerant sent to the liquid-side ends of the second and third heat exchange paths 32, 33 then passes through the second and third heat exchange paths 32, 33 from the liquid-side ends toward the gas-side ends of the second and third heat exchange paths 32, 33, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates (see point A in FIGS. 7 and 8). The low-pressure refrigerant evaporated in the second and third heat exchange paths 32, 33 then passes from the gas-side ends of the second and third heat exchange paths 32, 33, through the second and third header communication tubes 65b, 65c, the second and third header-side heat exchange path selection valves 74b, 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the first heat exchange path 31 is initiated while the air in the room continues to be warmed. Defrosting of the first heat exchange path 31 is then performed until defrosting of the first heat exchange path 31 is complete (step S3). In this case, defrosting is performed until the first heat exchange path 31 defrosting time duration t_1 reaches a predetermined time duration that has been set in advance (i.e., a time at which defrosting of the first heat exchange path 31 can be considered to be complete).

[0052] The second heat exchange path 32 is defrosted (step S4) by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 26, similar to the first heat exchange path 31. Specifically, the valves are switched to a state in which the second branching-tube-side heat exchange path selection valve 73b is opened, the first and third branching-tube-side heat exchange path selection valves 73a, 73c are closed, the second header-side heat exchange path selection valve 74b is closed, the first and third header-side heat exchange path selection valves 74a, 74c are opened, and the diverter-tube-side selection valve 75 is closed. Because the first heat exchange path 31 is defrosted until prior to the start of defrosting of the second heat exchange path 32, a switching action is performed for opening the second branching-tube-side heat exchange path selection valve 73b, closing the first branching-tube-side heat exchange path selection valve 73a, opening the first header-side heat exchange path selection valve 74a, and closing the second header-side heat exchange path selection valve 74b. Refrigerant thereby flows to the heat exchange path supply tube 71 and the second heat exchange path branching tube 72b of the defrosting flow channel mechanism 26.

[0053] In the refrigerant circuit 10 in this state, low-pressure refrigerant in the refrigeration cycle is com-

pressed in the compressor 21 to a high pressure in the refrigeration cycle, similar to the defrosting of the first heat exchange path 31; the refrigerant undergoes heat exchange with indoor air in the indoor heat exchanger 41 and radiates heat, and the refrigerant is depressurized in the expansion valve 24 to an intermediate pressure in the refrigeration cycle and sent to the outdoor heat exchanger 23. The intermediate pressure refrigerant depressurized in the expansion valve 24 is then sent from the liquid refrigerant tube 27 to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is then sent through the second heat exchange path branching tube 72b, the second branching-tube-side heat exchange path selection valve 73b, and the second header communication tube 65b to the gas-side end of the second heat exchange path 32 of the outdoor heat exchanger 23. Thus, all of the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 is sent to the gas-side end of the second heat exchange path 32 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the second heat exchange path 32 passes through the second heat exchange path 32 from the gas-side end of the second heat exchange path 32 toward the liquid-side end, and melts the frost adhering to the second heat exchange path 32 of the outdoor heat exchanger 23. The second heat exchange path 32 of the outdoor heat exchanger 23 is thereby defrosted. The intermediate pressure refrigerant passed through the second heat exchange path 32 is then sent from the liquid-side end of the second heat exchange path 32, through the second capillary tube 63b, to the refrigerant flow diverter 64. At this time, because intermediate pressure refrigerant flows through the second capillary tube 63b at a greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure and the low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is branched to the first and third capillary tubes 63a, 63c and sent to the liquid-side ends of the first and third heat exchange paths 31, 33. At this time, due to passing through the first and third capillary tubes 63a, 63c, the refrigerant is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the liquid-side ends of the first and third heat exchange paths 31, 33 then passes through the first and third heat exchange paths 31, 33 from the liquid-side ends of the first and third heat exchange paths 31, 33 toward the gas-side ends, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates. The low-pressure refrigerant evaporated in the first and third

heat exchange paths 31, 33 then passes from the gas-side ends of the first and third heat exchange paths 31, 33, through the first and third header communication tubes 65a, 65c, the first and third header-side heat exchange path selection valves 74a, 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the second heat exchange path 32 is initiated while the air in the room continues to be warmed. Defrosting of the second heat exchange path 32 is then performed until defrosting of the second heat exchange path 32 is complete (step S5). In this case, defrosting is performed until the second heat exchange path 32 defrosting time duration t_2 reaches a predetermined time duration that has been set in advance (i.e. a time at which defrosting of the second heat exchange path 32 can be considered to be complete). Because the second heat exchange path 32 and the other heat exchange paths 31, 33 have different positions in the up-down direction, the times at which defrosting can be considered to be complete are also different. Therefore, the predetermined time duration of defrosting the second heat exchange path 32 is preferably different from the predetermined time duration of defrosting the other heat exchange paths 31, 33. The heat exchange paths 31 to 33 herein have different positional relationships to the outdoor fan 25 and there is deviation in the quantities of outdoor air passing through the heat exchange paths 31 to 33, and a heat exchange path of greater air quantity therefore tends to have more frost formed thereon. Therefore, one possible option is to make the predetermined time duration of defrosting a heat exchange path of a greater air quantity longer than the predetermined time duration of defrosting a heat exchange path of lesser air quantity.

[0054] The third heat exchange path 33 (step S6) is defrosted by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 26, similar to the first and second heat exchange paths 31, 32. Specifically, the valves are switched to a state in which the third branching-tube-side heat exchange path selection valve 73c is opened, the first and second branching-tube-side heat exchange path selection valves 73a, 73b are closed, the third header-side heat exchange path selection valve 74c is closed, the first and second header-side heat exchange path selection valves 74a, 74b are opened, and the diverter-tube-side selection valve 75 is closed. Because the second heat exchange path 32 is defrosted until prior to the start of defrosting of the third heat exchange path 33, a switching action is performed for opening the third branching-tube-side heat exchange path selection valve 73c, closing the second branching-tube-side heat exchange path selection valve 73b, opening the second header-side heat exchange path selection valve 74b, and closing the third header-side heat exchange path selection valve 74c. Refrigerant thereby flows to the heat exchange path supply tube 71 and the

third heat exchange path branching tube 72c of the defrosting flow channel mechanism 26.

[0055] In the refrigerant circuit 10 in this state, low-pressure refrigerant in the refrigeration cycle is compressed in the compressor 21 to a high pressure in the refrigeration cycle, similar to the first and second heat exchange paths 31, 32; the refrigerant undergoes heat exchange with indoor air in the indoor heat exchanger 41 and radiates heat, and the refrigerant is depressurized in the expansion valve 24 to an intermediate pressure in the refrigeration cycle and sent to the outdoor heat exchanger 23. The intermediate pressure refrigerant depressurized in the expansion valve 24 is then sent from the liquid refrigerant tube 27 to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is then sent through the third heat exchange path branching tube 72c, the third branching-tube-side heat exchange path selection valve 73c, and the third header communication tube 65c to the gas-side end of the third heat exchange path 33 of the outdoor heat exchanger 23. Thus, all of the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 is sent to the gas-side end of the third heat exchange path 33 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the third heat exchange path 33 passes through the third heat exchange path 33 from the gas-side end of the third heat exchange path 33 toward the liquid-side end, and melts the frost adhering to the third heat exchange path 33 of the outdoor heat exchanger 23. The third heat exchange path 33 of the outdoor heat exchanger 23 is thereby defrosted. The intermediate pressure refrigerant passed through the third heat exchange path 33 is then sent from the liquid-side end of the third heat exchange path 33, through the third capillary tube 63c, to the refrigerant flow diverter 64. At this time, because intermediate pressure refrigerant flows through the third capillary tube 63c at a greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure and the low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is branched to the first and second capillary tubes 63a, 63b and sent to the liquid-side ends of the first and second heat exchange paths 31, 32. At this time, due to passing through the first and second capillary tubes 63a, 63b, the refrigerant is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the liquid-side ends of the first and second heat exchange paths 31, 32 then passes through the first and second heat exchange paths 31, 32 from the liquid-side ends of the first and second heat exchange paths 31, 32 toward the

gas-side ends, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates. The low-pressure refrigerant evaporated in the first and second heat exchange paths 31, 32 then passes from the gas-side ends of the first and second heat exchange paths 31, 32, through the first and second header communication tubes 65a, 65b, the first and second header-side heat exchange path selection valves 74a, 74b, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the third heat exchange path 33 is initiated while the air in the room continues to be warmed. Defrosting of the third heat exchange path 33 is then performed until defrosting of the third heat exchange path 33 is complete (step S7). In this case, defrosting is performed until the third heat exchange path 33 defrosting time duration t3 reaches a predetermined time duration that has been set in advance (i.e. a time at which defrosting of the third heat exchange path 33 can be considered to be complete). Taking into account factors such as the positional relationships of the heat exchange paths 31 to 33 to the outdoor fan 25, the predetermined time duration of defrosting the third heat exchange path 33 is also preferably different from the predetermined time duration of defrosting the other heat exchange paths 31, 32.

[0056] After defrosting of all of the heat exchange paths 31 to 33 of the outdoor heat exchanger 23 has been completed by the processes of steps S2 to S7 described above, the air-warming operation is resumed (step S8).

[0057] As described above, the air-warming defrost operation for evaporating refrigerant sent from the indoor heat exchanger 41 to the outdoor heat exchanger 23 is performed while an arbitrarily selected heat exchange path of the heat exchange paths 31 to 33 is defrosted by the defrosting flow channel mechanism 26. The entire outdoor heat exchanger 23 is defrosted while the air in the room continues to be warmed, by sequentially performing the air-warming defrost operation on the plurality of heat exchange paths 31 to 33.

(Characteristics)

[0058] The air conditioning apparatus 1 of the present embodiment has characteristics such as the following.

[0059] As described above, the air conditioning apparatus 1 is configured by sequentially connecting a compressor 21 for compressing refrigerant, an indoor heat exchanger 41 for radiating the heat of the refrigerant compressed in the compressor 21, and an outdoor heat exchanger 23 for evaporating the refrigerant heat-radiated in the indoor heat exchanger 41 by heat exchange with outdoor air. The air conditioning apparatus 1 is capable of performing an air-warming operation for circulating refrigerant in order through the compressor 21, the indoor heat exchanger 41, the outdoor heat exchanger 23, and the compressor 21. The outdoor heat exchanger 23 has a plurality (three in this case) of heat exchange paths 31

to 33 connected to each other in parallel. The liquid-side ends of the plurality of heat exchange paths 31 to 33 are connected in parallel by a refrigerant flow diverter 64 for branching the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 to the liquid-side ends of the plurality of heat exchange paths 31 to 33.

[0060] The air conditioning apparatus 1 is also provided with a defrosting flow channel mechanism 26 for sending the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 to the gas-side end of an arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33, without channeling the refrigerant into the refrigerant flow diverter 64. In this air conditioning apparatus 1, the defrosting flow channel mechanism 26 performs an air-warming defrost operation for evaporating the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 while defrosting the arbitrarily selected heat exchange path. In the air-warming defrost operation, the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 is not channeled into the refrigerant flow diverter 64 by the defrosting flow channel mechanism 26, but is passed through the arbitrarily selected heat exchange path, from the gas-side end to the liquid-side end of the arbitrarily selected heat exchange path. The refrigerant passed through the arbitrarily selected heat exchange path then flows through the refrigerant flow diverter 64 to be passed through another heat exchange path other than the arbitrarily selected heat exchange path, from the liquid-side end to the gas-side end of the other heat exchange path. In the air conditioning apparatus 1, the entire outdoor heat exchanger 23 can be defrosted by sequentially performing the air-warming defrost operation using the defrosting flow channel mechanism 26 on the plurality of heat exchange paths 31 to 33.

[0061] In the defrosting system of Patent Literature 1, electromagnetic valves are provided to the liquid-side ends of the plurality of heat exchange paths of the outdoor heat exchanger and the electromagnetic valve of the arbitrarily selected heat exchange path is closed, whereby the flow of refrigerant in this heat exchange path is stopped and the arbitrarily selected heat exchange path is defrosted by the heat of the outdoor air. In the defrosting system of Patent Literature 2, a bypass channel is provided for sending some of the refrigerant discharged from the compressor not to the indoor heat exchanger but to the liquid-side ends of the plurality of heat exchange paths of the outdoor heat exchanger, and some of the refrigerant discharged from the compressor is sent through this bypass channel not to the indoor heat exchanger but to the arbitrarily selected heat exchange path of the outdoor heat exchanger, whereby the arbitrarily selected heat exchange path is defrosted by the heat of the refrigerant (see FIG. 9). FIG. 9 is a pressure-enthalpy graph depicting the refrigeration cycle during a conventional (Patent Literature 2) defrost operation.

[0062] In the air-warming defrost operation in the air

conditioning apparatus 1, all of the refrigerant compressed in the compressor 21 is sent to the indoor heat exchanger 41 and used for air warming (see the progression from point B to point C in FIGS. 7 and 8), after which defrosting is performed by the heat of the refrigerant sent to the outdoor heat exchanger 23 from the indoor heat exchanger 41 (see the progression from point D to point E in FIGS. 7 and 8).

[0063] Therefore, in the air conditioning apparatus 1, unlike the defrost system of Patent Literature 2, there is virtually no reduction of air-warming capability because all of the refrigerant compressed in the compressor 21 is supplied for warming the air in the room. Moreover, in the air conditioning apparatus 1, unlike the defrost systems of Patent Literatures 1 and 2, a high defrosting capability can be achieved because all of the refrigerant compressed in the compressor 21 is supplied for defrosting the arbitrarily selected heat exchange path of the outdoor heat exchanger 23. Defrosting can thereby be completed in a shorter amount of time than in the defrost systems of Patent Literatures 1 and 2, the time of performing air warming can be lengthened, and the integral air-warming capability can be increased. Furthermore, in the air conditioning apparatus 1, unlike the defrost system of Patent Literature 1, the outdoor heat exchanger 23 can be defrosted even in weather conditions of an outside air temperature of 0°C or less because the heat of the refrigerant is used for defrosting.

[0064] In the air conditioning apparatus 1, defrosting is performed from the heat exchange path constituting the top part of the outdoor heat exchanger 23 (the first heat exchange path 31 in this case) toward the heat exchange path constituting the bottom part (the third heat exchange path 33 in this case). Therefore, drain water produced by defrosting can be smoothly expelled to the bottom plate 52 of the unit casing 51.

[0065] In the air conditioning apparatus 1, defrosting of the heat exchange paths 31 to 33 constituting the outdoor heat exchanger 23 is performed only for a predetermined time duration which is set in light of the differences in the heat exchange path positions. Taking into account the deviation in the quantities of outdoor air passing through the heat exchange paths 31 to 33 due to the differences in the positions of the heat exchange paths 31 to 33 relative to the outdoor fan 25, the predetermined time duration of defrosting a heat exchange path of greater air quantity is longer than the predetermined time duration of defrosting a heat exchange path of lesser air quantity. Therefore, the predetermined time duration of defrosting a heat exchange path having more frost adhering due to a greater air quantity can be lengthened, the predetermined time duration of defrosting a heat exchange path having less frost adhering due to a lesser air quantity can be shortened, and defrosting can thereby be performed appropriately with an appropriate predetermined time duration taking into account for the differences in the heat exchange path positions.

(Modification 1)

[0066] In the air-warming defrost operation of the embodiment described above, defrosting of the heat exchange paths 31 to 33 was performed until the defrosting time durations t_1 to t_3 reached the predetermined time duration set in advance as shown in steps S3, S5, and S7 of FIG. 6, but such a configuration is not provided by way of limitation to the present invention.

[0067] For example, defrosting of the first heat exchange path 31, which is defrosted first among the plurality (three in this case) of heat exchange paths 31 to 33 constituting the outdoor heat exchanger 23, is performed until the saturation temperature T_{sat} detected by the outdoor heat exchange temperature sensor 67 increases to a predetermined temperature or above (step S11), as shown in FIG. 10. This predetermined temperature is set to a temperature at which the defrosting of the first heat exchange path 31 can be considered to be complete. The defrosting time duration t_1 at this time may be measured, the predetermined time duration of defrosting the second and third heat exchange paths 32, 33 may be set from this defrosting time duration t_1 (step S12), and defrosting the second and third heat exchange paths 32, 33 may be performed only for this set predetermined time duration (steps S5 and S7). At this time, the predetermined time duration for the second and third heat exchange paths 32, 33 may be set to be equal to the defrosting time duration t_1 of the first heat exchange path 31, and it may be set also taking into account the differences in heat exchange path positions. FIG. 10 is a flow-chart of the air-warming defrost operation according to the present modification.

[0068] Thus, the air-warming defrost operation of the present modification differs from the former air-warming defrost operation in which completion of the defrosting of the heat exchange paths is determined over a time duration. Specifically, in the air-warming defrost operation of the present modification, defrosting completion is sensed from a temperature change in the heat exchange path defrosted first, at which time completion of defrosting another heat exchange path is determined depending on a predetermined time duration obtained from the time duration actually required for defrosting.

[0069] Therefore, in the air-warming defrost operation of the present modification, a predetermined time duration for defrosting each heat exchange path is set for each air-warming defrost operation in accordance with the state of frost formation on the outdoor heat exchanger 23. Therefore, in the air-warming defrost operation of the present modification, the predetermined time duration for defrosting each heat exchange path can be set more appropriately for each air-warming defrost operation than in cases in which the heat exchange paths are defrosted until a predetermined time duration set in advance is reached.

(Modification 2)

[0070] In the air conditioning apparatus 1 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 26 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0071] For example, a switching valve 77 may be used in which the branching-tube-side heat exchange path selection valves 73a to 73c are integrated, as shown in FIGS. 11 and 12. The switching valve 77 herein is a switching valve that has a function for selecting either to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the heat exchange path branching tubes 72a to 72c, or not to send the refrigerant to any of the heat exchange path branching tubes 72a to 72c. A rotary switching valve is used herein as the switching valve 77. This switching valve 77 is connected to the heat exchange path supply tube 71 and the heat exchange path branching tubes 72a to 72c. In the configuration of the present modification, the switching valve 77 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c in the control block diagram of FIG. 2. FIG. 11 is a schematic configuration diagram of the air conditioning apparatus 1 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 12 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 1 during the air-warming defrost operation in the present modification.

[0072] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 77 so that refrigerant is not sent to any of the heat exchange path branching tubes 72a to 72c, as shown in FIG. 11. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valve 77 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 77 so that the refrigerant flowing through the heat exchange path supply tube 71 is sent to any one of the heat exchange path branching tubes 72a to 72c, as shown in FIG. 12.

[0073] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 26 can be reduced in comparison to the configuration of the above embodiment and Modification 1.

(Modification 3)

[0074] In the air conditioning apparatus 1 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 26 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0075] For example, a switching valve 78 may be used in which the heat exchange path supply tube 71, the branching-tube-side heat exchange path selection valves 73a to 73c, and the diverter-tube-side selection valve 75 are integrated, as shown in FIGS. 13 and 14. The switching valve 78 herein is a switching valve that has a function for selecting either to channel the refrigerant flowing through the liquid refrigerant tube 27 to the refrigerant flow diverter 64 or to send the refrigerant to any one of the heat exchange path branching tubes 72a to 72c, and for selecting which of the heat exchange path branching tubes 72a to 72c to send the refrigerant when sending the refrigerant to any one of the heat exchange path branching tubes 72a to 72c. A rotary switching valve is used herein as the switching valve 78. This switching valve 78 is connected to the liquid refrigerant tube 27, the refrigerant flow diverter 64, and the heat exchange path branching tubes 72a to 72c. In the configuration of the present modification, the switching valve 78 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c and the diverter-tube-side selection valve 75 in the control block diagram of FIG. 2. FIG. 13 is a schematic configuration diagram of the air conditioning apparatus 1 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 14 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 1 during the air-warming defrost operation in the present modification.

[0076] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 78 so that the refrigerant flowing through the liquid refrigerant tube 27 is channeled to the refrigerant flow diverter 64, as shown in FIG. 13. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valve 78 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 78 so that the refrigerant flowing through the liquid refrigerant tube 27 is sent to any one of the heat exchange path branching tubes 72a to 72c without flowing to the refrigerant flow diverter 64, as shown in FIG. 14.

[0077] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 26 can be reduced in comparison to the configurations of the above embodiment and Modification 1, as well as the configuration of Modification 2.

(Modification 4)

[0078] In the air conditioning apparatus 1 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 26 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0079] For example, a switching valve 79 may be used in which the heat exchange path branching tubes 72a to 72c, the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, and the header 66 are integrated as shown in FIGS. 15 and 16. The switching valve 79 herein is a switching valve that has a function for either selecting to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the header communication tubes 65a to 65c, and connecting the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the heat exchange path supply tube 71 is sent; or selecting to not send the refrigerant to any of the header communication tubes 65a to 65c. A rotary switching valve is used herein as the switching valve 79. This switching valve 79 is connected to the heat exchange path supply tube 71, the header communication tubes 65a to 65c, and the gas refrigerant tube 28. In the configuration of the present modification, the switching valve 79 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c and the header-side heat exchange path selection valves 74a to 74c in the control block diagram of FIG. 2. FIG. 15 is a schematic configuration diagram of the air conditioning apparatus 1 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 16 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 1 during the air-warming defrost operation in the present modification.

[0080] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 79 so that the refrigerant is not sent to any of the header communication tubes 65a to 65c, as shown in FIG. 15. The same air-cooling operation as the above embodiment can also be

performed in the same actuated state of the switching valve 79 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 79 so as to select to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the heat exchange path supply tube 71 is sent, as shown in FIG. 16.

[0081] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 26 can be reduced in comparison to the configurations of the above embodiment and Modification 1, as well as the configurations of Modifications 2 and 3.

(Modification 5)

[0082] In the air conditioning apparatus 1 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 26 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0083] For example, a switching valve 80 may be used in which the heat exchange path supply tube 71, the heat exchange path branching tubes 72a to 72c, the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, the diverter-tube-side selection valve 75, and the header 66 are integrated as shown in FIGS. 17 and 18. The switching valve 80 herein is a switching valve that has a function for selecting either to channel the refrigerant flowing through the liquid refrigerant tube 27 to the refrigerant flow diverter 64 or to send the refrigerant to any one of the header communication tubes 65a to 65c, and connecting the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the liquid refrigerant tube 27 is sent. A rotary switching valve is used herein as the switching valve 80. This switching valve 80 is connected to the liquid refrigerant tube 27, the refrigerant flow diverter 64, the header communication tubes 65a to 65c, and the gas refrigerant tube 28. In the configuration of the present modification, the switching valve 80 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, and the diverter-tube-side selection valve 75 in the control block diagram of FIG. 2. FIG. 17 is a schematic configuration diagram

of the air conditioning apparatus 1 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 18 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 1 during the air-warming defrost operation in the present modification.

[0084] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 80 so that the refrigerant flowing through the liquid refrigerant tube 27 flows to the refrigerant flow diverter 64, as shown in FIG. 17. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valve 80 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 80 so as to select to send the refrigerant flowing through the liquid refrigerant tube 27 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the liquid refrigerant tube 27 is sent, as shown in FIG. 18.

[0085] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 26 can be reduced in comparison to the configurations of the above embodiment and Modification 1, as well as the configurations of Modifications 2 through 4.

(Modification 6)

[0086] In the air conditioning apparatus 1 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 26 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0087] For example, switching valves 81a to 81c may be used in which the branching-tube-side heat exchange path selection valves 73a to 73c and the header-side heat exchange path selection valves 74a to 74c are integrated as shown in FIGS. 19 and 20. The switching valves 81a to 81c herein are switching valves that have a function for selecting either to send the refrigerant flowing through the heat exchange path supply tube 71 from the gas-side ends of the heat exchange paths 31 to 33 toward the liquid-side ends, or to send the refrigerant passing through the refrigerant flow diverter 64 from the liquid-side ends of the heat exchange paths 31 to 33 toward the gas-side ends to the header 66. Three-way valves are used herein as the switching valves 81a to

81c. These switching valves 81a to 81c are connected to the heat exchange path branching tubes 72a to 72c and the header communication tubes 65a to 65c. In the configuration of the present modification, the switching valves 81a to 81c are connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c and the header-side heat exchange path selection valves 74a to 74c in the control block diagram of FIG. 2. FIG. 19 is a schematic configuration diagram of the air conditioning apparatus 1 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 1 during the air-warming operation. FIG. 20 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 1 during the air-warming defrost operation in the present modification.

[0088] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valves 81a to 81c so that the refrigerant passing through the refrigerant flow diverter 64 from the liquid-side ends of the heat exchange paths 31 to 33 toward the gas-side ends is sent to the header 66, as shown in FIG. 19. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valves 81a to 81c as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating any one of the switching valves 81a to 81c so as to send the refrigerant flowing through the heat exchange path supply tube 71 from the gas-side ends of the heat exchange paths 31 to 33 toward the liquid-side ends, and activating the other switching valves so as to send the refrigerant passing through the refrigerant flow diverter 64 from the liquid-side ends of the heat exchange paths 31 to 33 toward the gas-side ends to the header 66, as shown in FIG. 20.

[0089] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 26 can be reduced in comparison to the configurations of the above embodiment and Modification 1.

<Second Embodiment>

[0090] In the above embodiment and the modifications thereof, the configuration of the air-warming defrost operation according to the present invention was applied to an outdoor heat exchanger 23 having a plurality of heat exchange paths 31 to 33 connected to each other in parallel, but such a configuration is not provided by way of limitation to the present invention. The configuration of the air-warming defrost operation according to the present invention may be applied herein to an outdoor heat exchanger 123 having not only the plurality of heat exchange paths 31 to 33, but also a subcooling path 34 through which refrigerant passes before flowing into the

refrigerant flow diverter 64.

[0091] FIG. 21 is a schematic configuration diagram of the air conditioning apparatus 101 according to the second embodiment of the present invention. The air conditioning apparatus 101 has primarily an outdoor unit 102, an indoor unit 4, and a liquid refrigerant communication tube 5 and a gas refrigerant communication tube 6 connecting the outdoor unit 102 and the indoor unit 4. By being connected via the liquid refrigerant communication tube 5 and the gas refrigerant communication tube 6, the outdoor unit 102 and the indoor unit 4 constitute a refrigerant circuit 110 for performing a vapor compression type refrigeration cycle.

(Indoor unit)

[0092] The indoor unit 4, which is installed indoors, constitutes part of the refrigerant circuit 110. The indoor unit 4 has primarily an indoor heat exchanger 41. The configuration of the indoor unit 4 is identical to the configuration of the indoor unit 4 of the first embodiment and is therefore not described herein.

(Outdoor unit)

[0093] The outdoor unit 102, which is installed outdoors, constitutes part of the refrigerant circuit 110. The outdoor unit 102 has primarily a compressor 21, a four-way switching valve 22, an outdoor heat exchanger 123, an expansion valve 24, an outdoor fan 25, and a defrosting flow channel mechanism 126. The configuration of the outdoor unit 102 is identical to the configuration of the outdoor unit 2 of the first embodiment except for the configurations of the outdoor heat exchanger 123 and the defrosting flow channel mechanism 126, and the configurations of the outdoor heat exchanger 123 and the defrosting flow channel mechanism 126 are therefore described in detail herein.

