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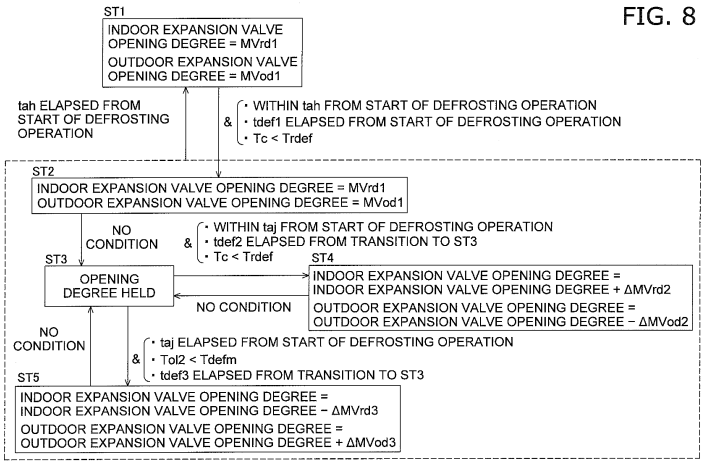
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(54) AIR CONDITIONER

(57) An air conditioning apparatus (1) comprising a refrigerant circuit (10) having a compressor (21), an outdoor heat exchanger (23), indoor heat exchangers (42a, 42b), and a heat storage heat exchanger (28) for performing heat exchange between a refrigerant and a heat storage medium; the air conditioning apparatus being capable of performing a heat storage operation, and also of simultaneously performing a heat-storage-utilizing operation and an air-warming operation during a defrosting operation. In the air conditioning apparatus (1), indoor units (4a, 4b) provided with indoor expansion valves (41a, 41b) have indoor-side control parts (48a, 48b) for deciding the opening degrees of the indoor expansion valves (41a, 41b) when only an air-warming operation is performed, and an outdoor unit (2) provided with an outdoor expansion valve (24) has an outdoor-side control part (38) for deciding the opening degree of the outdoor expansion valve (24) when only the air-warming operation is performed, and deciding the opening degrees of the indoor expansion valves (41a, 41b) and the opening degree of the outdoor expansion valve (24) when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation.

FIG. 8



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Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus, and particularly to an air conditioning apparatus comprising a refrigerant circuit having a heat storage heat exchanger for performing heat exchange between a refrigerant and a heat storage medium, it being possible for a heat storage operation for storing heat in the heat storage medium to be performed by causing the heat storage heat exchanger to function as a heat radiator of the refrigerant, and an air-warming operation and a heat-storage-utilizing operation for radiating heat from the heat storage medium to be performed simultaneously by causing the heat storage heat exchanger to function as an evaporator of the refrigerant during a defrosting operation.

BACKGROUND ART

[0002] In the past, there have been air conditioning apparatuses that comprise a refrigerant circuit having a compressor, an outdoor heat exchanger, an indoor heat exchanger, and a heat storage heat exchanger for performing heat exchange between a refrigerant and a heat storage medium, in which a heat storage operation is performed, and a heat-storage-utilizing operation and an air-warming operation can be performed simultaneously during a defrosting operation, as shown in Patent Literature 1 (Japanese Laid-open Patent Application No. 2005-337657). The heat storage operation is an operation for storing heat in a heat storage medium by causing the heat storage heat exchanger to function as a heat radiator of the refrigerant. The defrosting operation is an operation for defrosting the outdoor heat exchanger by causing the outdoor heat exchanger to function as a heat radiator of the refrigerant. The heat-storage-utilizing operation is an operation for radiating heat from the heat storage medium by causing the heat storage heat exchanger to function as an evaporator of the refrigerant. The air-warming operation is an operation for causing the indoor heat exchanger to function as a heat radiator of the refrigerant.

SUMMARY OF THE INVENTION

[0003] The conventional air conditioning apparatus described above has an indoor unit provided with an indoor heat exchanger and an indoor expansion valve for varying the flow rate of refrigerant flowing through the indoor heat exchanger, and an outdoor unit provided with an outdoor heat exchanger and an outdoor expansion valve for varying the flow rate of refrigerant flowing through the outdoor heat exchanger. During a normal air-warming operation (i.e. during an air-warming operation that does not accompany a heat-storage-utilizing operation or a defrosting operation), the opening degree of the indoor expansion valve is controlled on the basis of the degree of subcooling of the refrigerant in the outlet of the indoor heat exchanger (degree of subcooling control by the indoor expansion valve), and the air-warming capability of the indoor heat exchanger is thereby ensured. The opening degree of the indoor expansion valve in this degree of subcooling control is decided by an indoor-side control part provided to the indoor unit.

[0004] In such an air conditioning apparatus, even in cases in which the air-warming operation is performed simultaneously during a defrosting operation accompanying a heat-storage-utilizing operation, the indoor-side control part preferably controls the opening degree of the indoor expansion valve and ensures the air-warming capability of the indoor heat exchanger, similar to during normal air-warming operation, when there is excess in the defrosting capability of the outdoor heat exchanger.

[0005] However, when there is no excess in the defrosting capability of the outdoor heat exchanger, the opening degree of the indoor expansion valve must be different from the opening degree during the normal air-warming operation in order to limit the air-warming capability of the indoor heat exchanger. When the opening degree of the indoor expansion valve is too great relative to the opening degree of the outdoor expansion valve, the limit on the air-warming capability of the indoor heat exchanger becomes insufficient, the defrosting capability of the outdoor heat exchanger becomes insufficient, and the defrosting operation therefore ends while the outdoor heat exchanger is not yet fully defrosted. Conversely, when the opening degree of the indoor expansion valve is too small relative to the opening degree of the outdoor expansion valve, the defrosting capability of the outdoor heat exchanger is sufficient but the limit on the air-warming capability of the indoor heat exchanger becomes excessive, and it is therefore not possible to sufficiently achieve the advantage of performing an air-warming operation by means of a defrosting operation accompanying a heat-storage-utilizing operation.

[0006] An object of the present invention is to provide an air conditioning apparatus that comprises a refrigerant circuit having a heat storage heat exchanger for performing heat exchange between a refrigerant and a heat storage medium, that can perform a heat storage operation, and that can perform a heat-storage-utilizing operation and an air-warming operation simultaneously during a defrosting operation, wherein the opening degrees of the indoor expansion valve and the outdoor expansion valve can be appropriately decided when the air-warming operation is performed simultaneously during the defrosting operation accompanying the heat-storage-utilizing operation.

[0007] An air conditioning apparatus according to a first aspect comprises a refrigerant circuit having a compressor, an outdoor heat exchanger, indoor heat exchangers, and a heat storage heat exchanger for performing heat exchange between a refrigerant and a heat storage medium, the air conditioning apparatus being capable of per-

forming a heat storage operation, and simultaneously performing a heat-storage-utilizing operation and an air-warming operation during a defrosting operation. The heat storage operation is an operation for storing heat in the heat storage medium by causing the heat storage heat exchanger to function as a heat radiator of the refrigerant. The defrosting operation is an operation for defrosting the outdoor heat exchanger by causing the outdoor heat exchanger to function as a heat radiator of the refrigerant. The heat-storage-utilizing operation is an operation for radiating heat from the heat storage medium by causing the heat storage heat exchanger to function as an evaporator of the refrigerant. The air-warming operation is an operation for causing the indoor heat exchangers to function as heat radiators of the refrigerant. The refrigerant circuit also has indoor expansion valves for varying the flow rate of the refrigerant flowing through the indoor heat exchangers, and an outdoor expansion valve for varying the flow rate of the refrigerant flowing through the outdoor heat exchanger. The indoor heat exchangers and the indoor expansion valves herein are provided to indoor units, and the outdoor heat exchanger and the outdoor expansion valve are provided to an outdoor unit. In this air conditioning apparatus, the indoor units have indoor-side control parts for deciding the opening degrees of the indoor expansion valves when only the air-warming operation is performed, and the outdoor unit has an outdoor-side control part for deciding the opening degree of the outdoor expansion valve when only the air-warming operation is performed and deciding the opening degrees of the indoor expansion valves and the opening degree of the outdoor expansion valve when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation.

[0008] When only the air-warming operation is performed herein, the indoor-side control parts decide the opening degrees of the indoor expansion valves and the outdoor-side control part decides the opening degree of the outdoor expansion valve, but when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the outdoor-side control part decides not only the opening degree of the outdoor expansion valve but also the opening degrees of the indoor expansion valves. Therefore, when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the outdoor-side control part can decide the opening degree of the outdoor expansion valve and the opening degrees of the indoor expansion valves all together, taking into account a balance between the defrosting capability of the outdoor heat exchanger and the air-warming capabilities of the indoor heat exchangers.

[0009] The opening degrees of the indoor expansion valves and the outdoor expansion valve can thereby be appropriately decided herein when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation.

[0010] An air conditioning apparatus according to a second aspect is the air conditioning apparatus according to the first aspect, wherein when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the opening degrees of the indoor expansion valves are decided on the basis of the correlation between the condensation temperature of the refrigerant in the refrigerant circuit and the indoor temperatures of the spaces being air-conditioned by the indoor units, until a first defrosting time elapses from the start of the defrosting operation.

[0011] When the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the opening degrees of the indoor expansion valves must be decided while the air-warming capabilities of the indoor heat exchangers are reliably ensured. However, when the outdoor-side control part decides the opening degrees of the indoor expansion valves, it is difficult to take into account the effects of pressure loss and the like in the refrigerant in the refrigerant pipes connecting the outdoor unit and the indoor units.

[0012] In view of this, the opening degrees of the indoor expansion valves are decided herein on the basis of the correlation between the condensation temperature of the refrigerant in the refrigerant circuit and the indoor temperatures of the spaces being air-conditioned by the indoor units until the first defrosting time elapses from the start of the defrosting operation, as described above. For example, when the condensation temperature is lower than a threshold temperature obtained from the indoor temperatures, the outdoor-side control part determines that the air-warming capabilities of the indoor heat exchangers are not being ensured, and increases the opening degrees of the indoor expansion valves so that the air-warming capabilities of the indoor heat exchangers are ensured. Moreover, as described above, such a decision about the opening degree for the indoor expansion valves is performed until the first defrosting time elapses from the start of the defrosting operation, and in the initial period of the defrosting operation, the defrosting operation is performed with priority given to ensuring the air-warming capabilities of the indoor heat exchangers.

[0013] The outdoor-side control part thereby appropriately decides the opening degrees of the indoor expansion valves on the basis of the correlation between the condensation temperature and the indoor temperatures, whereby the defrosting operation can be performed with priority given to ensuring the air-warming capabilities of the indoor heat exchangers.

[0014] An air conditioning apparatus according to a third aspect is the air conditioning apparatus according to the second aspect, wherein after the first defrosting time has elapsed from the start of the defrosting operation, the opening degrees of the indoor expansion valves and the outdoor expansion valve are altered so that the air-warming capabilities of the indoor heat exchangers decrease and the defrosting capability of the outdoor heat

exchanger increases.

[0015] When the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the defrosting capability of the outdoor heat exchanger must be increased in order to reliably end defrosting of the outdoor heat exchanger.

[0016] In view of this, after the first defrosting time has elapsed from the start of the defrosting operation, the opening degrees of the indoor expansion valves and the outdoor expansion valve are herein altered so that the air-warming capabilities of the indoor heat exchangers decrease and the defrosting capability of the outdoor heat exchanger increases, as described above. For example, after the first defrosting time has elapsed from the start of the defrosting operation, the outdoor-side control part reduces the opening degrees of the indoor expansion valves and increases the opening degree of the outdoor expansion valve to reduce the air-warming capabilities of the indoor heat exchangers and increase the defrosting capability of the outdoor heat exchanger, whereby operation of the air conditioning apparatus transitions from prioritizing air-warming to prioritizing defrosting.

[0017] The outdoor-side control part thereby appropriately decides the opening degrees of the indoor expansion valves and the outdoor expansion valve, whereby operation can be made to transition from prioritizing air-warming to prioritizing defrosting, and the defrosting of the outdoor heat exchanger can be reliably ended.

[0018] An air conditioning apparatus according to a fourth aspect is the air conditioning apparatus according to the third aspect, wherein the first defrosting time is decided on the basis of the outdoor temperature of the external space where the outdoor unit is disposed.

[0019] The time required for defrosting is affected by heat radiation loss from the heat storage medium and/or the devices constituting the refrigerant circuit, and this time therefore tends to be longer as the outdoor temperature decreases. Therefore, the first defrosting time, which is the time during which an operation prioritizing air-warming is performed, is also preferably decided on the basis of the outdoor temperature.

[0020] In view of this, the first defrosting time herein is decided on the basis of the outdoor temperature as described above. For example, the lower the outdoor temperature, the shorter the time must be for an operation prioritizing air-warming and the longer the time must be for an operation prioritizing defrosting, and the first defrosting time is therefore decided so as to be shorter as the outdoor temperature decreases.

[0021] The first defrosting time during which an operation prioritizing air-warming is performed is thereby herein decided on the basis of the outdoor temperature, whereby a longer operation prioritizing defrosting can be performed, and defrosting of the outdoor heat exchanger can be reliably ended.

[0022] An air conditioning apparatus according to a fifth aspect is the air conditioning apparatus according to any one of the second through fourth aspects, wherein during the defrosting operation, the air conditioning apparatus determines whether or not the opening degrees of the indoor expansion valves are too large on the basis of the degree of superheating of the refrigerant discharged from the compressor.

[0023] When the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the refrigerant in the outlets of the indoor heat exchangers readily reaches a gas-liquid two-phase state when the opening degrees of the indoor expansion valves become too large. Refrigerant in a gas state then readily fills the refrigerant pipes connecting the outlet sides (liquid sides) of the indoor heat exchangers and the inlet side (liquid side) of the heat storage heat exchanger functioning as an evaporator of the refrigerant. In cases in which the refrigerant circuit does not have a receiver provided to the portion connecting the outlet sides (liquid sides) of the indoor heat exchangers and the inlet side (liquid side) of the heat storage heat exchanger functioning as an evaporator of the refrigerant, there is a risk that "liquid backflow" may occur, in which the liquid refrigerant returns to the compressor via the heat storage heat exchanger. When liquid backflow occurs, a tendency for the degree of superheating of the refrigerant discharged from the compressor to decrease is observed.

