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(54) AIR CONDITIONER

(57) An air conditioning apparatus (1) is provided with a refrigerant circuit (10) further provided with a compressor (21), an outdoor heat exchanger (23), an indoor heat exchanger (42a, 42b), and a stored-heat heat exchanger (28) that exchanges heat between a refrigerant and a heat storage material, and is capable of performing a heat storage operation during a heating operation and a stored-heat usage operation during a defrosting operation. The refrigerant circuit (10) is further provided with a heat storage valve (29) for varying the quantity of refrigerant flowing into the stored-heat heat exchanger (28). With this air conditioning apparatus (1), in the heat storage operation, the opening degree of the heat storage expansion valve (29) is controlled so as to be the setting heat storage operation opening degree determined according to a function based on the condensation pressure of the refrigerant, the liquid pipe pressure in the outlet and inlet of the heat storage expansion valve (29), and the enthalpy of refrigerant at the outlet and inlet of the stored-heat heat exchanger (28).

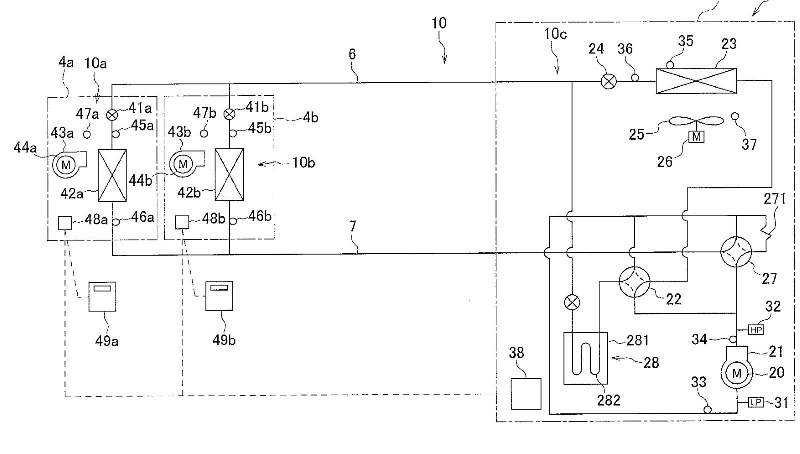

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus, and more specifically, an air conditioning apparatus provided with a refrigerant circuit having a stored-heat heat exchanger that exchanges heat between a refrigerant and a heat storage material, and that is capable, during a heating operation, of performing a heat storage operation that stores heat to the heat storage material by causing the stored-heat heat exchanger to function as a radiator of the refrigerant, and that is capable during a defrosting operation, of performing a stored-heat usage operation that releases heat from the heat storage material by causing the stored-heat heat exchanger to function as an evaporator of the refrigerant.

BACKGROUND ART

[0002] In the conventional art, as disclosed in patent document 1 (Japanese Laid-open Patent Application No. 2005-337657), is an air conditioning apparatus provided with a refrigerant circuit having a compressor, an outdoor heat exchanger, an indoor heat exchanger, and a stored-heat heat exchanger that exchanges heat between a refrigerant and a heat storage material, that is capable during the heating operation, of performing a heat storage operation and that is capable during the defrosting operation of performing a stored-heat usage operation. Here, the heating operation is an operation in which the indoor heat exchanger is caused to function as a radiator of the refrigerant. The heat storage operation is an operation that stores heat to the heat storage material by causing the stored-heat heat exchanger to function as a radiator of the refrigerant. The defrosting operation is an operation that defrosts the outdoor heat exchanger by causing the outdoor heat exchanger to function as a radiator of the refrigerant. The stored-heat usage operation is an operation that releases heat from the heat storage material by causing the stored-heat heat exchanger to function as an evaporator of the refrigerant.

SUMMARY OF THE INVENTION

[0003] In the above described air conditioning apparatus of the conventional art, a heat storage expansion valve is further provided to the refrigerant circuit in order to vary the quantity of the refrigerant flowing into the stored-heat heat exchanger, and during the heat storage operation, the opening degree of the heat storage expansion valve is controlled based on the subcooling degree of the refrigerant at the outlet of the stored-heat heat exchanger (controlling the subcooling degree by the heat storage expansion valve).

[0004] However, when controlling the subcooling degree by the heat storage expansion valve in this way, there are cases in which, during the heat storage operation it is not possible to sufficiently maintain the quantity of refrigerant flowing into the stored-heat heat exchanger, raising concerns that insufficient heat may be stored to the heat storage material even though the heat storage operation has ended.

[0005] An object of the present invention is to provide an air conditioning apparatus provided with a refrigerant circuit having a stored-heat heat exchanger that exchanges heat between the refrigerant and the heat storage material, and that is capable of performing a heat storage operation during the heating operation and performing a stored-heat usage operation during the defrosting operation, and in which the occurrence of insufficient heat being stored to the heat storage material when the heat storage operation has ended is suppressed.

[0006] An air conditioning apparatus according to a first aspect of the present invention is provided with a refrigerant circuit having a compressor, an outdoor heat exchanger, an indoor heat exchanger and a stored-heat heat exchanger that exchanges heat between a refrigerant and a heat storage material, being capable of performing a heat storage operation during a heating operation and a stored-heat usage operation during a defrosting operation. Here, the heating operation is an operation in which the indoor heat exchanger is caused to function as radiators of the refrigerant. The heat storage operation is an operation that stores heat to the heat storage material by causing the stored-heat heat exchanger to function as a radiator of the refrigerant. The defrosting operation is an operation that defrosts the outdoor heat exchanger by causing the outdoor heat exchanger to function as a radiator of the refrigerant. The stored-heat usage operation is an operation that releases heat from the heat storage material by causing the stored-heat exchanger to function as an evaporator of the refrigerant. Moreover, the refrigerant circuit is further provided with a heat storage expansion valve in order to vary the quantity of the refrigerant flowing into the stored-heat heat exchanger. During the heat storage operation in this air conditioning apparatus, the opening degree of the heat storage expansion valve is controlled so as to be a setting heat storage operation opening degree determined according to a function based on a condensation pressure that is a saturation pressure that corresponds to a condensation temperature of the refrigerant in the refrigerant circuit, a liquid pipe pressure that is a pressure of the refrigerant at an outlet of the heat storage expansion valve, and an enthalpy of the refrigerant at an inlet and outlet of the stored-heat heat exchanger.

[0007] Here, the opening degree of the heat storage expansion valve is controlled so as to be the setting heat storage operation opening degree, determined by a function based on the condensation pressure, the liquid pipe pressure, and the enthalpy of the refrigerant at the outlet and inlet of the stored-heat heat exchanger. Thus the plurality of state quantities of the refrigerant related to the stored-heat heat exchanger come to be reflected in the determination of the opening degree of the heat storage expansion valve, and the opening degree of the heat storage expansion valve during the heat storage operation can be made the opening degree that maintains sufficient quantity of refrigerant flowing into the stored-heat heat exchanger.

[0008] In this way, the opening degree of the heat storage expansion valve during the heat storage operation can be suitably controlled, suppressing the occurrence of insufficient heat being stored to the heat storage material when the heat storage operation has ended.

[0009] An air conditioning apparatus according to a second aspect of the present invention is the air conditioning apparatus according to the first aspect in which the function for determining the setting heat storage operation opening degree further includes utilizing the density of the refrigerant in the outlet of the stored-heat heat exchanger.