[0094] The outdoor heat exchanger 123 is a heat exchanger which functions as a heat radiator of refrigerant during the air-cooling operation and functions as an evaporator of refrigerant during the air-warming operation. The outdoor heat exchanger 123 herein is a cross fin type fin-and-tube heat exchanger configured from a heat transfer tube and numerous fins. The liquid side of the outdoor heat exchanger 123 is connected to the expansion valve 24 via a liquid refrigerant tube 27, and the gas side is connected to the four-way switching valve 22 via a gas refrigerant tube 28.

[0095] More specifically, the outdoor heat exchanger 123 has numerous fins 61, and numerous heat transfer tubes 62 attached in a state of passing through the fins 61 in the plate thickness direction (see FIG. 2), similar to the outdoor heat exchanger 23 of the first embodiment. In this outdoor heat exchanger 123, the heat transfer tubes 62 are assorted in a plural system (four in this case) in the up-down direction, forming a first heat exchange path 31, a second heat exchange path 32, and a third

heat exchange path 33 which are independent of each other, as well as the subcooling path 34 shared by the first through third heat exchange paths 31 to 33, as shown in FIG. 22. FIG. 22 is a diagram schematically depicting the outdoor heat exchanger 123 and the surrounding structure. The liquid-side ends of the first through third heat exchange paths 31 to 33 are connected to a refrigerant flow diverter 64 via first through third capillary tubes 63a to 63c, respectively. The refrigerant flow diverter 64 is a tube member for converging the first through third capillary tubes 63a to 63c connected to the liquid-side ends of the first through third heat exchange paths 31 to 33, and the refrigerant flow diverter 64 is connected to a subcooling path-heat exchange path communication tube 35. The gas-side ends of the first through third heat exchange paths 31 to 33 are connected to a header 66 via first through third header communication tubes 65a to 65c, respectively. The header 66 is a tube member for converging the first through third header communication tubes 65a to 65c connected to the gas-side ends of the first through third heat exchange paths 31 to 33, and the header 66 is connected to the gas refrigerant tube 28. The subcooling path 34 is connected to all of the liquid-side ends of the first through third heat exchange paths 31 to 33. The liquid-side end of the subcooling path 34 is connected to the liquid refrigerant tube 27. The gas-side end of the subcooling path 34 is connected to the subcooling path-heat exchange path communication tube 35. Thus, the plurality (three in this case) of heat exchange paths 31 to 33 constituting the outdoor heat exchanger 123 are connected in parallel to each other via the refrigerant flow diverter 64 and the header 66. The subcooling path 34 constituting the outdoor heat exchanger 123 is connected to the liquid-side ends of the heat exchange paths 31 to 33 via the refrigerant flow diverter 64 and the subcooling path-heat exchange path communication tube 35. During the air-cooling operation, all of the heat exchange paths 31 to 33 function as heat radiators of refrigerant and the subcooling path 34 functions as a subcooler of refrigerant heat-radiated in the heat exchange paths 31 to 33. During the air-warming operation, the subcooling path 34 functions as a heat radiator of intermediate pressure refrigerant that has passed through the expansion valve 24, preventing frost from forming in the lowest part of the outdoor heat exchanger 123, and all of the heat exchange paths 31 to 33 function as evaporators of refrigerant.

[0096] The defrosting flow channel mechanism 126 is a mechanism for sending the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 to the gas-side end of an arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33, without channeling the refrigerant to the refrigerant flow diverter 64, after the refrigerant has been passed through the subcooling path 34. The defrosting flow channel mechanism 126 is provided in order to perform an air-warming defrost operation, described hereinafter. The air-warming defrost operation is an operation for

evaporating the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 while defrosting the arbitrarily selected heat exchange path of the heat exchange paths 31 to 33 constituting the outdoor heat exchanger 123. The defrosting flow channel mechanism 126 has primarily a heat exchange path supply tube 71, a plurality (three in this case) of heat exchange path branching tubes 72a to 72c, a plurality (three in this case) of branching-tube-side heat exchange path selection valves 73a to 73c, a plurality (three in this case) of header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75.

[0097] The heat exchange path supply tube 71 is a refrigerant tube for causing the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 to branch from the subcooling path-heat exchange path communication tube 35, after the refrigerant has passed through the subcooling path 34 and before the refrigerant flows into the refrigerant flow diverter 64. One end of the heat exchange path supply tube 71 is connected to the portion of the subcooling path-heat exchange path communication tube 35 that is between the gas-side end of the subcooling path 34 and the refrigerant flow diverter 64, and the other end is connected to the heat exchange path branching tubes 72a to 72c.

[0098] The first through third heat exchange path branching tubes 72a to 72c are refrigerant tubes for supplying the refrigerant flowing through the heat exchange path supply tube 71 to the gas-side ends of the first through third heat exchange paths 31 to 33. The first through third heat exchange path branching tubes 72a to 72c are connected at one end to the heat exchange path supply tube 71, and connected at the other end to the first through third header communication tubes 65a to 65c, respectively.

[0099] The first through third branching-tube-side heat exchange path selection valves 73a to 73c, together with the first through third header-side heat exchange path selection valves 74a to 74c, are electromagnetic valves for selecting which heat exchange path gas-side end of the heat exchange paths 31 to 33 the refrigerant flowing through the heat exchange path supply tube 71 will be sent to. The first through third branching-tube-side heat exchange path selection valves 73a to 73c are provided to the first through third heat exchange path branching tubes 72a to 72c, respectively. The first through third branching-tube-side heat exchange path selection valves 73a to 73c are all designed to be closed during both the air-cooling operation and the air-warming operation. During the air-warming defrost operation, of the first through third branching-tube-side heat exchange path selection valves 73a to 73c, the branching-tube-side heat exchange path selection valve corresponding to the heat exchange path being defrosted is opened, while the branching-tube-side heat exchange path selection valves corresponding to the other heat exchange paths are closed.

[0100] The first through third header-side heat ex-

change path selection valves 74a to 74c, together with the first through third branching-tube-side heat exchange path selection valves 73a to 73c, are electromagnetic valves for selecting which heat exchange path gas-side end of the heat exchange paths 31 to 33 the refrigerant flowing through the heat exchange path supply tube 71 will be sent to. The first through third header-side heat exchange path selection valves 74a to 74c are provided to respective portions of the first through third header communication tubes 65a to 65c that are between the header 66 and the positions where the other ends of the first through third heat exchange path branching tubes 72a to 72c are connected. The first through third header-side heat exchange path selection valves 74a to 74c are all designed to be open during both the air-cooling operation and the air-warming operation. During the air-warming defrost operation, of the first through third header-side heat exchange path selection valves 74a to 74c, the header-side heat exchange path selection valve corresponding to the heat exchange path being defrosted is closed, while the header-side heat exchange path selection valves corresponding to the other heat exchange paths are open.

[0101] The diverter-tube-side selection valve 75 is an electromagnetic valve for selecting whether or not the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 will be made to branch from the subcooling path-heat exchange path communication tube 35 after passing through the subcooling path 34 and before flowing into the refrigerant flow diverter 64. The diverter-tube-side selection valve 75 is provided to a portion in the subcooling path-heat exchange path communication tube 35 that is between the refrigerant flow diverter 64 and the position where the heat exchange path supply tube 71 branches. The diverter-tube-side selection valve 75 is designed so as to be open during both the air-cooling operation and the air-warming operation. The diverter-tube-side selection valve 75 is also designed so as to be closed during the air-warming defrost operation.

(Action)

[0102] Next is a description of the action of the air conditioning apparatus 101 having the configuration described above. The controls of the various instruments, the various processes, and the like needed to perform the following action are performed by the controller 8, similar to the air conditioning apparatus 1 of the first embodiment.

[0103] The operations of the air conditioning apparatus 101 include the air-cooling operation for cooling the air in the room, the air-warming operation for only warming the air in the room, and the air-warming defrost operation for both defrosting the outdoor heat exchanger 123 and warming the air in the room. The actions during these operations are described below using FIGS. 23, 6, 24, and 25. FIG. 23 is a diagram showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 24 is a diagram showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming defrost operation (when the first heat exchange path 31 is being defrosted). FIG. 25 is pressure-enthalpy graph depicting the refrigeration cycle during the air-warming defrost operation.

erant in the air conditioning apparatus 101 during the air-warming operation. FIG. 24 is a diagram showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming defrost operation (when the first heat exchange path 31 is being defrosted). FIG. 25 is pressure-enthalpy graph depicting the refrigeration cycle during the air-warming defrost operation.

-Air-cooling operation-

[0104] The air-cooling operation is an operation for circulating refrigerant in order through the compressor 21, the outdoor heat exchanger 123, the indoor heat exchanger 41, and the compressor 21. In the air-cooling operation, the outdoor heat exchanger 123 functions as a heat radiator of refrigerant and the indoor heat exchanger 41 functions as an evaporator of refrigerant, thereby cooling the indoor air.

[0105] In the air-cooling operation, the four-way switching valve 22 is switched so as to create a state in which the outdoor heat exchanger 123 functions as a heat radiator of refrigerant and the indoor heat exchanger 41 functions as an evaporator of refrigerant (i.e. the state shown by the solid lines of the four-way switching valve 22 in FIG. 21). This is also a state in which the first through third branching-tube-side heat exchange path selection valves 73a to 73c are all closed, the first through third header-side heat exchange path selection valves 74a to 74c are all open, and the diverter-tube-side selection valve 75 is open. Specifically, this is a state in which refrigerant does not flow to the heat exchange path supply tube 71 and the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 126.

[0106] In the refrigerant circuit 110 in this state, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 to the outdoor heat exchanger 123. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22, the gas refrigerant tube 28, the header 66, the header communication tubes 65a to 65c, and the header-side heat exchange path selection valves 74a to 74c to the gas-side ends of the heat exchange paths 31 to 33 of the outdoor heat exchanger 123. The high-pressure refrigerant sent to the gas-side ends of the heat exchange paths 31 to 33 undergoes heat exchange in the heat exchange paths 31 to 33 with the outdoor air supplied by the outdoor fan 25, and the refrigerant radiates heat. The high-pressure refrigerant that has radiated heat in the heat exchange paths 31 to 33 is sent from the liquid-side ends of the heat exchange paths 31 to 33 through the capillary tubes 63a to 63c, the refrigerant flow diverter 64, the subcooling path-heat ex-

change path communication tube 35, and the diverter-tube-side selection valve 75 to the gas-side end of the subcooling path 34 of the outdoor heat exchanger 123. The high-pressure refrigerant sent to the gas-side end of the subcooling path 34 undergoes heat exchange in the subcooling path 34 with the outdoor air supplied by the outdoor fan 25, and the refrigerant radiates more heat. The high-pressure refrigerant subcooled in the subcooling path 34 is sent through the liquid refrigerant tube 27 to the expansion valve 24. The refrigerant sent to the expansion valve 24 is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant depressurized in the expansion valve 24 is sent through the liquid refrigerant communication tube 5 to the indoor heat exchanger 41. The low-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with the indoor air in the indoor heat exchanger 41, and the refrigerant evaporates. The low-pressure refrigerant evaporated in the indoor heat exchanger 41 is drawn through the gas refrigerant communication tube 6 and the four-way switching valve 22 back into the compressor 21.

-Air-warming operation-

[0107] The air-warming operation is an operation for circulating refrigerant in order through the compressor 21, the indoor heat exchanger 41, the outdoor heat exchanger 123, and the compressor 21. In the air-warming operation, the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 123 functions as an evaporator of refrigerant, thereby heating the indoor air.

[0108] In the air-warming operation, the four-way switching valve 22 is switched so as to create a state in which the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 123 functions as an evaporator of refrigerant (i.e. the state shown by the dashed lines of the four-way switching valve 22 in FIGS. 21 and 23). This is also a state in which the first through third branching-tube-side heat exchange path selection valves 73a to 73c are all closed, the first through third header-side heat exchange path selection valves 74a to 74c are all open, and the diverter-tube-side selection valve 75 is open. Specifically, this is a state in which refrigerant does not flow to the heat exchange path supply tube 71 and the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 126.

[0109] In the refrigerant circuit 110 in this state, low-pressure refrigerant in the refrigeration cycle is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged. The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 and through the gas refrigerant communication tube 6 to the indoor heat exchanger 41. The high-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat

exchange with the indoor air in the indoor heat exchanger 41, and the refrigerant radiates heat. The high-pressure refrigerant that has radiated heat in the indoor heat exchanger 41 is sent through the liquid refrigerant communication tube 5 to the expansion valve 24 and depressurized to an intermediate pressure in the refrigeration cycle. The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent to the outdoor heat exchanger 123. The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent through the liquid refrigerant tube 27 to the liquid-side end of the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant sent to the liquid-side end of the subcooling path 34 undergoes heat exchange in the subcooling path 34 with outdoor air supplied by the outdoor fan 25 and radiates heat, thereby preventing frost from forming in the lowest part of the outdoor heat exchanger 123. The low-pressure refrigerant heat-radiated in the subcooling path 34 is sent from the gas-side end of the subcooling path 34, through the subcooling path-heat exchange path communication tube 35, the diverter-tube-side selection valve 75, the refrigerant flow diverter 64, and the capillary tubes 63a to 63c, to the liquid-side ends of the heat exchange paths 31 to 33 of the outdoor heat exchanger 123. The low-pressure refrigerant sent to the liquid-side ends of the heat exchange paths 31 to 33 undergoes heat exchange with the outdoor air supplied by the outdoor fan 25 in the heat exchange paths 31 to 33, and the refrigerant evaporates. The low-pressure refrigerant evaporated in the heat exchange paths 31 to 33 is drawn from the gas-side ends of the heat exchange paths 31 to 33, through the header communication tubes 65a to 65c, the header-side heat exchange path selection valves 74a to 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, back into the compressor 21.

-Air-warming defrost operation-

[0110] The air-warming defrost operation is an operation in which the outdoor heat exchanger 123 is defrosted by the defrosting flow channel mechanism 126 while an operation is performed for circulating refrigerant in order through the compressor 21, the indoor heat exchanger 41, the outdoor heat exchanger 123, and the compressor 21, similar to the air-warming operation. In the air-warming defrost operation, the indoor heat exchanger 41 functions as a heat radiator of refrigerant, any one of the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 123 functions as a heat radiator of refrigerant, and the remaining heat exchange paths 31 to 33 function as evaporators of refrigerant. The indoor air is thereby heated while the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 123 are sequentially defrosted.

[0111] The switched state of the four-way switching valve 22 in the air-warming defrost operation is the same as during the air-warming operation. Specifically, the

four-way switching valve 22 goes into a state in which the indoor heat exchanger 41 functions as a heat radiator of refrigerant and the outdoor heat exchanger 123 functions as an evaporator of refrigerant (i.e. the state shown by the dashed lines of the four-way switching valve 22 in FIGS. 21 and 24). To sequentially defrost the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 123, the selection valves 73a to 73c, 74a to 74c, and 75 are switched to different opened and closed states from the states during the air-cooling operation and during the air-warming operation. Specifically, the state in the air-warming defrost operation is such that refrigerant flows to the heat exchange path supply tube 71 and the first through third heat exchange path branching tubes 72a to 72c of the defrosting flow channel mechanism 126. The action during the air-warming defrost operation is described below in detail, including the procedure from the start to the end of the air-warming defrost operation. First, in step S1, a determination is made as to whether or not the amount of frost formed in the outdoor heat exchanger 123 has been increased by the air-warming operation and defrosting is required. This determination of whether or not defrosting is required is identical to step S1 of the air-warming defrost operation of the first embodiment, and is therefore not described herein.

[0112] Next, in steps S2 to S7, the first through third heat exchange paths 31 to 33 of the outdoor heat exchanger 123 are sequentially defrosted. Defrosting of the first through third heat exchange paths 31 to 33 may essentially be arbitrarily selected, but taking into account the flow of drain water produced by defrosting and expelled to the bottom plate 52 of the unit casing 51, defrosting is preferably performed from the top of the outdoor heat exchanger 123 toward the bottom. Therefore, defrosting herein is performed in order of the first heat exchange path 31, the second heat exchange path 32, and the third heat exchange path 33.

[0113] Defrosting of the first heat exchange path 31 (step S2) is performed by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 126. Specifically, the valves are switched to a state in which the first branching-tube-side heat exchange path selection valve 73a is opened, the second and third branching-tube-side heat exchange path selection valves 73b, 73c are closed, the first header-side heat exchange path selection valve 74a is closed, the second and third header-side heat exchange path selection valves 74b, 74c are opened, and the diverter-tube-side selection valve 75 is closed. Because the air-warming operation is performed until prior to the start of the defrosting of the first heat exchange path 31, a switching action is performed for opening the first branching-tube-side heat exchange path selection valve 73a, closing the first header-side heat exchange path selection valve 74a, and closing the diverter-tube-side selection valve 75. Refrigerant thereby flows to the heat exchange path supply tube 71 and the first heat exchange path branching tube

72a of the defrosting flow channel mechanism 126.

[0114] In the refrigerant circuit 110 in this state, low-pressure refrigerant in the refrigeration cycle (see point A in FIGS. 24 and 25) is drawn into the compressor 21, compressed to a high pressure in the refrigeration cycle, and then discharged (see point B in FIGS. 24 and 25). The high-pressure refrigerant discharged from the compressor 21 is sent through the four-way switching valve 22 and through the gas refrigerant communication tube 6 to the indoor heat exchanger 41. The high-pressure refrigerant sent to the indoor heat exchanger 41 undergoes heat exchange with indoor air in the indoor heat exchanger 41, and the refrigerant radiates heat (see point C in FIGS. 24 and 25). So far the process has been identical to the air-warming operation. The high-pressure refrigerant heat-radiated in the indoor heat exchanger 41 is sent through the liquid refrigerant communication tube 5 to the expansion valve 24, and depressurized to a pressure between the high pressure and low pressure in the refrigeration cycle (referred to below as the intermediate pressure) (see point D in FIGS. 24 and 25). The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent to the outdoor heat exchanger 123. The intermediate pressure refrigerant depressurized in the expansion valve 24 is sent from the liquid refrigerant tube 27 to the liquid-side end of the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant sent to the liquid-side end of the subcooling path 34 heats the drain water that has melted due to the defrosting of the first heat exchange path 31 and flowed down to the lowest part of the outdoor heat exchanger 123 in the subcooling path 34, thereby preventing the drain water from refreezing as a result of the low temperature of the bottom plate 52 functioning as a drain pan (see point D' in FIGS. 24 and 25). Drain water refreezing prevention is thereby performed in the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant passed through the subcooling path 34 is then sent from the gas-side end of the subcooling path 34, through the subcooling path-heat exchange path communication tube 35, to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is sent through the first heat exchange path branching tube 72a, the first branching-tube-side heat exchange path selection valve 73a, and the first header communication tube 65a to the gas-side end of the first heat exchange path 31 of the outdoor heat exchanger 123. Thus, all of the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 is sent to the gas-side end of the first heat exchange path 31 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the first heat exchange path 31 passes through the first heat exchange path 31 from the gas-side end toward the liquid-side end of the first heat exchange path 31, and melts the frost adhering to the first heat exchange path 31 of the outdoor heat exchanger 123 (see point E in FIGS. 24

and 25). The first heat exchange path 31 of the outdoor heat exchanger 123 is thereby defrosted. The intermediate pressure refrigerant passing through the first heat exchange path 31 is then sent from the liquid-side end of the first heat exchange path 31, through the first capillary tube 63a, to the refrigerant flow diverter 64. At this time, because intermediate pressure refrigerant flows through the first capillary tube 63a at a greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure (i.e. the pressure at point E in FIGS. 24 and 25) and the low pressure in the refrigeration cycle (see point F in FIGS. 24 and 25). The low pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is branched to the second and third capillary tubes 63b, 63c and sent to the liquid-side ends of the second and third heat exchange paths 32, 33. At this time, due to passing through the second and third capillary tubes 63b, 63c, the refrigerant is depressurized to a low pressure in the refrigeration cycle (see point G in FIGS. 24 and 25). The low-pressure refrigerant sent to the liquid-side ends of the second and third heat exchange paths 32, 33 then passes through the second and third heat exchange paths 32, 33 from the liquid-side ends toward the gas-side ends of the second and third heat exchange paths 32, 33, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates (see point A in FIGS. 24 and 25). The low-pressure refrigerant evaporated in the second and third heat exchange paths 32, 33 then passes from the gas-side ends of the second and third heat exchange paths 32, 33, through the second and third header communication tubes 65b, 65c, the second and third header-side heat exchange path selection valves 74b, 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the first heat exchange path 31 is initiated while the air in the room continues to be warmed. Defrosting of the first heat exchange path 31 is then performed until defrosting of the first heat exchange path 31 is complete (step S3).

[0115] The second heat exchange path 32 is defrosted (step S4) by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 126, similar to the defrosting of the first heat exchange path 31. Specifically, the valves are switched to a state in which the second branching-tube-side heat exchange path selection valve 73b is opened, the first and third branching-tube-side heat exchange path selection valves 73a, 73c are closed, the second header-side heat exchange path selection valve 74b is closed, the first and third header-side heat exchange path selection valves 74a, 74c are opened, and the diverter-tube-side selection valve 75 is

closed. Because the first heat exchange path 31 is defrosted until prior to the start of defrosting of the second heat exchange path 32, a switching action is performed for opening the second branching-tube-side heat exchange path selection valve 73b, closing the first branching-tube-side heat exchange path selection valve 73a, opening the first header-side heat exchange path selection valve 74a, and closing the second header-side heat exchange path selection valve 74b. Refrigerant thereby flows to the heat exchange path supply tube 71 and the second heat exchange path branching tube 72b of the defrosting flow channel mechanism 126.

[0116] In the refrigerant circuit 110 in this state, low-pressure refrigerant in the refrigeration cycle is compressed in the compressor 21 to a high pressure in the refrigeration cycle, similar to the defrosting of the first heat exchange path 31; the refrigerant undergoes heat exchange with indoor air in the indoor heat exchanger 41 and radiates heat, and the refrigerant is depressurized in the expansion valve 24 to an intermediate pressure in the refrigeration cycle and sent to the outdoor heat exchanger 123. The intermediate pressure refrigerant depressurized in the expansion valve 24 is then sent from the liquid refrigerant tube 27 to the liquid-side end of the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant sent to the liquid-side end of the subcooling path 34 heats the drain water that has melted due to the defrosting of the second heat exchange path 32 and flowed down to the lowest part of the outdoor heat exchanger 123 in the subcooling path 34, thereby preventing the drain water from refreezing as a result of the low temperature of the bottom plate 52 functioning as a drain pan. Drain water refreezing prevention is thereby performed in the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant passed through the subcooling path 34 is then sent from the gas-side end of the subcooling path 34, through the subcooling path-heat exchange path communication tube 35, to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is sent through the second heat exchange path branching tube 72b, the second branching-tube-side heat exchange path selection valve 73b, and the second header communication tube 65b to the gas-side end of the second heat exchange path 32 of the outdoor heat exchanger 123. Thus, all of the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 is sent to the gas-side end of the second heat exchange path 32 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the second heat exchange path 32 passes through the second heat exchange path 32 from the gas-side end of the second heat exchange path 32 toward the liquid-side end, and melts the frost adhering to the second heat exchange path 32 of the outdoor heat exchanger 123. The second heat exchange path 32 of the outdoor heat exchanger 123 is thereby defrosted. The intermediate pressure re-

refrigerant passed through the second heat exchange path 32 is then sent from the liquid-side end of the second heat exchange path 32, through the second capillary tube 63b, to the refrigerant flow diverter 64. At this time, because intermediate pressure refrigerant flows through the second capillary tube 63b at a greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure and the low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is branched to the first and third capillary tubes 63a, 63c and sent to the liquid-side ends of the heat exchange paths 31, 33. At this time, due to passing through the first and third capillary tubes 63a, 63c, the refrigerant is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the liquid-side ends of the heat exchange paths 31, 33 then passes through the heat exchange paths 31, 33 from the liquid-side ends of the heat exchange paths 31, 33 toward the gas-side ends, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates. The low-pressure refrigerant evaporated in the heat exchange paths 31, 33 then passes from the gas-side ends of the heat exchange paths 31, 33, through the first and third header communication tubes 65a, 65c, the first and third header-side heat exchange path selection valves 74a, 74c, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the second heat exchange path 32 is initiated while the air in the room continues to be warmed. Defrosting of the second heat exchange path 32 is then performed until defrosting of the second heat exchange path 32 is complete (step S5).

[0117] The third heat exchange path 33 (step S6) is defrosted by switching the opened and closed states of the selection valves 73a to 73c, 74a to 74c, and 75 of the defrosting flow channel mechanism 126, similar to the defrosting of the first and second heat exchange paths 31, 32. Specifically, the valves are switched to a state in which the third branching-tube-side heat exchange path selection valve 73c is opened, the first and second branching-tube-side heat exchange path selection valves 73a, 73b are closed, the third header-side heat exchange path selection valve 74c is closed, the first and second header-side heat exchange path selection valves 74a, 74b are opened, and the diverter-tube-side selection valve 75 is closed. Because the second heat exchange path 32 is defrosted until prior to the start of defrosting of the third heat exchange path 33, a switching action is performed for opening the third branching-tube-side heat exchange path selection valve 73c, closing the second branching-tube-side heat exchange path

selection valve 73b, opening the second header-side heat exchange path selection valve 74b, and closing the third header-side heat exchange path selection valve 74c. Refrigerant thereby flows to the heat exchange path supply tube 71 and the third heat exchange path branching tube 72c of the defrosting flow channel mechanism 126.