[0024] In view of this, the outdoor-side control part herein is designed to determine, on the basis of the degree of superheating of the refrigerant discharged from the compressor, that liquid backflow is occurring due to the opening degrees of the indoor expansion valves being too large. For example, when the degree of superheating of the refrigerant discharged from the compressor is lower than a threshold degree of superheating, the outdoor-side control part determines that liquid backflow is occurring. The opening degrees of the indoor expansion valves are then reduced as necessary.

[0025] It is thereby possible herein to perform the air-warming operation while appropriately determining whether or not the opening degrees of the indoor expansion valves have become too large during the defrosting operation accompanying the heat-storage-utilizing operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

FIG. 1 is a schematic overview of an air conditioning apparatus according to an embodiment of the present invention;

FIG. 2 is a schematic overview of the heat storage heat exchanger;

FIG. 3 is a control block diagram of the air conditioning apparatus;

FIG. 4 is a drawing showing the flow of refrigerant within the refrigerant circuit during the air-cooling operation;

FIG. 5 is a drawing showing the flow of refrigerant within the refrigerant circuit during the air-warming operation;
FIG. 6 is a drawing showing the flow of refrigerant within the refrigerant circuit during the heat storage operation (the heat storage operation during the air-warming operation);
FIG. 7 is a drawing showing the flow of refrigerant within the refrigerant circuit during the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation);
FIG. 8 is a flowchart of the process of deciding the opening degrees of the indoor expansion valves and the outdoor expansion valve during the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation);
FIG. 9 is a graph showing the change over time in the opening degrees of the indoor expansion valves and the outdoor expansion valve during the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation); and
FIG. 10 is a flowchart of the process of deciding the opening degrees of the indoor expansion valves and the outdoor expansion valve during the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation) according to Modification 2.

DESCRIPTION OF EMBODIMENTS

[0027] An embodiment of the air conditioning apparatus according to the present invention is described below with reference to the drawings. The specific configuration of the embodiment of the air conditioning apparatus according to the present invention is not limited to the following embodiment or the modifications thereof, and can be modified within a range that does not deviate from the scope of the invention.

(1) Basic Configuration of Air Conditioning Apparatus

[0028] FIG. 1 is a schematic overview of an air conditioning apparatus 1 according to an embodiment of the present invention. The air conditioning apparatus 1 is an apparatus used to air-condition the interior of a room in a building or the like by performing a vapor-compression refrigeration cycle operation. The air conditioning apparatus 1 is configured by connecting primarily an outdoor unit 2 and a plurality (two in this case) of indoor units 4a, 4b. The outdoor unit 2 and the plurality of indoor units 4a, 4b herein are connected via a liquid refrigerant communication pipe 6 and a gas refrigerant communication pipe 7. Specifically, a vapor-compression refrigerant circuit 10 of the air conditioning apparatus 1 is configured by connecting the outdoor unit 2 and the plurality of indoor units 4a, 4b via the refrigerant communication pipes 6, 7.

<Indoor Units>

[0029] The indoor units 4a, 4b are installed in a room. The indoor units 4a, 4b, which are connected to the outdoor unit 2 via the refrigerant communication pipes 6, 7, constitute part of the refrigerant circuit 10.

[0030] Next, the configuration of the indoor units 4a, 4b will be described. Because the indoor unit 4b has a configuration identical to that of the indoor unit 4a, only the configuration of the indoor unit 4a is described herein, and the configuration of the indoor unit 4b, for which the components are not described, uses the letter "b" in place of the letter "a" indicating the components of the indoor unit 4a.

[0031] The indoor unit 4a has primarily an indoor-side refrigerant circuit 10a constituting part of the refrigerant circuit 10 (the indoor unit 4b has an indoor-side refrigerant circuit 10b). The indoor-side refrigerant circuit 10a has primarily an indoor expansion valve 41a and an indoor heat exchanger 42a.

[0032] The indoor expansion valve 41a is a valve for depressurizing the refrigerant flowing through the indoor-side refrigerant circuit 10a and varying the flow rate of the refrigerant flowing through the indoor heat exchanger 42a. The indoor expansion valve 41a is an electric expansion valve connected to the liquid side of the indoor heat exchanger 42a.

[0033] The indoor heat exchanger 42a is composed of, e.g., a cross-fin-type fin-and-tube heat exchanger. An indoor fan 43a for sending indoor air to the indoor heat exchanger 42a is provided in proximity to the indoor heat exchanger 42a. Heat exchange between the refrigerant and indoor air is performed in the indoor heat exchanger 42a by the blowing of indoor air to the indoor heat exchanger 42a by the indoor fan 43a. The indoor fan 43a is designed to be rotatably driven by an indoor fan motor 44a. The indoor heat exchanger 42a is thereby designed to function as a heat radiator of the refrigerant and/or an evaporator of the refrigerant.

[0034] Various sensors are provided to the indoor unit 4a. A liquid-side temperature sensor 45a for detecting the temperature Trla of refrigerant in a liquid state or a gas-liquid two-phase state is provided to the liquid side of the indoor heat exchanger 42a. A gas-side temperature sensor 46a for detecting the temperature Trga of refrigerant in a gas state is provided to the gas side of the indoor heat exchanger 42a. An indoor temperature sensor 47a for detecting the temperature of indoor air (i.e. the indoor temperature Tra) in the space to be air-conditioned by the indoor unit 4a is provided in the indoor air intake port side of the indoor unit 4a. The indoor unit 4a also has an indoor-side control part 48a for controlling the actions of the components constituting the indoor unit 4a. The indoor-side control part 48a, which has components such as a microcomputer and/or a memory provided in order to perform controls for the indoor unit 4a, is designed to be capable of exchanging control signals and the like with a remote controller 49a for operating

the indoor unit 4a individually, and exchanging control signals and the like with the outdoor unit 2. The remote controller 49a is a device for the user to perform various settings and/or operations/stop commands pertaining to air conditioning operation.

<Outdoor Unit>

[0035] The outdoor unit 2 is installed outside of the room. The outdoor unit 2, which is connected to the indoor units 4a, 4b via the refrigerant communication pipes 6, 7, constitutes part of the refrigerant circuit 10.

[0036] Next, the configuration of the outdoor unit 2 will be described.

[0037] The outdoor unit 2 has primarily an outdoor-side refrigerant circuit 10c constituting part of the refrigerant circuit 10. The outdoor-side refrigerant circuit 10c has primarily a compressor 21, a first switching mechanism 22, an outdoor heat exchanger 23, an outdoor expansion valve 24, a second switching mechanism 27, a heat storage heat exchanger 28, and a heat storage expansion valve 29.

[0038] The compressor 21 is a hermetic compressor accommodating a compression element (not shown) inside a casing and a compressor motor 20 for rotatably driving the compression element. The compressor motor 20 is supplied with electric power via an inverter apparatus (not shown), and the operating capacity can be varied by changing the frequency (i.e. the rotational speed) of the inverter apparatus.

[0039] The first switching mechanism 22 is a four-way switching valve for switching the direction of refrigerant flow. When the outdoor heat exchanger 23 is made to function as a heat radiator of the refrigerant, the first switching mechanism 22 performs a switch connecting the discharge side of the compressor 21 and the gas side of the outdoor heat exchanger 23, and connecting the gas side of the heat storage heat exchanger 28 and the intake side of the compressor 21 (outdoor heat-radiating switched state; refer to the solid lines of the first switching mechanism 22 in FIG. 1). When the first switching mechanism 22 is switched to the outdoor heat-radiating switched state, the heat storage heat exchanger 28 can be made to function as an evaporator of the refrigerant. When the outdoor heat exchanger 23 is made to function as an evaporator of the refrigerant, the first switching mechanism 22 performs a switch connecting the intake side of the compressor 21 and the gas side of the outdoor heat exchanger 23, and connecting the gas side of the heat storage heat exchanger 28 and the discharge side of the compressor 21 (outdoor evaporating switched state; refer to the dashed lines of the first switching mechanism 22 in FIG. 1). When the first switching mechanism 22 is switched to the outdoor evaporating switched state, the heat storage heat exchanger 28 can be made to function as a heat radiator of the refrigerant. Instead of being a four-way switching valve, the first switching mechanism 22 may be configured by combining a three-way valve, an electromagnetic valve, and/or the like to fulfill the same function.

[0040] The outdoor heat exchanger 23 is composed of, e.g., a cross-fin-type fin-and-tube heat exchanger. An outdoor fan 25 for sending outdoor air to the outdoor heat exchanger 23 is provided in proximity to the outdoor heat exchanger 23. Heat exchange between the refrigerant and outdoor air is performed in the outdoor heat exchanger 23 by the blowing of outdoor air to the outdoor heat exchanger 23 by the outdoor fan 25. The outdoor fan 25 is designed to be rotatably driven by an outdoor fan motor 26. The outdoor heat exchanger 23 is thereby designed to function as a heat radiator of the refrigerant and/or an evaporator of the refrigerant.

[0041] The outdoor expansion valve 24 is a valve for depressurizing the refrigerant flowing through the outdoor heat exchanger 23 within the outdoor-side refrigerant circuit 10c and varying the flow rate of the refrigerant flowing through the outdoor heat exchanger 23. The outdoor expansion valve 24 is an electric expansion valve connected to the liquid side of the outdoor heat exchanger 23.

[0042] The second switching mechanism 27 is a four-way switching valve for switching the direction of refrigerant flow. When the indoor heat exchangers 42a, 42b are made to function as evaporators of the refrigerant, the second switching mechanism 27 performs a switch connecting the intake side of the compressor 21 and the gas refrigerant communication pipe 7 (indoor evaporating switched state; refer to the solid lines of the second switching mechanism 27 in FIG. 1). When the indoor heat exchangers 42a, 42b are made to function as heat radiators of the refrigerant, the second switching mechanism 27 performs a switch connecting the discharge side of the compressor 21 and the gas refrigerant communication pipe 7 (indoor heat-radiating switched state; refer to the dashed lines of the second switching mechanism 27 in FIG. 1). One of the four ports of the second switching mechanism 27 (the port near the right of the image in FIG. 1) is substantially an unused port, due to being connected to the port connected to the intake side of the compressor 21 (the port near the top of the image in FIG. 1) via a capillary tube 271. Instead of being a four-way switching valve, the second switching mechanism 27 may be configured by combining a three-way valve, an electromagnetic valve, and/or the like to fulfill the same function.

[0043] The heat storage heat exchanger 28, which is a heat exchanger for performing heat exchange between the refrigerant and the heat storage medium, is made to function as a heat radiator of the refrigerant to cause heat to be stored in the heat storage medium, and is made to function as an evaporator of the refrigerant to cause heat to be radiated (heat storage to be utilized) from the heat storage medium. The heat storage heat exchanger 28 has primarily a heat storage tank 281 in which the heat storage medium is retained, and a heat transfer tube group 282 disposed so as to be submerged in the heat

storage medium. The heat storage tank 281 herein is a box shaped as a substantial rectangular parallelepiped as shown in FIG. 2, the heat storage medium being retained in the interior. A substance that stores heat by changing phases is used herein as the heat storage medium. Specifically, a medium such as polyethylene glycol, sodium sulfate hydrate, paraffin, or the like, having a phase change temperature of about 30°C to 40°C, is used so that the heat storage medium changes phases (melts) and stores heat when the heat storage heat exchanger 28 is used as a heat radiator of the refrigerant, and changes phases (congeals) to allow the heat storage to be utilized when the heat storage heat exchanger 28 is used as an evaporator of the refrigerant. The heat transfer tube group 282 has a structure in which a plurality of heat transfer tubes 285 are branched and connected via a header pipe 283 and a flow diverter 284 provided to the refrigerant exit and entrance, as shown in FIG. 2. The plurality of heat transfer tubes 285 all have shapes that vertically turn back, and the ends of the plurality of heat transfer tubes 285 are connected to the header tube 283 and the flow diverter 284, thereby constituting the heat transfer tube group 282. The gas side of the heat storage heat exchanger 28 (i.e. one end of the heat transfer tube group 282) is connected to the first switching mechanism 22, and the liquid side of the heat storage heat exchanger 28 (i.e. the other end of the heat transfer tube group 282) is connected via the heat storage expansion valve 29 to the portion of the refrigerant circuit 10 (the outdoor-side refrigerant circuit 10c herein) that is between the outdoor expansion valve 24 and the liquid refrigerant communication pipe 6. FIG. 2 herein is a schematic overview of the heat storage heat exchanger 28.

[0044] The heat storage expansion valve 29 is a valve for depressurizing the refrigerant flowing through the heat storage heat exchanger 28 within the outdoor-side refrigerant circuit 10c and varying the flow rate of the refrigerant flowing through the heat storage heat exchanger 28. The heat storage expansion valve 29 is an electric expansion valve connected to the liquid side of the heat storage heat exchanger 28.

[0045] Various sensors are provided to the outdoor unit 2. The outdoor unit 2 is provided with an intake pressure sensor 31 for detecting the intake pressure Ps of the compressor 21, a discharge pressure sensor 32 for detecting the discharge pressure Pd of the compressor 21, an intake temperature sensor 33 for detecting the intake temperature Ts of the compressor 21, and a discharge temperature sensor 34 for detecting the discharge temperature Td of the compressor 21. The outdoor heat exchanger 23 is provided with an outdoor heat exchange temperature sensor 35 for detecting the temperature Tol1 of refrigerant in a gas-liquid two-phase state. The liquid side of the outdoor heat exchanger 23 is provided with a liquid-side temperature sensor 36 for detecting the temperature Tol2 of refrigerant in a liquid state or a gas-liquid two-phase state. The outdoor air intake port side of the outdoor unit 2 is provided with an outdoor temperature sensor 37 for detecting the temperature of outdoor air (i.e. the outdoor temperature Ta) in the external space where the outdoor unit 2 (i.e. the outdoor heat exchanger 23 and/or the heat storage heat exchanger 28) is located. The outdoor unit 2 also has an outdoor-side control part 38 for controlling the actions of the components constituting the outdoor unit 2. The outdoor-side control part 38, which has components such as a microcomputer and/or a memory provided in order to perform controls for the outdoor unit 2 and/or an inverter device for controlling the compressor motor 20, is designed to be capable of exchanging control signals and the like with the indoor-side control parts 48a, 48b of the indoor units 4a, 4b.

<Refrigerant Communication Pipes>

[0046] The refrigerant communication pipes 6, 7 are refrigerant pipes constructed on site when the air conditioning apparatus 1 is installed; these pipes have various lengths and diameters, depending on the conditions in which the outdoor unit 2 and the indoor units 4a, 4b are installed.