[0010] Here, the density of refrigerant in the outlet of the stored-heat heat exchanger that is one of the state quantities of the refrigerant related to the stored-heat heat exchanger, is further reflected in the determination of the opening degree of the heat storage expansion valve, thereby enabling the opening degree of the heat storage expansion valve to be more appropriately controlled during the heat storage operation.

[0011] An air conditioning apparatus according to a third aspect of the present invention is the air conditioning apparatus according to the first aspect or the second aspect, in which, in the heat storage operation, each time a normal opening degree heat storage time passes, for just the duration of an refrigerant discharge opening degree time, the setting heat storage operation opening degree is corrected so as to be greater than during the normal opening degree heat storage time.

[0012] The stored-heat heat exchanger primarily consists of a heat storage tank in which the heat storage material is stored, and a heat-transfer tube group arranged so as to be immersed in the heat storage material. The heat-transfer tube group has a configuration in which a plurality of heat-transfer tubes are branched and connected via a header pipe and/or a distributor provided at the refrigerant outlet and inlet. Thus, in the heat storage operation, there is concern that uneven flow of refrigerant may occur between the heat-transfer tubes comprising the heat-transfer tube group of the stored-heat heat exchanger. If uneven flow of refrigerant between the heat-transfer tubes occurs, the unevenness occurs to the extent that heat is stored to the heat storage material in the heat storage tank, a condition of coexistence arises having the heat-transfer tubes in the vicinity of heat storage material in the condition in which the temperature is higher than the phase change temperature of the heat storage material (that is, the heat-transfer tubes in the vicinity of the heat storage material for which phase change has completed), and the heat-transfer tubes in the vicinity of heat storage material in the condition in which the temperature is lower than the phase change temperature of the heat storage material (that is, the heat-transfer tubes in the vicinity of the heat storage material for which phase change has not completed). In this case, a phenomenon which may easily occur, is that the refrigerant in a gas state flows to the heat-transfer tubes in the vicinity of the heat storage material for which phase change has completed, while the liquid refrigerant accumulates in the heat-transfer tubes in the vicinity of the heat storage material for which phase change has not completed (a phenomenon of refrigerant accumulating in the stored-heat heat exchanger). Accordingly, uneven flow to the extent that heat is stored to the heat storage material is difficult to solved, even leading to insufficient heat being stored to the heat storage material when the heat storage operation has finished.

[0013] Thus here, as described above, in the heat storage operation, each time the normal opening degree heat storage time passes, for just the duration of the refrigerant discharge opening degree time (that is, regularly), the setting heat storage operation opening degree is corrected so as to increase. For example, the setting heat storage operation opening degree during the refrigerant discharge opening degree time is set to be 1.5 times the opening degree during the normal opening degree heat storage time. By doing this, liquid refrigerant accumulated in the heat-transfer tubes in the vicinity of the heat storage material for which phase change is not completed is able to be regularly discharged from the outlet-side of the stored-heat heat exchanger.

[0014] Thus occurrence of the phenomenon of liquid refrigerant accumulating in the stored-heat exchanger is suppressed, and the unevenness of an extent of stored heat in the heat storage material can be solved.

[0015] The air conditioning apparatus according to a fourth aspect of the present invention is the air conditioning apparatus according to any of the first through third aspects, in which the defrosting operation is judged to have ended normally or ended abnormally based on an outdoor heat exchange outlet temperature that is a temperature of the refrigerant at an outlet of the outdoor heat exchanger. In this air conditioning apparatus, in the heat storage operation after the defrosting operation ends abnormally, the setting heat storage operation opening degree is corrected so as to be greater than for the heat storage operation after the defrosting operation ends normally.

[0016] In the case in which the defrosting operation ends normally, that is, in the case in which the defrosting operation ends with the outdoor heat exchange outlet temperature greater than or equal to a predetermined defrosting operation finish temperature, it can be judged that in the heat storage operation performed prior to the defrosting operation, an insufficiency in the quantity of heat stored to the heat storage material did not occur. Thus, for a heat storage operation performed after the defrosting operation, it is suitable to control the opening degree of the heat storage expansion valve so as to be the setting heat storage operation opening degree determined by a function based on the condensation pressure, the liquid pipe pressure and the enthalpy of the refrigerant at the outlet and inlet of the stored-heat heat exchanger. However, in the case when the defrosting operation ends abnormally, that is, in the case when the defrosting operation ends with the outdoor heat exchange outlet temperature not being greater than or equal to the predetermined defrosting operation finish temperature, it can be judged that in the heat storage operation performed prior to the defrosting operation, an insufficiency in the quantity of heat stored to the heat storage material did occur. Thus, for a heat storage operation performed after the defrosting operation, simply by controlling the opening degree of the heat storage expansion valve so as to be the setting heat storage operation opening degree determined by a function based on the condensation pressure, the liquid pipe pressure and the enthalpy of the refrigerant at the outlet and inlet of the stored-heat heat exchanger, an insufficiency in the quantity of heat stored to the heat storage material may reoccur, raising concerns of abnormal ending of the defrosting operation occurring repeatedly.

[0017] Thus here, as described above, in a heat storage operation after the defrosting operation ends abnormally, the setting heat storage operation opening degree is corrected so as to be greater than for the heat storage operation after the defrosting operation ends normally. For example, the setting heat storage operation opening degree during a heat storage operation performed after the defrosting operation ends abnormally is set to be not less than 1.1 times the opening degree during a heat storage operation performed after the defrosting operation ends normally. By doing so, in the heat storage operation performed after the defrosting operation ends abnormally, it becomes more difficult for an insufficiency of heat quantity being stored to the heat storage material to occur.

[0018] Thus here, the opening degree of the heat storage expansion valve during the heat storage operation is appropriately controlled, taking account of whether the defrosting operation performed prior to the heat storage operation ended normally or abnormally, enabling repeated occurrences of the defrosting operation ending abnormally to be suppressed.

[0019] The air conditioning apparatus according to a fifth aspect of the present invention is the air conditioning apparatus according to any of the first through fourth aspects, in which the refrigerant circuit is configured such that in the heat storage operation during the heating operation, the refrigerant discharged from the compressor can be delivered in parallel to the indoor heat exchanger and the stored-heat heat exchanger. Moreover, with this air conditioning apparatus, in the heat storage operation during the heating operation, a heating capacity of the indoor heat exchanger is restricted so as to decrease in stages as the condensation temperature decreases.

[0020] Decrease in the condensation temperature in the heat storage operation during the heating operation means the heat quantity released to the heat storage material from the refrigerant through the stored-heat heat exchanger decreases, and storage of heat to the heat storage material becomes more difficult. As storage of heat to the heat storage material becomes more difficult, insufficient heat being stored to the heat storage material when the heat storage operation has ended occurs more readily.

[0021] Here, as described above, the heating capacity of the indoor heat exchanger is restricted so as to decrease in stages as the condensation temperature decreases. By doing so, the heat storage capacity of the stored-heat heat exchanger can be increased just to the extent that the heating capacity of the indoor heat exchanger decreases.

[0022] Accordingly here, the heating capacity of the indoor heat exchanger is restricted taking account of the condensation temperature in the heat storage operation during the heating operation, enabling the occurrence of insufficient heat being stored to the heat storage material when the heat storage operation has ended to be suppressed.