[0118] In the refrigerant circuit 110 in this state, low-pressure refrigerant in the refrigeration cycle is compressed in the compressor 21 to a high pressure in the refrigeration cycle, similar to the defrosting of the first and second heat exchange paths 31, 32; the refrigerant undergoes heat exchange with indoor air in the indoor heat exchanger 41 and radiates heat, and the refrigerant is depressurized in the expansion valve 24 to an intermediate pressure in the refrigeration cycle and sent to the outdoor heat exchanger 123. The intermediate pressure refrigerant depressurized in the expansion valve 24 is then sent from the liquid refrigerant tube 27 to the liquid-side end of the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant sent to the liquid-side end of the subcooling path 34 heats the drain water that has melted due to the defrosting of the third heat exchange path 33 and flowed down to the lowest part of the outdoor heat exchanger 123 in the subcooling path 34, thereby preventing the drain water from refreezing as a result of the low temperature of the bottom plate 52 functioning as a drain pan. Drain water refreezing prevention is thereby performed in the subcooling path 34 of the outdoor heat exchanger 123. The intermediate pressure refrigerant passed through the subcooling path 34 is then sent from the gas-side end of the subcooling path 34, through the subcooling path-heat exchange path communication tube 35, to the heat exchange path supply tube 71. The intermediate pressure refrigerant sent to the heat exchange path supply tube 71 is then sent through the third heat exchange path branching tube 72c, the third branching-tube-side heat exchange path selection valve 73c, and the third header communication tube 65c to the gas-side end of the third heat exchange path 33 of the outdoor heat exchanger 123. Thus, all of the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 is sent to the gas-side end of the third heat exchange path 33 without flowing into the refrigerant flow diverter 64. The intermediate pressure refrigerant sent to the gas-side end of the third heat exchange path 33 passes through the third heat exchange path 33 from the gas-side end of the third heat exchange path 33 toward the liquid-side end, and melts the frost adhering to the third heat exchange path 33 of the outdoor heat exchanger 123. The third heat exchange path 33 of the outdoor heat exchanger 123 is thereby defrosted. The intermediate pressure refrigerant passed through the third heat exchange path 33 is then sent from the liquid-side end of the third heat exchange path 33, through the third capillary tube 63c, to the refrigerant flow diverter 64. At this time, because intermediate pressure refrigerant flows through the third capillary tube 63c at a

greater flow rate than during the air-cooling operation or the air-warming operation, pressure loss is greater than that of refrigerant flow during the air-cooling operation or the air-warming operation, and the refrigerant is depressurized to a pressure between the intermediate pressure and the low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the refrigerant flow diverter 64 is then passed through the refrigerant flow diverter 64 so as to turn back because the diverter-tube-side selection valve 75 is closed, and the refrigerant is branched to the first and second capillary tubes 63a, 63b and sent to the liquid-side ends of the first and second heat exchange paths 31, 32. At this time, due to passing through the first and second capillary tubes 63a, 63b, the refrigerant is depressurized to a low pressure in the refrigeration cycle. The low-pressure refrigerant sent to the liquid-side ends of the first and second heat exchange paths 31, 32 then passes through the first and second heat exchange paths 31, 32 from the liquid-side ends of the first and second heat exchange paths 31, 32 toward the gas-side ends, undergoes heat exchange with the outdoor air supplied by the outdoor fan 25, and evaporates. The low-pressure refrigerant evaporated in the first and second heat exchange paths 31, 32 then passes from the gas-side ends of the first and second heat exchange paths 31, 32, through the first and second header communication tubes 65a, 65b, the first and second header-side heat exchange path selection valves 74a, 74b, the header 66, the gas refrigerant tube 28, and the four-way switching valve 22, to be drawn back into the compressor 21. Thus, defrosting of the third heat exchange path 33 is initiated while the air in the room continues to be warmed. Defrosting of the third heat exchange path 33 is then performed until defrosting of the third heat exchange path 33 is complete (step S7).

[0119] After defrosting of all of the heat exchange paths 31 to 33 of the outdoor heat exchanger 123 has been completed by the processes of steps S2 to S7 described above, the air-warming operation is resumed (step S8).

[0120] As described above, the air-warming defrost operation for evaporating refrigerant sent from the indoor heat exchanger 41 to the outdoor heat exchanger 123 is performed while an arbitrarily selected heat exchange path of the heat exchange paths 31 to 33 is defrosted by the defrosting flow channel mechanism 126. The entire outdoor heat exchanger 123 is defrosted while the air in the room continues to be warmed, by sequentially performing the air-warming defrost operation on the plurality of heat exchange paths 31 to 33. Moreover, because refrigerant can be passed through the subcooling path 34 during the air-warming defrost operation as well, drain water that has melted due to the defrosting of the heat exchange paths 31 to 33 and flowed down to the lowest part of the outdoor heat exchanger 123 is heated, and the drain water is thereby prevented from refreezing as a result of the low temperature of the bottom plate 52 functioning as a drain pan.

(Characteristics)

[0121] In the air conditioning apparatus 101 of the present embodiment, similar to the air conditioning apparatus 1 of the first embodiment, all of the refrigerant compressed in the compressor 21 is sent to the indoor heat exchanger 41 and used for air warming (see the progression from point B to point C in FIGS. 24 and 25), after which defrosting is performed by the heat of the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 (see the progression from point D to point E in FIGS. 24 and 25). Therefore, in the air-warming defrost operation of the air conditioning apparatus 101, the outdoor heat exchanger 123 can be defrosted with virtually no reduction of air-warming capability.

[0122] Moreover, because refrigerant can be passed through the subcooling path 34 during the air-warming defrost operation as well in the air conditioning apparatus 101, the drain water produced by defrosting the heat exchange paths 31 to 33 can be prevented from refreezing and can be quickly expelled from the bottom of the outdoor heat exchanger 123.

(Modification 1)

[0123] The same air-warming defrost operation as in Modification 1 of the first embodiment (see FIG. 10) may be performed in the air-warming defrost operation of the above embodiment as well.

(Modification 2)

[0124] In the air conditioning apparatus 101 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 126 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0125] For example, a switching valve 82 may be used in which the heat exchange path branching tubes 72a to 72c, the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, and the header 66 are integrated, as shown in FIGS. 26 and 27. The switching valve 82 herein is a switching valve that has a function for selecting either to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the header communication tubes 65a to 65c, and connecting the gas refrigerant tube 28 with a header communication tube other than the header communication tube to which the refrigerant flowing through the heat exchange path supply tube 71 is sent; or selecting to not send the refrigerant to any of the header communication tubes 65a to

65c. A rotary switching valve is used herein as the switching valve 82. This switching valve 82 is connected to the heat exchange path supply tube 71, the header communication tubes 65a to 65c, and the gas refrigerant tube 28. In the configuration of the present modification, the switching valve 82 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c and the header-side heat exchange path selection valves 74a to 74c in the control block diagram of FIG. 2. FIG. 26 is a schematic configuration diagram of the air conditioning apparatus 101 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 27 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 101 during the air-warming defrost operation in the present modification.

[0126] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 82 so that the refrigerant is not sent to any of the header communication tubes 65a to 65c, as shown in FIG. 26. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valve 82 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 82 so as to select to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the heat exchange path supply tube 71 is sent, as shown in FIG. 27.

[0127] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 126 can be reduced in comparison to the configurations of the above embodiment and Modification 1.

(Modification 3)

[0128] In the air conditioning apparatus 101 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 126 is configured from a heat exchange path supply tube 71, heat exchange path branching tubes 72a to 72c, branching-tube-side heat exchange path selection valves 73a to 73c, header-side heat exchange path selection valves 74a to 74c, and a diverter-tube-side selection valve 75, but such a configuration is not provided by way of limitation to the air conditioning apparatus.

[0129] For example, a switching valve 83 may be used in which the heat exchange path supply tube 71, the heat exchange path branching tubes 72a to 72c, the branching-tube-side heat exchange path selection valves 73a

to 73c, the header-side heat exchange path selection valves 74a to 74c, the diverter-tube-side selection valve 75, and the header 66 are integrated as shown in FIGS. 28 and 29. The switching valve 83 herein is a switching valve that has a function for selecting either to channel the refrigerant flowing through the subcooling path-heat exchange path communication tube 35 to the refrigerant flow diverter 64 or to send the refrigerant to any one of the header communication tubes 65a to 65c, and connecting the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the subcooling path-heat exchange path communication tube 35 is sent. A rotary switching valve is used herein as the switching valve 83. This switching valve 83 is connected to the subcooling path-heat exchange path communication tube 35, the refrigerant flow diverter 64, the header communication tubes 65a to 65c, and the gas refrigerant tube 28. In the configuration of the present modification, the switching valve 83 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, and the diverter-tube-side selection valve 75 in the control block diagram of FIG. 2. FIG. 28 is a schematic configuration diagram of the air conditioning apparatus 101 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 29 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 101 during the air-warming defrost operation in the present modification.

[0130] Even with such a configuration, the same air-warming operation as the above embodiment can be performed by activating the switching valve 83 so that the refrigerant flowing through the subcooling path-heat exchange path communication tube 35 flows to the refrigerant flow diverter 64, as shown in FIG. 28. The same air-cooling operation as the above embodiment can also be performed in the same actuated state of the switching valve 83 as during the air-warming operation. The same air-warming defrost operation as in the above embodiment or Modification 1 can be performed by activating the switching valve 83 so as to select to send the refrigerant flowing through the subcooling path-heat exchange path communication tube 35 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the subcooling path-heat exchange path communication tube 35 is sent, as shown in FIG. 29.

[0131] In the configuration of the present modification, the number of components constituting the defrosting flow channel mechanism 126 can be reduced in comparison to the configurations of the above embodiment and Modification 1, as well as the configuration of Modification

2.

(Modification 4)

[0132] In the air conditioning apparatus 101 according to the above embodiment and Modification 1, the defrosting flow channel mechanism 126 is configured so that refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 can be sent to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33 after passing through the subcooling path 34, without flowing into the refrigerant flow diverter 64. However, in the air-warming defrost operation, when the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 does not need to pass through the subcooling path 34, the defrosting flow channel mechanism 126 may be configured so that the same refrigerant flow as the air-warming defrost operation of the first embodiment can be achieved.

[0133] For example, in the air conditioning apparatus 101 of the above embodiment, the heat exchange path supply tube 71 may be provided with an electromagnetic valve 76 such that the heat exchange path supply tube 71 branches from a position between the expansion valve 24 of the liquid refrigerant tube 27 and the liquid-side end of the subcooling path 34, as shown in FIGS. 30 and 31. In the configuration of the present modification, the electromagnetic valve 76 is connected to the controller 8 together with the branching-tube-side heat exchange path selection valves 73a to 73c, the header-side heat exchange path selection valves 74a to 74c, and the diverter-tube-side selection valve 75 in the control block diagram of FIG. 2. FIG. 30 is a schematic configuration diagram of the air conditioning apparatus 101 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 31 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 101 during the air-warming defrost operation in the present modification.

[0134] In such a configuration, the same air-warming operation as in the above embodiment can be performed by opening the diverter-tube-side selection valve 75 and closing the electromagnetic valve 76, as shown in FIG. 30. The same air-cooling operation as in the above embodiment can also be performed in the same actuated states of the diverter-tube-side selection valve 75 and the electromagnetic valve 76 as in the air-warming operation. The same air-warming defrost operation as in the first embodiment can be performed without passing refrigerant through the subcooling path 34, by closing the diverter-tube-side selection valve 75 and opening the electromagnetic valve 76 as shown in FIG. 31. It is thereby possible to use the heat of the refrigerant solely for defrosting the heat exchange paths.

(Modification 5)

[0135] In the air conditioning apparatus 101 according to Modification 2 described above, the defrosting flow channel mechanism 126 is configured so that refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 can be sent to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33 after passing through the subcooling path 34, without flowing into the refrigerant flow diverter 64. However, in the air-warming defrost operation, when the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 does not need to pass through the subcooling path 34, the defrosting flow channel mechanism 126 may be configured so that the same refrigerant flow as the air-warming defrost operation of the first embodiment can be achieved.

[0136] For example, in the air conditioning apparatus 101 of Modification 2 described above, the heat exchange path supply tube 71 may be made to branch from a position between the expansion valve 24 of the liquid refrigerant tube 27 and the liquid-side end of the subcooling path 34, as shown in FIGS. 32 and 33. In the configuration of the present modification, similar to Modification 2 described above, the switching valve 82 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c and the header-side heat exchange path selection valves 74a to 74c in the control block diagram of FIG. 2. FIG. 32 is a schematic configuration diagram of the air conditioning apparatus 101 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 33 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 101 during the air-warming defrost operation in the present modification.

[0137] Even with such a configuration, the same air-warming operation as in the above embodiment can be performed by activating the switching valve 82 so that refrigerant is not sent to any of the header communication tubes 65a to 65c, as shown in FIG. 32. The same air-cooling operation as in the above embodiment can also be performed in the same actuated state of the switching valve 82 as in the air-warming operation. The same air-warming defrost operation as in the first embodiment can be performed without passing refrigerant through the subcooling path 34, by activating the switching valve 82 so as to close the diverter-tube-side selection valve 75 and select to send the refrigerant flowing through the heat exchange path supply tube 71 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the heat exchange path supply tube 71 is sent, as shown in FIG. 33.

(Modification 6)

[0138] In the air conditioning apparatus 101 according to Modification 3 described above, the defrosting flow channel mechanism 126 is configured so that refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 can be sent to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths 31 to 33 after passing through the subcooling path 34, without flowing into the refrigerant flow diverter 64. However, in the air-warming defrost operation, when the refrigerant sent to the outdoor heat exchanger 123 from the indoor heat exchanger 41 does not need to pass through the subcooling path 34, the defrosting flow channel mechanism 126 may be configured so that the same refrigerant flow as the air-warming defrost operation of the first embodiment can be achieved.

[0139] For example, in the air conditioning apparatus 101 of Modification 3 described above, the liquid refrigerant tube 27 may be connected to the switching valve 83 instead of the subcooling path-heat exchange path communication tube 35, as shown in FIGS. 34 and 35. In the configuration of the present modification, similar to Modification 3 described above, the switching valve 83 is connected to the controller 8 instead of the branching-tube-side heat exchange path selection valves 73a to 73c, and the header-side heat exchange path selection valves 74a to 74c, and the diverter-tube-side selection valve 75 in the control block diagram of FIG. 2. FIG. 34 is a schematic configuration diagram of the air conditioning apparatus 101 according to the present modification, showing the flow of refrigerant in the air conditioning apparatus 101 during the air-warming operation. FIG. 35 is a diagram showing the flow of refrigerant (when the first heat exchange path 31 is being defrosted) in the air conditioning apparatus 101 during the air-warming defrost operation in the present modification.

[0140] Even with such a configuration, the same air-warming operation as in the above embodiment can be performed by activating the switching valve 83 so that the refrigerant flowing through the liquid refrigerant tube 27 flows to the subcooling path-heat exchange path communication tube 35, as shown in FIG. 34. The same air-cooling operation as in the above embodiment can also be performed in the same actuated state of the switching valve 83 as in the air-warming operation. The same air-warming defrost operation as in the first embodiment can be performed without passing refrigerant through the subcooling path 34, by activating the switching valve 83 so as to select to send the refrigerant flowing through the liquid refrigerant tube 27 to any one of the header communication tubes 65a to 65c, and to connect the gas refrigerant tube 28 with the header communication tubes other than the header communication tube to which the refrigerant flowing through the liquid refrigerant tube 27 is sent, as shown in FIG. 35.

<Other Embodiments>

[0141] Embodiments of the present invention and modifications thereof were described above based on the drawings, but the specific configuration is not limited to these embodiments and modifications thereof, and can be altered within a range that does not deviate from the scope of the invention.

10 (A)

[0142] In the above embodiments and the modifications thereof, the first embodiment (see FIG. 1 etc.) and the second embodiment (see FIG. 21 etc.) having the branching-tube-side heat exchange path selection valves 73a to 73c are configured such that the defrosting flow channel mechanisms 26, 126 have a heat exchange path supply tube 71 and heat exchange path branching tubes 72a to 72c.

20 **[0143]** However, another option is a configuration having a header 68 in place of the heat exchange path supply tube 71 and the heat exchange path branching tubes 72a to 72c, as shown in FIG. 36. In this configuration, the liquid refrigerant tube 27 is directly connected to the header 68, the branching-tube-side heat exchange path selection valves 73a to 73c are directly connected at one end to the header 68, and the branching-tube-side heat exchange path selection valves 73a to 73c is directly connected at the other end to the header communication tubes 65a to 65c. FIG. 36 shows an example in which the defrosting flow channel mechanism 26 having a header 68 is employed in the configuration of the first embodiment, but the defrosting flow channel mechanism 126 having a header 68 directly connected to the subcooling path-heat exchange path communication tube 35 can be employed in the configuration of the second embodiment as shown in FIG. 37.

35 **[0144]** Even with such a configuration, the same air-warming defrost operation as in the above embodiments and the modifications thereof can be performed. With these configurations, the heat exchange path supply tube 71 and the heat exchange path branching tubes 72a to 72c can be omitted while still retaining the configurations of the defrosting flow channel mechanisms 26, 126 that have the branching-tube-side heat exchange path selection valves 73a to 73c, and the configurations of the defrosting flow channel mechanisms 26, 126 can be simplified.

50 (B)

[0145] The above embodiments and the modifications thereof had configurations in which one indoor unit was connected to one outdoor unit, but the configuration is not limited as such. For example, a plurality of indoor units may be connected to an outdoor unit, one indoor unit may be connected to a plurality of outdoor units, or a plurality of indoor units may be connected to a plurality

of outdoor units.

[0146] In the above embodiments and the modifications thereof, the air conditioning apparatus was designed such that the switch between air cooling and air warming could be made by a four-way switching valve, but such a configuration is not provided by way of limitation to the air conditioning apparatus. For example, the configuration may be solely for air warming (i.e. the configuration may constantly use an indoor heat exchanger as a heat radiator with no four-way switching valve).

(C)

[0147] In the above embodiments and the modifications thereof, an outdoor unit was employed in which outdoor air was blown out in a transverse direction, but the outdoor unit is not limited as such. Another type of outdoor unit may be used, such as an outdoor unit or the like in which the outdoor fan is placed above the outdoor heat exchanger and outdoor air is thereby blown out upward, for example.

(D)

[0148] In the above embodiments and the modifications thereof, a cross fin type fin-and-tube heat exchanger was employed as the outdoor heat exchanger, but the outdoor heat exchanger is not limited as such. Another type of heat exchanger may be used, such as a stacked heat exchanger or the like which uses corrugated fins. The number of heat exchange paths constituting the outdoor heat exchanger is not limited to three, and may be four or more.

INDUSTRIAL APPLICABILITY

[0149] The present invention can be widely applied to air conditioning apparatuses that can perform an air-warming operation.

REFERENCE SIGNS LIST

[0150]

1, 101	Air conditioning apparatus
21	Compressor
23, 123	Outdoor heat exchanger
26, 126	Defrosting flow channel mechanism
31-33	Heat exchange paths
34	Subcooling path
41	Indoor heat exchanger

64 Refrigerant flow diverter

CITATION LIST

5 PATENT LITERATURE

[0151]

10 [Patent Literature 1] Japanese Laid-open Patent Application No. 2000-274780

[Patent Literature 2] Japanese Laid-open Patent Application No. 2001-059994

15 Claims

1. An air conditioning apparatus (1, 101) configured by sequentially connecting a compressor (21) for compressing refrigerant, an indoor heat exchanger (41) for radiating the heat of the refrigerant compressed in the compressor, and an outdoor heat exchanger (23, 123) for evaporating the refrigerant heat-radiated in the indoor heat exchanger by heat exchange with outdoor air, the air conditioning apparatus being capable of performing an air-warming operation for circulating refrigerant in order through the compressor, the indoor heat exchanger, the outdoor heat exchanger, and the compressor; wherein
20 the outdoor heat exchanger has a plurality of heat exchange paths (31-33) connected in parallel to each other; liquid-side ends of the heat exchange paths are connected in parallel by a refrigerant flow diverter (64) for branching the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the liquid-side ends of the heat exchange paths; a defrosting flow channel mechanism (26, 126) is provided for sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to a gas-side end of an arbitrarily selected heat exchange path of the plurality of heat exchange paths, without channeling the refrigerant into the refrigerant flow diverter; and
35 an air-warming defrost operation is performed by the defrosting flow channel mechanism in which the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger is not channeled into the refrigerant flow diverter but is passed through the arbitrarily selected heat exchange path from the gas-side end to the liquid-side end of the arbitrarily selected heat exchange path, and the refrigerant passed through the arbitrarily selected heat exchange path flows through the refrigerant flow diverter to be passed through other heat exchange paths other than the arbitrarily selected heat exchange path, from the liquid-side end to the gas-side end of the other heat exchange paths, whereby the refrigerant

erant sent from the indoor heat exchanger to the outdoor heat exchanger is evaporated while the arbitrarily selected heat exchange path is defrosted.

2. The air conditioning apparatus (101) according to claim 1, wherein the outdoor heat exchanger (123) further has a sub-cooling path (34) through which the refrigerant sent from the indoor heat exchanger (41) to the outdoor heat exchanger passes before flowing into the refrigerant flow diverter (64); and the defrosting flow channel mechanism (126) is provided so as to be capable of sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths (31-33) after the refrigerant has passed through the subcooling path.
3. The air conditioning apparatus (101) according to claim 1, wherein the outdoor heat exchanger (123) further has a sub-cooling path (34) through which the refrigerant sent from the indoor heat exchanger (41) to the outdoor heat exchanger passes before flowing into the refrigerant flow diverter (64); and the defrosting flow channel mechanism (126) is provided so as to be capable of sending the refrigerant sent to the outdoor heat exchanger from the indoor heat exchanger to the gas-side end of the arbitrarily selected heat exchange path of the plurality of heat exchange paths (31-33) without passing the refrigerant through the subcooling path.

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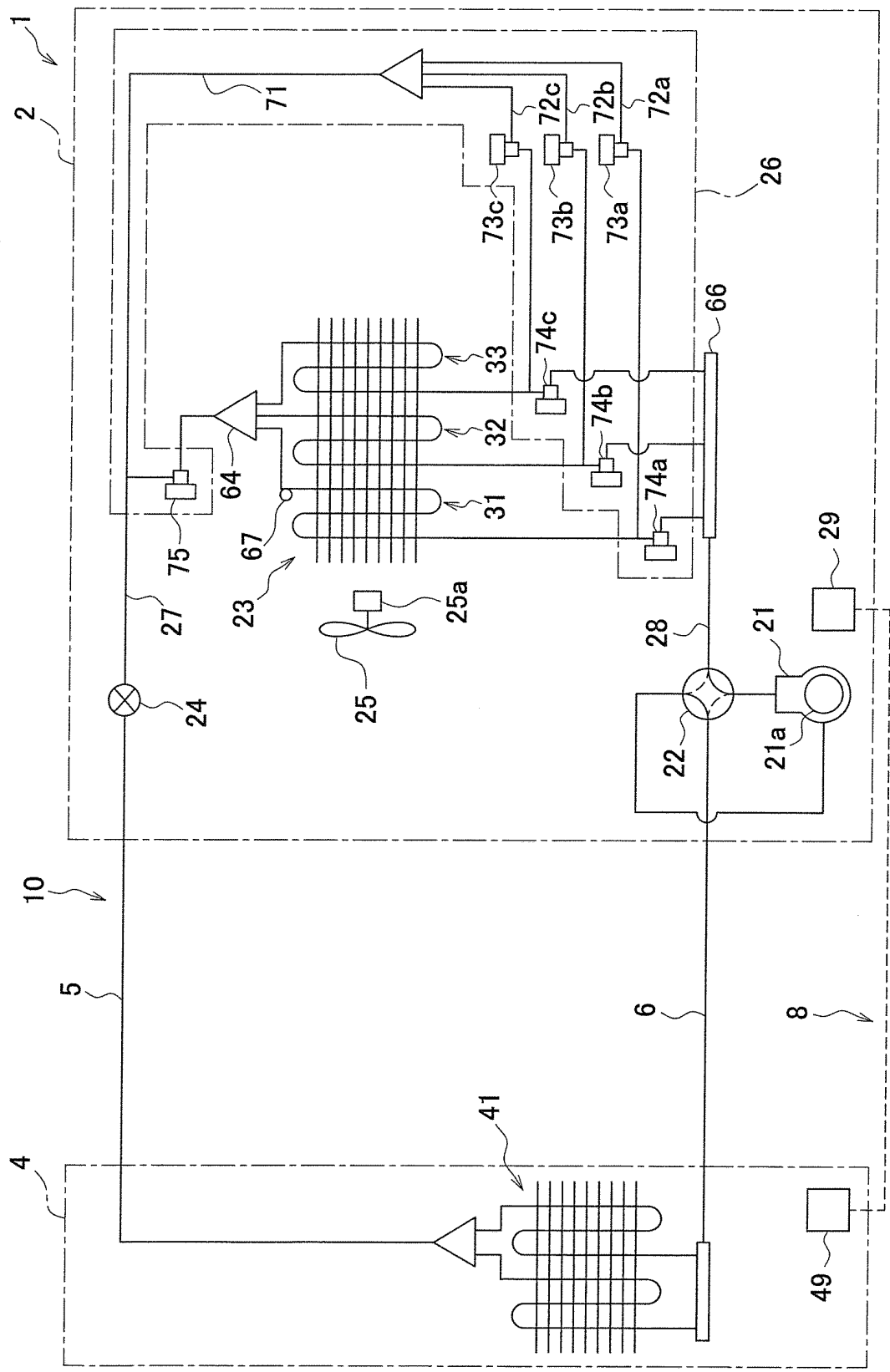