<Control Part>

[0047] The remote controllers 49a, 49b for individually operating the indoor units 4a, 4b, the indoor-side control parts 48a, 48b of the indoor units 4a, 4b, and the outdoor-side control part 38 of the outdoor unit 2 constitute a control part 8 for performing operation controls for the entire air conditioning apparatus 1, as shown in FIG. 1. The control part 8 is connected so as to be capable of receiving detection signals from various sensors such as 31 to 37, 45a, 45b, 46a, 46b, 47a, and 47b, as shown in FIG. 3. The control part 8 is configured so as to be capable of performing air conditioning operations (an air-cooling operation and an air-warming operation) by controlling various devices and valves 20, 22, 24, 26, 41a, 41b, 44a, and 44b on the basis of these detection signals and the like. FIG. 3 is a control block diagram of the air conditioning apparatus 1.

[0048] As described above, the air conditioning apparatus 1 has the refrigerant circuit 10 configured by connecting a plurality (two in this case) of indoor units 4a, 4b to the outdoor unit 2. In the air conditioning apparatus 1, operation controls such as the following are performed by the control part 8.

(2) Basic Action of the Air Conditioning Apparatus

[0049] Next, FIGS. 4 to 7 are used to describe the basic actions of the air-cooling operation, the air-warming operation, the heat storage operation, and a defrosting operation of the air conditioning apparatus 1. FIG. 4 is a drawing showing the flow of refrigerant through the refrigerant circuit in the air-cooling operation. FIG. 5 is a drawing showing the flow of refrigerant through the re-

frigerant circuit in the air-warming operation. FIG 6 is a drawing showing the flow of refrigerant through the refrigerant circuit in the heat storage operation (the heat storage operation during the air-warming operation). FIG. 7 is a drawing showing the flow of refrigerant through the refrigerant circuit in the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation).

<Air-Cooling Operation>

[0050] When an air-cooling operation command is issued from the remote controllers 49a, 49b, the first switching mechanism 22 is switched to the outdoor heat-radiating switched state (the state shown by the solid lines of the first switching mechanism 22 in FIG. 4), the second switching mechanism 27 is switched to the indoor evaporating switched state (the state shown by the solid lines of the second switching mechanism 27 in FIG. 4), the heat storage expansion valve 29 is closed (i.e. the heat storage heat exchanger 28 is not used), and the compressor 21, the outdoor fan 25, and the indoor fans 43a, 43b start up.

[0051] The low-pressure gas refrigerant in the refrigerant circuit 10 is then drawn into the compressor 21 and compressed to high-pressure gas refrigerant. This high-pressure gas refrigerant is sent through the first switching mechanism 22 to the outdoor heat exchanger 23. The high-pressure gas refrigerant sent to the outdoor heat exchanger 23 is condensed to high-pressure liquid refrigerant by being cooled by heat exchange with outdoor air supplied by the outdoor fan 25 in the outdoor heat exchanger 23 functioning as a heat radiator of the refrigerant. This high-pressure liquid refrigerant is sent through the outdoor expansion valve 24 and the liquid refrigerant communication pipe 6, from the outdoor unit 2 to the indoor units 4a, 4b.

[0052] The high-pressure liquid refrigerant sent to the indoor units 4a, 4b is depressurized by the indoor expansion valves 41a, 41b to low-pressure gas-liquid two-phase refrigerant. This low-pressure gas-liquid two-phase refrigerant is sent to the indoor heat exchangers 42a, 42b. The low-pressure gas-liquid two-phase refrigerant sent to the indoor heat exchangers 42a, 42b is evaporated to low-pressure gas refrigerant by being heated by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as evaporators of the refrigerant. This low-pressure gas refrigerant is sent through the gas refrigerant communication pipe 7, from the indoor units 4a, 4b to the outdoor unit 2.

[0053] The low-pressure gas refrigerant sent to the outdoor unit 2 is drawn through the second switching mechanism 27 back into the compressor 21.

<Air-Warming Operation>

[0054] When an air-warming operation command is issued from the remote controllers 49a, 49b, the first switching mechanism 22 is switched to the outdoor evaporating switched state (the state shown by the dashed lines of the first switching mechanism 22 in FIG. 5), the second switching mechanism 27 is switched to the indoor heat-radiating switched state (the state shown by the dashed lines of the second switching mechanism 27 in FIG. 5), the heat storage expansion valve 29 is closed (i.e. the heat storage heat exchanger 28 is not used), and the compressor 21, the outdoor fan 25, and the indoor fans 43a, 43b start up.

[0055] The low-pressure gas refrigerant in the refrigerant circuit 10 is then drawn into the compressor 21 and compressed to high-pressure gas refrigerant. This high-pressure gas refrigerant is sent through the second switching mechanism 27 and the gas refrigerant communication pipe 7, from the outdoor unit 2 to the indoor units 4a, 4b.

[0056] The high-pressure gas refrigerant sent to the indoor units 4a, 4b is sent to the indoor heat exchangers 42a, 42b. The high-pressure gas refrigerant sent to the indoor heat exchangers 42a, 42b is condensed to high-pressure liquid refrigerant by being cooled by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as heat radiators of the refrigerant. This high-pressure liquid refrigerant is depressurized by the indoor expansion valves 41a, 41b. The refrigerant depressurized by the indoor expansion valves 41a, 41b is sent through the gas refrigerant communication pipe 7, from the indoor units 4a, 4b to the outdoor unit 2.

[0057] The refrigerant sent to the outdoor unit 2 is sent to the outdoor expansion valve 24 and is depressurized by the outdoor expansion valve 24 to low-pressure gas-liquid two-phase refrigerant. This low-pressure gas-liquid two-phase refrigerant is sent to the outdoor heat exchanger 23. The low-pressure gas-liquid two-phase refrigerant sent to the outdoor heat exchanger 23 is evaporated to low-pressure gas refrigerant by being heated by heat exchange with outdoor air supplied by the outdoor fan 25 in the outdoor heat exchanger 23 functioning as an evaporator of the refrigerant. This low-pressure gas refrigerant is drawn through the first switching mechanism 22 back into the compressor 21.

<Heat Storage Operation (heat storage operation during air-warming operation)>

[0058] During the air-warming operation, the heat storage operation is performed, in which heat is stored in the heat storage medium by causing the heat storage heat exchanger 28 to function as a heat radiator of the refrigerant. Specifically, during the air-warming operation in which the outdoor heat exchanger 23 is made to function as an evaporator of the refrigerant and the indoor heat exchangers 42a, 42b are made to function as heat radiators of the refrigerant, the heat storage operation (the heat storage operation during the air-warming operation)

is performed wherein heat is stored in the heat storage medium by causing the heat storage heat exchanger 28 to function as a heat radiator of the refrigerant. The heat storage operation during the air-warming operation is performed by opening the heat storage expansion valve 29 when the switching mechanisms 22, 27 have been switched to the same switched state as the air-warming operation (see FIG. 6).

[0059] The low-pressure gas refrigerant in the refrigerant circuit 10 is then drawn into the compressor 21 and compressed to high-pressure gas refrigerant. Some of this high-pressure gas refrigerant is sent through the second switching mechanism 27 and the gas refrigerant communication pipe 7, from the outdoor unit 2 to the indoor units 4a, 4b, similar to the air-warming operation. This high-pressure gas refrigerant sent to the indoor units 4a, 4b is condensed to high-pressure liquid refrigerant by being cooled by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as heat radiators of the refrigerant. This high-pressure liquid refrigerant is depressurized by the indoor expansion valves 41a, 41b. The refrigerant depressurized by the indoor expansion valves 41a, 41b is sent through the gas refrigerant communication pipe 7, from the indoor units 4a, 4b to the outdoor unit 2.

[0060] The rest of the high-pressure gas refrigerant discharged from the compressor 21 is sent through the first switching mechanism 22 to the heat storage heat exchanger 28. The high-pressure gas refrigerant sent to the heat storage heat exchanger 28 is condensed to high-pressure liquid refrigerant by being cooled by heat exchange with the heat storage medium in the heat storage heat exchanger 28 functioning as a heat radiator of the refrigerant. This high-pressure liquid refrigerant is depressurized by the heat storage expansion valve 29. The heat storage medium of the heat storage heat exchanger 28 herein changes phases (melts) and stores heat due to being heated by heat exchange with the refrigerant.

[0061] The refrigerant depressurized by the heat storage expansion valve 29 converges with the refrigerant sent from the indoor units 4a, 4b to the outdoor unit 2, and the converged refrigerant is sent to the outdoor expansion valve 24 and depressurized by the outdoor expansion valve 24 to low-pressure gas-liquid two-phase refrigerant. This low-pressure gas-liquid two-phase refrigerant is sent to the outdoor heat exchanger 23. The low-pressure gas-liquid two-phase refrigerant sent to the outdoor heat exchanger 23 is evaporated to low-pressure gas refrigerant by being heated by heat exchange with outdoor air supplied by the outdoor fan 25 in the outdoor heat exchanger 23 functioning as an evaporator of the refrigerant. This low-pressure gas refrigerant is drawn through the first switching mechanism 22 back into the compressor 21. Thus, in the heat storage operation during the air-warming operation, the heat storage heat exchanger 28 is designed to function as a heat radiator of the refrigerant in parallel with the indoor heat exchangers 42a, 42b. Specifically, the refrigerant circuit 10 is configured to be capable of sending high-pressure gas refrigerant discharged from the compressor 21 in parallel to the indoor heat exchangers 42a, 42b and the heat storage heat exchanger 28 in the heat storage operation during the air-warming operation.

<Defrosting Operation (defrosting operation accompanying heat-storage-utilizing operation)>

[0062] During the air-warming operation, the defrosting operation is performed for defrosting the outdoor heat exchanger by causing the outdoor heat exchanger 23 to function as a heat radiator of the refrigerant. During the defrosting operation, the heat-storage-utilizing operation is performed for radiating heat from the heat storage medium by causing the heat storage heat exchanger 28 to function as an evaporator of the refrigerant. Specifically, the heat-storage-utilizing operation (the heat-storage-utilizing operation during the defrosting operation, and the defrosting operation accompanying the heat-storage-utilizing operation) is performed wherein the outdoor heat exchanger 23 is made to function as a heat radiator of the refrigerant and the heat storage heat exchanger 28 is made to function as an evaporator of the refrigerant. Moreover, the air-warming operation is also performed simultaneously herein by causing the indoor heat exchangers 42a, 42b to function as heat radiators of the refrigerant. Specifically, the heat-storage-utilizing operation and the air-warming operation are performed simultaneously during the defrosting operation (or the air-warming operation is performed simultaneously during the defrosting operation accompanying the heat-storage-utilizing operation). This heat-storage-utilizing operation during the defrosting operation (or the defrosting operation accompanying the heat-storage-utilizing operation) is performed by opening the heat storage expansion valve 29 when the first switching mechanism 22 has been switched to the outdoor heat-radiating switched state and the second switching mechanism 27 has been switched to the indoor heat-radiating switched state (see FIG. 7). During the defrosting operation, the outdoor fan 25 is stopped.

[0063] The low-pressure gas refrigerant in the refrigerant circuit 10 is then drawn into the compressor 21 and compressed to high-pressure gas refrigerant. Some of this high-pressure gas refrigerant is sent through the second switching mechanism 27 and the gas refrigerant communication pipe 7, from the outdoor unit 2 to the indoor units 4a, 4b, similar to the air-warming operation. The high-pressure gas refrigerant sent to the indoor units 4a, 4b is condensed to high-pressure liquid refrigerant by being cooled by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as heat radiators of the refrigerant. This high-pressure liquid refrigerant is depressurized by the indoor expansion valves 41a, 41b. The refrigerant depressurized by the indoor expansion valves 41a, 41b is sent through the gas refrigerant communication pipe

7, from the indoor units 4a, 4b to the outdoor unit 2.

[0064] The rest of the high-pressure gas refrigerant discharged from the compressor 21 is sent through the first switching mechanism 22 to the outdoor heat exchanger 23. The high-pressure gas refrigerant sent to the outdoor heat exchanger 23 is cooled by heat exchange with the frost and/or ice adhering to the outdoor heat exchanger 23, in the outdoor heat exchanger 23 functioning as a heat radiator of the refrigerant. This high-pressure refrigerant is depressurized by the outdoor expansion valve 24. The frost and/or ice adhering to the outdoor heat exchanger 23 herein is melted by being heated by heat exchange with the refrigerant, and the outdoor heat exchanger 23 is defrosted.

[0065] The high-pressure refrigerant depressurized by the outdoor expansion valve 24 converges with the refrigerant sent from the indoor units 4a, 4b to the outdoor unit 2, and this converged refrigerant is sent to the heat storage expansion valve 29 and depressurized by the heat storage expansion valve 29 to low-pressure gas-liquid two-phase refrigerant. This low-pressure gas-liquid two-phase refrigerant is sent to the heat storage heat exchanger 28. The low-pressure gas-liquid two-phase refrigerant sent to the heat storage heat exchanger 28 is evaporated to low-pressure gas refrigerant by being heated by heat exchange with the heat storage medium in the heat storage heat exchanger 28 functioning as an evaporator of the refrigerant. This low-pressure gas refrigerant is drawn through the first switching mechanism 22 back into the compressor 21. The heat storage medium of the heat storage heat exchanger 28 herein changes phases (congeals) due to being cooled by heat exchange with the refrigerant, and the heat storage medium is utilized for heat storage. Thus, when the air-warming operation is performed simultaneously during the defrosting operation accompanying the heat-storage-utilizing operation (or the heat-storage-utilizing operation during the defrosting operation), the indoor heat exchangers 42a, 42b are designed to function as heat radiators of the refrigerant in parallel with the outdoor heat exchanger 23. Specifically, the refrigerant circuit 10 is configured so as to be capable of sending the high-pressure gas refrigerant discharged from the compressor 21 in parallel to the outdoor heat exchanger 23 and the indoor heat exchangers 42a, 42b, when the air-warming operation is performed simultaneously during the defrosting operation accompanying the heat-storage-utilizing operation (or the heat-storage-utilizing operation during the defrosting operation).