[0023] The air conditioning apparatus according to a sixth aspect of the present invention is the air conditioning apparatus according to the fifth aspect, in which the refrigerant circuit is further provided with an indoor expansion valve for varying the quantity of the refrigerant flowing into the indoor heat exchanger, and in the heating operation, the indoor expansion valve is controlled (control of the subcooling degree by the indoor expansion valve) such that the subcooling degree of the refrigerant at the outlets of the indoor heat exchanger reaches the target subcooling degree for indoor heat exchange. Moreover this air conditioning apparatus is further provided with an indoor fan for supplying air to the indoor heat exchanger. With this air conditioning apparatus, in the heat storage operation during the heating operation, restriction of the heating capacity of the indoor heat exchanger is performed by increasing the target subcooling degree for indoor heat exchange, by decreasing the rotational speed of the indoor fan, and/or by reducing the upper limit opening degree of the indoor expansion valve.

[0024] Restriction of the heating capacity of the indoor heat exchanger in the heat storage operation during the heating operation can be performed using the above three methods in combination or any one of these methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 shows a schematic structural diagram of the air conditioning apparatus according to an embodiment of the present invention;
FIG. 2 shows a schematic structural diagram of the stored-heat heat exchanger;
FIG. 3 shows a control block diagram of the air conditioning apparatus;
FIG. 4 shows the flow of refrigerant in the refrigerant circuit in the cooling operation;
FIG. 5 shows the flow of refrigerant in the refrigerant circuit in the heating operation;
FIG. 6 shows the flow of refrigerant in the refrigerant circuit in the heat storage operation (heat storage operation during the heating operation);
FIG. 7 shows the flow of refrigerant in the refrigerant circuit in the defrosting operation (stored-heat usage operation during the defrosting operation);
FIG. 8 shows the flow of refrigerant in the refrigerant circuit in the defrosting operation (stored-heat usage operation during the defrosting operation);
FIG. 9 shows the flow of refrigerant in the refrigerant circuit in the defrosting operation (stored-heat usage operation during the defrosting operation);
FIG. 10 is a flowchart showing the steps for determining that the heat storage operation has ended;
FIG. 11 is a flowchart showing the heat retention operation after the heat storage operation;
FIG. 12 is a flowchart showing correction of the opening degree of the heat storage expansion valve in the heat storage operation during the heat storage operation, in the air conditioning apparatus according to modification 2;
FIG. 13 is a flowchart showing restriction of heating capacity of the indoor heat exchanger during the heat storage operation in the air conditioning apparatus according to modification 3;
FIG. 14 is a flowchart showing the heat retention operation after the heat storage operation in the air conditioning apparatus according to modification 4; and
FIG. 15 is a flowchart showing recommencement of the heat storage operation after the heat storage operation in the air conditioning apparatus according to modification 5.

DESCRIPTION OF EMBODIMENTS

[0026] The embodiments of the air conditioning apparatus according to the present invention will now be described with reference to the drawings. Note that the basic configuration of the air conditioning apparatus according to the present invention in the embodiments and modifications hereinbelow is illustrative and not restrictive. It is therefore understood that numerous modifications and variations can be devised without departing from the scope of the invention.

(1) Basic configuration of the air conditioning apparatus

[0027] FIG. 1 shows a schematic structural diagram of the air conditioning apparatus 1 according to an embodiment of the present invention. The air conditioning apparatus 1 is a device used for air conditioning inside a building for example, by performing a vapor compression type refrigerant cycle. The air conditioning apparatus 1 comprises primarily an outdoor unit 2 connected to a plurality (in this case, two) of indoor units 4a, 4b. Here, the outdoor unit 2 and the plurality of indoor units 4a, 4b are connected via a liquid refrigerant communication pipe 6 and a gas refrigerant communication pipe 7. That is, the vapor compression type refrigerant circuit 10 of the air conditioning apparatus 1 is configured such that the outdoor unit 2 and the plurality of indoor units 4a, 4b are connected via the refrigerant communication pipes 6, and 7.

<Indoor unit>

[0028] The indoor units 4a, 4b are installed indoors. The indoor units 4a, 4b are connected to the outdoor unit 2 via the refrigerant communication pipes 6, 7, and comprise a part of the refrigerant circuit 10.

[0029] The configuration of the indoor units 4a, 4b will now be described. Note that as the indoor unit 4b has the same configuration as that of the indoor unit 4a, only the configuration of the indoor unit 4a is described below, and the configuration of each part of the indoor unit 4b is omitted, it being understood that the character "a" indicating the respective parts of the indoor unit 4a, would be replaced by the character "b" in the case of the indoor unit 4b.

[0030] The indoor unit 4a has primarily an indoor refrigerant circuit 10a (in the case of the indoor unit 4b, an indoor refrigerant circuit 10b), comprising a part of the refrigerant circuit 10. The indoor refrigerant circuit 10a has primarily an indoor expansion valve 41a and an indoor heat exchanger 42a.

[0031] The indoor expansion valve 41a is a valve that depressurizes the refrigerant flowing in the indoor refrigerant circuit 10a and varies the quantity of refrigerant flowing into the indoor heat exchanger 42a. The indoor expansion valve 41a is an electronic expansion valve connected at the side of the indoor heat exchanger 42a to which the liquid refrigerant flows (the liquid-side).

[0032] For example, the indoor heat exchanger 42a is formed as a cross fin type, fin and tube heat exchanger. An indoor fan 43a for directing indoor air to the indoor heat exchanger 42a is disposed in the vicinity of the indoor heat exchanger 42a. As indoor air is delivered to the indoor heat exchanger 42a by the indoor fan 43a, the indoor heat exchanger 42a exchanges heat between the refrigerant and the indoor air. The rotations of the indoor fan 43a are driven by an indoor fan motor 44a. Thus the indoor heat exchanger 42a comes to function as a radiator of the refrigerant or as an evaporator of the refrigerant.

[0033] Further, various kinds of 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 at the liquid-side of the indoor heat exchanger 42a. At the side of the indoor heat exchanger 42a to which the gas refrigerant flows (the gas-side), is provided a gas-side temperature sensor 46a for detecting the temperature Trga of refrigerant in a gaseous state. An indoor temperature sensor 47a for detecting the temperature (the indoor temperature Tra) of indoor air in the area of air relevant to the indoor unit 4a, is provided to the side of the indoor unit 4a on which the intake side for indoor air is positioned. Further, the indoor unit 4a has an indoor-side control part 48a for controlling the operation of each part comprising the indoor unit 4a. The indoor-side control part 48a has a microcomputer or memory or the like provided for performing control of the indoor unit 4a, and is capable of exchanging control signals and the like with a remote controller 49a to facilitate individual operation of the indoor unit 4a, and exchanging control signals and the like with the outdoor unit 2. The remote controller 49a is a device operated by a user for issuing instructions to operate or stop operation of the air conditioning apparatus or to implement various kinds of settings related to air conditioning operations.

<Outdoor unit>

[0034] The outdoor unit 2 is installed outdoors. The outdoor unit 2 is connected to the indoor units 4a, 4b via the refrigerant communication pipes 6 and 7, and comprises a part of the refrigerant circuit 10.

[0035] The configuration of the outdoor unit 2 will now be described.

[0036] The outdoor unit 2 has primarily an outdoor-side refrigerant circuit 10c that comprises a part of the refrigerant circuit 10. This 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 stored-heat heat exchanger 28, and a heat storage expansion valve 29.

[0037] The compressor 21 is a hermetically sealed compressor accommodating compression elements in a casing not shown in the drawing and a compressor motor 20 that drives the rotation of the compression elements. The compressor motor 20 is capable of being supplied with power via an inverter device not shown in the drawing, and the operating capacity of the compressor motor 20 is able to be varied as the frequency (that is, the rotational speed) of the inverter device is caused to change.