FIG. 1

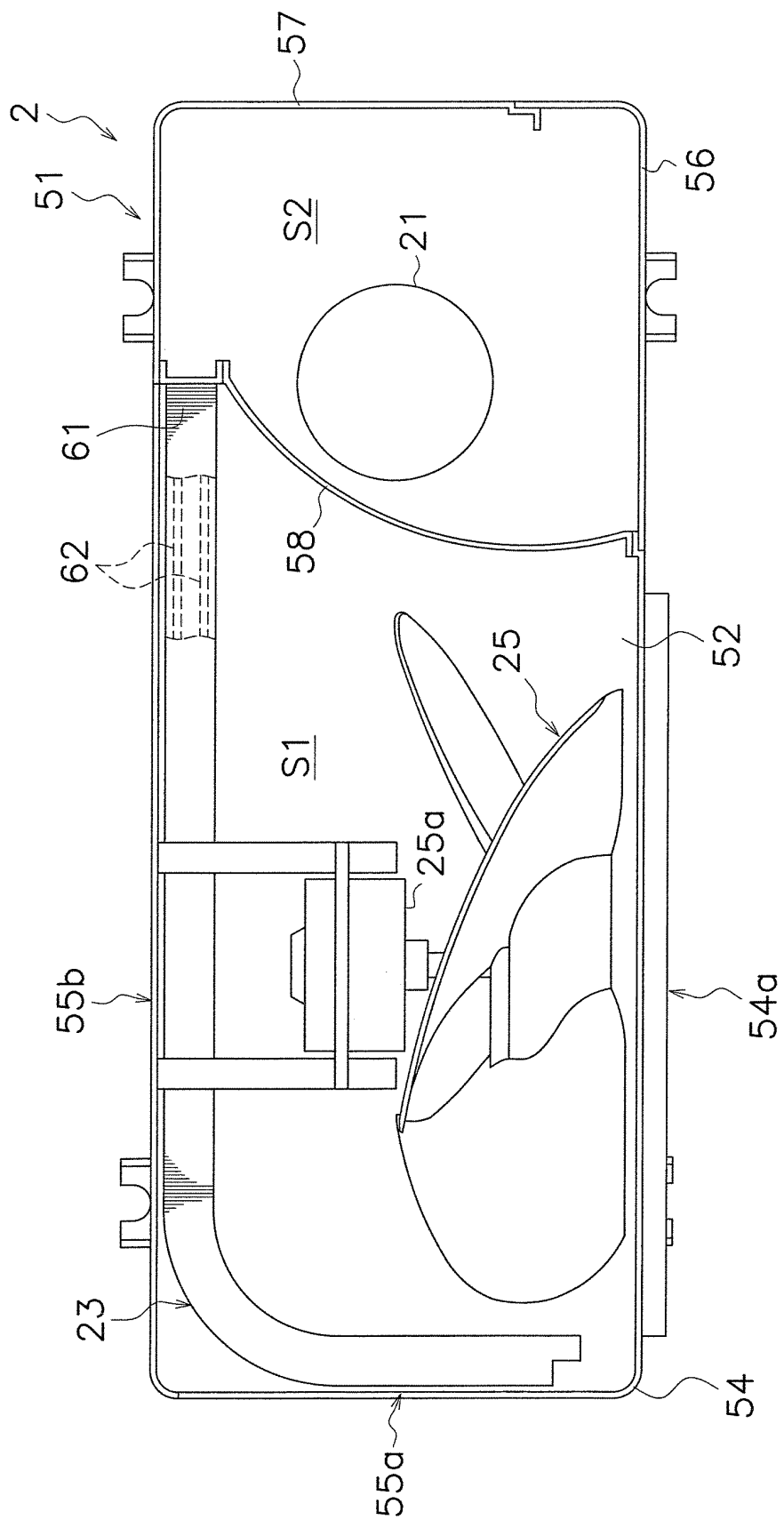


FIG. 2

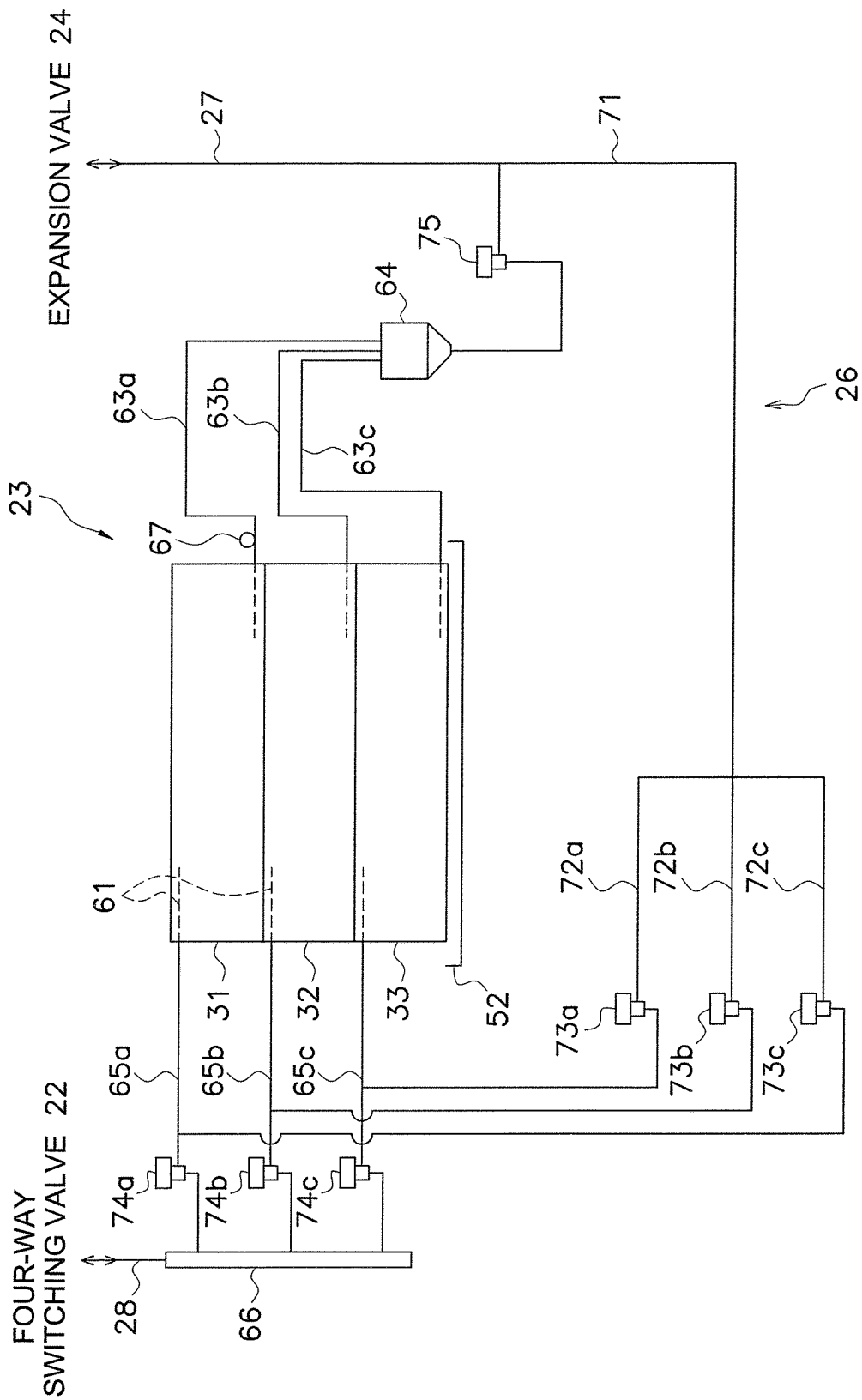


FIG. 3

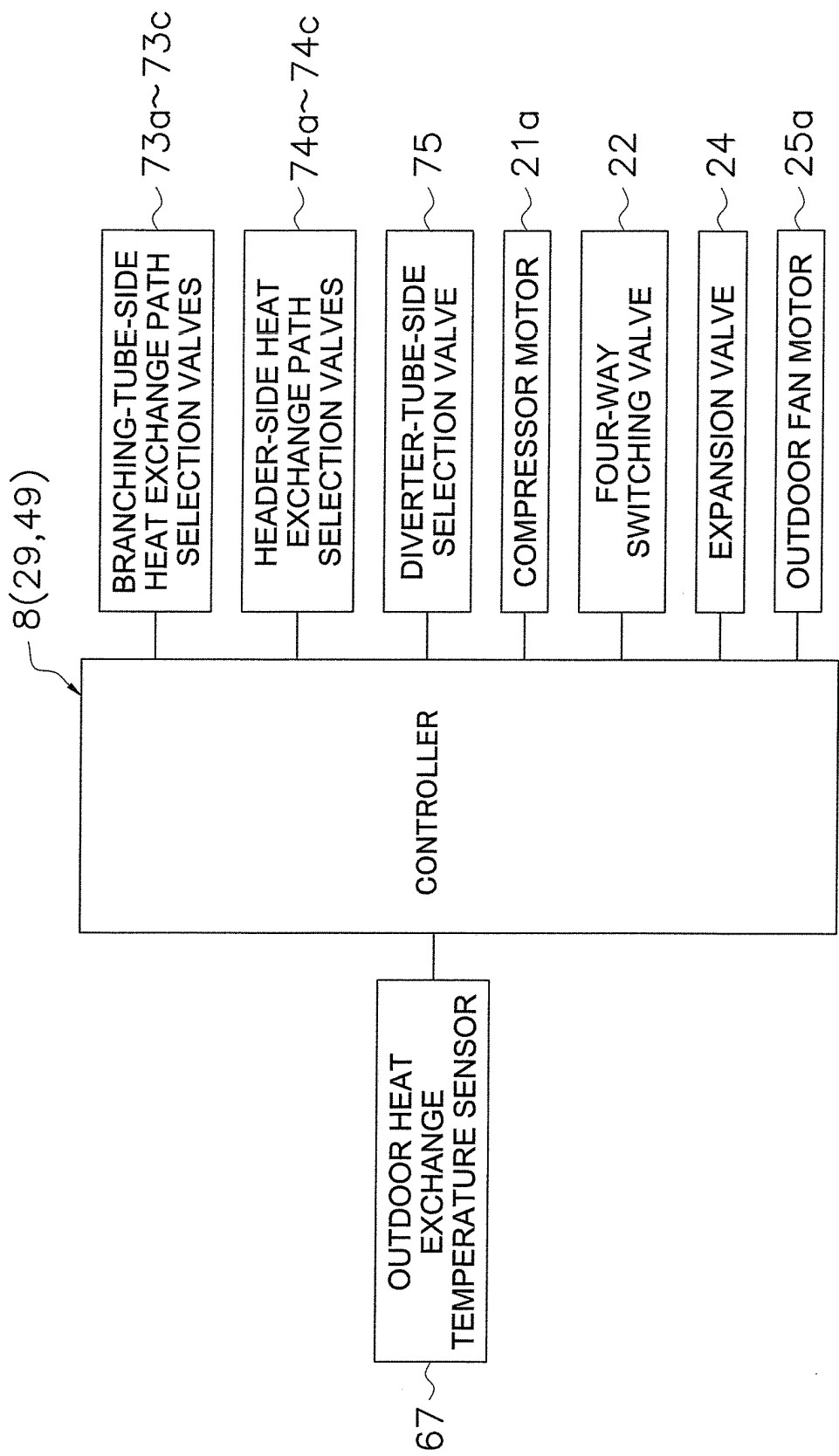


FIG. 4

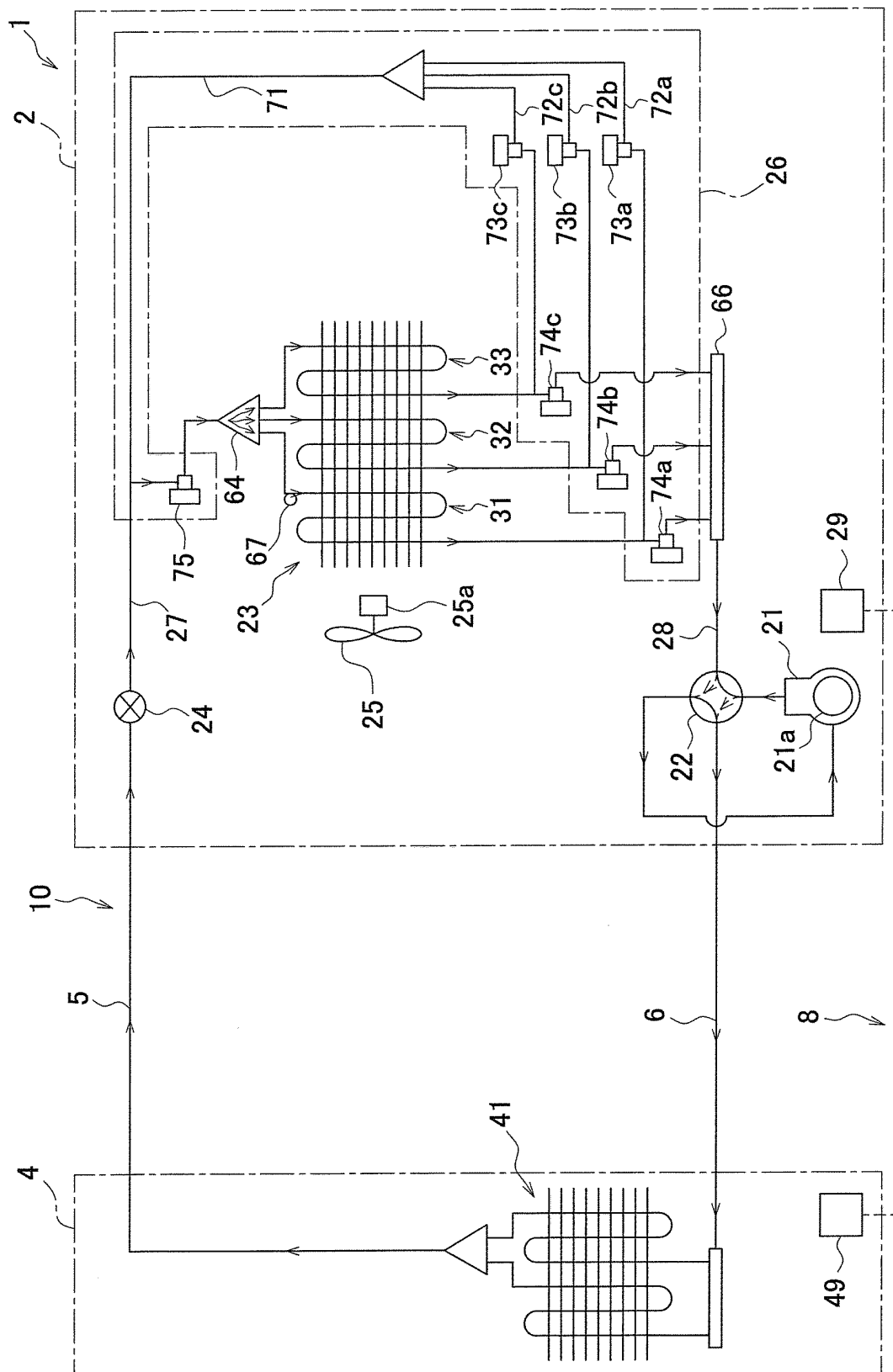


FIG. 5

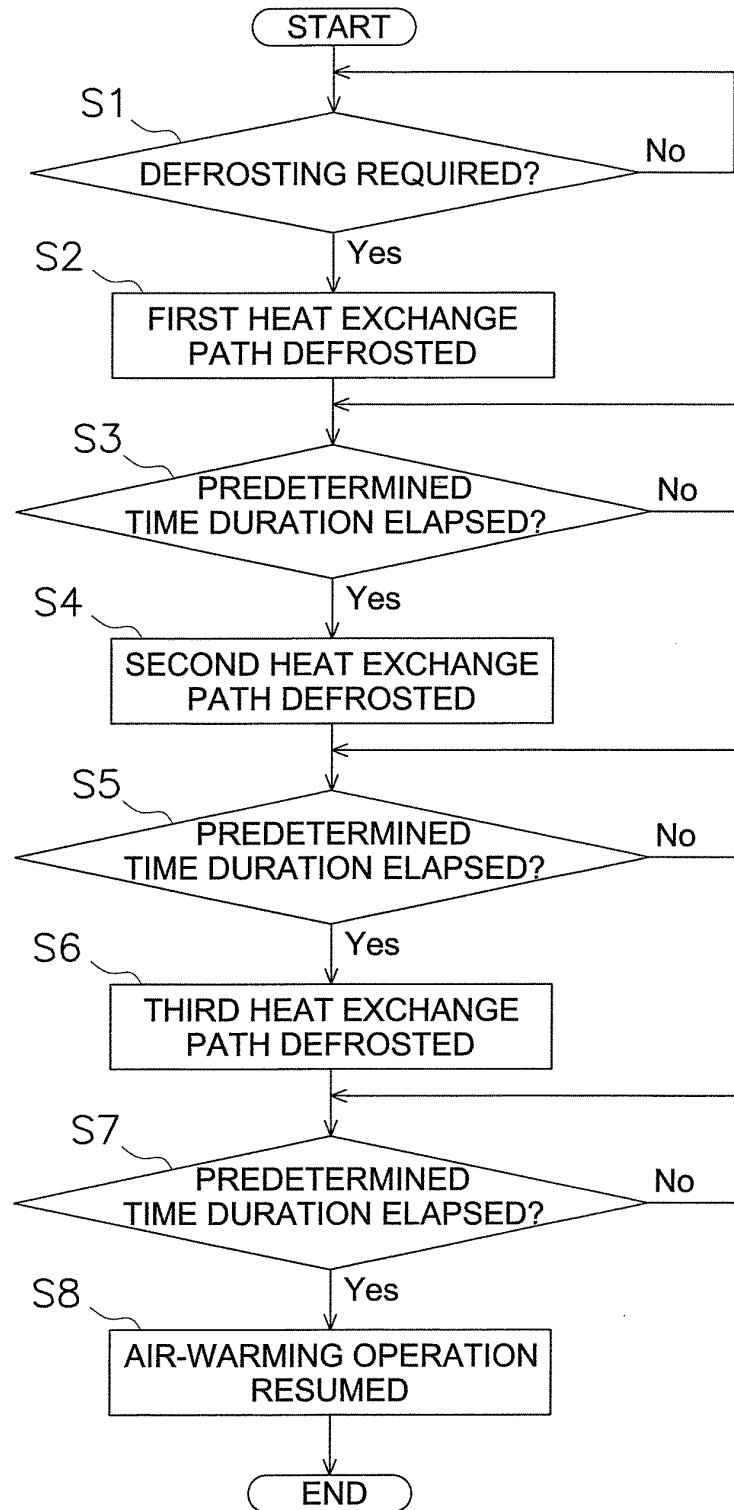


FIG. 6

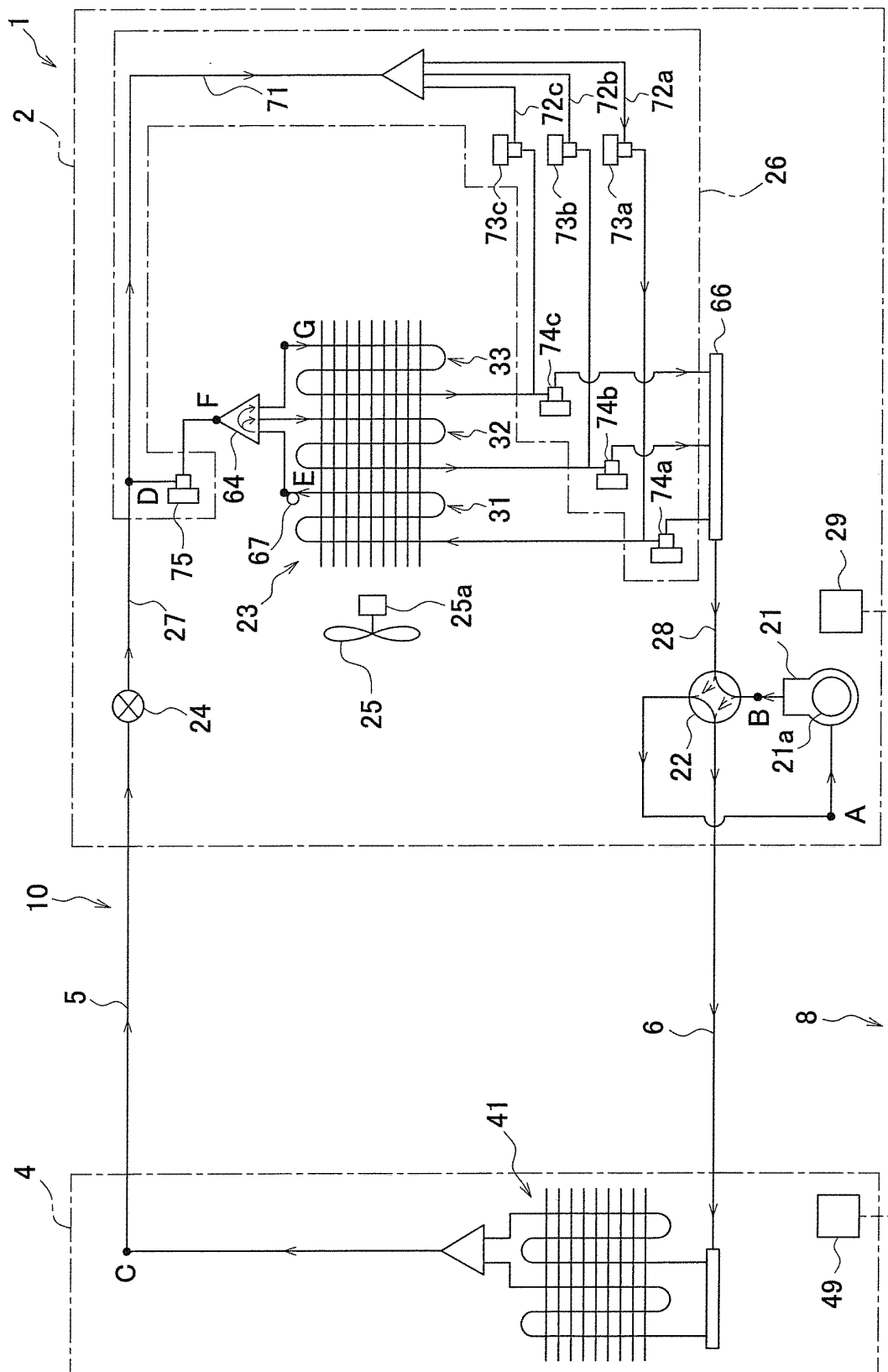


FIG. 7

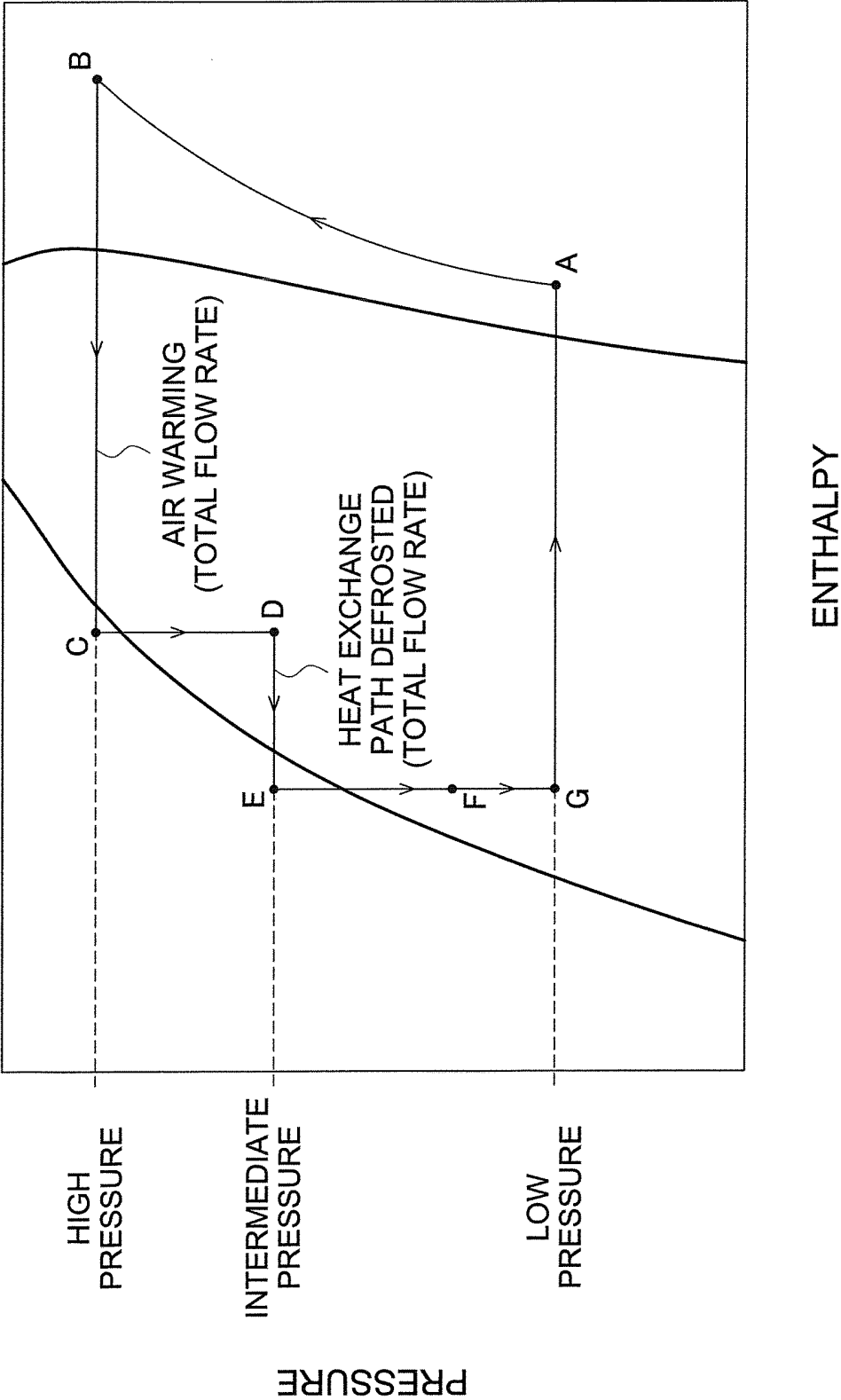


FIG. 8

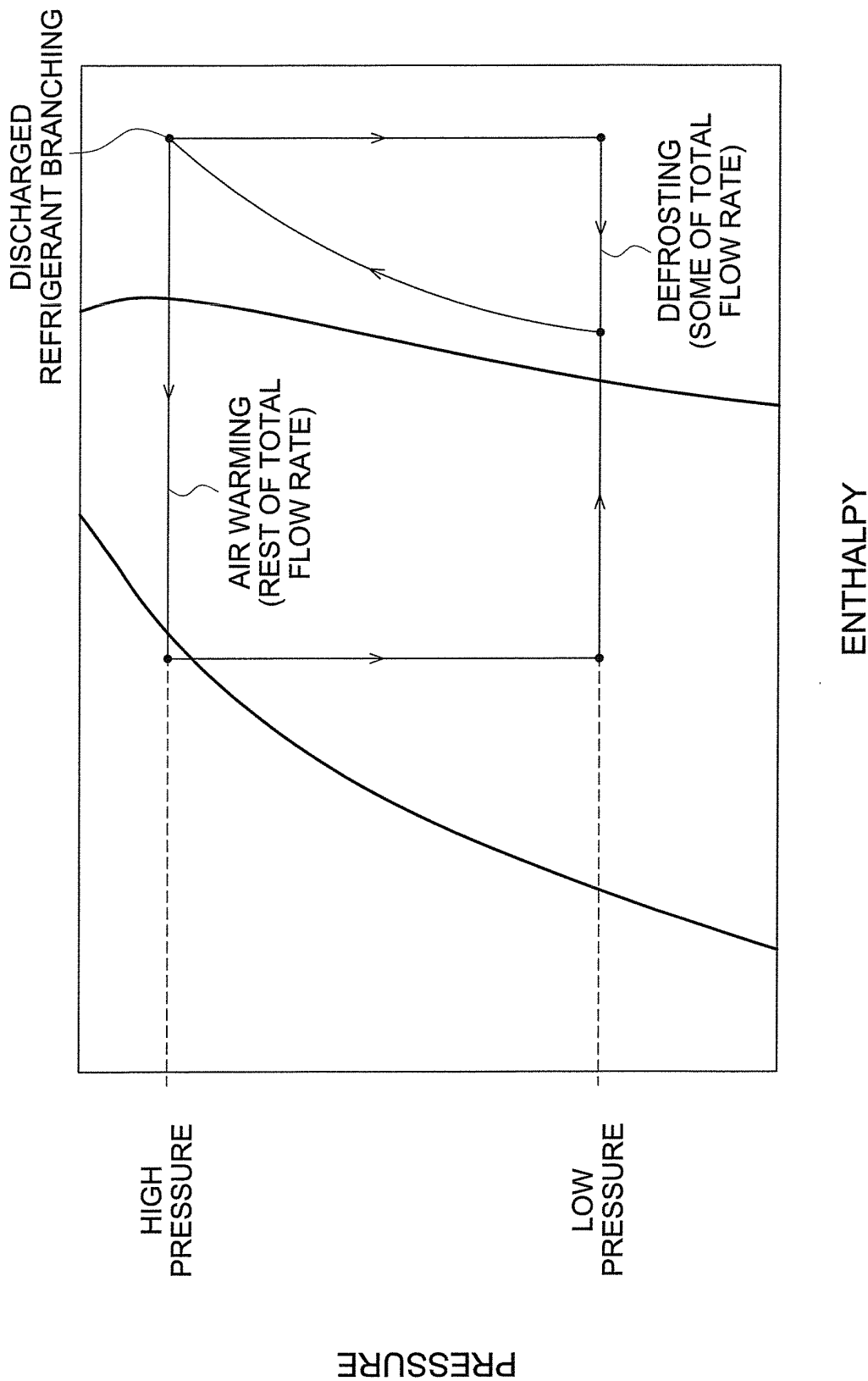


FIG. 9

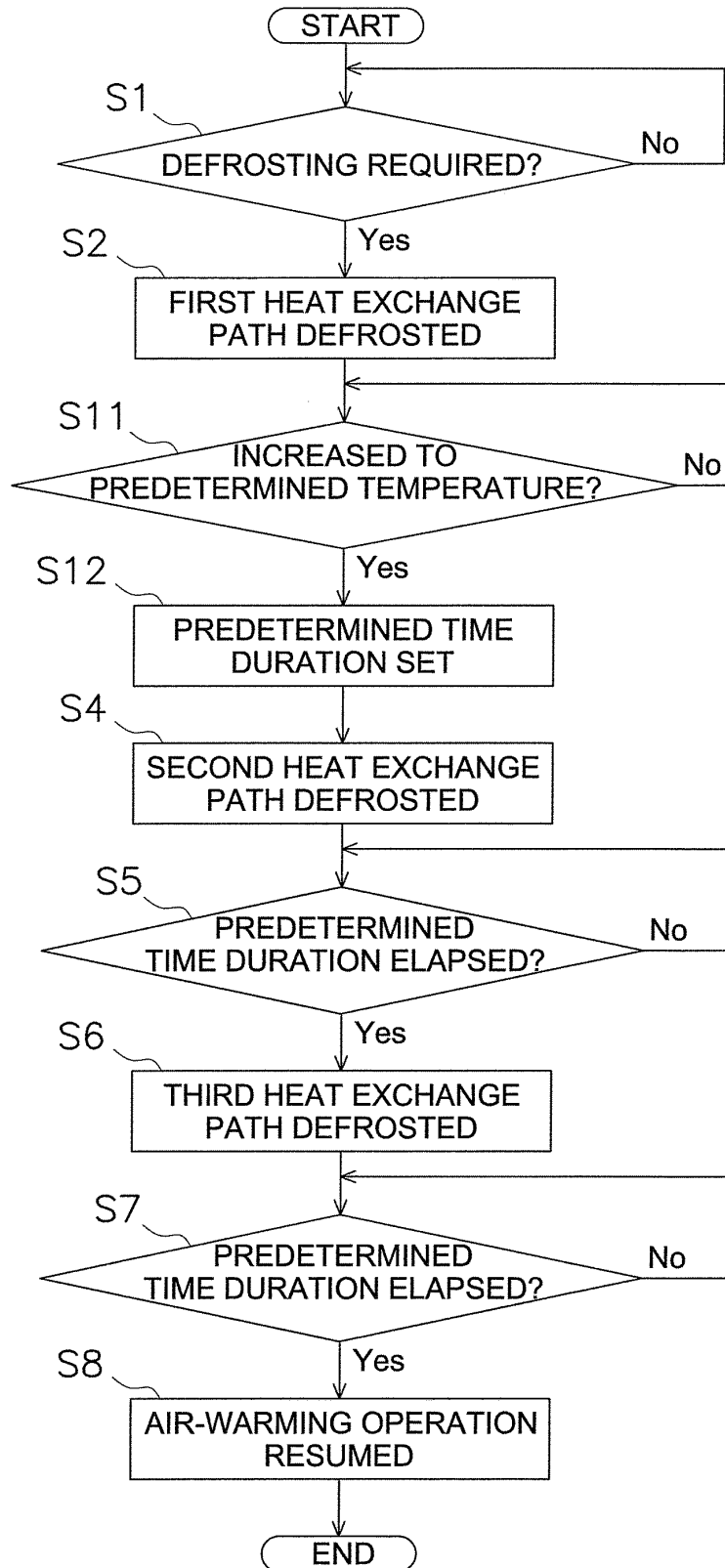


FIG. 10

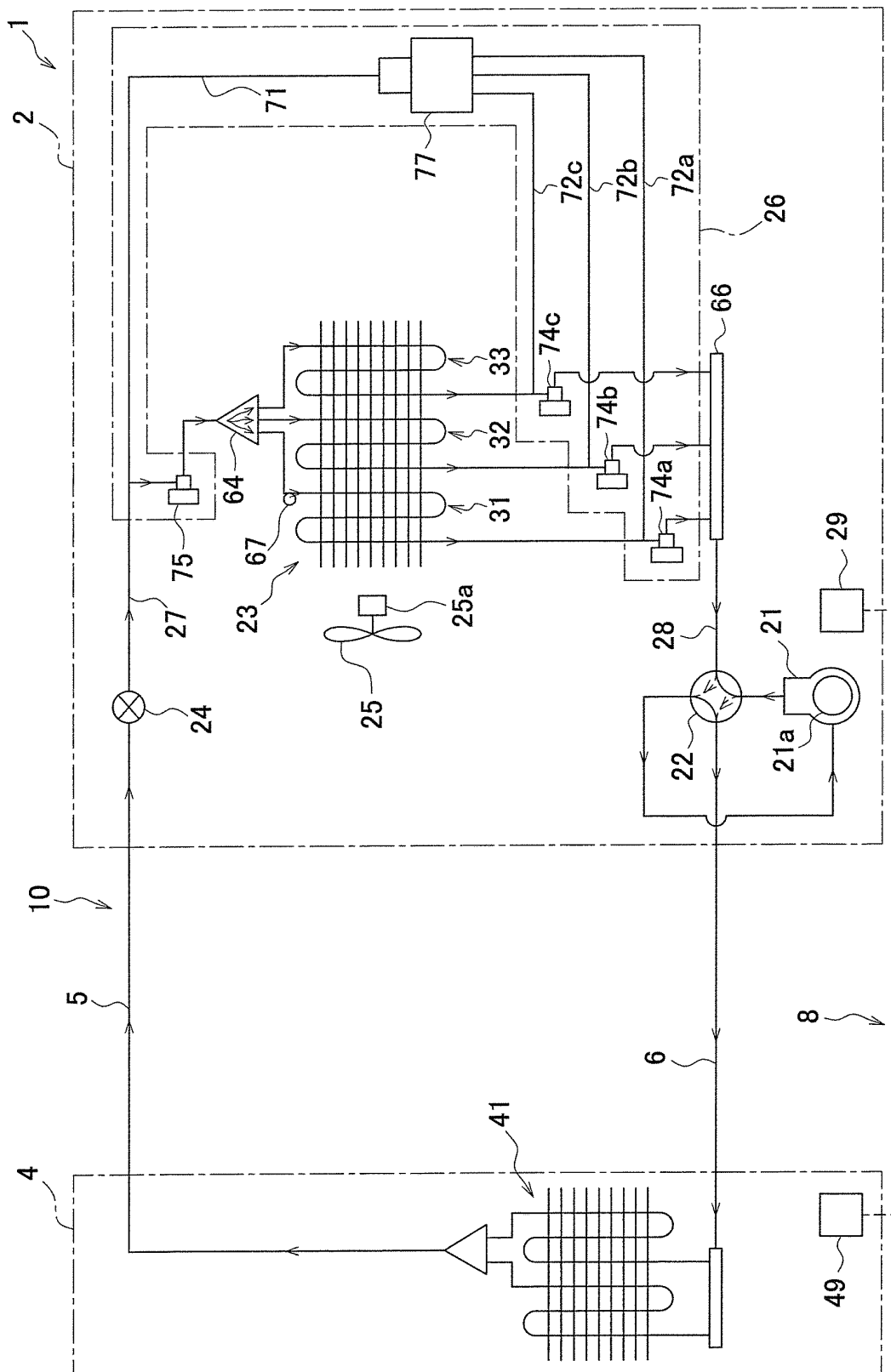


FIG. 11

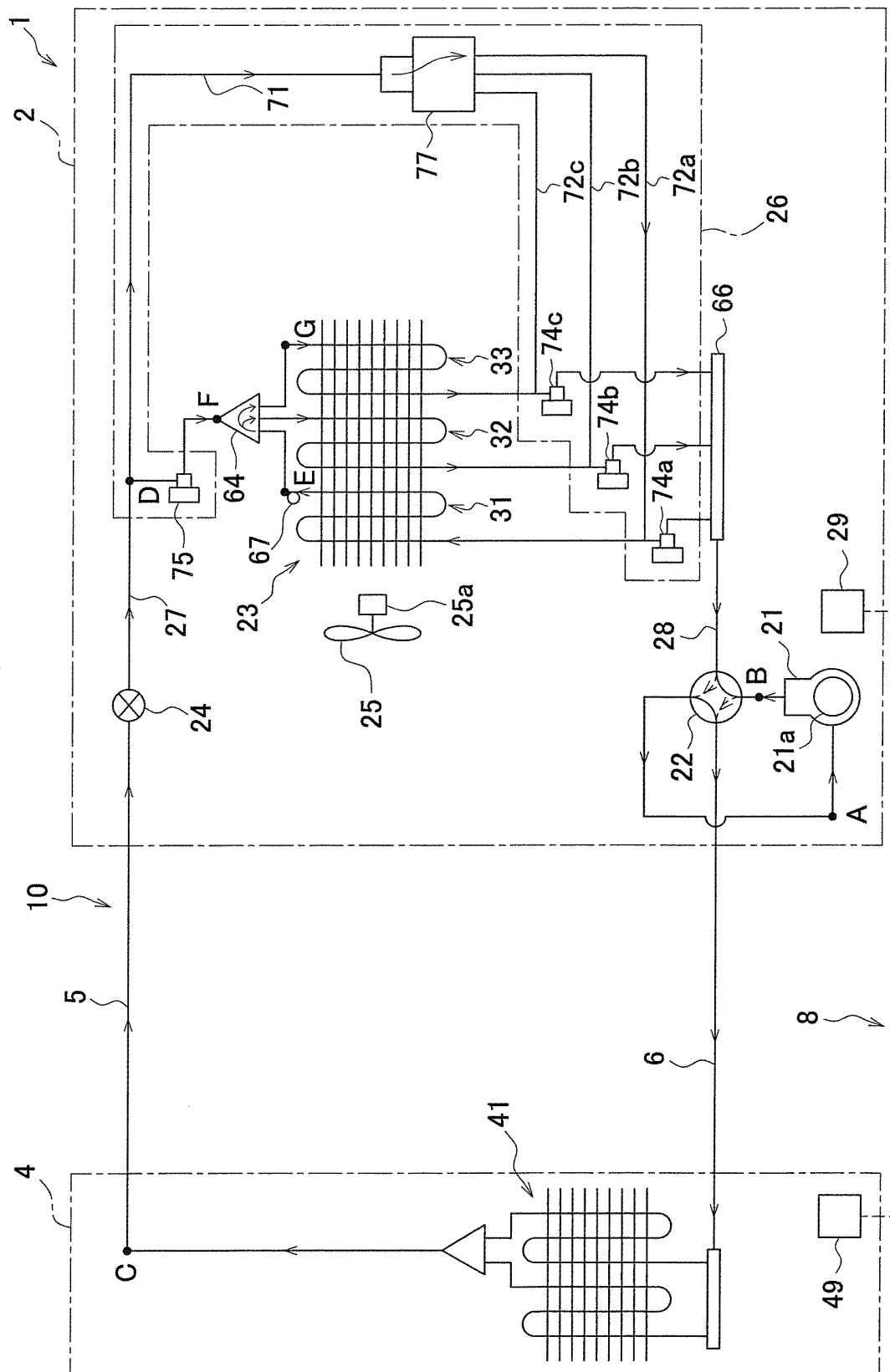


FIG. 12

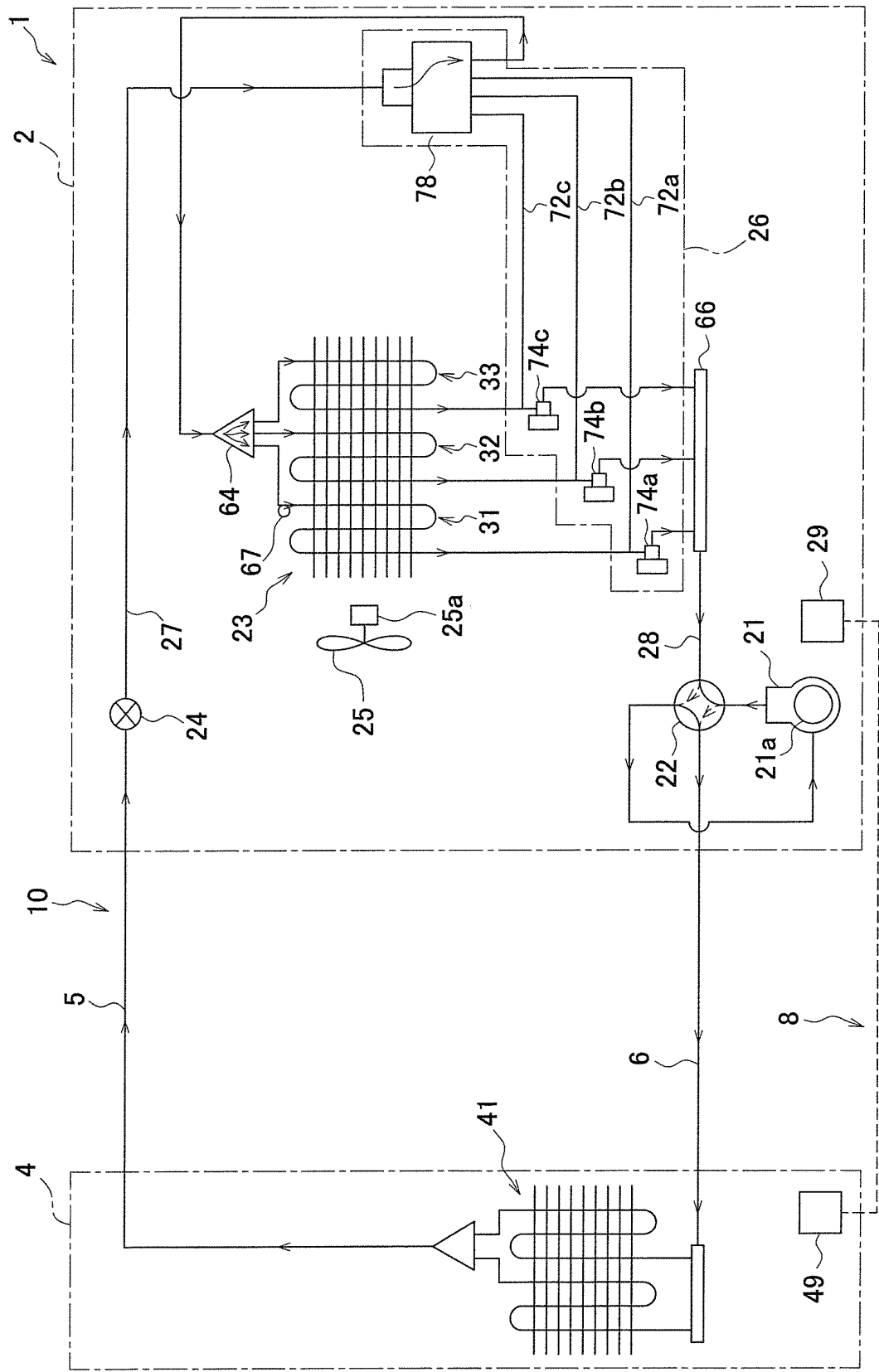


FIG. 13

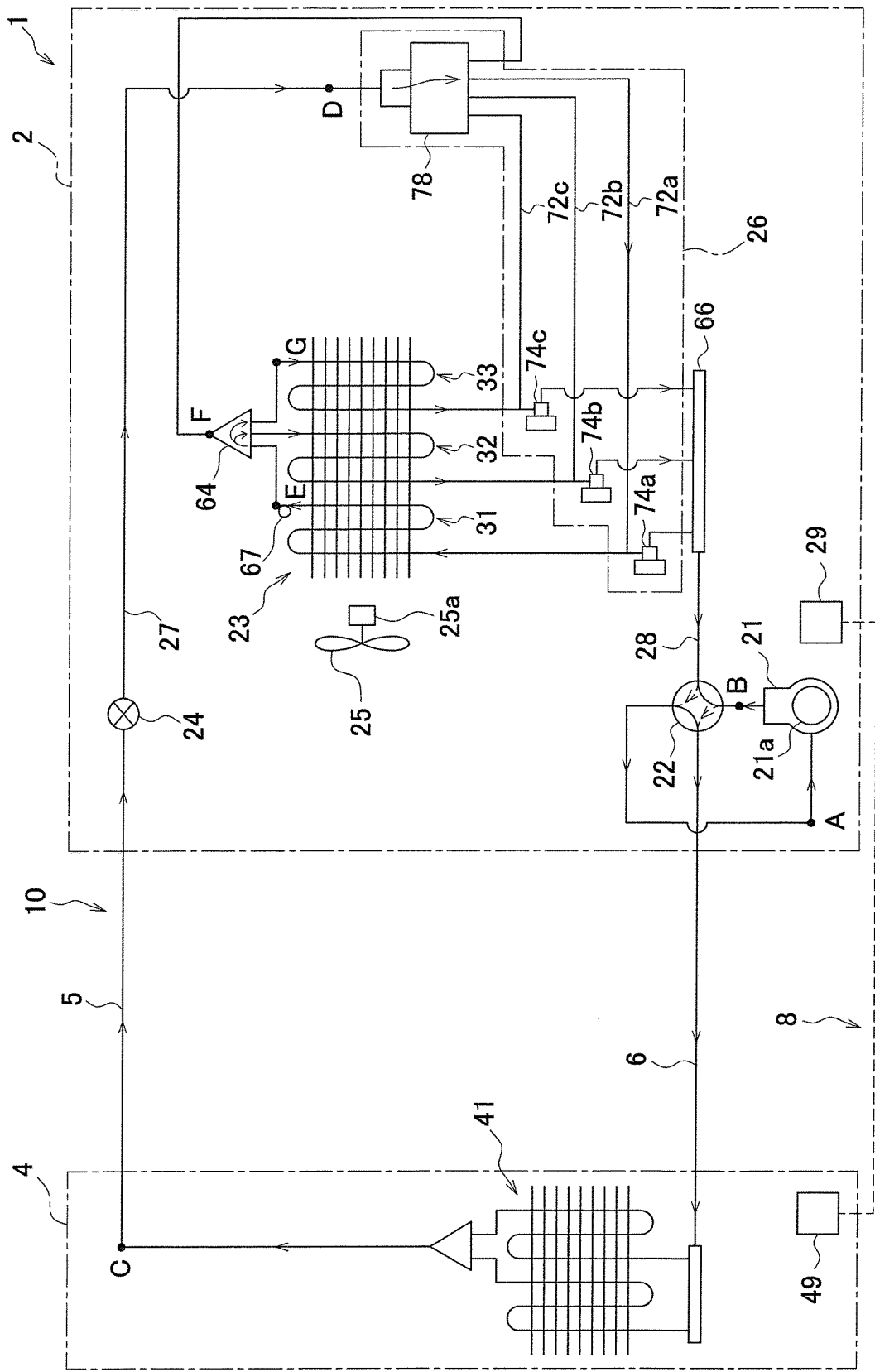


FIG. 14

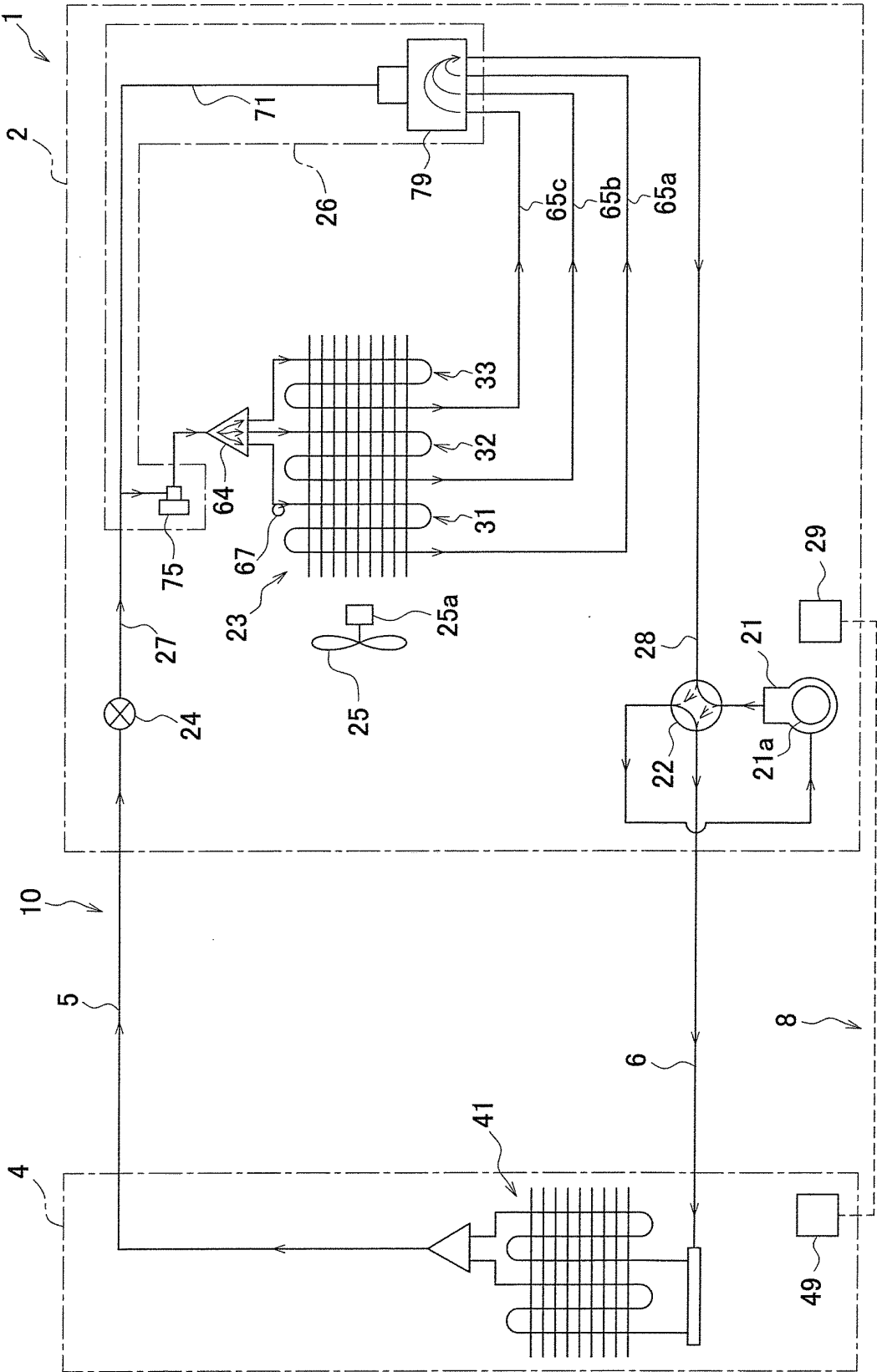


FIG. 15

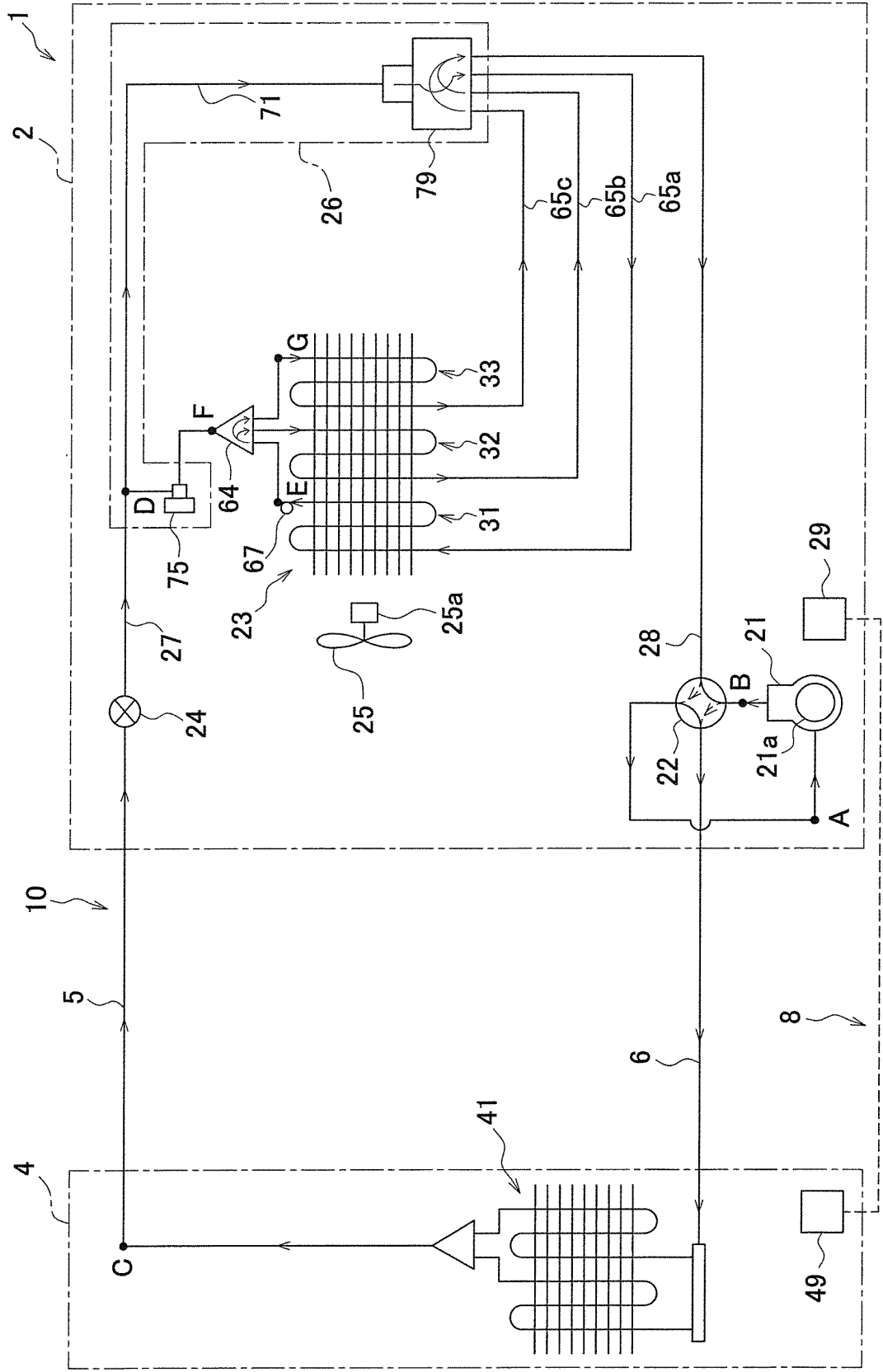