<Controls of Air-Cooling Operation, Air-Warming Operation, and Heat Storage Operation>

-Air-Cooling Operation-

[0066] In the air-cooling operation described above, the control part 8 determines and controls the opening degrees of the indoor expansion valves 41a, 41b so that the degrees of superheating SHra, SHrb of the refrigerant in the outlets of the indoor heat exchangers 42a, 42b reach target degrees of superheating SHras, SHrbs (this control is referred to below as "degree of superheating control by the indoor expansion valves"). The degrees of superheating SHra, SHrb herein are calculated from the intake pressure Ps detected by the intake pressure sensor 31, and the temperatures Trga, Trgb of refrigerant on the gas sides of the indoor heat exchangers 42a, 42b detected by the gas-side temperature sensors 46a, 46b. More specifically, first, the intake pressure Ps is converted to the refrigerant saturation temperature to obtain the evaporation temperature Te which is a state quantity equivalent to the evaporation pressure Pe in the refrigerant circuit 10 (i.e., the evaporation pressure Pe and the evaporation temperature Te are different terms but refer essentially to the same state quantity). The term "evaporation pressure Pe" means a pressure representing the low-pressure refrigerant flowing from the outlets of the indoor expansion valves 41 a, 41b, through the indoor heat exchangers 42a, 42b, to the intake side of the compressor 21 during the air-cooling operation. The degrees of superheating SHra, SHrb are then obtained by subtracting the evaporation temperature Te from the temperatures Trga, Trgb of refrigerant on the gas sides of the indoor heat exchangers 42a, 42b.

[0067] In the air-cooling operation, the controls of the different devices of the indoor units 4a, 4b, including the indoor expansion valves 41a, 41b, are performed by the indoor-side control parts 48a, 48b of the control part 8. The controls of the different devices of the outdoor unit 2, including the outdoor expansion valve 24, are performed by the outdoor-side control part 38 of the control part 8.

-Air-Warming Operation-

[0068] In the air-warming operation described above, the control part 8 determines and controls the opening degrees of the indoor expansion valves 41a, 41b so that the degrees of subcooling SCra, SCrb of the refrigerant in the outlets of the indoor heat exchangers 42a, 42b reach target degrees of subcooling SCras, SCrbs (this control is referred to below as "degree of subcooling control by the indoor expansion valves"). The degrees of subcooling SCra, SCrb herein are calculated from the discharge pressure Pd detected by the discharge pressure sensor 32, and the temperatures Trla, Trlb of refrigerant on the liquid sides of the indoor heat exchangers 42a, 42b detected by the liquid-side temperature sensors 45a, 45b. More specifically, first, the discharge pressure Pd is converted to the refrigerant saturation temperature to obtain the condensation temperature Tc which is a state quantity equivalent to the condensation pressure Pc in the refrigerant circuit 10 (i.e., the condensation pressure Pc and the condensation temperature Tc are different terms but mean essentially the same state quantity). The term "condensation pressure Pc" means a pressure

representing the high-pressure refrigerant flowing from the discharge side of the compressor 21, through the indoor heat exchangers 42a, 42b, to the indoor expansion valves 41a, 41b during the air-warming operation. The degrees of subcooling SCra, SCrb are then obtained by subtracting the temperatures Trla, Trlb of refrigerant in the liquid sides of the indoor heat exchangers 42a, 42b from the condensation temperature Tc.

[0069] In the air-warming operation, the controls of the different devices of the indoor units 4a, 4b, including the indoor expansion valves 41a, 41b, are performed by the indoor-side control parts 48a, 48b of the control part 8. The controls of the different devices of the outdoor unit 2, including the outdoor expansion valve 24, are performed by the outdoor-side control part 38 of the control part 8.

-Heat Storage Operation-

[0070] In the heat storage operation described above, the control part 8 ends the heat storage operation and transitions to the air-warming operation when heat storage in the heat storage medium of the heat storage heat exchanger 28 has ended. When a predetermined interval time Δtbet has elapsed after the start of the heat storage operation, a transition is made to the defrosting operation. Specifically, the interval time Δtbet means the interval time between the defrosting operations. Basically, during the interval time Δtbet, the heat storage operation during the air-warming operation and the air-warming operation following the end of the heat storage operation are performed, and the defrosting operation is performed with each elapse of the interval time Δtbet.

[0071] As described above, the air conditioning apparatus 1 is designed so that operation can switch between air-cooling and air-warming. Heat can be stored in the heat storage medium while the air-warming operation is continued by performing the heat storage operation during the air-warming operation, and the heat storage of the heat storage medium can be utilized to perform the defrosting operation by performing the heat-storage-utilizing operation during the defrosting operation.

(3) Control During Defrosting Operation

[0072] During the defrosting operation accompanying the heat-storage-utilizing operation described above, when there is excess in the defrosting capability of the outdoor heat exchanger 23, the indoor-side control parts 48a, 48b preferably perform opening degree control on the indoor expansion valves 41a, 41b (degree of subcooling control by the indoor expansion valves 41a, 41b herein), ensuring the air-warming capabilities of the indoor heat exchangers 42a, 42b, similar to during the normal air-warming operation (i.e. during an air-warming operation that does not accompany a heat-storage-utilizing operation and/or a defrosting operation). However, when there is no excess in the defrosting capability of the outdoor heat exchanger 23, the opening degree control of the indoor expansion valves 41a, 41b must be different from the control during the normal air-warming operation in order to limit the air-warming capabilities of the indoor heat exchangers 42a, 42b. When the opening degrees of the indoor expansion valves 41a, 41b are too great relative to the opening degree of the outdoor expansion valve 24, the limit on the air-warming capabilities of the indoor heat exchangers 42a, 42b becomes insufficient and the defrosting capability of the outdoor heat exchanger 23 becomes insufficient; therefore, the defrosting operation ends while the outdoor heat exchanger 23 is not yet fully defrosted. Conversely, when the opening degrees of the indoor expansion valves 41a, 41b are too small relative to the opening degree of the outdoor expansion valve 24, the defrosting capability of the outdoor heat exchanger 23 is sufficient but the limit on the air-warming capabilities of the indoor heat exchangers 41a, 41b becomes excessive, and it is therefore not possible to sufficiently achieve the merit of performing an air-warming operation by means of a defrosting operation accompanying a heat-storage-utilizing operation.

[0073] In view of this, when only the air-warming operation is performed, the indoor-side control parts 48a, 48b decide the opening degrees of the indoor expansion valves 41a, 41b and the outdoor-side control part 38 decides the opening degree of the outdoor expansion valve 24, but when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the outdoor-side control part 38 decides not only the opening degree of the outdoor expansion valve 24 but also the opening degrees of the indoor expansion valves 41a, 41b.

[0074] Therefore, when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the outdoor-side control part 38 can decide the opening degree of the outdoor expansion valve 24 and the opening degrees of the indoor expansion valves 41a, 41b all together, taking into account a balance between the defrosting capability of the outdoor heat exchanger 23 and the air-warming capabilities of the indoor heat exchangers 42a, 42b.

[0075] The opening degrees of the indoor expansion valves 41a, 41b and the outdoor expansion valve 24 can thereby be appropriately decided herein when first the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation.

[0076] When the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the opening degrees of the indoor expansion valves 41a, 41b must be decided while the air-warming capabilities of the indoor heat exchangers 42a, 42b are reliably ensured. However, when the outdoor-side control part 38 decides the opening degrees of the indoor expansion valves 41a, 41b, it is difficult to take into account the effects of pressure loss and the like in the refrigerant in the refrigerant pipes connecting the

outdoor unit 2 and the indoor units 4a, 4b (mainly the liquid refrigerant communication pipe 6 and the gas refrigerant communication pipe 7 herein). Moreover, when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the defrosting capability of the outdoor heat exchanger 23 must also be increased in order to reliably end the defrosting of the outdoor heat exchanger 23.

[0077] In view of this, until a first defrosting time taj has elapsed from the start of the defrosting operation, the opening degrees of the indoor expansion valves 41a, 41b are decided on the basis of the correlation between the condensation temperature Tc of the refrigerant in the refrigerant circuit 10 and the indoor temperatures Tra, Trb (collectively referred to as Tr) of the spaces to be air-conditioned by the indoor units 4a, 4b. After the first defrosting time taj has elapsed from the start of the defrosting operation, the opening degrees of the indoor expansion valves 41a, 41b and the outdoor expansion valve 24 are altered so that the air-warming capabilities of the indoor heat exchangers 42a, 42b decrease and the defrosting capability of the outdoor heat exchanger 23 increases.

[0078] Specifically, the opening degrees of the indoor expansion valves 41a, 41b and the outdoor expansion valve 24 are decided by the outdoor-side control part 38 in accordance with steps ST1 to ST5 shown in the flowchart of FIG. 8.

[0079] First, when the heat storage operation during the air-warming operation ends, the air-warming operation following the end of the heat storage operation ends, and the defrosting operation (the defrosting operation accompanying the heat-storage-utilizing operation) is started, in step ST1, the opening degrees of the indoor expansion valves 41a, 41b are set to an initial opening degree MVrd1 for the defrosting operation, and the opening degree of the outdoor expansion valve 24 is set to an initial opening degree MVod1 for the defrosting operation. The opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 are decided herein by the outdoor-side control part 38 as described above.

[0080] When the defrosting operation satisfies an air-warming/defrosting prioritizing start condition, the sequence transitions through the process of step ST2 to the process of steps ST3 to ST5, and control for deciding the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 is started, so that an operation prioritizing air-warming and/or an operation prioritizing defrosting is performed. The air-warming/defrosting prioritizing start condition herein is a condition for determining whether or not the current state allows for an operation prioritizing air-warming and/or an operation prioritizing defrosting to be performed by altering the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24. The air-warming/defrosting prioritizing start condition is satisfied herein in cases in which the time is within a second defrosting time tah from the start of the defrosting operation, a predetermined time tdef1 has elapsed from the start of the defrosting operation, and the condensation temperature Tc is less than a predetermined threshold temperature Trdef obtained from the indoor temperature Tr (e.g., a value obtained by adding a predetermined temperature to the indoor temperature Tr). The second defrosting time tah herein is the time taken to perform an operation prioritizing air-warming and/or an operation prioritizing defrosting from the start of the defrosting operation. The time tdef1 is a standby time from the start of the defrosting operation until a transition is made to an operation prioritizing air-warming and/or an operation prioritizing defrosting, and is an extremely short time compared to the second defrosting time tah.

[0081] Next, when the defrosting operation has transitioned from step ST2 to step ST3 satisfies an air-warming prioritizing condition, the sequence transitions to the process of step ST4, and control is performed for deciding the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 so that an operation prioritizing air-warming is performed. The air-warming prioritizing condition is a condition for determining whether or not the current state is not ensuring the air-warming capabilities of the indoor heat exchangers 42a, 42b. The air-warming prioritizing condition is concluded to be satisfied herein in cases in which the time is within the first defrosting time taj (a time shorter than the second defrosting time tah) from the start of the defrosting operation the start of the defrosting operation, a predetermined time tdef2 has elapsed from the start of the defrosting operation the transition to step ST3, and the condensation temperature Tc is less than a threshold temperature Trdef (the same as the threshold temperature Trdef in the air-warming/defrosting prioritizing start condition described above) obtained from the indoor temperature Tr. The time tdef2 herein is a standby time for maintaining the opening degree holding state of step ST3. When the air-warming prioritizing condition is satisfied during the process of step ST3, the sequence transitions to the process of step ST4, the opening degrees of the indoor expansion valves 41a, 41b are increased (by an opening degree ΔMVrd2 herein), the opening degree of the outdoor expansion valve 24 is reduced (by an opening degree ΔMVod2 herein), and the sequence returns to the process of step ST3. As described above, the outdoor-side control part 38 herein determines whether or not the air-warming prioritizing condition (including the determination according to the threshold temperature Trdef) is satisfied and/or decides the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24. Specifically, until the elapse of the first defrosting time taj from the start of the defrosting operation the start of the defrosting operation (the initial period of the defrosting operation), the opening degrees of the indoor expansion valves 41a, 41b are appropriately decided

herein on the basis of the correlation between the condensation temperature Tc and the indoor temperature Tr. By repeating this process of step ST3, the air-warming prioritizing condition determination, and step ST4, it is possible to perform the defrosting operation while prioritizing that the air-warming capabilities of the indoor heat exchangers 42a, 42b are ensured with increased opening degrees of the indoor expansion valves 41a, 41b and a reduced opening degree of the outdoor expansion valve 24, until the elapse of the first defrosting time taj from the start of the defrosting operation the start of the defrosting operation (i.e. in the initial period of the defrosting operation) as shown in FIG. 9.

[0082] Next, when the defrosting operation transitioning from step ST2 to step ST3 satisfies a defrosting prioritizing condition, the sequence transitions to the process of step ST5, and control is performed for deciding the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 so that an operation prioritizing defrosting is performed. The defrosting prioritizing condition is a condition for determining whether or not the current state is not ensuring the defrosting capability of the outdoor heat exchanger 23. The defrosting prioritizing condition is satisfied in cases in which the first defrosting time taj has elapsed from the start of the defrosting operation the start of the defrosting operation, a predetermined time tdef3 has elapsed from the start of the defrosting operation the transition to step ST3, and an outdoor heat exchange outlet temperature Tol2, which is the temperature of the refrigerant in the outlet of the outdoor heat exchanger 23, is less than a predetermined defrosting operation intermediate temperature Tdefm (a temperature equal to or less than a defrosting operation ending temperature Tdefe for determining whether or not the defrosting operation has ended). The time tdef3 herein is a standby time for maintaining the opening degree holding state of step ST3. When the defrosting prioritizing condition is satisfied during the process of step ST3, the sequence transitions to the process of step ST5, the opening degrees of the indoor expansion valves 41a, 41b are reduced (by an opening degree ΔMVrd3 herein), the opening degree of the outdoor expansion valve 24 is increased (by an opening degree ΔMVod3 herein), and the sequence returns to the process of step ST3. Determining whether or not the defrosting prioritizing condition is satisfied and/or deciding the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 herein is done by the outdoor-side control part 38, as described above. Specifically, after the first defrosting time taj has elapsed from the start of the defrosting operation the start of the defrosting operation (i.e., after the defrosting operation prioritizing air-warming has ended), the opening degrees of the indoor expansion valves 41a, 41b are appropriately decided herein on the basis of the outdoor heat exchange outlet temperature Tol2. By repeating this process of step ST3, the defrosting prioritizing condition determination, and step ST5, it is possible to make a transition from an operation prioritizing air-warming to an operation prioritizing defrosting by reducing the opening degrees of the indoor expansion valves 41a, 41b and increasing the opening degree of the outdoor expansion valve 24 to reduce the air-warming capabilities of the indoor heat exchangers 42a, 42b and increase the defrosting capability of the outdoor heat exchanger 23, after the first defrosting time taj has elapsed from the start of the defrosting operation the start of the defrosting operation as shown in FIG. 9.