[0038] The first switching mechanism 22 is a four-way switching valve for switching the direction of the flow of the refrigerant. When the first switching mechanism 22 causes the outdoor heat exchanger 23 to function as a radiator of the refrigerant, the first switching mechanism 22 performs a switch that connects the discharge side of the compressor 21 and the gas-side of the outdoor heat exchanger 23, and connects the gas-side of the stored-heat heat exchanger 28 and the intake side of the compressor 21 (refer to the solid line of the first switching mechanism 22 in FIG. 1, outdoor heat release switch condition). Here, when the first switching mechanism 22 is switched to the outdoor heat release switch condition, the stored-heat heat exchanger 28 can be caused to function as an evaporator of the refrigerant. Further, when the first switching mechanism 22 causes the outdoor heat exchanger 23 to function as an evaporator of the refrigerant, the first switching mechanism 22 performs a switch that connects the intake side of the compressor 21 and the gas-side of the outdoor heat exchanger 23, and connects the gas-side of the stored-heat heat exchanger 28 and the discharge side of the compressor 21 (refer to the broken line of the first switching mechanism 22 in FIG. 1, outdoor evaporation switch condition). Here, when the first switching mechanism 22 is switched to the outdoor evaporation switch condition, the stored-heat heat exchanger 28 can be caused to function as a radiator of the refrigerant. Note that it is also suitable for the first switching mechanism 22 to be configured so as to perform the same function as a combination of a three-way valve or electromagnetic valve or the like.

[0039] The outdoor heat exchanger 23 is formed for example from a cross fin type, fin and tube heat exchanger. An outdoor fan 25 for directing external air to the outdoor heat exchanger 23 is installed in the vicinity of the outdoor heat exchanger 23. As external air is delivered to the outdoor heat exchanger 23 by the outdoor fan 25, the outdoor heat exchanger 23 exchanges heat between the refrigerant and the external air. The rotations of the outdoor fan 25 are driven by an outdoor fan motor 26. Thus the outdoor heat exchanger 23 comes to function as a radiator of the refrigerant or as an evaporator of the refrigerant.

[0040] The outdoor expansion valve 24 depressurizes the refrigerant that flows to the outdoor heat exchanger 23 of the refrigerant in the outdoor-side refrigerant circuit 10c, and is a valve that can vary the quantity of refrigerant flowing into the outdoor heat exchanger 23. The outdoor expansion valve 24 is an electronic expansion valve connected at the liquid side of the outdoor heat exchanger 23.

[0041] The second switching mechanism 27 is a four-way switching valve for switching the direction of the flow of the refrigerant. When the second switching mechanism 27 causes the indoor heat exchangers 42a, 42b to function as evaporators of the refrigerant, the second switching mechanism 27 performs a switch that connects the intake side of the compressor 21 and the refrigerant communication pipe 7 (refer to the solid line of the second switching mechanism 27 in FIG. 1, indoor evaporation condition switch). Further, when the second switching mechanism 27 causes the indoor heat exchangers 42a, 42b to function as radiators for the refrigerant, the second switching mechanism 27 performs a switch that connects the discharge side of the compressor 21 and the refrigerant communication pipe 7 (refer to the broken line of the second switching mechanism 27 in FIG. 1, indoor heat release switch condition). Here, one of the ports from among the four ports of the second switching mechanism 27 (the port toward the right of the page in FIG. 1), being continuously connected to the port connected to the intake side of the compressor 21 (the upper port on the page in FIG. 1) via a capillary tube 271, is effectively not used. Note that it is also suitable for the second switching mechanism 27 to be configured so as to perform the same function as a combination of a three-way valve or electromagnetic valve or the like.

[0042] The stored-heat heat exchanger 28 is a heat exchanger that exchanges heat between the refrigerant and the heat storage material. The stored-heat heat exchanger 28, while storing heat to the heat storage material when caused to function as a radiator for the refrigerant, by being caused to function as an evaporator of the refrigerant, is used for performing heat release from the heat storage material (stored-heat usage). The stored-heat heat exchanger 28 has primarily a heat storage tank 281 in which the heat storage material is stored and a heat-transfer tube group 282 arranged so as to be immersed in the heat storage material. Here, as shown in FIG. 2, the heat storage tank 281 is a box having a substantially rectangular parallelepiped shape, inside of which the heat storage material is stored. Here a substance that facilitates heat storage through phase change is used as the heat storage material. Specifically, the heat storage material used is for example polyethylene glycol, sodium sulfate hydrate or paraffin or the like, having a phase change temperature of 30°C-40°C, such that phase change (melting) stores heat when the stored-heat heat exchanger 28 is used as a radiator for the refrigerant, and phase change (coagulation) uses stored heat when the stored-heat heat exchanger 28 is used as an evaporator of refrigerant. As shown in FIG. 2, the heat-transfer tube group 282 has a configuration in which a plurality of heat-transfer tubes 285 are branched and connected via a header pipe 283 and a distributor 284 provided at the refrigerant outlet and inlet. Here, each of the plurality of heat-transfer tubes 285 is of a form folding up and down, the heat-transfer tube group being formed by the connection of the ends of the plurality of heat-transfer tubes 285 to the distributor 284 and the header pipe 283. The gas-side of the stored-heat heat exchanger 28 (that is one end of the heat-transfer tube group) is connected to the first switching mechanism 22, while the liquid-side of the stored-heat heat exchanger 28 (that is the other end of the heat-transfer tube group 282) is connected via the heat storage expansion valve 29 to the portion between the refrigerant communication pipe 6 and the outdoor expansion valve 24 of the refrigerant circuit 10 (the outdoor-side refrigerant circuit 10c). FIG. 2 shows a schematic structural diagram of the stored-heat heat exchanger 28.

[0043] The heat storage expansion valve 29 is a valve that depressurizes the refrigerant that flows through the stored-heat heat exchanger 28 of the refrigerant in the outdoor-side refrigerant circuit 10c, and varies the quantity of the flow of the refrigerant to the stored-heat heat exchanger 28. The heat storage expansion valve 29 is an electronic expansion valve connected to the liquid side of the stored-heat heat exchanger 28.

[0044] Various kinds of sensors are provided in the outdoor unit 2. In the outdoor unit 2 are installed, 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. An outdoor heat exchange temperature sensor 35 for detecting the temperature Toll of refrigerant in a gas-liquid two-phase state is installed to the outdoor heat exchanger 23. To the liquid-side of the outdoor heat exchanger 23, a liquid-side temperature sensor 36 for detecting the temperature Tol2 of refrigerant in a liquid state or a gas-liquid two-phase state is installed. An external air temperature sensor 37 for detecting the temperature (that is the outdoor temperature Ta) of the external air in the outdoor space in which the outdoor unit 2 (that is the outdoor heat exchanger 23 or the stored-heat heat exchanger 28) is arranged, is provided to the external air intake side of the outdoor unit 2. Further, the outdoor unit 2 has an outdoor-side control part 38 for controlling the operation of each part comprising the outdoor unit 2. The outdoor-side control part 38 has a microcomputer or memory provided for controlling the outdoor unit 2 and an inverter device or the like for controlling the compressor motor 25, and is thus able to exchange control signals and the like with the indoor-side control parts 48a, 48b of the indoor units 4a and 4b.