FIG. 16

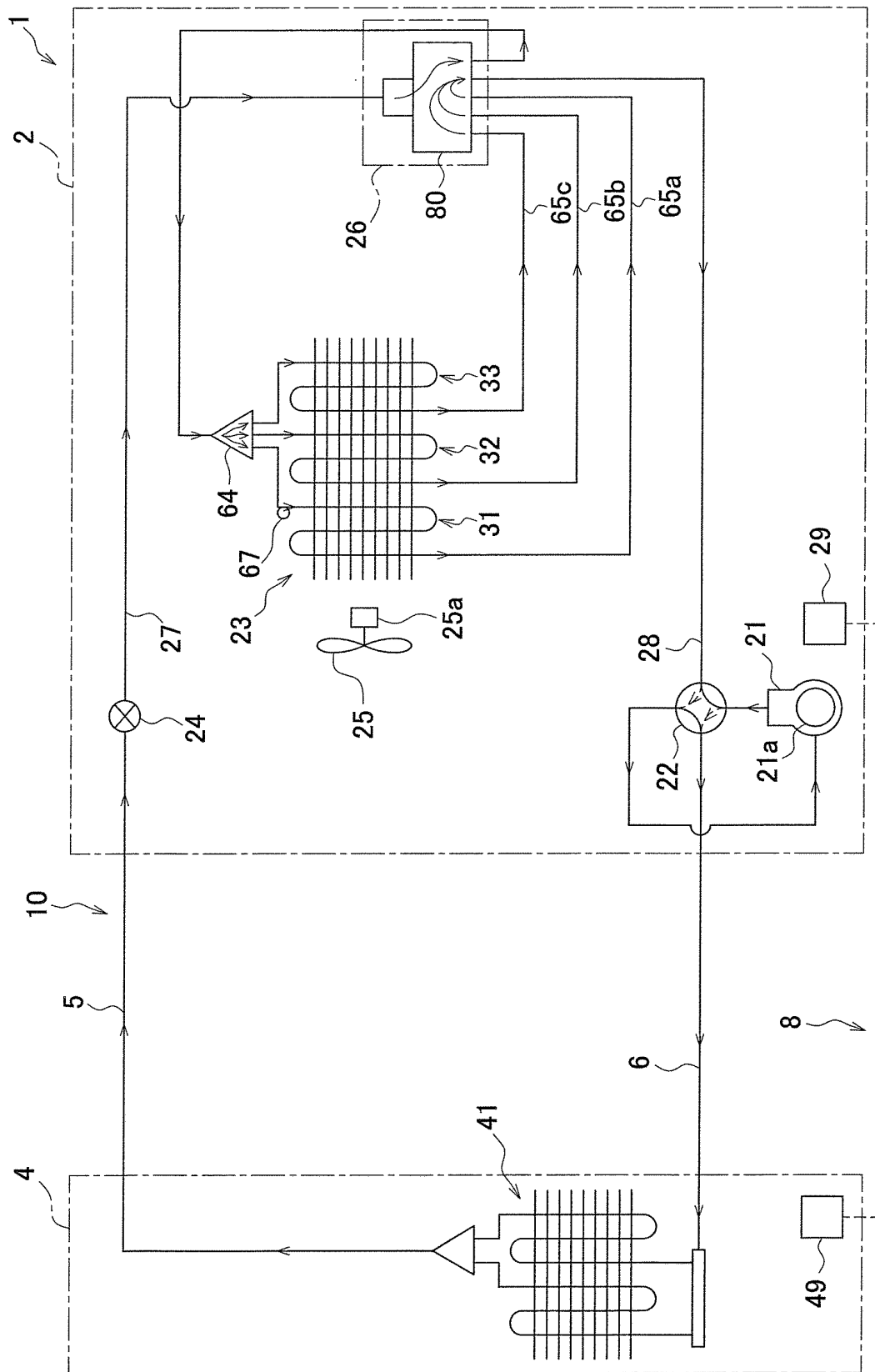


FIG. 17

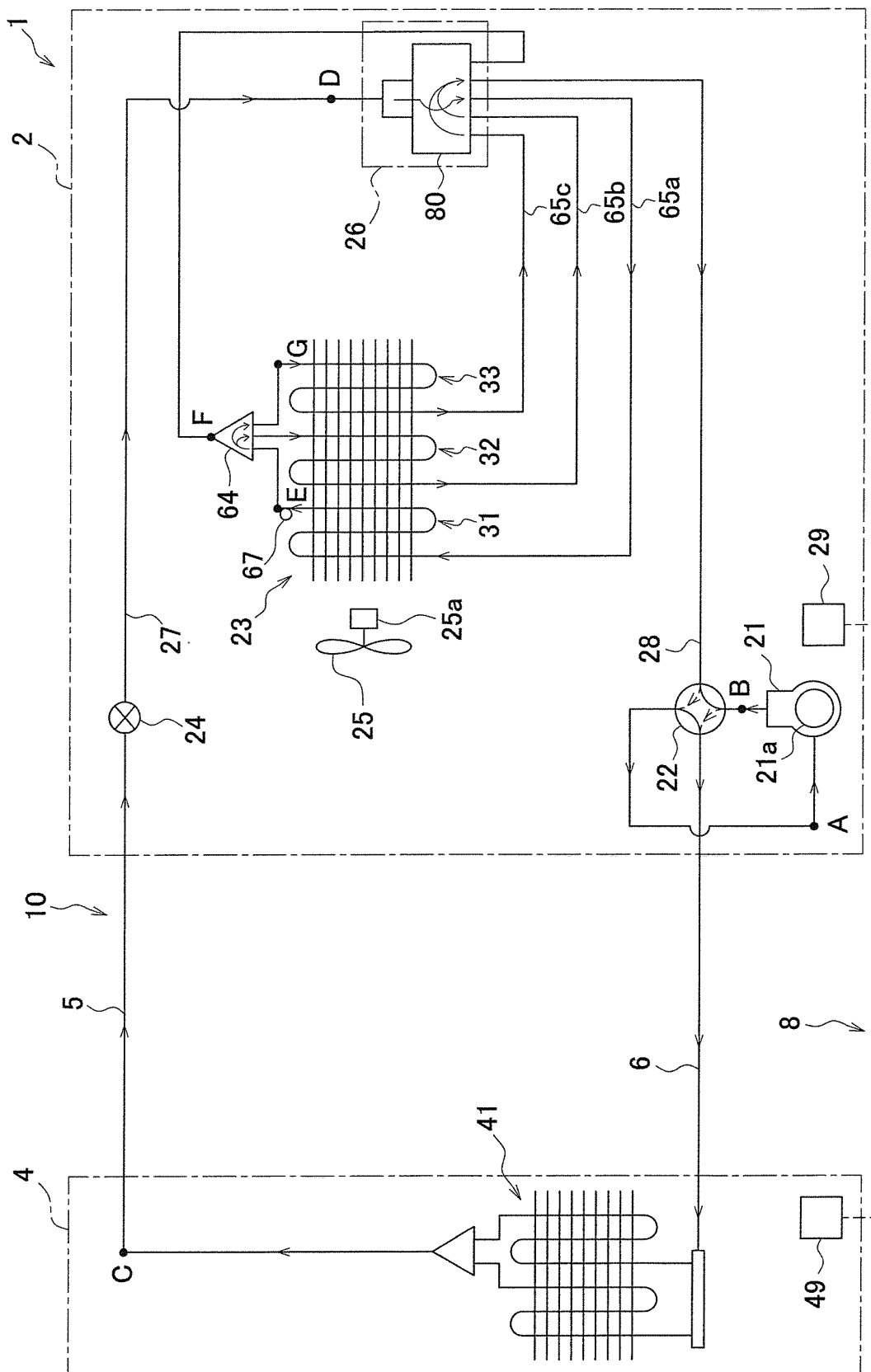


FIG. 18

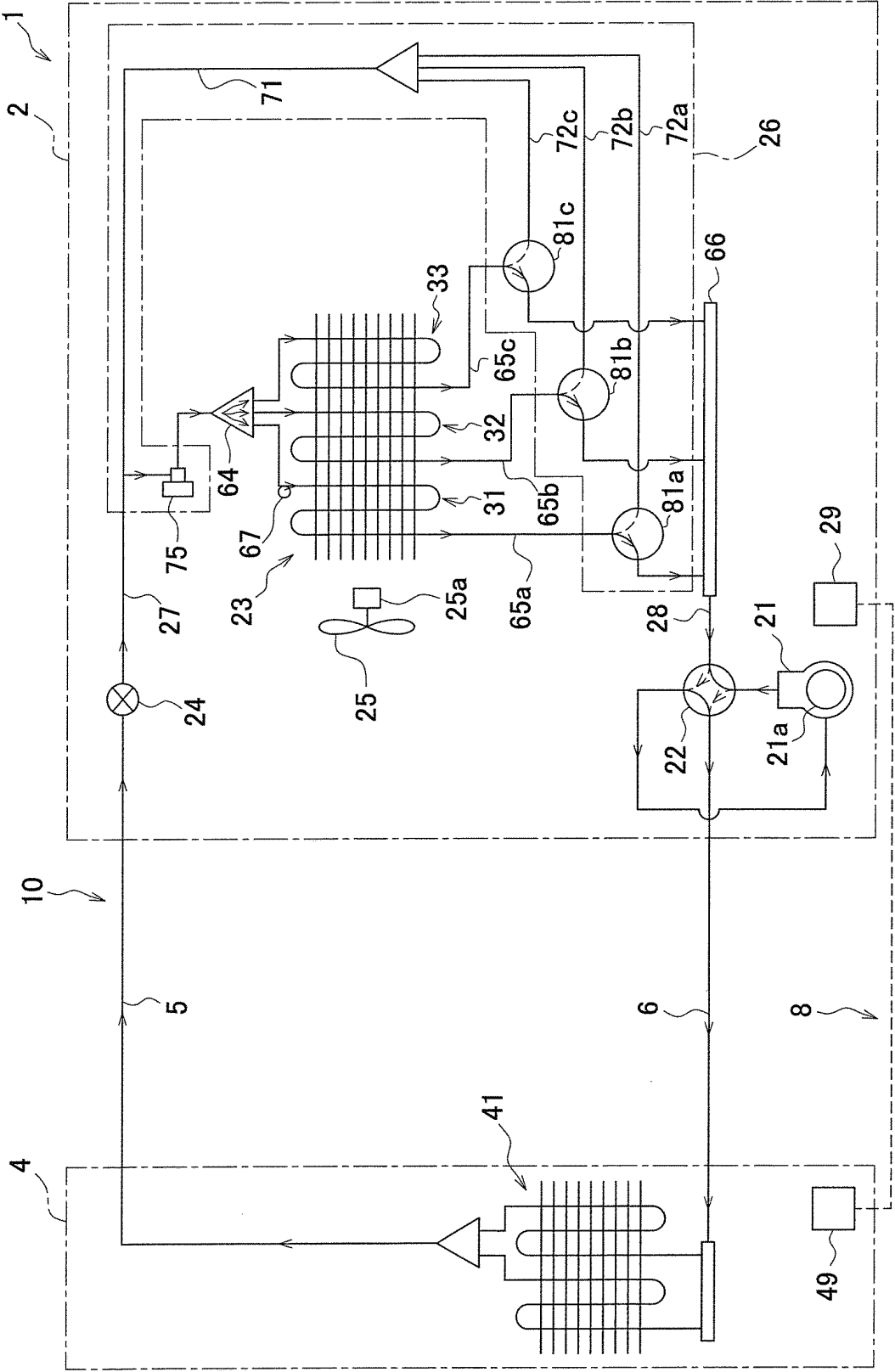


FIG. 19

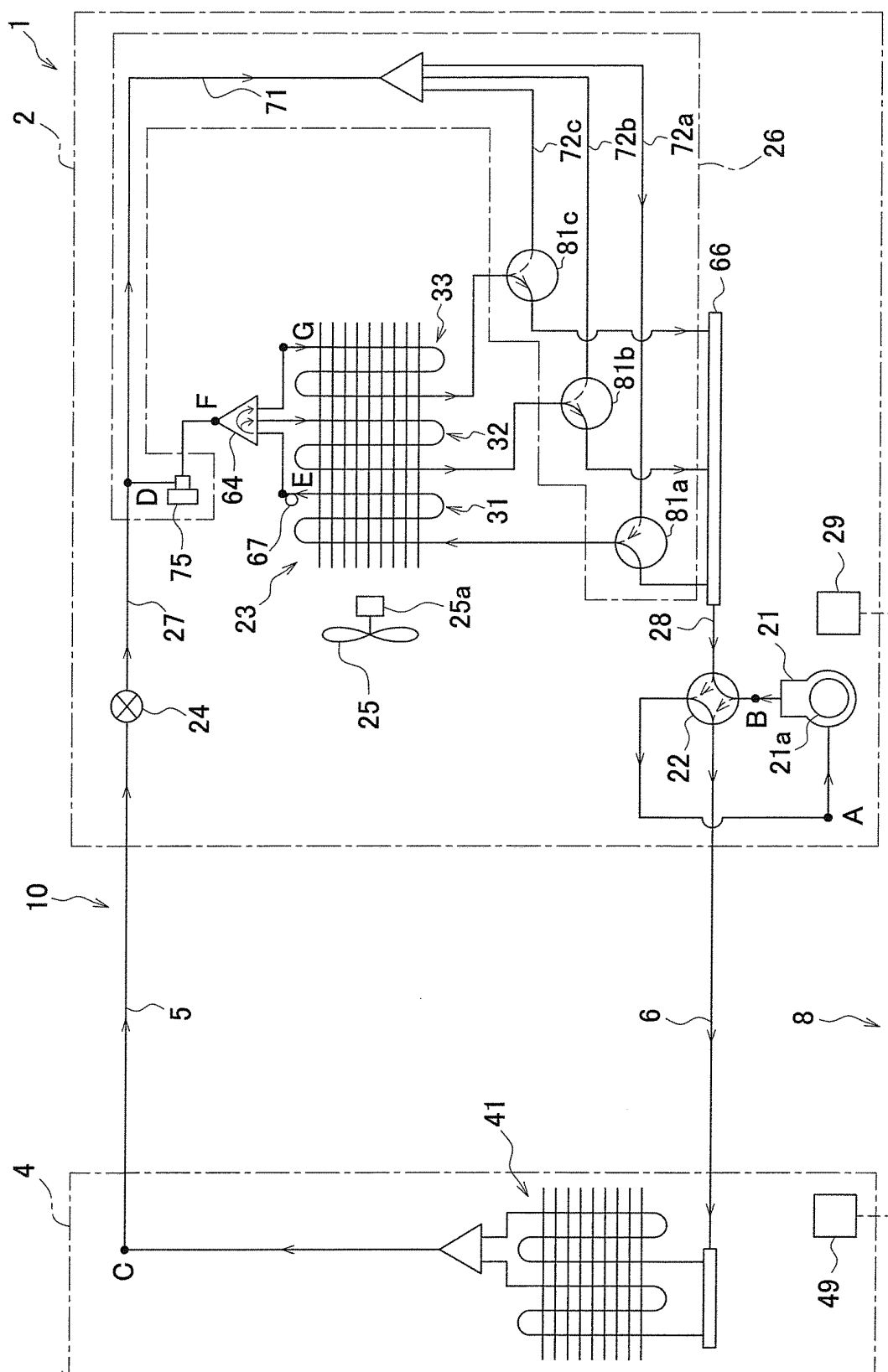


FIG. 20

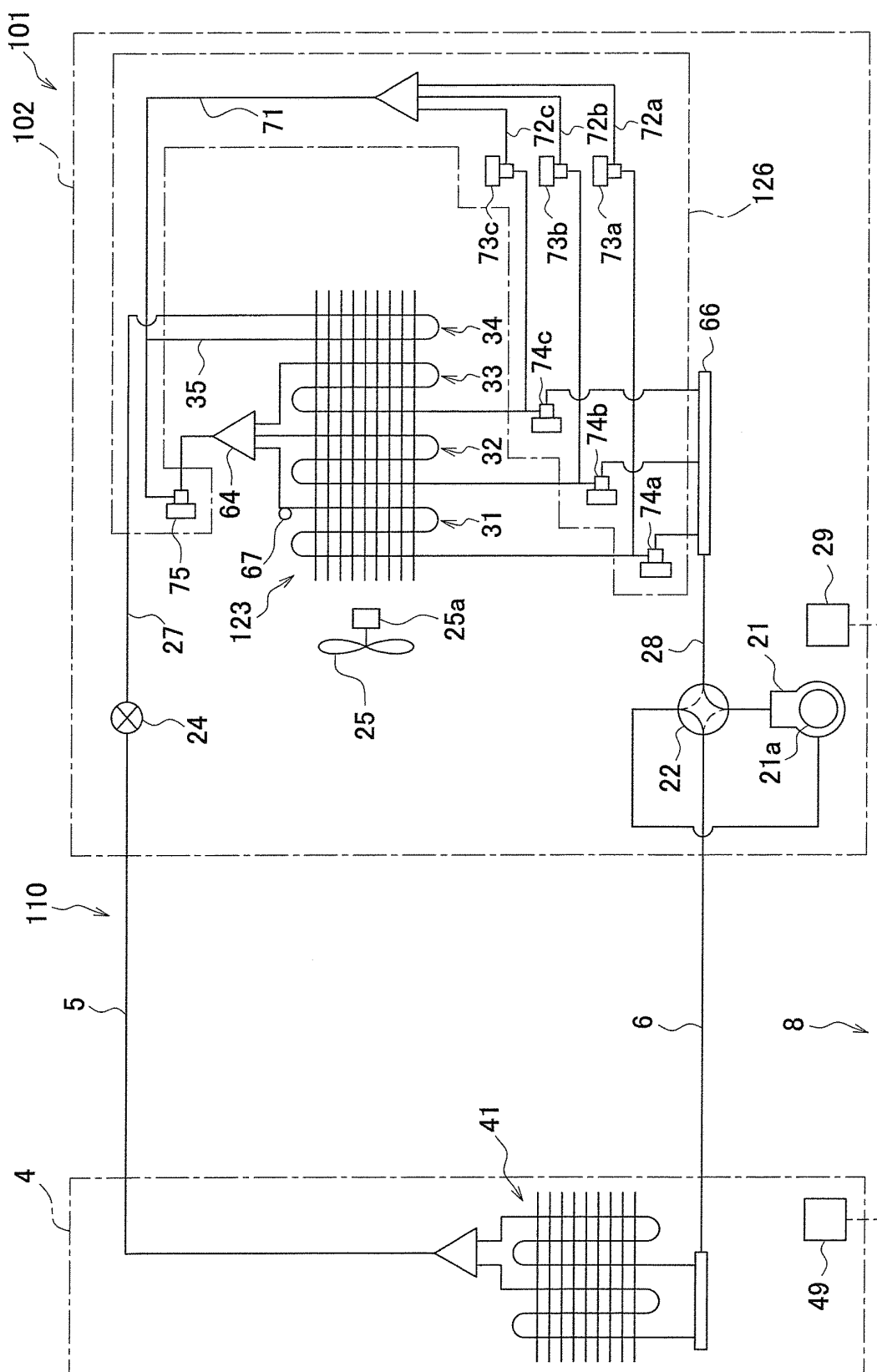


FIG. 21

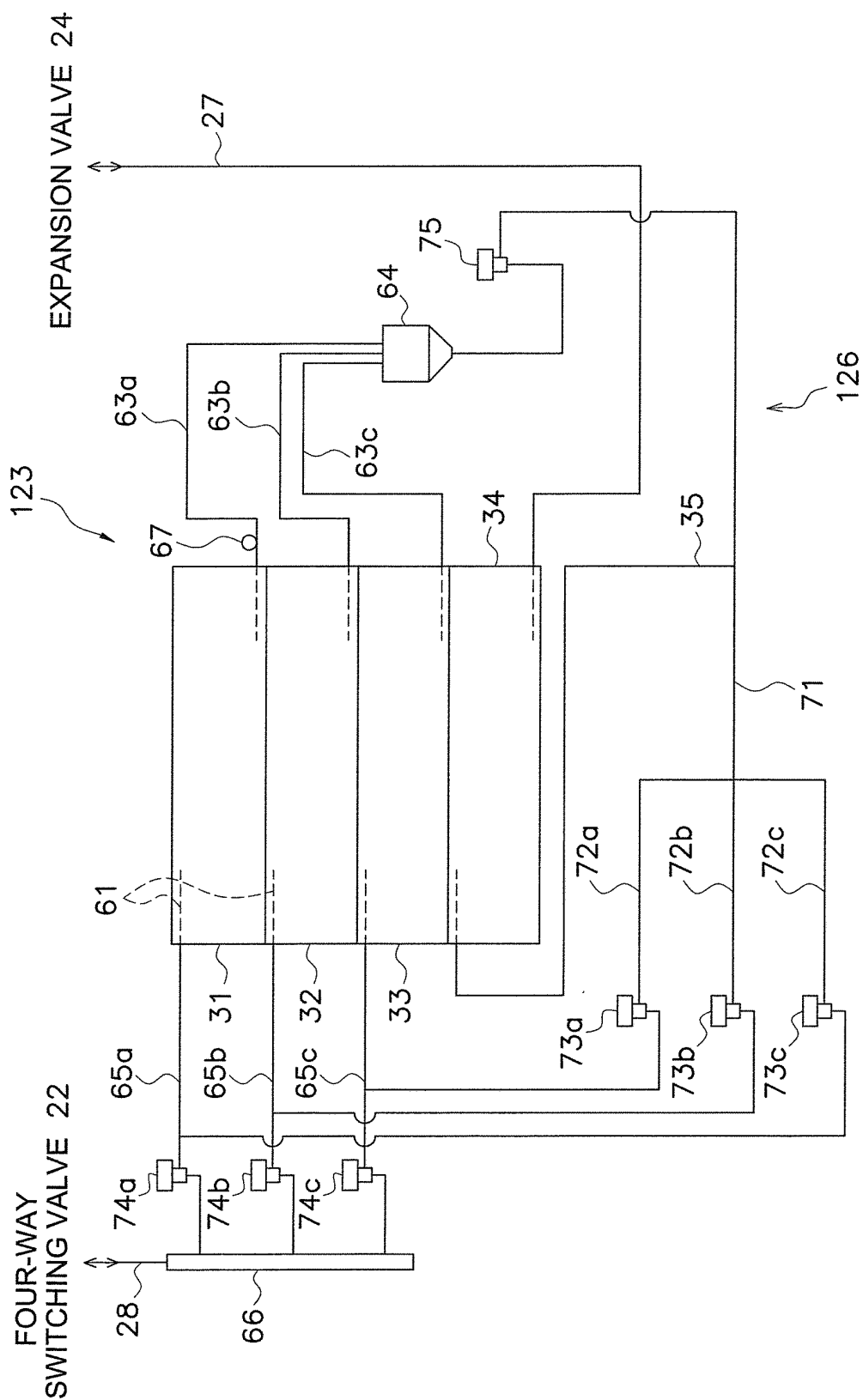


FIG. 22

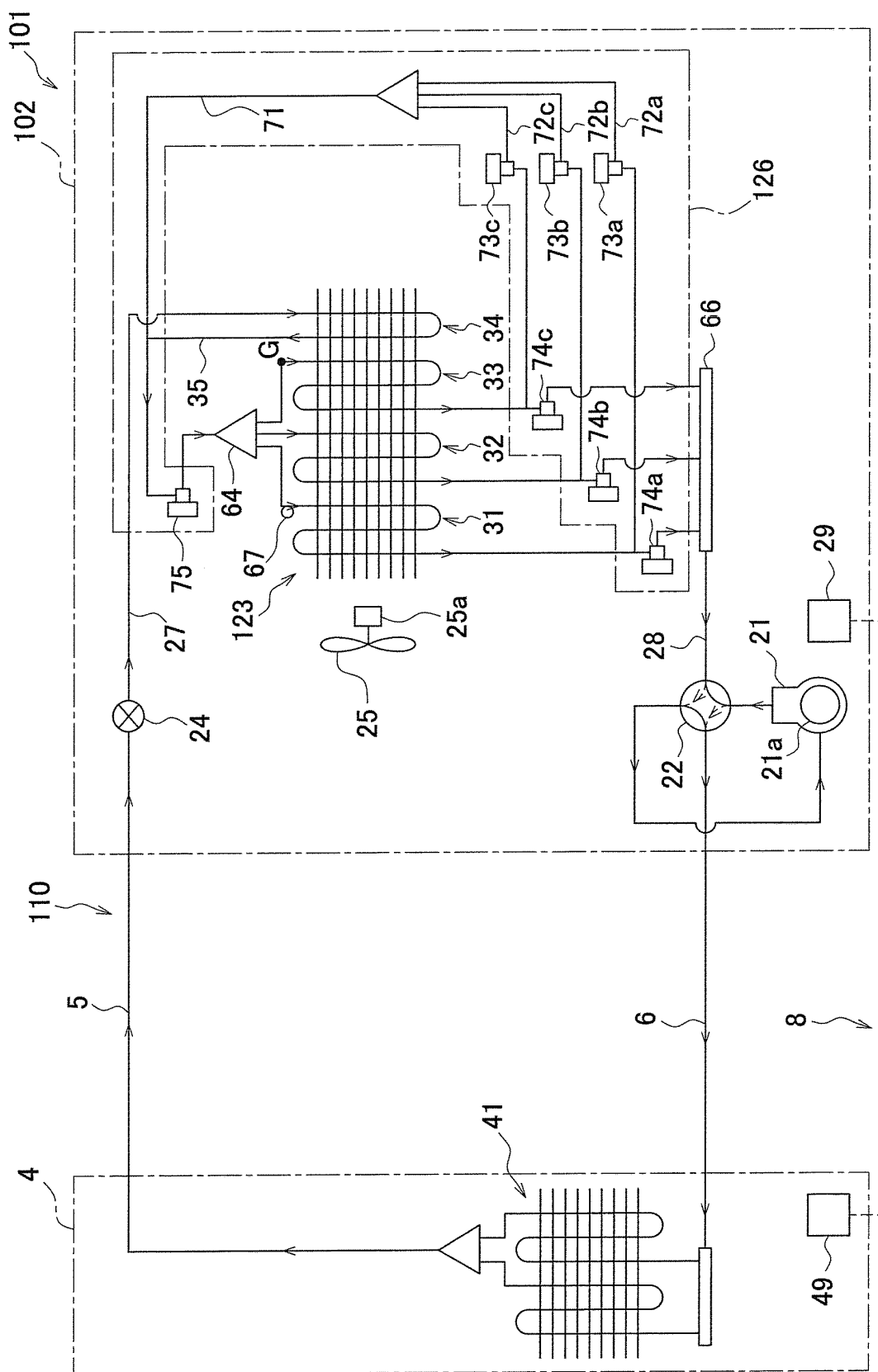


FIG. 23

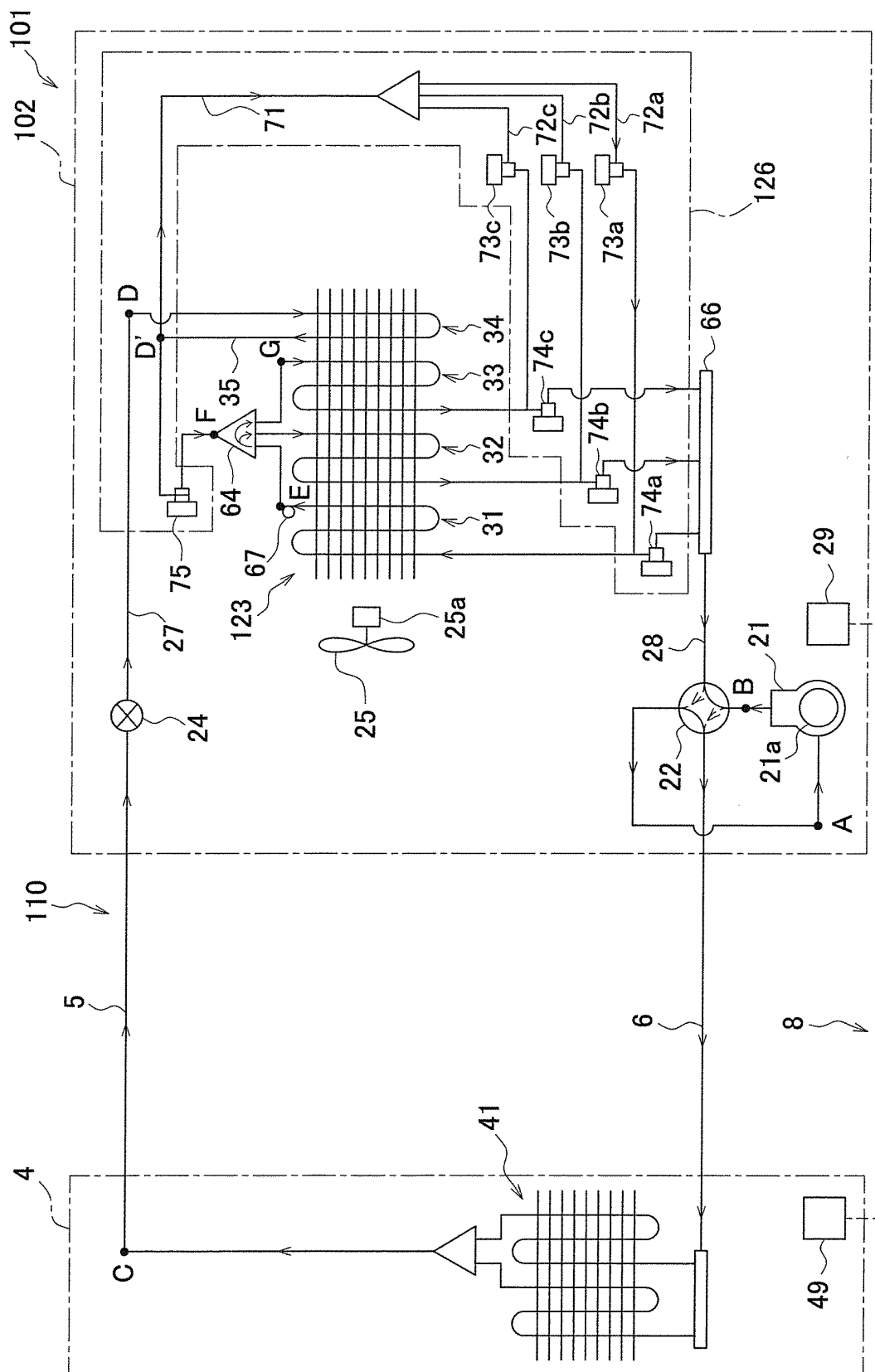


FIG. 24

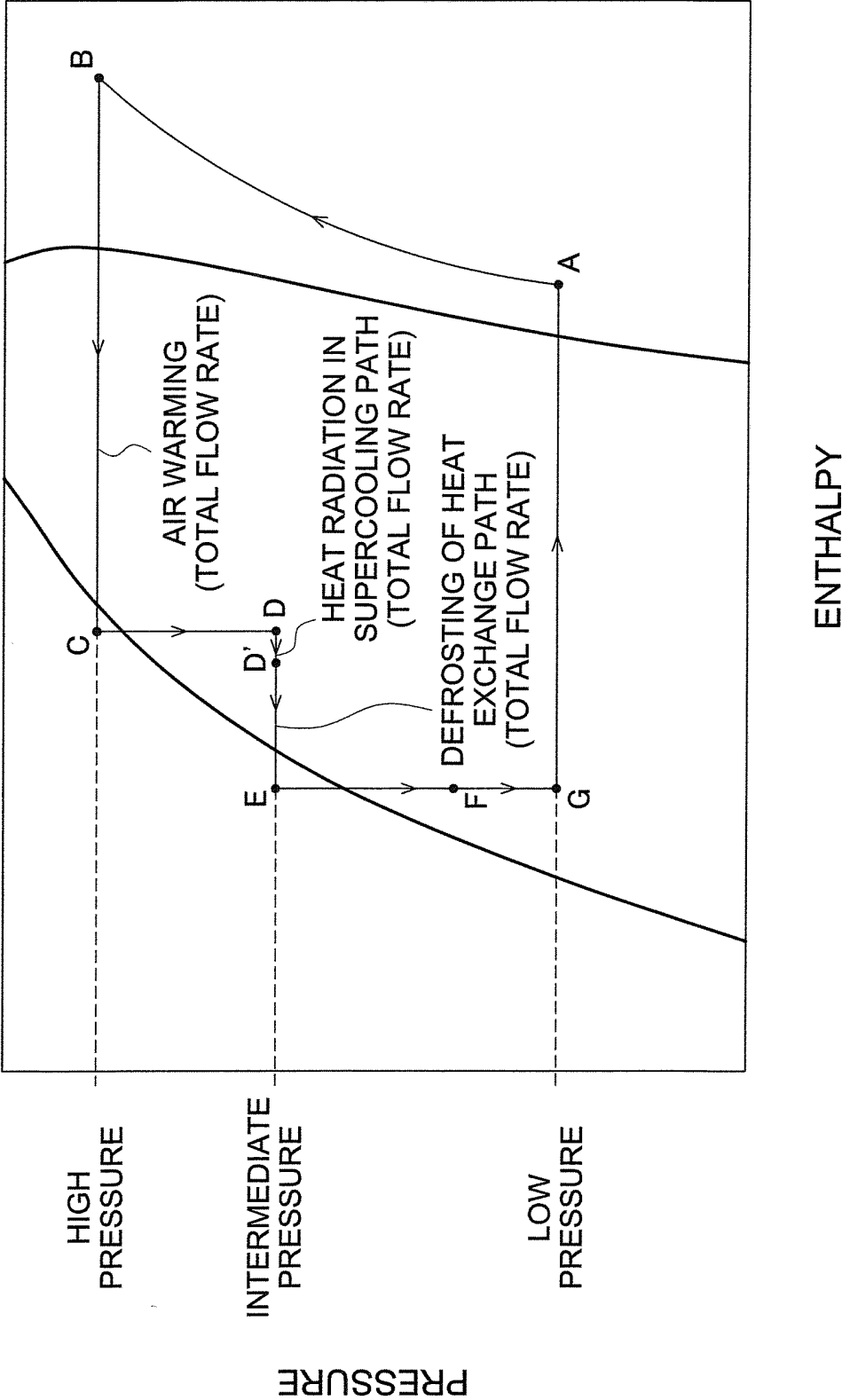


FIG. 25

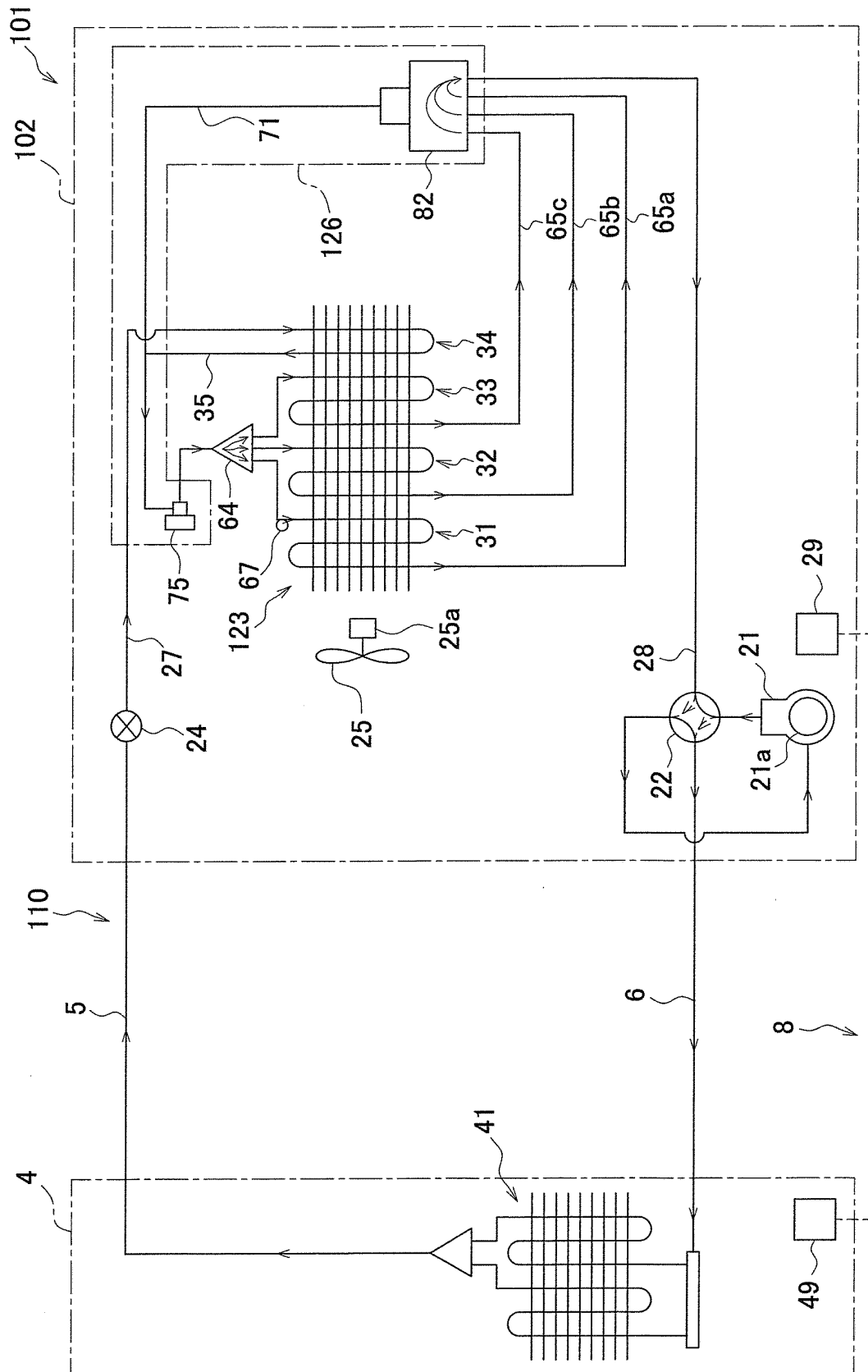


FIG. 26

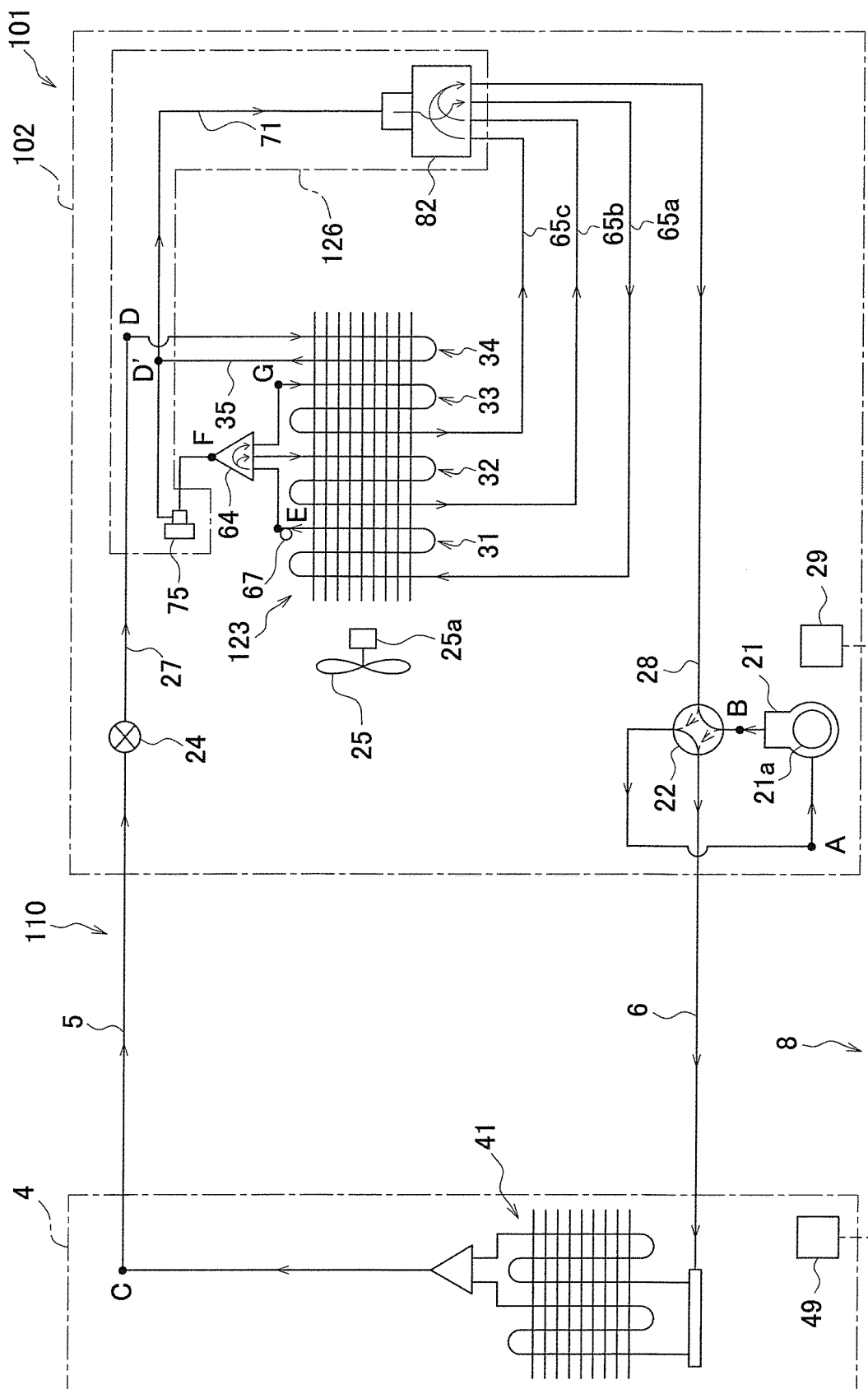


FIG. 27

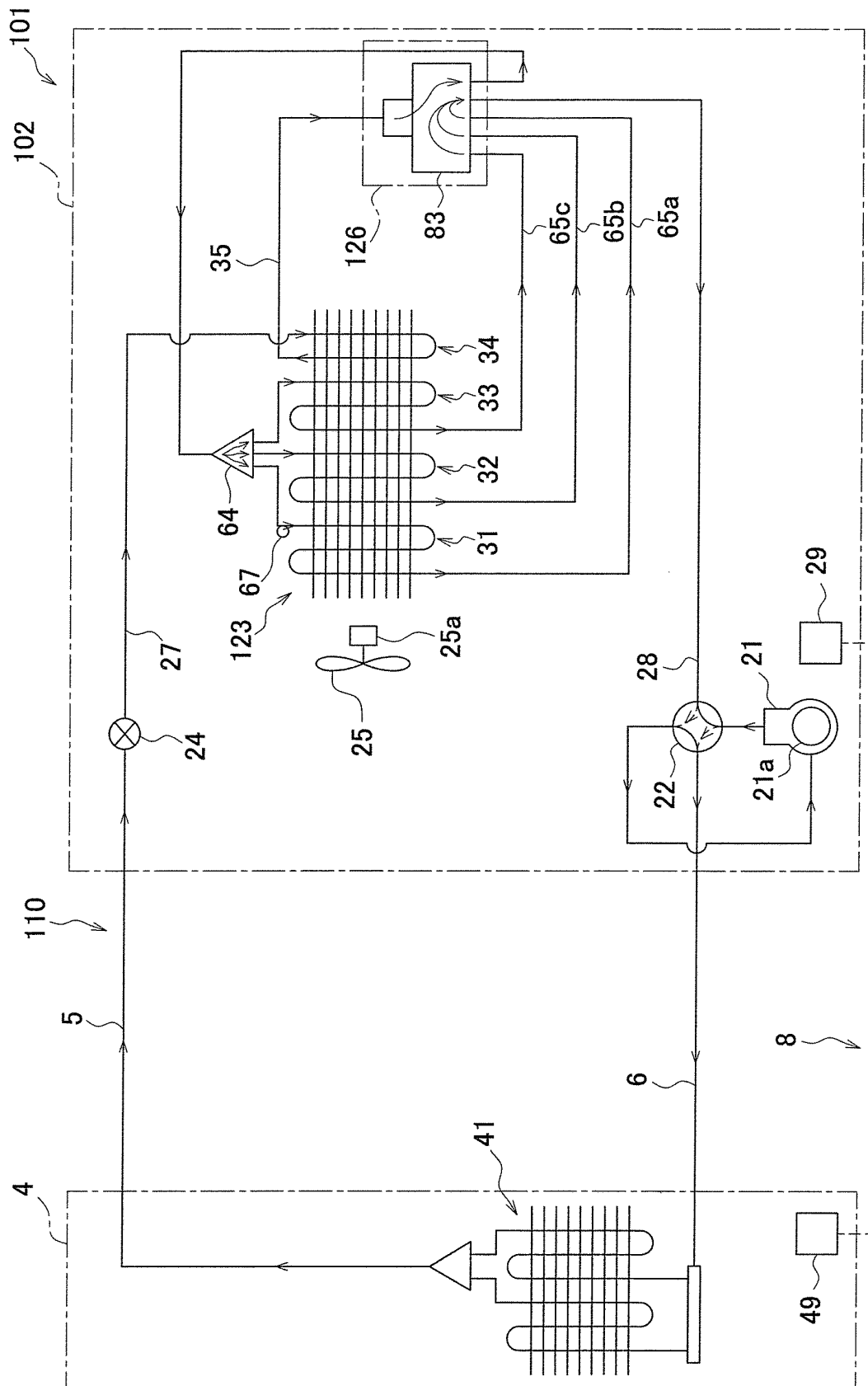


FIG. 28

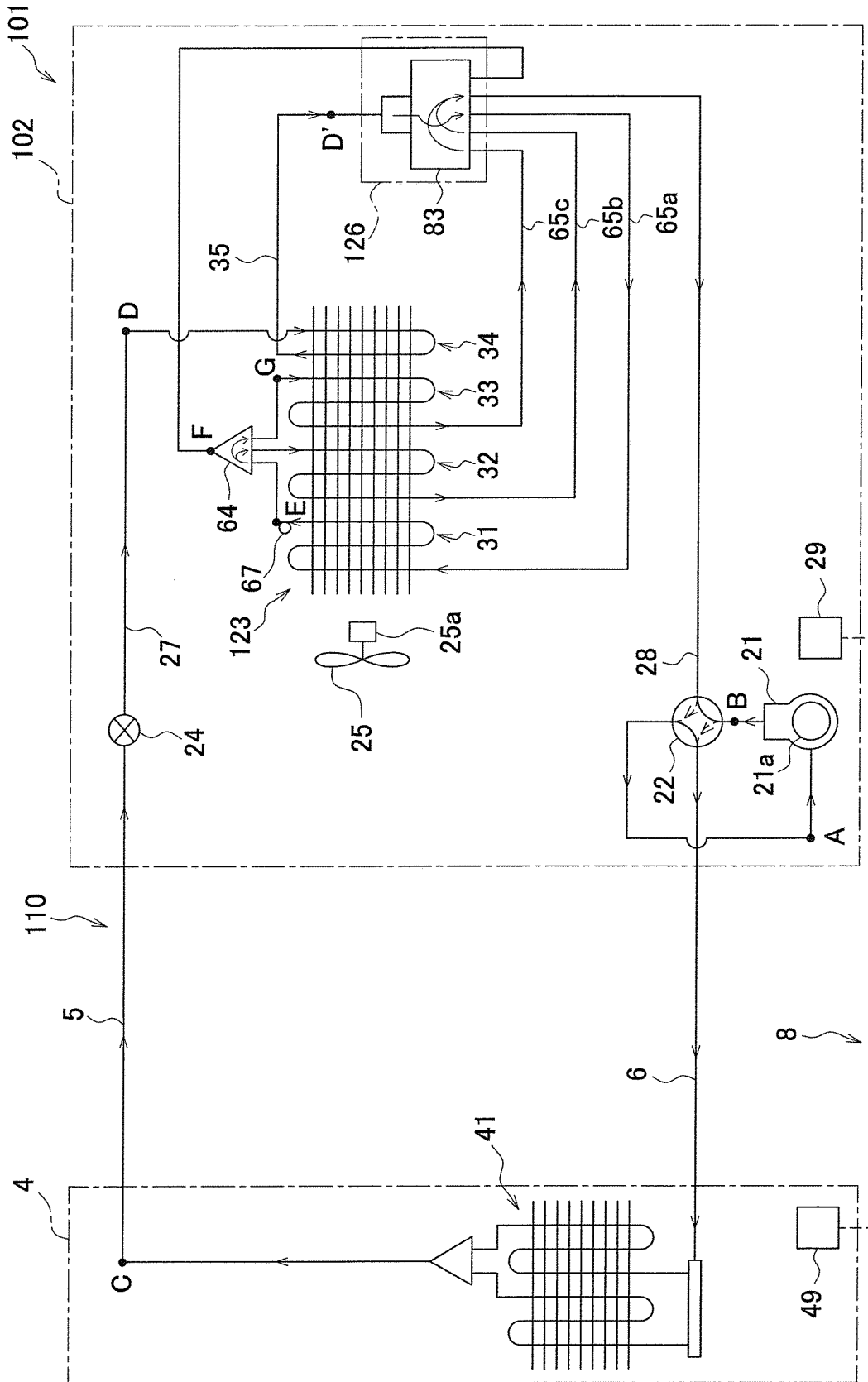


FIG. 29

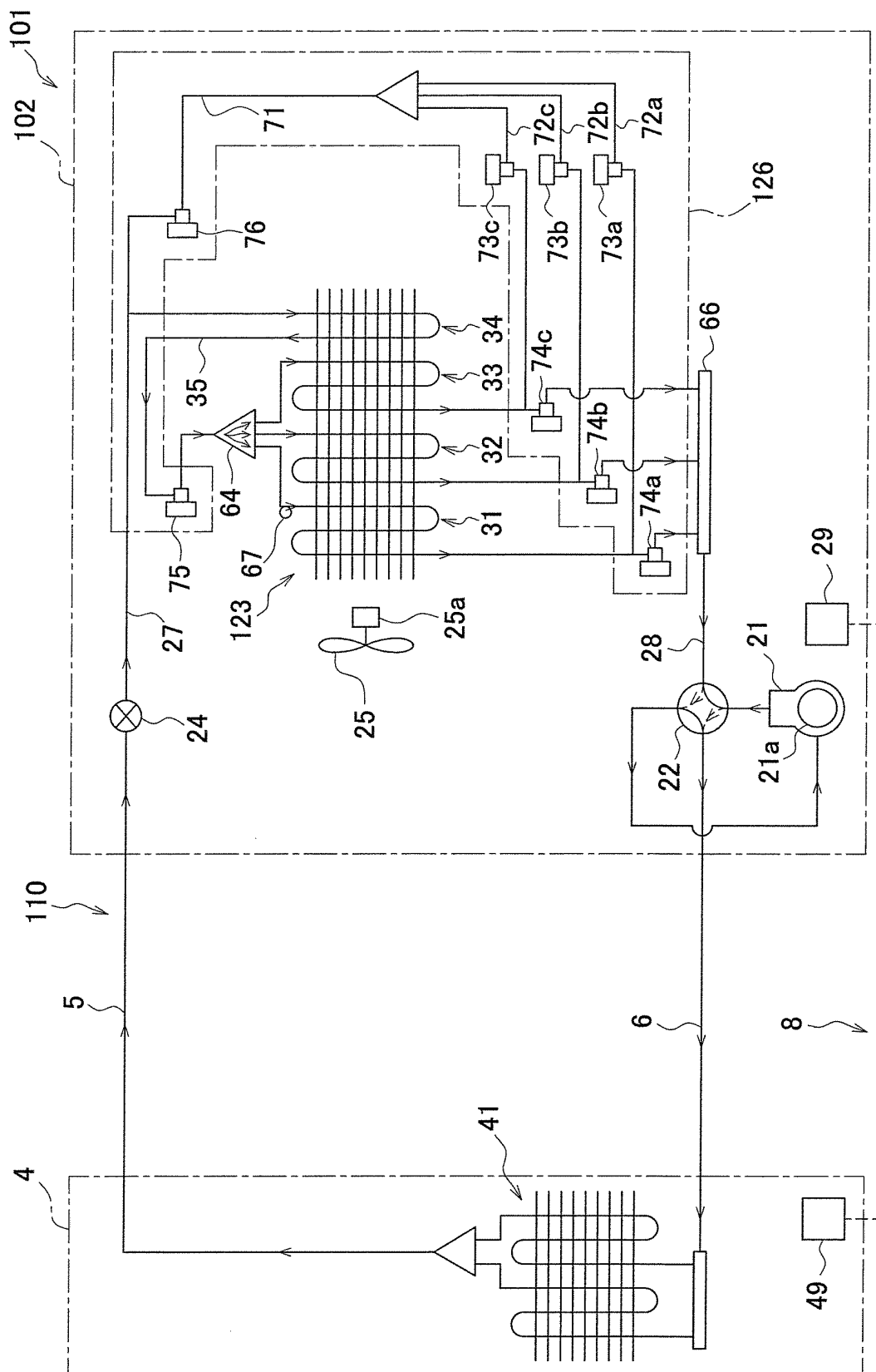


FIG. 30