[0083] Next, when the second defrosting time tah has elapsed from the start of the defrosting operation the start of the defrosting operation, the defrosting operation (including an operation prioritizing air-warming and/or an operation prioritizing defrosting), having transitioned from step ST2 to step ST3, returns to the process of step ST1, the opening degrees of the indoor expansion valves 41a, 41b are returned to the initial opening degree MVrd1 for the defrosting operation, and the opening degree of the outdoor expansion valve 24 is returned to the initial opening degree MVod1 for the defrosting operation. Therefore, the opening degrees of the indoor expansion valves 41a, 41b decrease more rapidly and the opening degree of the outdoor expansion valve 24 increases more rapidly than when the opening degrees of the indoor expansion valves 41a, 41b and the opening degree of the outdoor expansion valve 24 are altered by the process of steps ST4 and ST5, an operation prioritizing defrosting is therefore promoted even further until the defrosting operation is ended either by the outdoor heat exchange outlet temperature Tol2 being equal to or greater than a predetermined defrosting operation ending temperature Tdefe or by a predetermined defrosting operation ending time tdefe elapsing, and defrosting of the outdoor heat exchanger 23 can be reliably ended.

(4) Modification 1

[0084] In the above embodiment, the time required for defrosting is affected by heat radiation loss from the heat storage medium and/or the devices constituting the refrigerant circuit 10, and this time therefore tends to be longer as the outdoor temperature Ta is lower. Therefore, the first defrosting time taj, which is the time during which an operation prioritizing air-warming is performed, is also preferably decided on the basis of the outdoor temperature Ta.

[0085] In view of this, the first defrosting time taj is designed herein to be decided on the basis of the outdoor temperature Ta.

[0086] Specifically, first, the second defrosting time tah is decided as a function of the outdoor temperature Ta, such as the function shown in the following formula 1.

$$tah = Ta + tah0 \qquad \ldots(\text{formula } 1)$$

[0087] The value tah herein is a standard value of the second defrosting time tah. According to formula 1, the second defrosting time tah is shorter as the outdoor temperature Ta is lower. The defrosting operation thereby has a shorter time for the operation prioritizing defrosting by means of steps ST3 and ST5 described above, and a longer time for the operation (until the defrosting operation ends from the elapse of the second defrosting time tah) for setting to the opening degrees of the indoor expansion valves 41a, 41b (= MVrd1) and the opening degree of the outdoor expansion valve 24 (= MVod1) in step ST1 described above.

[0088] The first defrosting time taj is then decided using the second defrosting time tah decided by formula 1, and the following formula 2.

$$taj = tah - tah1 \qquad \ldots(\text{formula } 2)$$

The value tah1 herein is equivalent to the time for performing an operation prioritizing defrosting by means of steps ST3 and ST5 described above. According to formulas 1 and 2, the first defrosting time taj is shorter as the outdoor temperature Ta is lower. The defrosting operation thereby has a shorter time for an operation prioritizing air-warming by means of steps ST3 and ST4 described above.

[0089] The first defrosting time taj for performing an operation prioritizing air-warming is thereby decided herein on the basis of the outdoor temperature Ta, whereby a longer operation prioritizing defrosting is performed, and the defrosting of the outdoor heat exchanger 23 can be reliably ended.

[0090] The first defrosting time taj and the second defrosting time tah are both herein decided on the basis of the outdoor temperature Ta, but it is also possible for the first defrosting time taj alone to be decided on the basis of the outdoor temperature Ta.

(5) Modification 2

[0091] In the above embodiment and Modification 1, the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation. In this case, when the opening degrees of the indoor expansion valves 41a, 41b become too large, the refrigerant in the outlets of the indoor heat exchangers 42a, 42b readily reaches the gas-liquid two-phase state. Refrigerant in a gas state then readily fills the refrigerant pipes (such as the liquid refrigerant communication pipe 6 herein) connecting the outlet sides (liquid sides) of the indoor heat exchangers 42a, 42b and the inlet side (liquid side) of the heat storage heat exchanger 28 functioning as an evaporator of the refrigerant. In cases in which no receiver is provided to the portion connecting the outlet sides (liquid sides) of the indoor heat exchangers 42a, 42b and the inlet side (liquid side) of the heat storage heat exchanger 28 functioning as an evaporator of the refrigerant, as is the case in the refrigerant circuit 10, there is a risk of so-called liquid backflow occurring, in which the liquid refrigerant returns to the compressor 21 via the heat storage heat exchanger 28. When liquid backflow occurs, a tendency for the degree of superheating SHd of the refrigerant discharged from the compressor 21 to decrease is observed.

[0092] In view of this, the outdoor-side control part 38 herein is designed to determine, on the basis of the degree of superheating SHd of the refrigerant discharged from the compressor 21, that liquid backflow is occurring due to the opening degrees of the indoor expansion valves 41a, 41b being too large. The degree of superheating SHd of the refrigerant discharged from the compressor 21 is calculated herein from the discharge pressure Pd detected by the discharge pressure sensor 32 and the discharge temperature Td detected by the discharge temperature sensor 34. More specifically, the discharge pressure Pd is first converted to a refrigerant saturation temperature to obtain the condensation temperature Tc. The degree of superheating SHd is then found by subtracting the condensation temperature Tc from the discharge temperature Td.

[0093] Specifically, the outdoor-side control part 38 determines that liquid backflow is occurring when the degree of superheating SHd is lower than a threshold degree of superheating during the above-described defrosting operation control, as shown in FIG. 10. The opening degrees of the indoor expansion valves 41a, 41b are reduced as necessary.

[0094] First, in the air-warming/defrosting prioritizing start condition, which is the condition for transitioning from step ST1 to step ST2, a further condition that the degree of superheating SHd be equal to or greater than a first threshold degree of superheating SHd1 is added as the condition for transitioning from step ST1 to step ST2. It is thereby possible to prevent transition to an operation prioritizing air-warming (the process of steps ST3 and ST4), which has a risk of the opening degrees of the indoor expansion valves 41a, 41b being too large, during the process of step ST1, or in other words in a state in which the opening degrees of the indoor expansion valves 41a, 41b have been set to the initial opening degree MVrd1 and the opening degree of the outdoor expansion valve 24 has been set to the initial opening degree MVod1.

[0095] During the process of step ST1, when a predetermined time tdef4 (a standby time from the start of the defrosting operation until the transition to the next process) has elapsed from the start of the defrosting operation and the degree of superheating SHd is less than a predetermined third threshold degree of superheating SHd3, it is determined that liquid backflow is occurring in the compressor 21 and the sequence transitions to the process of step ST6. The third threshold degree of superheating SHd3 herein is set to a value lower than the first threshold degree of superheating SHd1. In step ST6, the

opening degrees of the indoor expansion valves 41a, 41b are set to a liquid-backflow-eliminating opening degree MVrd4 (an opening degree less than the initial opening degree MVrd1), and the opening degree of the outdoor expansion valve 24 is set to a liquid-backflow-eliminating opening degree MVod4 (herein the same opening degree as the initial opening degree MVod1). The liquid backflow in the compressor 21 is thereby eliminated. When the liquid backflow in the compressor 21 is eliminated and the degree of superheating SHd is equal to or greater than the predetermined third threshold degree of superheating SHd3, the sequence returns again to the process of step ST1, or in other words to a state in which the opening degrees of the indoor expansion valves 41a, 41b have been set to the initial opening degree MVrd1 and the opening degree of the outdoor expansion valve 24 has been set to the initial opening degree MVod1.

[0096] Furthermore, during the process of steps ST2 to ST5, it is determined that liquid backflow is occurring in the compressor 21 when the degree of superheating SHd is less than a predetermined second threshold degree of superheating SHd2, the process of steps ST2 to ST5 is terminated even if the second defrosting time tah has not elapsed from the start of the defrosting operation, and the sequence returns to the process of step ST1, or in other words to a state in which the opening degrees of the indoor expansion valves 41a, 41b have been set to the initial opening degree MVrd1 and the opening degree of the outdoor expansion valve 24 has been set to the initial opening degree MVod1. The liquid backflow in the compressor 21 is thereby eliminated.

[0097] It is thereby possible herein to perform the air-warming operation while appropriately determining whether or not the opening degrees of the indoor expansion valves 41a, 41b have become too large during the defrosting operation accompanying the heat-storage-utilizing operation.

INDUSTRIAL APPLICABILITY

[0098] The present invention can be widely applied to air conditioning apparatuses comprising a refrigerant circuit having a heat storage heat exchanger for performing heat exchange between a refrigerant and a heat storage medium, wherein a heat storage operation for storing heat in the heat storage medium can be performed by causing the heat storage heat exchanger to function as a heat radiator of the refrigerant, and an air-warming operation and a heat-storage-utilizing operation for radiating heat from the heat storage medium can be performed simultaneously by causing the heat storage heat exchanger to function as an evaporator of the refrigerant during a defrosting operation.

REFERENCE SIGNS LIST

[0099]

1	Air conditioning apparatus
2	Outdoor unit
4a, 4b	Indoor units
10	Refrigerant circuit
21	Compressor
23	Outdoor heat exchanger
24	Outdoor expansion valve
28	Heat storage heat exchanger
38	Outdoor-side control part
41a, 41b	Indoor expansion valves
42a, 42b	Indoor heat exchangers
48a, 48b	Indoor-side control parts

CITATION LIST

PATENT LITERATURE

[Patent Literature 1]

[0100] Japanese Laid-open Patent Application No. 2005-337657

Claims

1. An air conditioning apparatus (1) comprising a refrigerant circuit (10) having a compressor (21), an outdoor heat exchanger (23), indoor heat exchangers (42a, 42b), and a heat storage heat exchanger (28) for performing heat exchange between a refrigerant and a heat storage medium, the air conditioning apparatus being capable of performing a heat storage operation for storing heat in the heat storage medium by causing the heat storage heat exchanger to function as a heat radiator of the refrigerant, and, during a defrosting operation for defrosting the outdoor heat exchanger by causing the outdoor heat exchanger to function as a heat radiator of the refrigerant, simultaneously performing a heat-storage-utilizing operation for radiating heat from the heat storage medium by causing the heat storage heat exchanger to function as an evaporator of the refrigerant and an air-warming operation for causing the indoor heat exchangers to function as heat radiators of the refrigerant; wherein
the refrigerant circuit also has indoor expansion valves (41a, 41b) for varying the flow rate of the refrigerant flowing through the indoor heat exchangers, and an outdoor expansion valve (24) for varying the flow rate of the refrigerant flowing through the outdoor heat exchanger;
the indoor heat exchangers and the indoor expansion valves are provided to indoor units (4a, 4b);
the indoor units have indoor-side control parts (48a, 48b) for deciding the opening degrees of the indoor expansion valves when only the air-warming operation is performed;
the outdoor heat exchanger and the outdoor expan-

sion valve are provided to an outdoor unit (2); and the outdoor unit has an outdoor-side control part (38) for deciding the opening degree of the outdoor expansion valve when only the air-warming operation is performed and deciding the opening degrees of the indoor expansion valves and the opening degree of the outdoor expansion valve when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation.

2. The air conditioning apparatus (1) according to claim 1, wherein
when the air-warming operation is performed during the defrosting operation accompanying the heat-storage-utilizing operation, the opening degrees of the indoor expansion valves (41a, 41b) are decided on the basis of the correlation between the condensation temperature of the refrigerant in the refrigerant circuit (10) and the indoor temperatures of the spaces being air-conditioned by the indoor units (4a, 4b), until a first defrosting time elapses from the start of the defrosting operation.

3. The air conditioning apparatus (1) according to claim 2, wherein
after the first defrosting time has elapsed from the start of the defrosting operation, the opening degrees of the indoor expansion valves (41a, 41b) and the outdoor expansion valve (24) are altered so that the air-warming capabilities of the indoor heat exchangers (42a, 42b) decrease and the defrosting capability of the outdoor heat exchanger (23) increases.

4. The air conditioning apparatus (1) according to claim 3, wherein
the first defrosting time is decided on the basis of the outdoor temperature of the external space where the outdoor unit (2) is disposed.

5. The air conditioning apparatus (1) according to any one of claims 2 through 4, wherein
during the defrosting operation, whether or not the opening degrees of the indoor expansion valves (41a, 41b) are too large is determined on the basis of the degree of superheating of the refrigerant discharged from the compressor (21).