<Refrigerant communication pipes>

[0045] The refrigerant communication pipes 6 and 7 are refrigerant pipes constructed on site when the air conditioning apparatus 1 is installed, and can be of various lengths and diameters depending on the installation conditions of the outdoor unit 2 and the indoor units 4a and 4b.

<Control part>

[0046] As shown in FIG. 1, the remote controllers 49a and 49b for individually controlling 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 comprise the control part 8 that performs operation control of the entire air conditioning apparatus 1. As shown in FIG. 3, the control part 8 is connected so as to be capable of receiving detection signals of each of the sensors 31-37, 45a, 45b, 46a, 46b, 47a and 48b etc. The control part 8, is configured so as to be capable of performing air conditioning operations (cooling operation and heating operation) by controlling each of the devices and valves 20, 22, 24, 26, 41a, 41b, 44a and 44b based on each of these detection signals. FIG. 3 shows a control block diagram of the air conditioning apparatus 1.

[0047] As described above, the air conditioning apparatus 1 has the refrigerant circuit 10 configured by the connection of the plurality (in this case, two) of the indoor units 4a, 4b to the outdoor unit 2. In the air conditioning apparatus 1 the operation controls described below are performed by the control part 8.

(2) Basic operations of the air conditioning apparatus

[0048] The basic operations of the cooling operation, the heating operation, the heat storage operation and the defrosting operation of the air conditioning apparatus 1 will now be described with reference to FIGS. 4 through 9. Here, FIG. 4 shows the flow of refrigerant in the refrigerant circuit in the cooling operation. FIG. 5 shows the flow of refrigerant in the refrigerant circuit in the heating operation. FIG. 6 shows the flow of refrigerant in the refrigerant circuit in the heat storage operation (heat storage operation during the heating operation). FIGS. 7 through 9 show the flow of refrigerant in the refrigerant circuit for the defrosting operation (stored-heat usage operation during the defrosting operation).

<Cooling operation>

[0049] When an instruction for the cooling operation is issued from the remote controllers 49a, 49b, the first switching mechanism 22 switches to implement the outdoor heat release switch condition (the condition indicated by the solid line of the first switching mechanism 22 in FIG. 4), and the second switching mechanism 27 switches to implement the indoor evaporation condition switch (the condition indicated by the solid line of the second switching mechanism 27 in FIG. 4), the heat storage expansion valve 29 is put into the closed condition (that is, the condition in which the stored-heat heat exchanger 28 is not used), and the compressor 21, the outdoor fan 25, and the indoor fans 43a 43b start.

[0050] Now, the low-pressure gas refrigerant inside the refrigerant circuit 10 is taken into the compressor 21 and compressed, becoming high-pressure gas refrigerant. This high-pressure gas refrigerant is delivered to the outdoor heat exchanger 23 via the first switching mechanism 22. The high-pressure gas refrigerant delivered to the outdoor heat exchanger 23 is condensed through being cooled by heat exchange with external air supplied by the outdoor fan 25, in the outdoor heat exchanger 23 functioning as a radiator of the refrigerant, becoming high-pressure liquid refrigerant. This high-pressure liquid refrigerant is delivered from the outdoor unit 2 to the indoor units 4a, 4b via the outdoor expansion valve 24 and the refrigerant communication pipe 6.

[0051] The high-pressure refrigerant delivered to the indoor units 4a, 4b is depressurized by the indoor expansion valves 41a, 41b, to become low-pressure refrigerant in a gas-liquid two-phase state, which is then delivered to the indoor heat exchangers 42a, 42b. This low-pressure refrigerant in a gas-liquid two-phase state delivered to the indoor heat exchangers 42a, 42b is evaporated by being heated through 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, to become low-pressure gas refrigerant. This low-pressure gas refrigerant is delivered from the indoor units 4a, 4b to the outdoor unit 2 via the refrigerant communication pipe 7.

[0052] The low-pressure gas refrigerant delivered to the outdoor unit 2 is again taken into the compressor 21 via the second switching mechanism 27.

<Heating operation>

[0053] When an instruction for the heating operation is issued from the remote controllers 49a, 49b, the first switching mechanism 22 switches to implement the outdoor evaporation switch condition (the condition indicated by the broken line of the first switching mechanism 22 in FIG. 5), and the second switching mechanism 27 switches to implement the indoor heat release switch condition (the condition indicated by the broken line of the second switching mechanism 27 in FIG. 5), the heat storage expansion valve 29 is put into the closed condition (that is, the condition in which the stored-heat heat exchanger 28 is not used), and the compressor 21, the outdoor fan 25, and the indoor fans 43a 43b start.

[0054] Now, the low-pressure gas refrigerant inside the refrigerant circuit 10 is taken into the compressor 21 and compressed, becoming high-pressure gas refrigerant. This high-pressure gas refrigerant is delivered from the outdoor unit 2 to the indoor units 4a, 4b via the second switching mechanism 27 and the refrigerant communication pipe 7.

[0055] The high-pressure gas refrigerant delivered to the indoor units 4a, 4b is delivered to the indoor heat exchangers 42a, 42b and is there condensed through being cooled by heat exchange with internal air supplied by indoor fans 43a 43b, in the indoor heat exchangers 42a, 42b functioning as radiators of the refrigerant, becoming high-pressure liquid 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 delivered from the indoor units 4a, 4b to the outdoor unit 2 via the refrigerant communication pipe 7.

[0056] The refrigerant delivered to the outdoor unit 2 is then delivered to the outdoor expansion valve 24 where it is depressurized, becoming low-pressure refrigerant in a gas-liquid two-phase state, which is then delivered to the outdoor heat exchanger 23, wherein this refrigerant is evaporated by being heated through heat exchange with external air supplied by the outdoor fan 25, in the outdoor heat exchanger 23 functioning as an evaporator of the refrigerant, to become low-pressure gas refrigerant. The low-pressure gas refrigerant is again taken into the compressor 21 via the first switching mechanism 22.

<Heat storage operation (Heat storage operation during the heating operation)>

[0057] During the heating operation, the heat storage operation is performed that stores heat to the heat storage material by causing the stored-heat heat exchanger 28 to function as a radiator of the refrigerant. That is, during the heating operation in which the outdoor heat exchanger 23 is caused to function as an evaporator of the refrigerant, moreover the indoor heat exchangers 42a, 42b are caused to function as radiators of the refrigerant, the heat storage operation (heat storage operation during the heating operation) that stores heat to the heat storage material is performed by causing the stored-heat heat exchanger 28 to function as a radiator of the refrigerant. This heat storage operation during the heating operation is performed through opening of the heat storage expansion valve 29, with the switching mechanisms 22, 27 being switched to the same condition as the condition that applies for the heating operation (refer FIG. 6).

[0058] Here, the low-pressure gas refrigerant inside the refrigerant circuit 10 is taken into the compressor 21 and compressed, becoming high-pressure gas refrigerant. Part of this high-pressure gas refrigerant, in the same manner as applies during the heating operation, is delivered to the indoor units 4a, 4b from the outdoor unit 2 via the second switching mechanism 27 and the refrigerant communication pipe 7. This high-pressure gas refrigerant delivered to the indoor units 4a, 4b is condensed through cooling performed by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as radiators of the refrigerant, becoming high-pressure liquid 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 delivered from the indoor units 4a, 4b to the outdoor unit 2 via the refrigerant communication pipe 7.