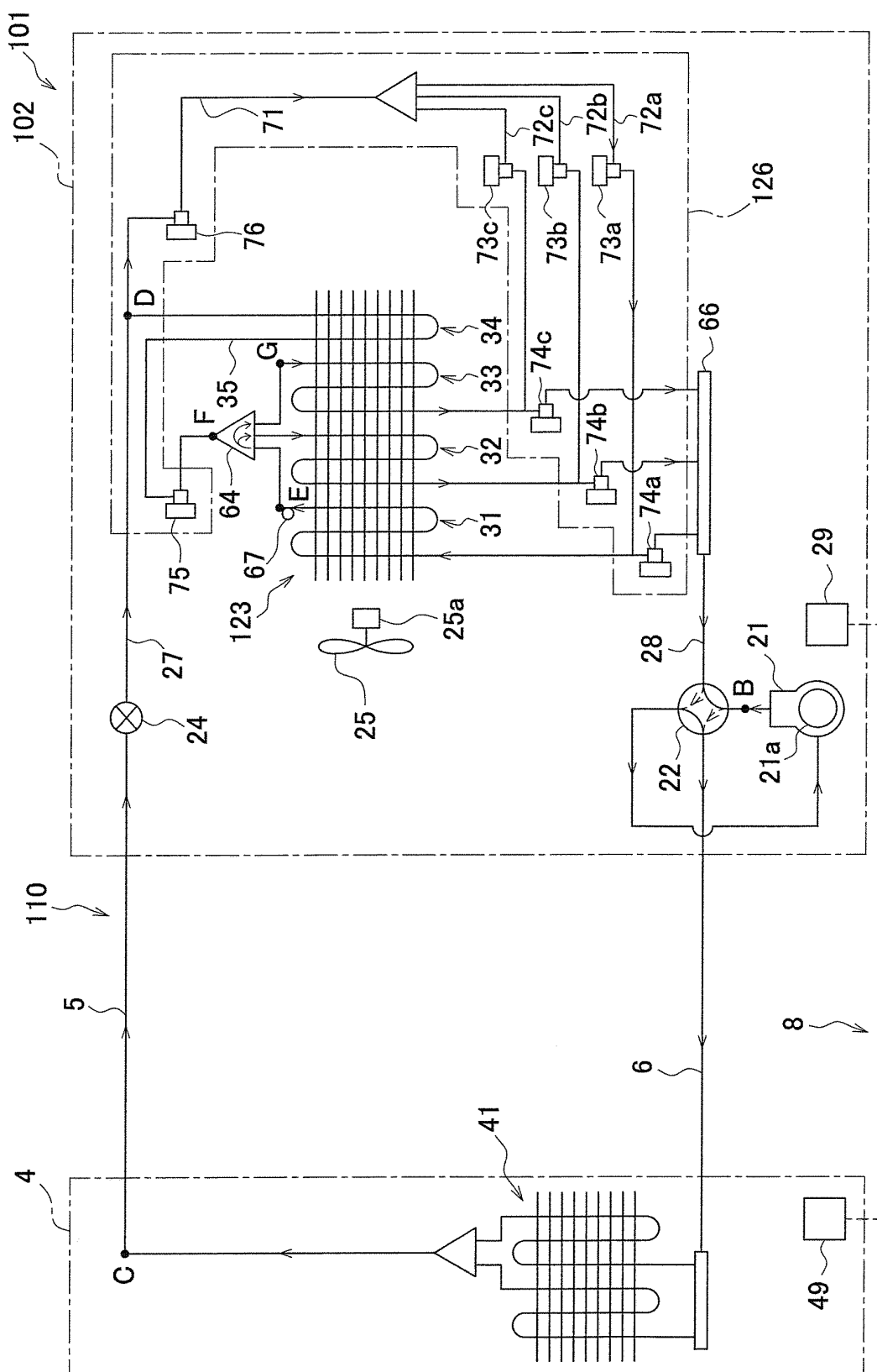
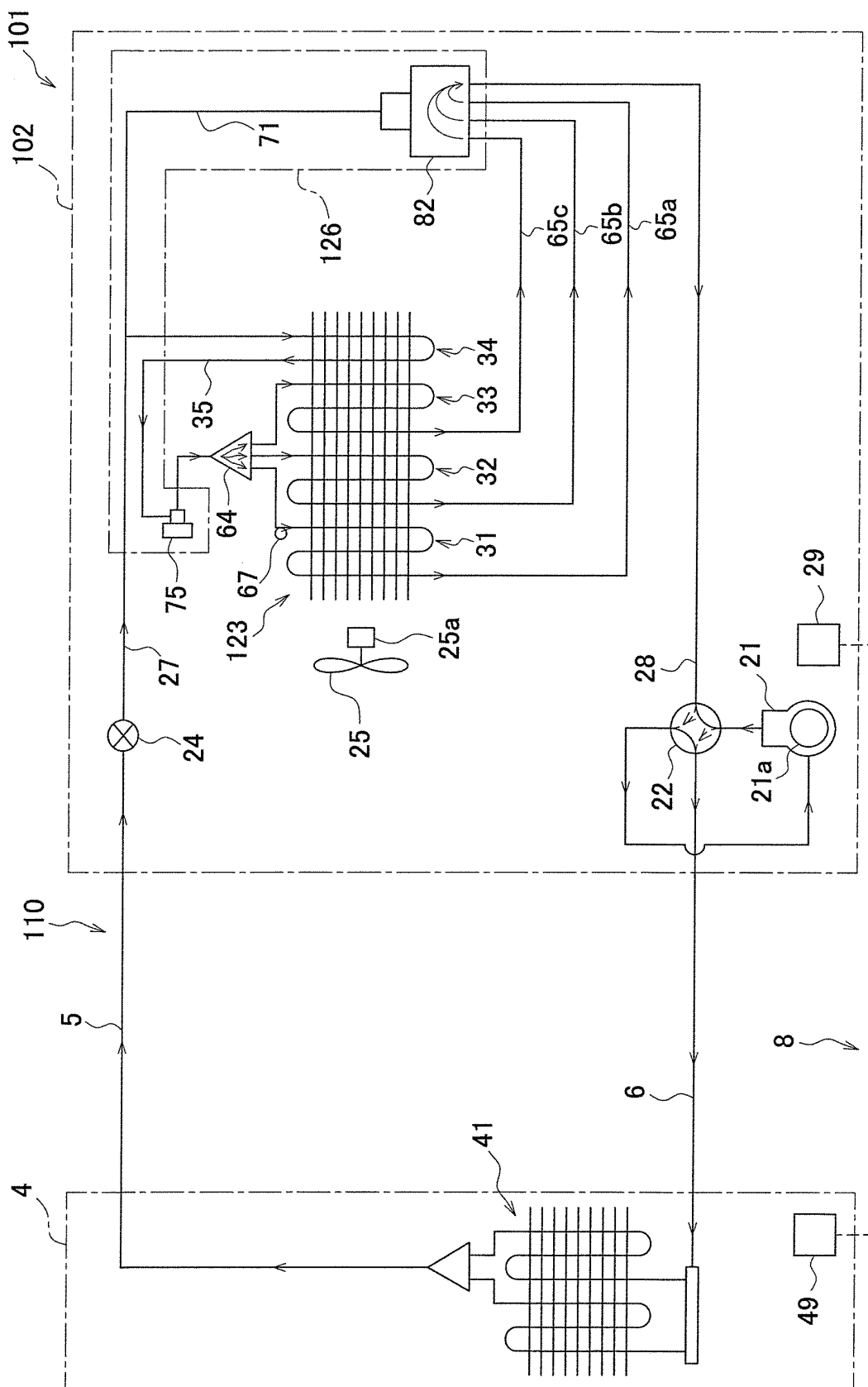


FIG. 31



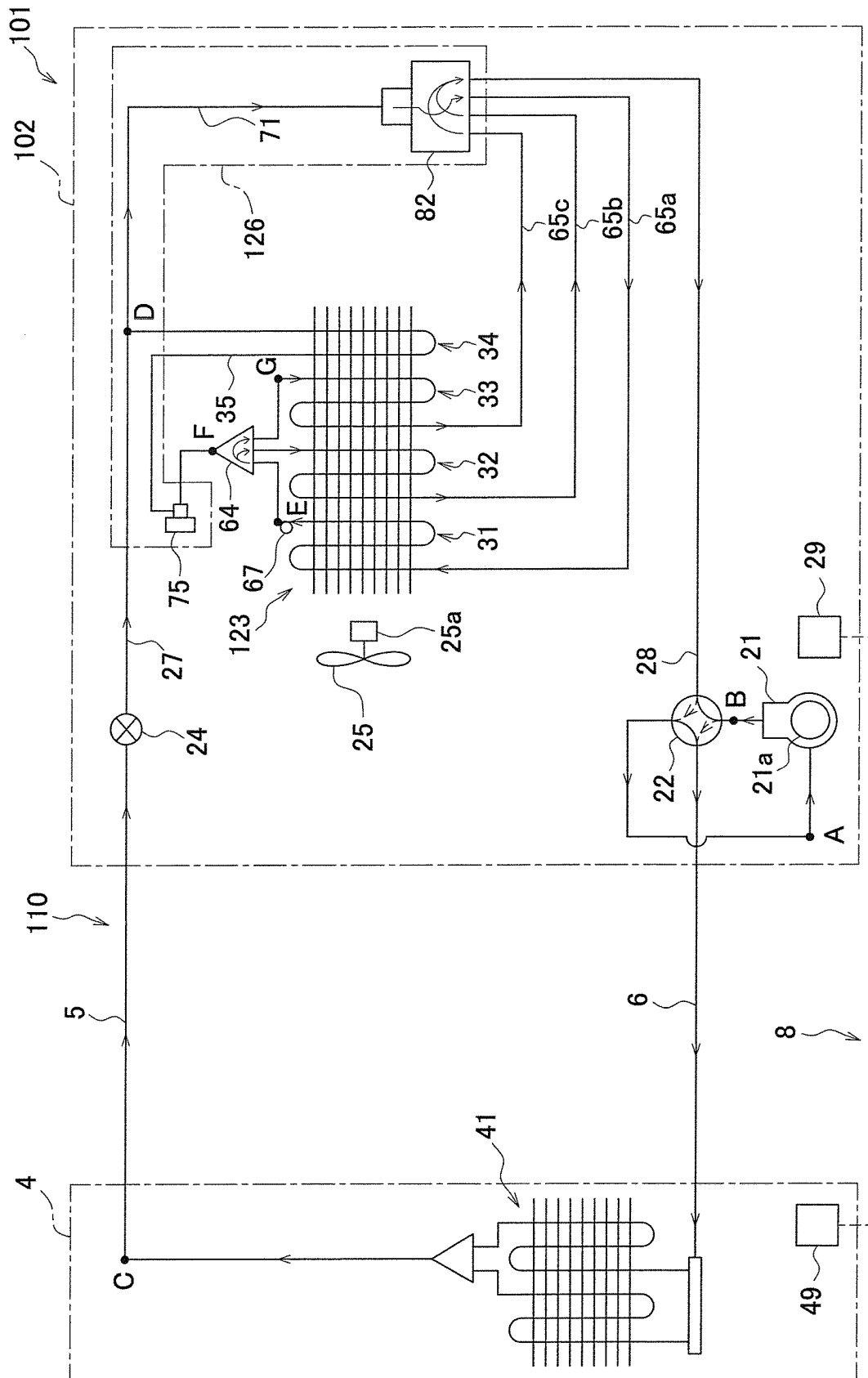


FIG. 33

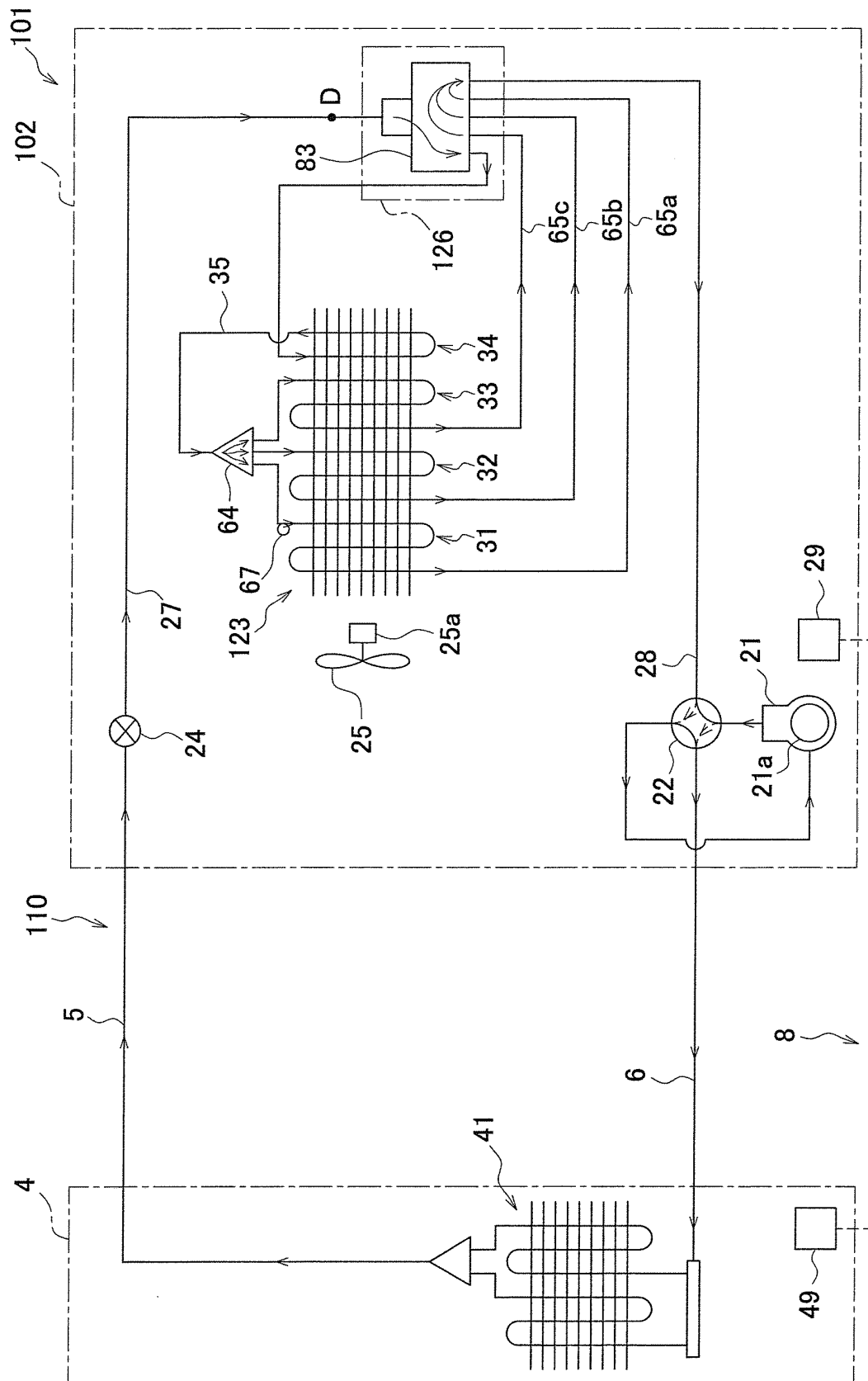


FIG. 34

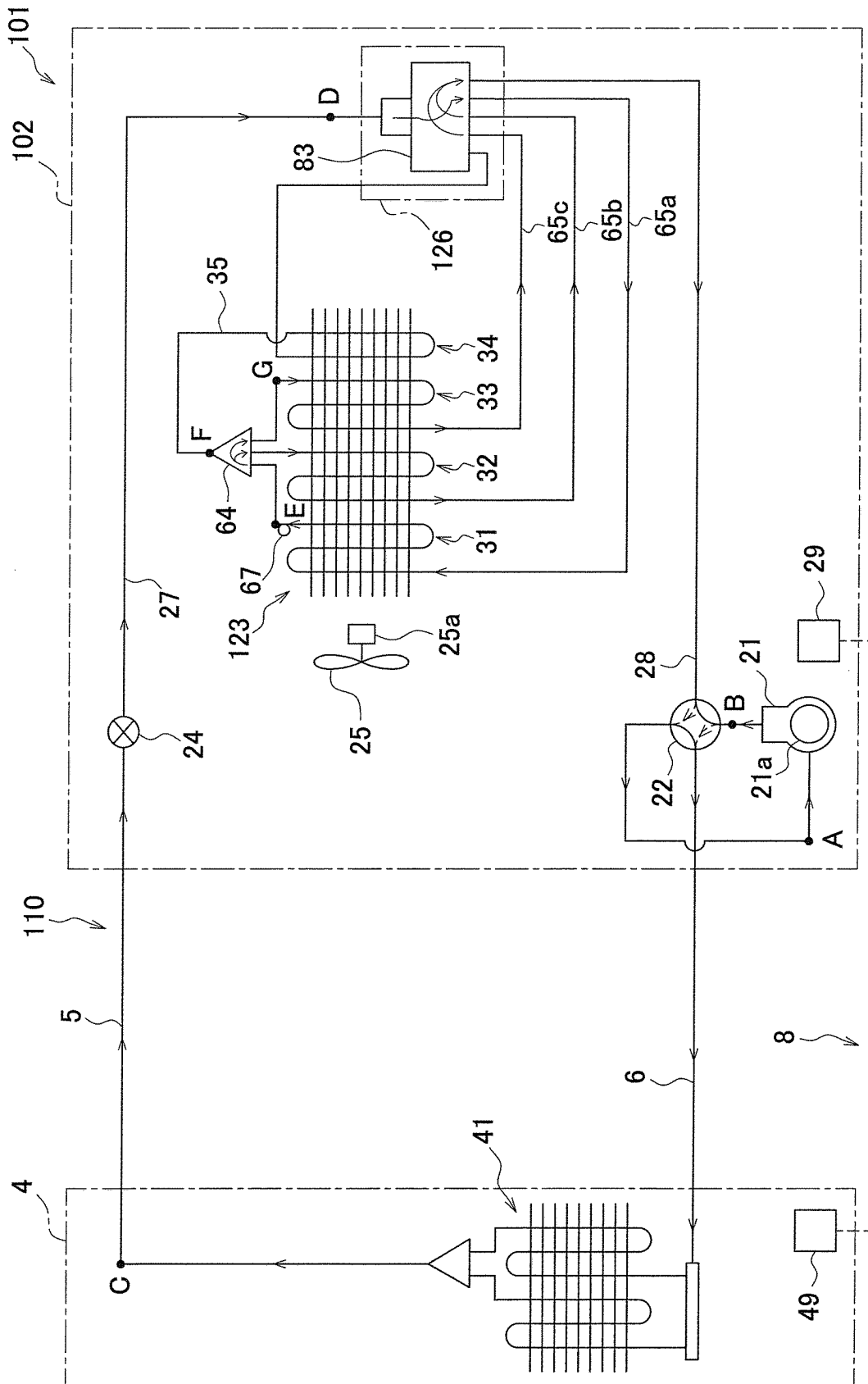


FIG. 35

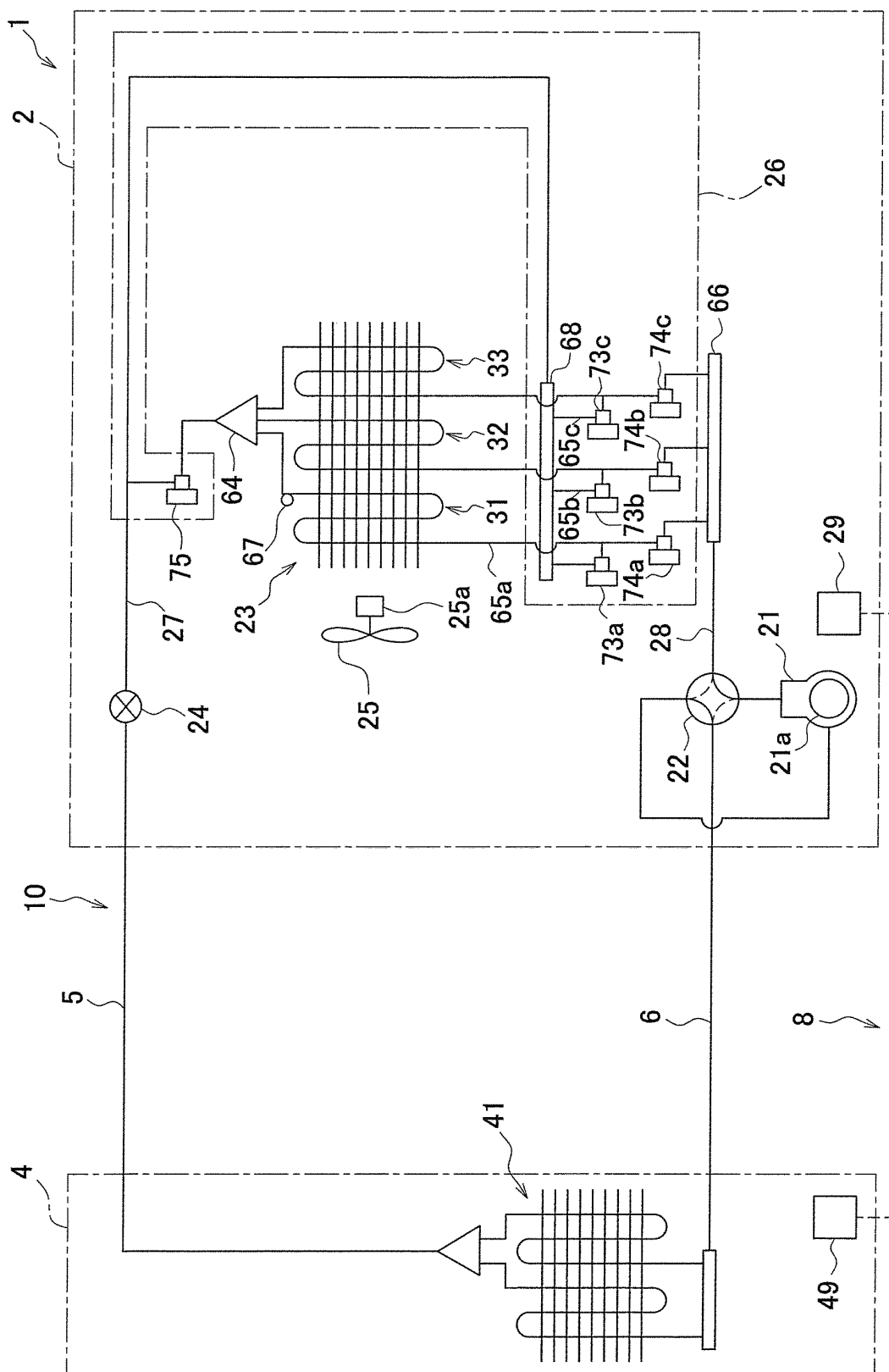


FIG. 36

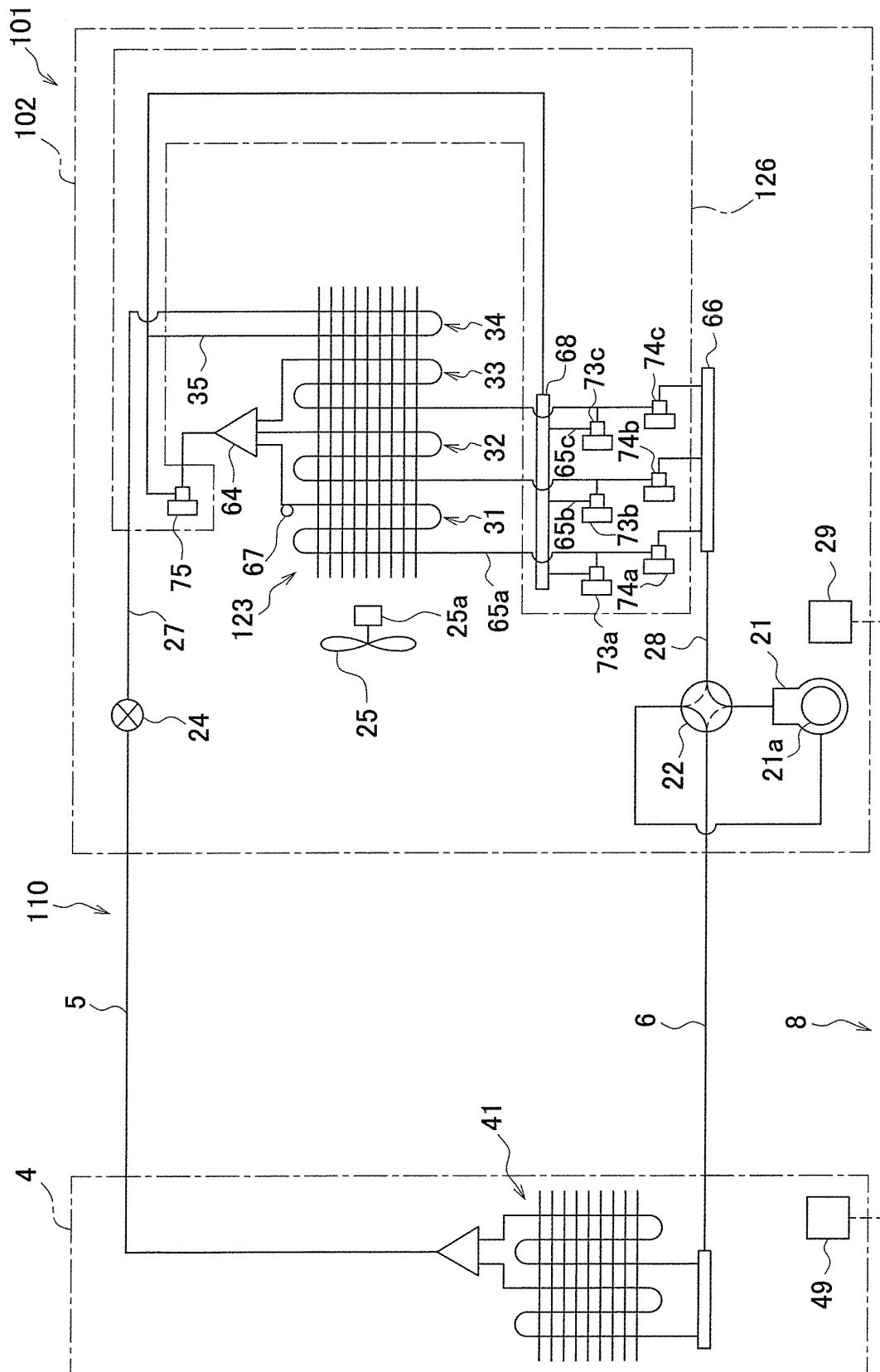


FIG. 37

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/064098

A. CLASSIFICATION OF SUBJECT MATTER F24F11/02(2006.01)i, F25B47/02(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) F24F11/02, F25B47/02		
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 1996-2012 Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012		