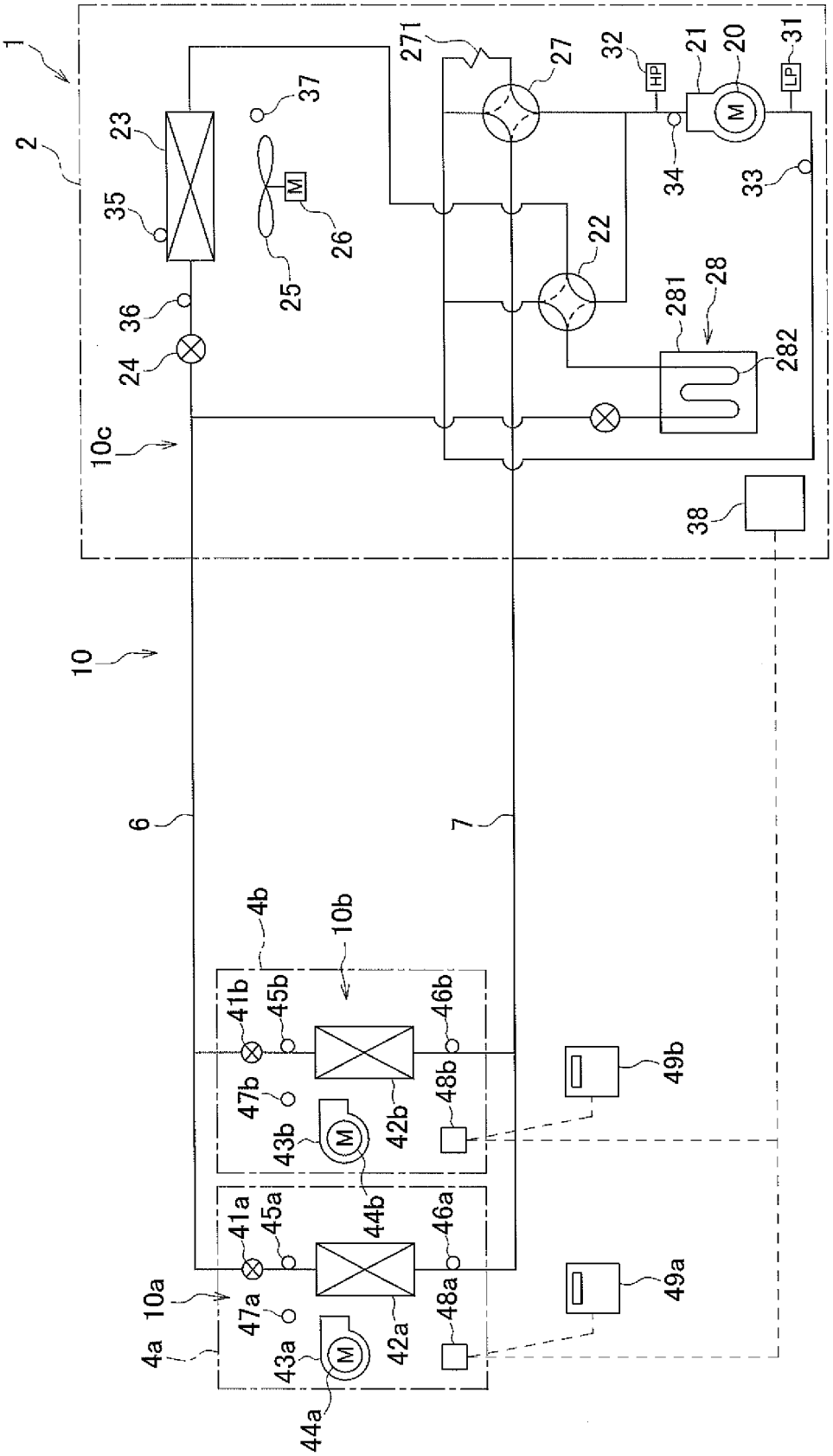

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FIG. 1

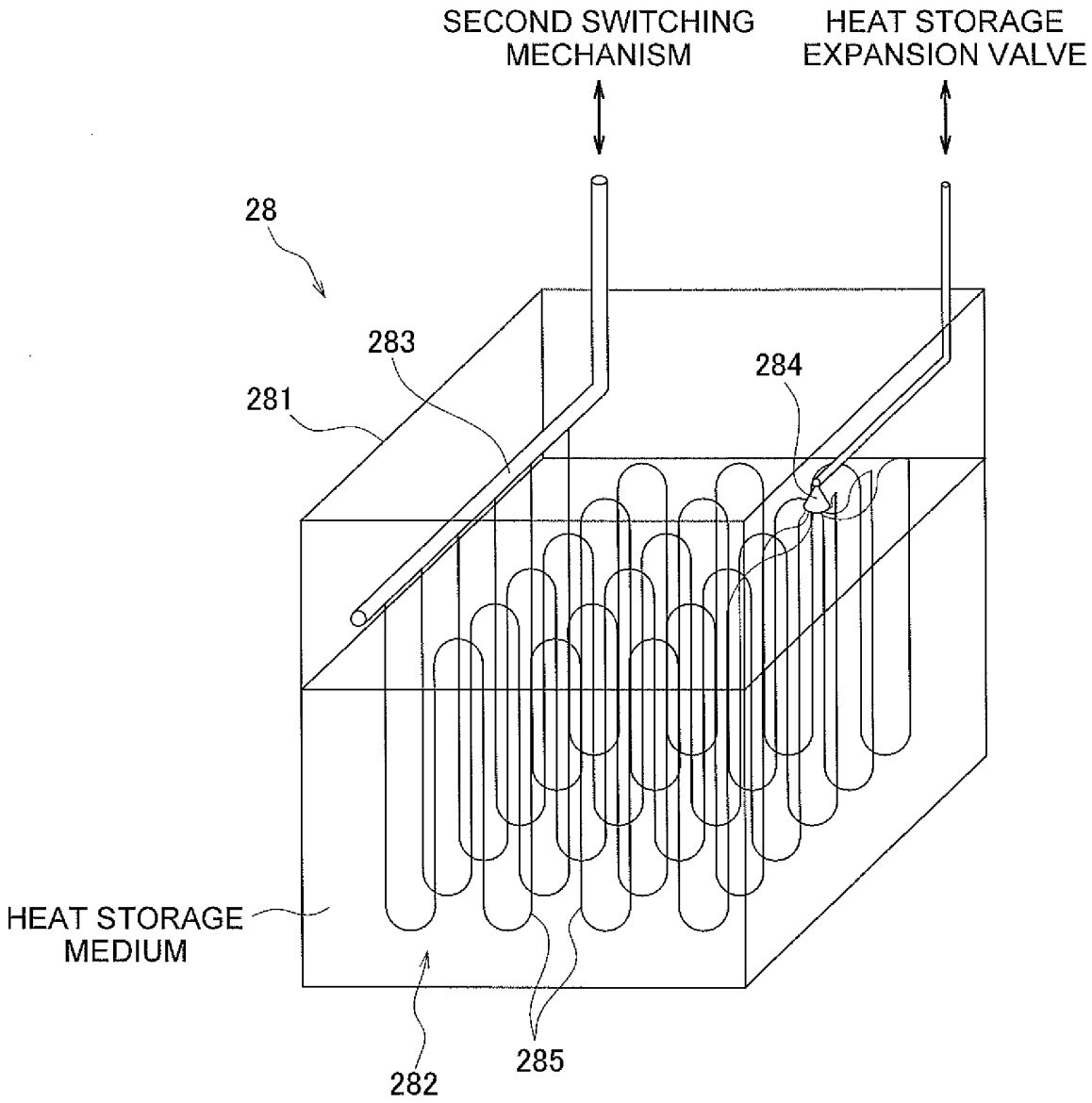

SECOND SWITCHING MECHANISM
HEAT STORAGE EXPANSION VALVE
28
283
281
284
HEAT STORAGE MEDIUM
282
285

FIG. 2

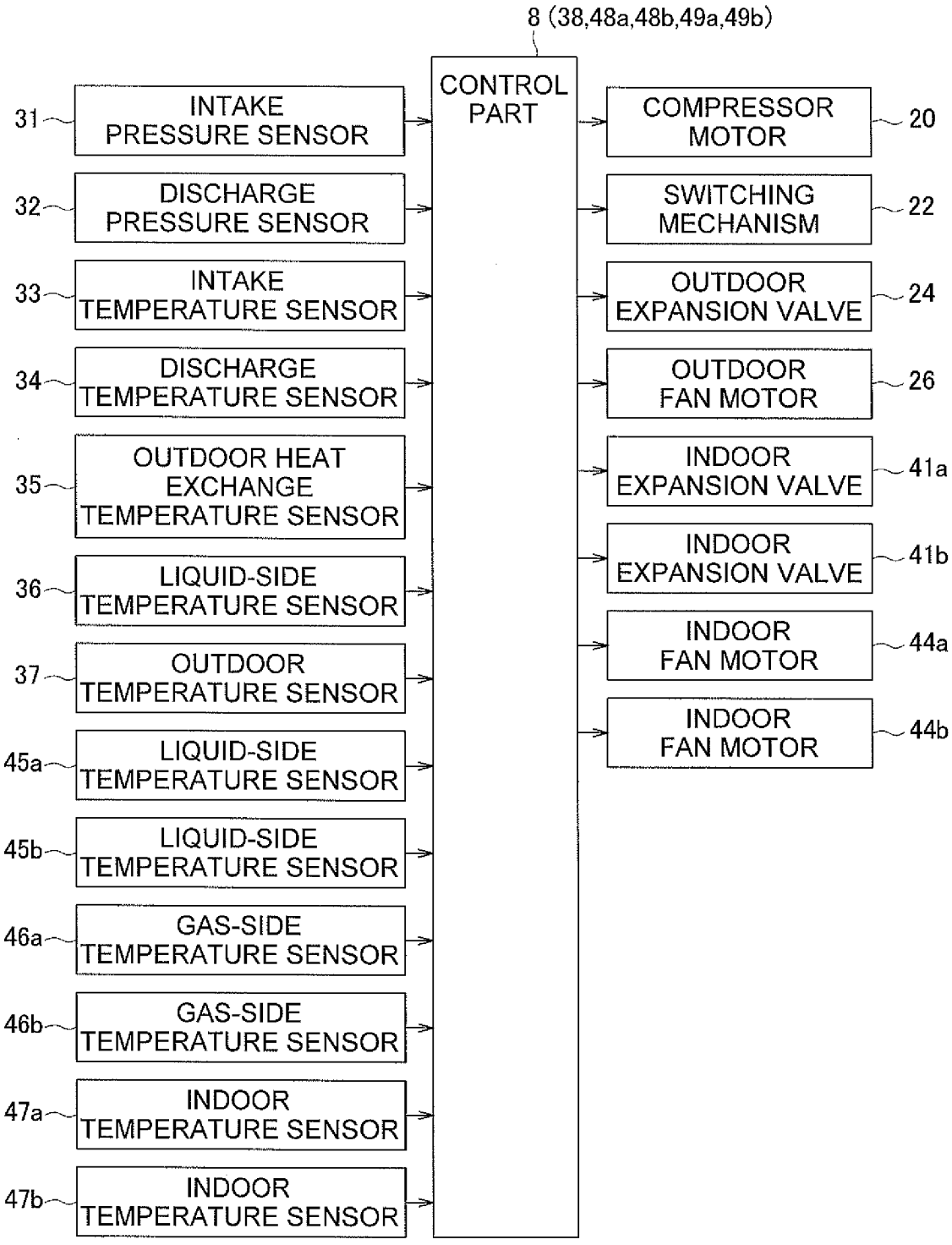

8 (38,48a,48b,49a,49b)
CONTROL PART
31
INTAKE PRESSURE SENSOR
32
DISCHARGE PRESSURE SENSOR
33
INTAKE TEMPERATURE SENSOR
34
DISCHARGE TEMPERATURE SENSOR
35
OUTDOOR HEAT EXCHANGE TEMPERATURE SENSOR
36
LIQUID-SIDE TEMPERATURE SENSOR
37
OUTDOOR TEMPERATURE SENSOR
45a
LIQUID-SIDE TEMPERATURE SENSOR
45b
LIQUID-SIDE TEMPERATURE SENSOR
46a
GAS-SIDE TEMPERATURE SENSOR
46b
GAS-SIDE TEMPERATURE SENSOR
47a
INDOOR TEMPERATURE SENSOR
47b
INDOOR TEMPERATURE SENSOR
COMPRESSOR MOTOR
20
SWITCHING MECHANISM
22
OUTDOOR EXPANSION VALVE
24
OUTDOOR FAN MOTOR
26
INDOOR EXPANSION VALVE
41a
INDOOR EXPANSION VALVE
41b
INDOOR FAN MOTOR
44a
INDOOR FAN MOTOR
44b

FIG. 3

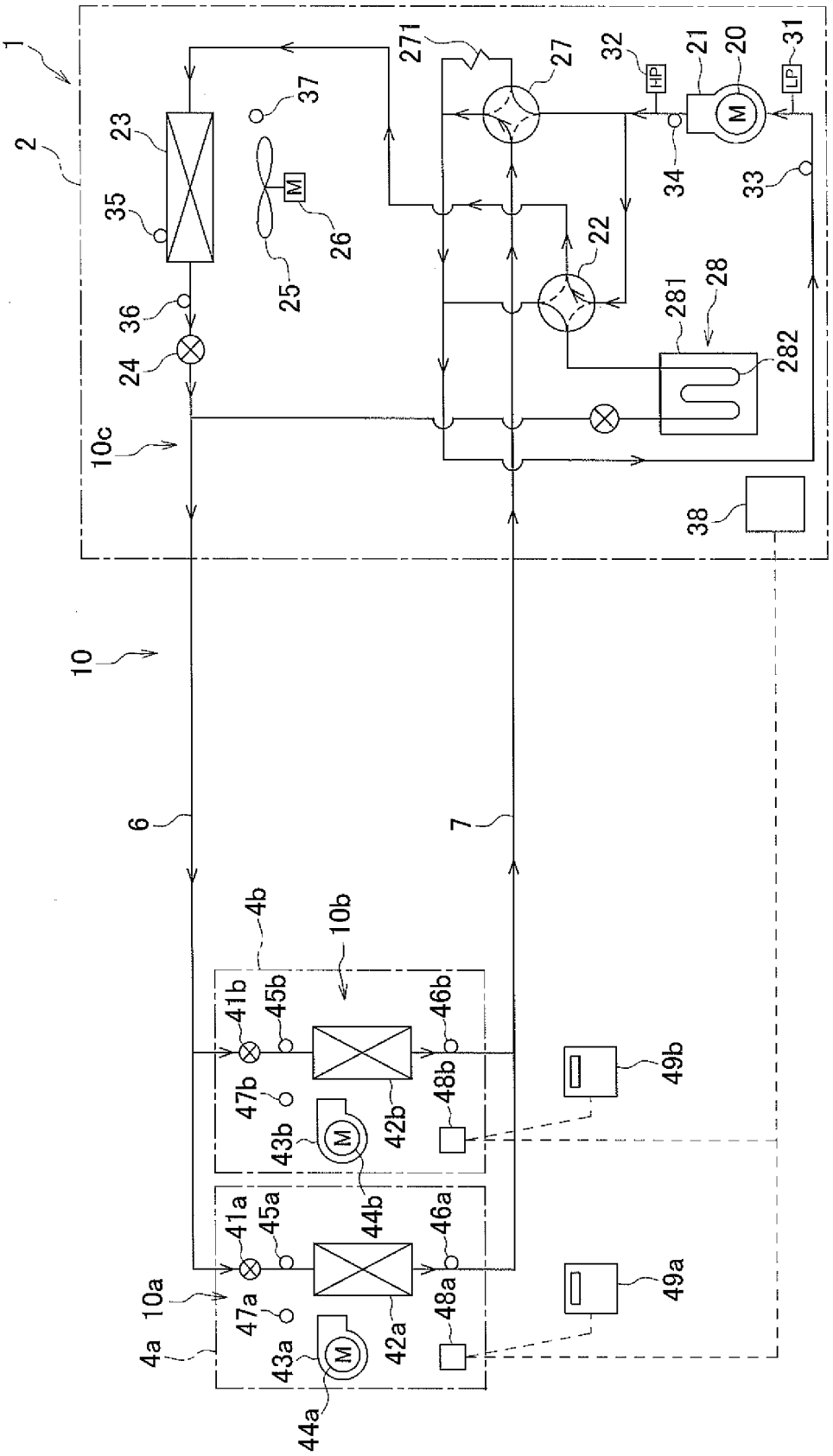

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46b
47b
43b
M
42b
48b
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FIG. 4