[0059] Further, the remaining high pressure gas refrigerant discharged from the compressor 21 is delivered, via the first switching mechanism 22 to the stored-heat heat exchanger 28, where this refrigerant is condensed by cooling performed through heat exchange with the heat storage material in the stored-heat heat exchanger 28 functioning as a radiator of the refrigerant, becoming high-pressure liquid refrigerant. This high-pressure liquid refrigerant is depressurized by the expansion valve 29. Here, the heat storage material of the stored-heat heat exchanger 28 stores heat by phase change (melting) through being heated by heat exchange with the refrigerant.

[0060] The refrigerant depressurized at the heat storage expansion valve 29 then merges with the refrigerant delivered from the indoor units 4a, 4b to the outdoor unit 2, the merged flow then being delivered to the outdoor expansion valve 24 where the refrigerant is depressurized, becoming low-pressure refrigerant in a gas-liquid two-phase state. This low-pressure refrigerant in a gas-liquid two-phase state is delivered to the outdoor heat exchanger 23 where the refrigerant is evaporated by being heated through performance of heat exchange with external air supplied by the outdoor fan 25, in the outdoor heat exchanger 23 functioning as an evaporator of the refrigerant, becoming low-pressure gas refrigerant. This low-pressure gas refrigerant is then taken into the compressor 21 again, via the first switching mechanism 22. In this way, in the heat storage operation during the heating operation, the stored-heat heat exchanger 28 is able to function in parallel with the indoor heat exchangers 42a, 42b as a radiator of the refrigerant. That is, the refrigerant circuit 10 is configured such that, in the heat storage operation during the heating operation, the high-pressure gas refrigerant discharged from the compressor 21 can be delivered to the indoor heat exchangers 42a, 42b and the stored-heat heat exchanger 28 in parallel.

<Defrosting operation (Stored-heat usage operation during the defrosting operation)>

[0061] During the heating operation, the defrosting operation that performs defrosting of the heat exchanger is carried out, by causing the outdoor heat exchanger 23 to function as a radiator of the refrigerant. During the defrosting operation, the stored-heat usage operation is performed that releases heat from the heat storage material, by causing the stored-heat heat exchanger 28 to function as an evaporator of the refrigerant. That is, the stored-heat usage operation (stored-heat usage operation during the defrosting operation, defrosting operation with stored-heat usage operation) is performed in which the outdoor heat exchanger 23 is caused to function as a radiator of the refrigerant, moreover the stored-heat heat exchanger 28 is caused to function as an evaporator of the refrigerant. Further, here, the heating operation is also performed simultaneously, by causing the indoor heat exchangers 42a, 42b to function as radiators of the refrigerant. That is, here, during the defrosting operation, the stored-heat usage operation and the heating operation are able to be performed simultaneously (or, in the defrosting operation with the stored-heat usage operation, the heating operation is performed simultaneously). This stored-heat usage operation during the defrosting operation (or defrosting operation with stored-heat usage operation) is performed through opening of the heat storage expansion valve 29 with the switching mechanism 22 switching to implement the outdoor heat release switch condition, moreover the second switching mechanism 27 switching to implement the indoor heat release switch condition (refer FIG. 7). Further, during the defrosting operation the outdoor fan 25 is stopped.

[0062] Here, the low-pressure gas refrigerant inside the refrigerant circuit 10 is taken into the compressor 21 and compressed, becoming high-pressure gas refrigerant. Part of this high-pressure gas refrigerant, in the same manner as applies during the heating operation, is delivered to the indoor units 4a, 4b from the outdoor unit 2 via the second switching mechanism 27 and the refrigerant communication pipe 7. This high-pressure gas refrigerant delivered to the indoor units 4a, 4b is condensed through cooling performed by heat exchange with indoor air supplied by the indoor fans 43a, 43b in the indoor heat exchangers 42a, 42b functioning as radiators of the refrigerant, becoming high-pressure liquid refrigerant. This high-pressure liquid refrigerant is depressurized by the indoor expansion valves 41a, 41b, the depressurized refrigerant then being delivered from the indoor units 4a, 4b to the outdoor unit 2 via the refrigerant communication pipe 7.

[0063] Further, the remaining high pressure gas refrigerant discharged from the compressor 21 is delivered via the first switching mechanism 22, to the outdoor heat exchanger 23, to be cooled by heat exchange with frost or ice adhering to the outdoor heat exchanger 23 functioning as a radiator of the refrigerant. This high-pressure refrigerant is depressurized by the outdoor expansion valve 24. Here, the frost or ice adhering to the outdoor heat exchanger 23 is melted by being heated through heat exchange with the refrigerant, such that defrosting of the outdoor heat exchanger 23 is performed.

[0064] The high-pressure refrigerant depressurized by the outdoor expansion valve 24, then merges with the refrigerant delivered from the indoor units 4a, 4b to the outdoor unit 2, the merged flow then being delivered to the heat storage expansion valve 29 where the refrigerant is depressurized, becoming low-pressure refrigerant in a gas-liquid two-phase state. This low-pressure refrigerant in a gas-liquid two-phase state is delivered to the stored-heat heat exchanger 28 where the refrigerant is evaporated by being heated through heat exchange with the heat storage material, in the stored-heat heat exchanger 28 functioning as an evaporator of the refrigerant, becoming low-pressure gas refrigerant. This low-pressure gas refrigerant is then taken into the compressor 21 again, via the first switching mechanism 22. The heat storage material of the stored-heat heat exchanger 28 undergoes phase change (coagulation) through being cooled by heat exchange with the refrigerant, stored heat being used. In this way, when in the stored-heat usage operation during the defrosting operation (or the defrosting operation with stored-heat usage operation) the heating operation is performed simultaneously, the indoor heat exchangers 42a, 42b come to function as evaporators of the refrigerant in parallel with the outdoor heat exchanger 23. That is, the refrigerant circuit 10 is configured such that when, in the stored-heat usage operation during the defrosting operation (or the defrosting operation with stored-heat usage operation) the heating operation is performed simultaneously, the high-pressure gas refrigerant discharged from the compressor 21 can be delivered to the outdoor heat exchanger 23 and the indoor heat exchangers 42a, 42b in parallel.

[0065] Further, the defrosting operation with stored-heat usage operation is not restricted to the above description (refer FIG. 7) and it is also suitable for the outdoor heat exchanger 23 to be caused to function as a radiator of the refrigerant, moreover for the stored-heat exchanger 28 to be caused to function as an evaporator of the refrigerant. For example, it is suitable to have the indoor expansion valves 41a, 41b closed and not perform the heating operation (refer FIG. 8), or, by switching the second switching mechanism 27 to the indoor evaporation switch condition, to cause the indoor heat exchangers 42a, 42b to function as evaporators of the refrigerant in parallel with the stored-heat heat exchanger 28 (refer FIG 9).