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 A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 87474/1987 (Laid-open No. 196061/1988) (Mitsubishi Heavy Industries, Ltd.), 16 December 1988 (16.12.1988), entire text; all drawings (Family: none)	1, 2 3
Y	JP 2010-270938 A (Sanyo Electric Co., Ltd.), 02 December 2010 (02.12.2010), paragraphs [0009] to [0013]; fig. 1 to 4 & US 2010/0293980 A1 & FR 2945858 A & CN 101893355 A & IT MI20100847 A & IT MI20100847 A1	1, 2
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "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 "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 26 July, 2012 (26.07.12)		Date of mailing of the international search report 07 August, 2012 (07.08.12)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/064098

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 2010-38416 A (Daikin Industries, Ltd.), 18 February 2010 (18.02.2010), paragraphs [0028] to [0047]; fig. 1 to 3 (Family: none)	1, 2
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 23427/1987 (Laid-open No. 132272/1988) (Fuji Electric Co., Ltd.), 30 August 1988 (30.08.1988), column 2, line 11 to column 6, line 2; fig. 5, 6 (Family: none)	1-3
A	JP 63-176969 A (Matsushita Electric Industrial Co., Ltd.), 21 July 1988 (21.07.1988), page 3, upper right column, lines 1 to 14; fig. 1, 2 (Family: none)	1-3
A	JP 2002-364936 A (Kobe Steel, Ltd.), 18 December 2002 (18.12.2002), paragraphs [0016] to [0018]; fig. 1 (Family: none)	3

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000274780 A [0003] [0151]
- JP 2001059994 A [0003] [0151]