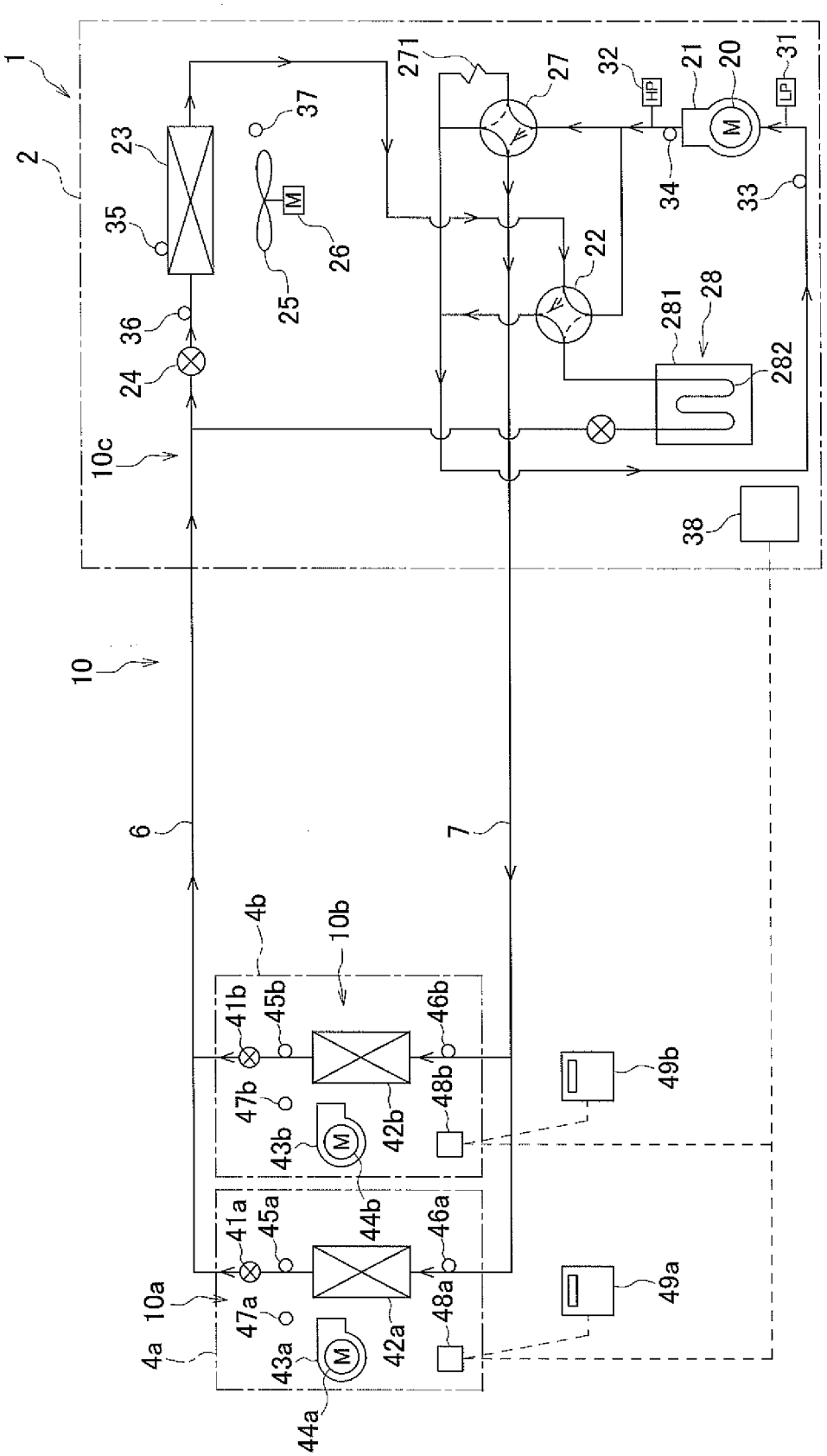

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FIG. 5

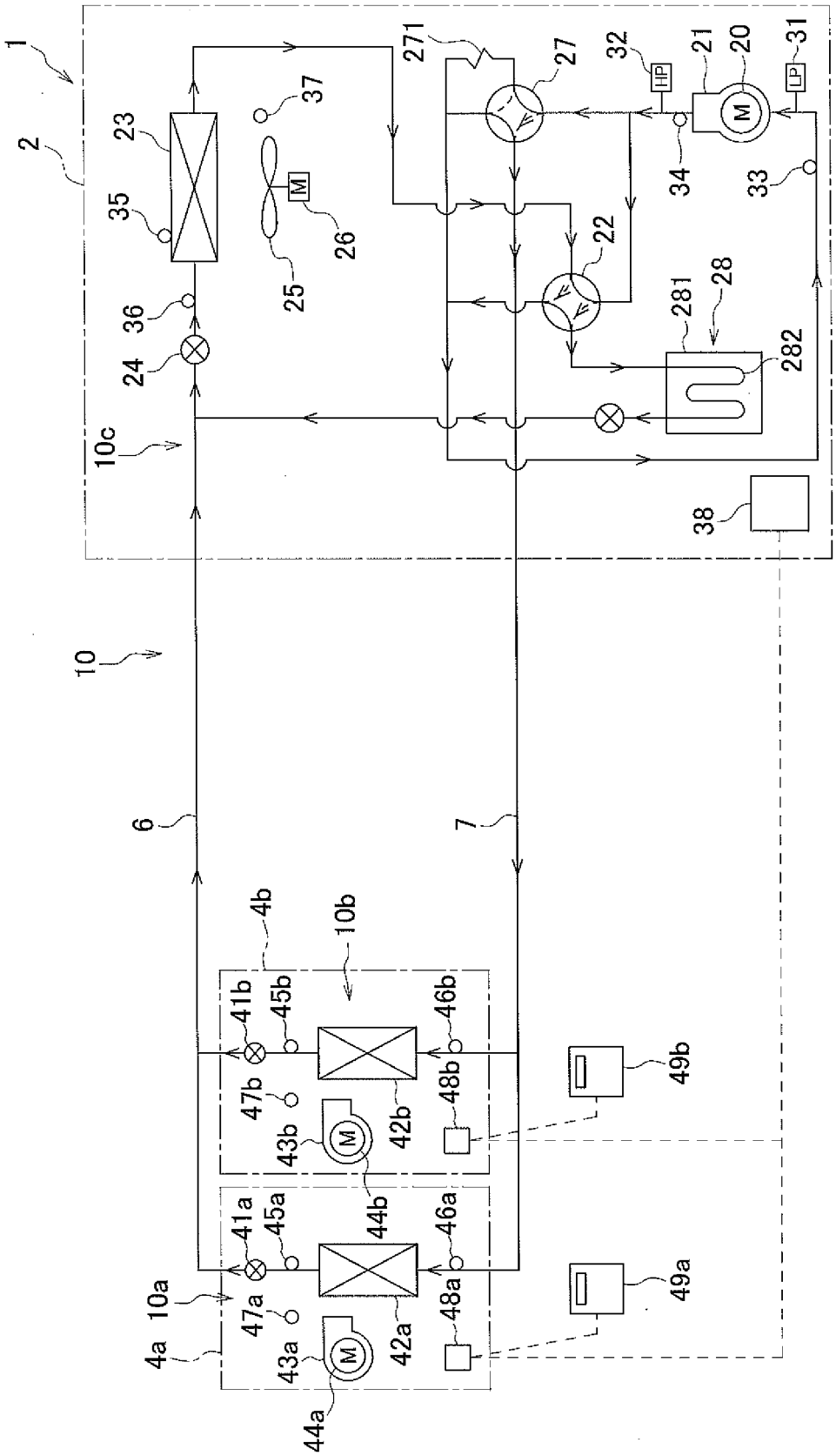

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FIG. 6

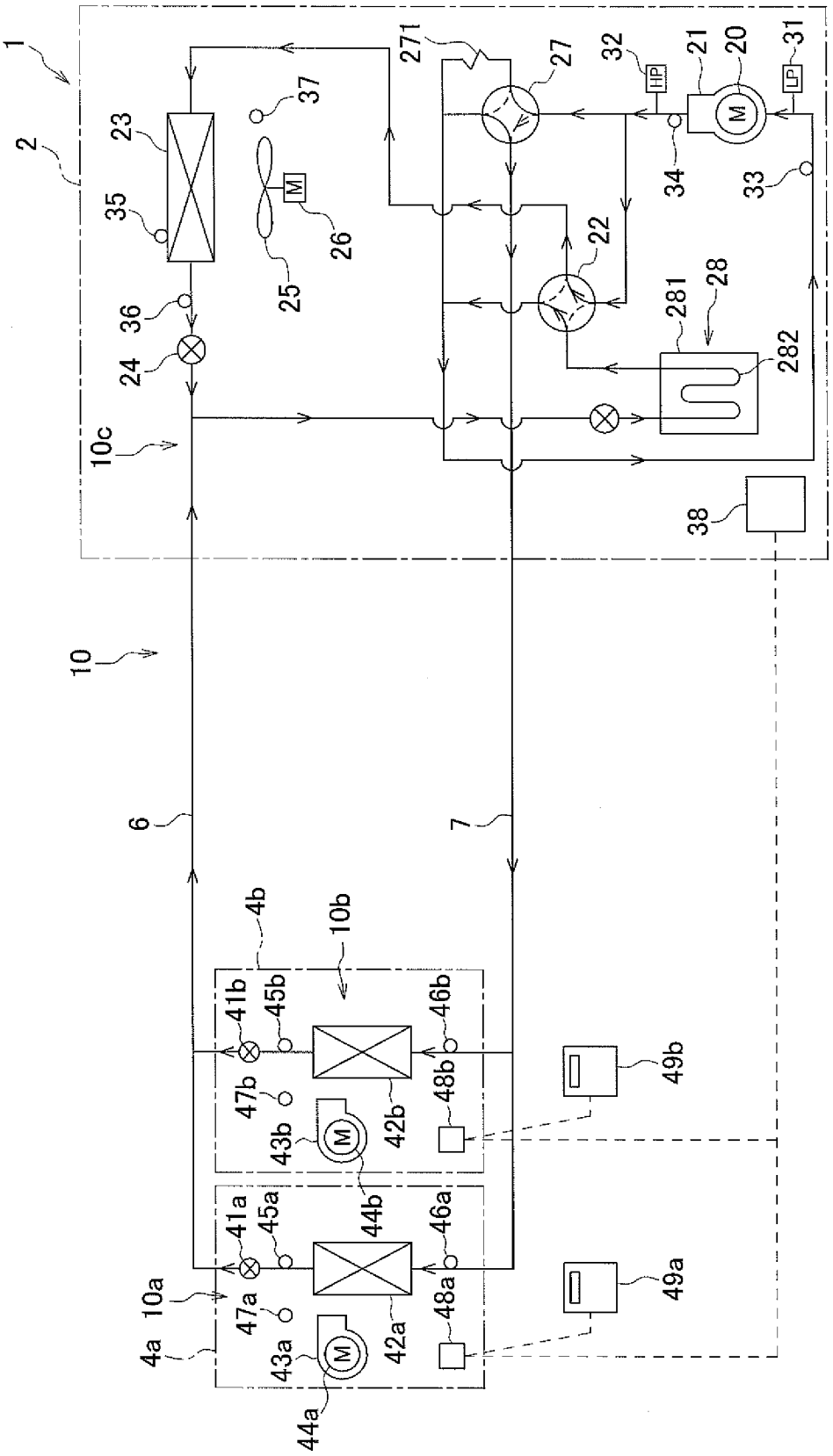
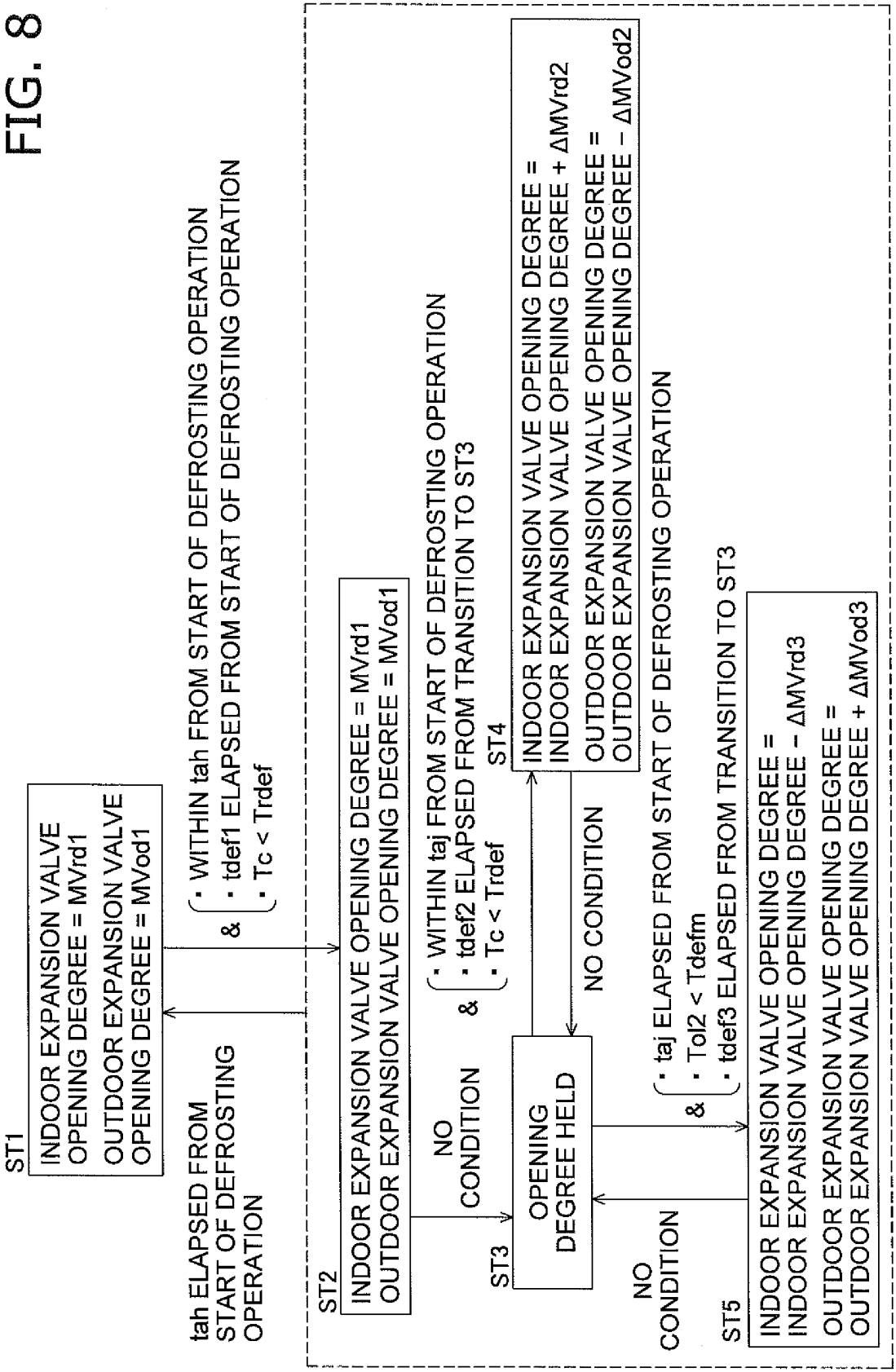