<Control for the cooling operation, the heating operation and the defrosting operation>

- Control during the cooling operation -

[0066] In the above mentioned cooling operation, the control part 8 implements control by determining the opening degree of each of the indoor expansion valves 41a, 41b, such that the superheating degrees SHra, SHrb of the refrigerant in the outlet of each of the indoor heat exchangers 42a, 42b become the target superheating degrees SHras, SHrbs. Here, the superheating degrees SHra, SHrb are calculated from the intake pressure Ps detected by the intake pressure sensor 31, and the temperatures Trga, Trgb of the refrigerant at the gas-side of the indoor heat exchangers 42a, 42b detected by the gas-side temperature sensors 46a, 46b. More specifically, firstly, the control part 8 converts the intake pressure Ps to the refrigerant saturation temperature, and obtains the evaporation temperature Te that is the equivalent quantity in that state corresponding to the evaporation pressure Pe in the refrigerant circuit 10 (that is, the evaporation pressure Pe and the evaporation temperature Te, while semantically different, in effect mean corresponding quantities in different states). Here, evaporation pressure Pe means the pressure representing the low-pressure refrigerant flowing from the outlets of the indoor expansion valves 41a, 41b via the indoor heat exchangers 42a, 42b to reach the intake-side of the compressor 21, in the cooling operation. Moreover, the superheating degrees SHra, SHrb are obtained by deducting the evaporation temperature Te from the temperatures Trga and Trgb of refrigerant at the gas-side of the respective indoor heat exchangers 42a, 42b.

[0067] Note that in the cooling operation, control of each device of the indoor units 4a, 4b including the indoor expansion valves 41a 41b, is performed by the indoor-side control parts 48a, 48b of the control part 8. Further, control of each device of the indoor unit 2 including the outdoor expansion valve 24 is performed by the outdoor-site control part 38 of the control part 8.

- Control during the heating operation -

[0068] In the above mentioned heating operation, the control part 8 implements control by determining the opening degree of each of the indoor expansion valves 41a, 41b, such that the subcooling degrees SCra, SCrb of the refrigerant in the outlet of each of the indoor heat exchangers 42a, 42b become the target subcooling degrees SCras, SCrbs. Here, the subcooling degrees SCra, SCrb are calculated from the discharge pressure Pd detected by the discharge pressure sensor 32, and the temperatures Trla, Trlb of the refrigerant at the liquid-side of the indoor heat exchangers 42a, 42b detected by the liquid-side temperature sensors 45a, 45b. More specifically, firstly, the control part 8 converts the discharge pressure Pd to the refrigerant saturation temperature, and obtains the condensation temperature Tc that is the equivalent quantity in that state corresponding to the condensation pressure Pc in the refrigerant circuit 10 (that is, the condensation pressure Pc and the condensation temperature Tc, while semantically different, in effect mean corresponding quantities in different states). The condensation pressure Pc means, the pressure representing the high-pressure refrigerant flowing from the discharge-side of the compressor 21 via the indoor heat exchangers 42a, 42b to reach the indoor expansion valves 41a, 41b during the heating operation. Moreover, the subcooling degrees SCra, SCrb are obtained by deducting from the condensation temperature Tc, the temperatures Trla and Trlb of the refrigerant at the liquid-side of the respective indoor heat exchangers 42a, 42b.

[0069] Note that in the heating operation, control of each device of the indoor units 4a, 4b including the indoor expansion valves 41a 41b, is performed by the indoor-side control parts 48a, 48b of the control part 8. Further, control of each device of the indoor unit 2 including the outdoor expansion valve 24 is performed by the outdoor-site control part 38 of the control part 8.

- Control during the defrosting operation -

[0070] In the above mentioned defrosting operation, in the case that the outdoor heat exchanger outlet temperature Tol2 that is the temperature of the refrigerant at the outlet of the outdoor heat exchanger 23 is greater than or equal to a predetermined defrosting operation finish temperature Tdefe, or the case that a predetermined defrosting operation time tdefe has elapsed, the defrosting operation is ended and the heating operation or heat storage operation during the heating operation is transitioned to.

[0071] As described above, the air conditioning apparatus 1 is able to switch between performing the cooling operation and the heating operation. By performing the heat storage operation during the heating operation, heat is stored to the heat storage material while the heating operation continues, and by performing the stored-heat usage operation during the defrosting operation, the defrosting operation can be performed while utilizing stored heat of the heat storage material.

(3) Control during the heat storage operation

[0072] The above mentioned heat storage operation (including the heating operation after the heat storage operation) has contrive for control as follows.

- Control of the opening degree of the heat storage expansion valve during the heat storage operation -

[0073] In the above mentioned heat storage operation, the quantity of refrigerant flowing into the stored-heat heat exchanger 28 must be maintained through controlling the opening degree of the heat storage expansion valve 29. However, when control of the opening degree of the heat storage expansion valve 29 involves controlling the subcooling degree using the heat storage expansion valve 29 as in patent document 1, in the case in which it is not possible to sufficiently maintain the quantity of refrigerant flowing into the stored-heat heat exchanger 28 during the heat storage operation, there is concern of an insufficiency of heat being stored to the heat storage material notwithstanding that the heat storage operation has ended.

[0074] Thus, in the heat storage operation, the opening degree of the heat storage expansion valve 29 is controlled, as shown in formula 1, to be the setting heat storage operation opening degree MVacs determined by a function based on the condensation pressure Pc that is the saturation pressure equivalent to the condensation temperature Tc of refrigerant in the refrigerant circuit 10, the liquid pipe pressure P1 that is the pressure of the refrigerant in the outlet of the heat storage expansion valve 29, and the enthalpy hi, ho of the refrigerant at the inlet and the outlet of the stored-heat heat exchanger 28.

$$\text{Formula 1: } \mathrm{MVacs} = \mathrm{k1} \times \mathrm{CVac} - \mathrm{k2}$$

[0075] Formula 1 describes the characteristics of the flow quantity of the refrigerant in the expansion valve 29. k1, k2 are coefficients. CVac is a flow coefficient of the expansion valve 29.

[0076] The flow coefficient of the heat storage expansion valve 29 CVac, is expressed in formula 2.

$$\text{Formula 2: } \mathrm{CVac} = \mathrm{k3} / \Delta \mathrm{h} / (27.9 \times (\Delta \mathrm{P} \times \mathrm{SLD})^{0.5})$$

[0077] Here, k3 is the coefficient corresponding to the heat storage capacity of the heat storage material. Δh is the enthalpy difference of the refrigerant in the outlet and inlet of the stored-heat heat exchanger 28, as expressed in formula 3.

$$\text{Formula 3: } \Delta \mathrm{h} = \mathrm{hi} - \mathrm{ho}$$

[0078] Here, hi is the enthalpy of refrigerant in the inlet of the stored-heat heat exchanger 28 (the gas-side of the stored-heat heat exchanger 28), and ho is the enthalpy of the refrigerant in the outlet of the stored-heat heat exchanger 28 (the liquid-side of the stored-heat heat exchanger 28). The inlet enthalpy hi uses an enthalpy of the refrigerant envisaging the case in which the superheating degree of the refrigerant in the inlet of the stored-heat heat exchanger 28 for the condensation pressure Pc is the superheating degree of the refrigerant (for example, 10°C) used for setting the opening degree. The outlet enthalpy ho uses an enthalpy of the refrigerant envisaging the case in which the subcooling degree of the refrigerant in the outlet of the stored-heat heat exchanger 28 for the condensation pressure Pc is the subcooling degree of the refrigerant (for example, 3°C) used for setting the opening degree. Note that when temperature sensors are installed to the outlet of the stored-heat heat exchanger 28, it is suitable to use the temperature detected by these temperature sensors to obtain the enthalpy of refrigerant in the inlet and the outlet of the stored-heat heat exchanger 28.