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43b
M
44b
49b
41a
45a
46a
47a
48a
42a
43a
M
44a
49a
10a
4a

FIG. 7

FIG. 8


ST1
INDOOR EXPANSION VALVE OPENING DEGREE = MVrd1
OUTDOOR EXPANSION VALVE OPENING DEGREE = MVod1
tah ELAPSED FROM START OF DEFROSTING OPERATION
&
• WITHIN tah FROM START OF DEFROSTING OPERATION
• tdef1 ELAPSED FROM START OF DEFROSTING OPERATION
• Tc < Trdef
ST2
INDOOR EXPANSION VALVE OPENING DEGREE = MVrd1
OUTDOOR EXPANSION VALVE OPENING DEGREE = MVod1
NO CONDITION
&
• WITHIN taj FROM START OF DEFROSTING OPERATION
• tdef2 ELAPSED FROM TRANSITION TO ST3
• Tc < Trdef
ST3
OPENING DEGREE HELD
ST4
INDOOR EXPANSION VALVE OPENING DEGREE = INDOOR EXPANSION VALVE OPENING DEGREE + ΔMVrd2
OUTDOOR EXPANSION VALVE OPENING DEGREE = OUTDOOR EXPANSION VALVE OPENING DEGREE – ΔMVod2
NO CONDITION
NO CONDITION
&
• taj ELAPSED FROM START OF DEFROSTING OPERATION
• Tol2 < Tdefm
• tdef3 ELAPSED FROM TRANSITION TO ST3
ST5
INDOOR EXPANSION VALVE OPENING DEGREE = INDOOR EXPANSION VALVE OPENING DEGREE – ΔMVrd3
OUTDOOR EXPANSION VALVE OPENING DEGREE = OUTDOOR EXPANSION VALVE OPENING DEGREE + ΔMVod3

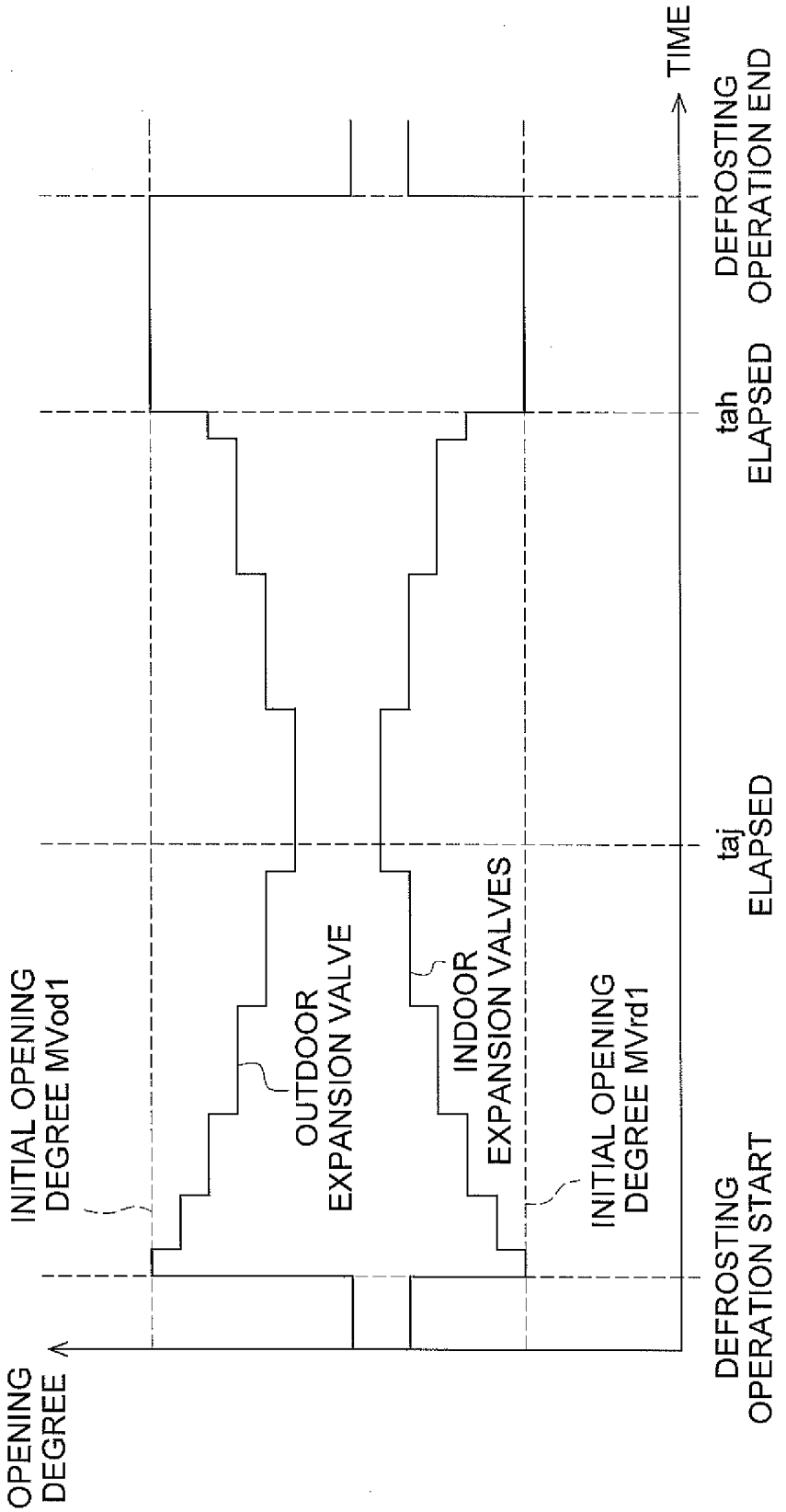
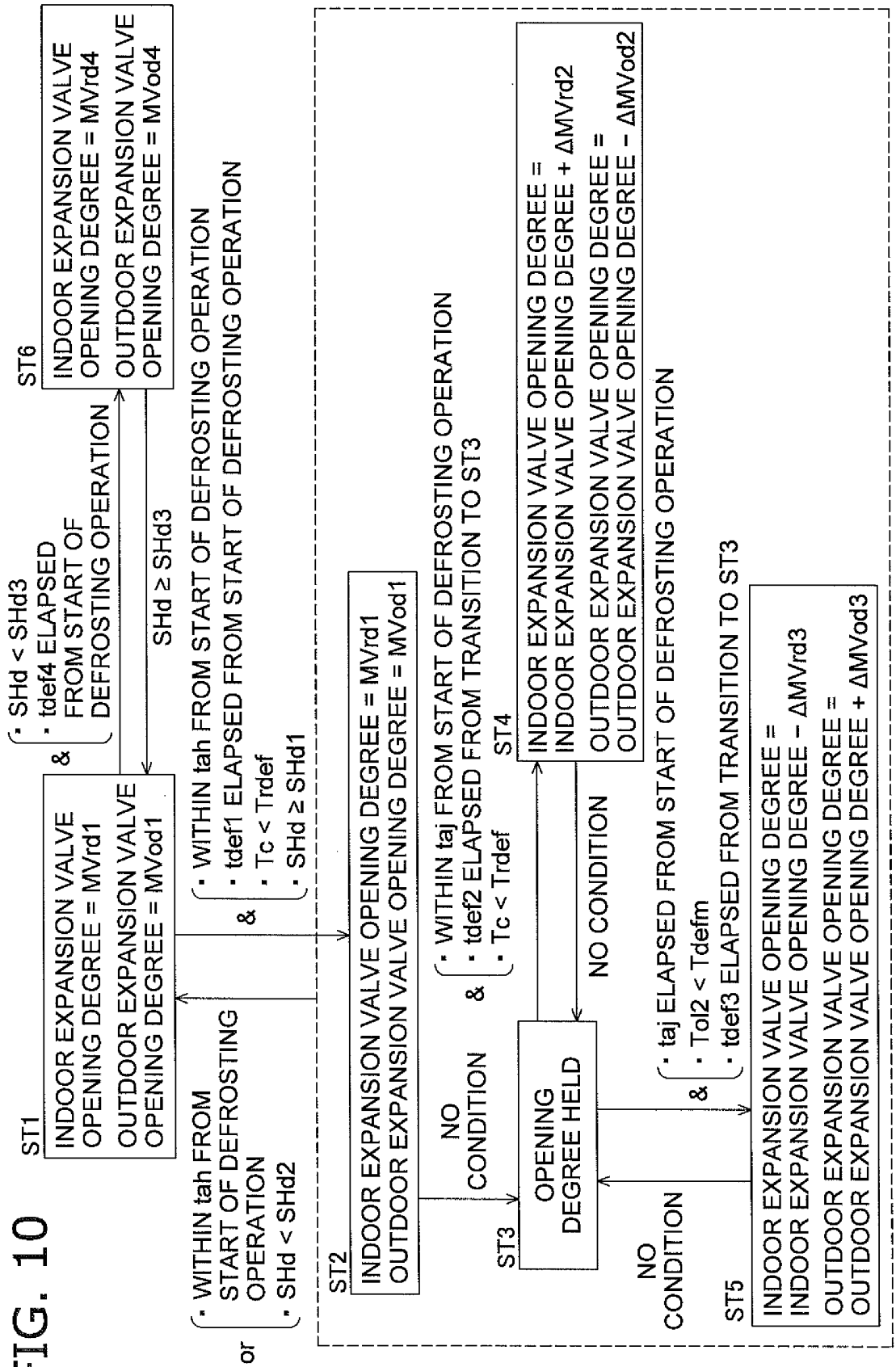

OPENING DEGREE
TIME
INITIAL OPENING DEGREE MVod1
OUTDOOR EXPANSION VALVE
INDOOR EXPANSION VALVES
INITIAL OPENING DEGREE MVrd1
DEFROSTING OPERATION START
taj ELAPSED
tah ELAPSED
DEFROSTING OPERATION END

FIG. 9

FIG. 10


ST1
INDOOR EXPANSION VALVE OPENING DEGREE = MVrd1
OUTDOOR EXPANSION VALVE OPENING DEGREE = MVod1
ST6
INDOOR EXPANSION VALVE OPENING DEGREE = MVrd4
OUTDOOR EXPANSION VALVE OPENING DEGREE = MVod4
• SHd < SHd3
• tdef4 ELAPSED FROM START OF DEFROSTING OPERATION
&
SHd ≥ SHd3
• WITHIN tah FROM START OF DEFROSTING OPERATION
• SHd < SHd2
or
• WITHIN tah FROM START OF DEFROSTING OPERATION
• tdef1 ELAPSED FROM START OF DEFROSTING OPERATION
• Tc < Trdef
• SHd ≥ SHd1
&
ST2
INDOOR EXPANSION VALVE OPENING DEGREE = MVrd1
OUTDOOR EXPANSION VALVE OPENING DEGREE = MVod1
NO CONDITION
ST3
OPENING DEGREE HELD
• WITHIN taj FROM START OF DEFROSTING OPERATION
• tdef2 ELAPSED FROM TRANSITION TO ST3
• Tc < Trdef
&
ST4
INDOOR EXPANSION VALVE OPENING DEGREE = INDOOR EXPANSION VALVE OPENING DEGREE + ΔMVrd2
OUTDOOR EXPANSION VALVE OPENING DEGREE = OUTDOOR EXPANSION VALVE OPENING DEGREE − ΔMVod2
NO CONDITION
• taj ELAPSED FROM START OF DEFROSTING OPERATION
• Tol2 < Tdefm
• tdef3 ELAPSED FROM TRANSITION TO ST3
&
ST5
INDOOR EXPANSION VALVE OPENING DEGREE = INDOOR EXPANSION VALVE OPENING DEGREE − ΔMVrd3
OUTDOOR EXPANSION VALVE OPENING DEGREE = OUTDOOR EXPANSION VALVE OPENING DEGREE + ΔMVod3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/076941

A. CLASSIFICATION OF SUBJECT MATTER
F25B47/02(2006.01)i, *F25B13/00*(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)
F25B47/02, F25B13/00

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	JP 2007-10288 A (JFE Engineering Corp.), 18 January 2007 (18.01.2007), fig. 1; paragraphs [0027] to [0034] (Family: none)	1,2
Y	JP 2008-185292 A (Daikin Industries, Ltd.), 14 August 2008 (14.08.2008), fig. 1; paragraphs [0065] to [0081] & US 2010/0024454 A1 & EP 2144018 A1 & WO 2008/093538 A1 & KR 10-2009-0115173 A & CN 101657686 A & AU 2008211449 A & CN 102080892 A	1,2
Y	JP 7-198187 A (Daikin Industries, Ltd.), 01 August 1995 (01.08.1995), paragraph [0046] (Family: none)	2

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

* Special categories of cited documents:
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"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
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"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
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Date of the actual completion of the international search	Date of mailing of the international search report
15 November, 2012 (15.11.12)	27 November, 2012 (27.11.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/076941

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3-28673 A (Daikin Industries, Ltd.), 06 February 1991 (06.02.1991), entire text; all drawings (Family: none)	1-5
A	JP 2012-117690 A (Hitachi Appliances, Inc.), 21 June 2012 (21.06.2012), paragraph [0069]; fig. 1 (Family: none)	1-5
A	JP 2008-298341 A (Daikin Industries, Ltd.), 11 December 2008 (11.12.2008), paragraphs [0062] to [0066] & US 2010/0293975 A1 & EP 2172722 A1 & WO 2008/149767 A1 & CN 101680694 A	1-5
A	JP 2005-127687 A (Samsung Electronics Co., Ltd.), 19 May 2005 (19.05.2005), paragraphs [0036], [0046] to [0050] & EP 1526341 A1 & KR 10-2005-0038115 A & CN 1609527 A	1-5

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 2005337657 A **[0002] [0100]**