[0079] Further, in formula 2, ΔP is the pressure difference corresponding to the pressure differential of the heat storage expansion valve 29, expressed by formula 4.

$$\text{Formula 4: } \Delta \mathrm{P} = \mathrm{Pc} - \mathrm{Pl}$$

[0080] Here, Pc is the condensation pressure. P1 is the liquid pipe pressure corresponding to the pressure of the refrigerant at the outlet side of the heat storage expansion valve 29, here, expressed by the following formula 5 derived from the function of condensation pressure Pc.

$$\text{Formula 5: } \mathrm{Pl} = \mathrm{k4} \times \mathrm{Pc}^2 + \mathrm{k5} \times \mathrm{Pc} + \mathrm{k6}$$

[0081] Here, k4-k6 are coefficients. In the case in which a pressure sensor is provided to the outlet of the heat storage expansion valve 29, it is suitable to use the pressure value as detected by this pressure sensor for the liquid pipe pressure.

[0082] Further, SLD in formula 2 is the density of the refrigerant in the outlet of the stored-heat heat exchanger 28. The value for the density of refrigerant used envisages the case in which the subcooling degree of the refrigerant in the outlet of the stored-heat heat exchanger 28 for the condensation pressure Pc is the subcooling degree of the refrigerant (for example, 3°C) used for setting the opening degree. Note that in the case in which a temperature sensor is provided to the outlet of the stored-heat heat exchanger 28, it is suitable to use the temperature value detected by this temperature sensor to obtain the density of refrigerant in the outlet of the stored-heat heat exchanger 28.

[0083] Thus, obtaining the liquid pipe pressure P1 from the condensation pressure Pc and formula 5, it is possible to obtain the pressure difference ΔP from the liquid pipe pressure P1 and formula 4. Further, obtaining the density SLD and the enthalpy hi and ho of the refrigerant in the outlet and inlet of the stored-heat heat exchanger 28 from the condensation pressure Pc, it is possible to obtain the enthalpy difference Δ h from the enthalpy hi, ho and formula 3. Moreover, obtaining the flow quantity coefficient CVac of the heat storage expansion valve 29 from enthalpy difference Δh, the pressure differential ΔP, SLD, and formula 2, it is possible to obtain the setting heat storage operation opening degree MVacs from the flow coefficient CVac and formula 1. Then, during the heat storage operation, the opening degree of the heat storage expansion valve 29 can be controlled so as to be the setting heat storage operation opening degree MVacs.

[0084] Thus in the heat storage operation the opening degree of the heat storage expansion valve 29 is controlled so as to be the setting heat storage operation opening degree MVacs, determined by the function based on the condensation pressure Pc, the liquid pipe pressure P1 and the enthalpy hi, ho of the refrigerant in the inlet and the outlet of the stored-heat heat exchanger 28. Accordingly, the plurality of state quantities of the refrigerant related to the stored-heat heat exchanger 28 come to be reflected in the determination of the opening degree of the heat storage expansion valve 29, and the opening degree of the heat storage expansion valve 29 during the heat storage operation can be made an opening degree that enables the flow quantity of refrigerant to the stored-heat heat exchanger 28 to be sufficiently maintained.

[0085] Thus the opening degree of the heat storage expansion valve 29 during the heat storage operation is appropriately controlled, and the occurrence of insufficiency of heat storage to the heat storage material when the heat storage operation has ended can be suppressed.

[0086] Further, the density SLD of the refrigerant in the outlet of the stored-heat heat exchanger 28 can also be used in the function for determining the setting heat storage operation opening degree MVacs. The density SLD of the refrigerant in the outlet of the stored-heat heat exchanger 28 that is one of the state quantities of the refrigerant related to the stored-heat heat exchanger 28 comes to be reflected in the determination of the opening degree of the heat storage expansion valve 29, enabling the opening degree of the heat storage expansion valve 29 during the heat storage operation to be controlled more appropriately.

- Judging that the heat storage operation has finished -

[0087] Further, it is preferable that the timing of when the above-mentioned heat storage operation has finished is judged appropriately after ascertaining whether heat storage to the heat storage material has been sufficiently performed. However here, as heat storage material that undergoes phase change is used, there being little temperature difference in the heat storage material during phase change and after phase change, and the heat-transfer tubes 285 comprising the stored-heat heat exchanger 28 being densely arranged in consideration of the thermal conductivity being small, therefore appropriately determining the timing of the ending of the heat storage operation is difficult.

[0088] Thus in the heat storage operation during the heating operation, when the heat storage cumulative time tac that is the integrated value for the time which the condensation temperature Tc of the refrigerant in the refrigerant circuit 10 is greater than or equal to a first heat storage condensation temperature Tcc1 as the heat storage completion condensation temperature, is greater than or equal to the heat storage completion cumulative time tace, the heat storage operation is ended.

[0089] Specifically here, judging that the heat storage operation ended is performed in accordance with steps ST1-ST4 as shown in the flowchart of FIG. 10.

[0090] Once the heat storage operation starts, firstly at step ST1, the time accumulating the heat storage cumulative time tac is reset.

[0091] In the case that the heat storage operation satisfies the heat storage time count commencement conditions, the processes of step ST2 are transitioned to, and the counting of the time accumulating the heat storage cumulative time tac commences. Here, the heat storage time count commencement conditions are the conditions for judging whether the condition is that heat storage to the heat storage material is in effect performed. The heat storage time count commencement conditions are satisfied when, the heat storage operation is performed during the heating operation, moreover, the condensation temperature Tc is higher than a prescribed first heat storage condensation temperature Tcc1 (here, a temperature higher than the phase change temperature of the heat storage material, for example 41°C), moreover the condensation temperature Tc is greater than or equal to a second heat storage condensation temperature Tcc2 that is slightly less than the first heat storage condensation temperature Tcc1 (here, substantially the same temperature as the phase change temperature of the heat storage material, for example 35°C) for a duration that continues beyond a predetermined time tac2 (for example 10 minutes).

[0092] Further, in the case that the heat storage time count finish condition is satisfied, this condition being that the heat storage cumulative time tac from commencement of the counting of time accumulating the heat storage cumulative time tac at step ST2 is greater than or equal to the predetermined heat storage completion cumulative time tace, the processes of step ST3 are transitioned to, the counting of time accumulating the heat storage cumulative time tac ends (count up) and the heat storage operation finishes.

[0093] After counting of the time accumulating the heat storage cumulative time tac has commenced at step ST2, in the case in which the heat storage operation satisfies the heat storage time hold condition, step ST4 is transitioned to, and the counting of the time accumulating the heat storage cumulative time tac is interrupted (put on hold). Here, the heat storage time hold condition is the condition for judging whether it cannot be said that heat storage to the heat storage material is in effect performed. Here, the heat storage time hold condition is satisfied when the condensation temperature Tc is less than a third heat storage condensation temperature Tcc3 that is slightly lower than the first heat storage condensation temperature Tcc1 (here, the temperature between the first heat storage condensation temperature Tcc1 and the second heat storage condensation temperature Tcc2, for example 40°C).

[0094] Moreover after the time count accumulating heat storage cumulative time tac is interrupted at step ST4, in the case in which the heat storage operation satisfies the heat storage time count recommence condition, the processes of step ST2 are returned to, and the time count accumulating the heat storage cumulative time tac is recommenced. Here, the heat storage time count recommence condition is the condition for judging whether there has been a return to the condition in which heat storage to the heat storage material is in effect performed. In the case in which the condensation temperature Tc is higher than the first heat storage condensation temperature Tcc1, the heat storage time count recommence condition is satisfied. In this way, the counting of the time accumulating the heat storage cumulative time tac is performed only when the condensation temperature Tc is greater than or equal to the first heat storage condensation temperature Tcc1, as the heat storage completion condensation temperature.

[0095] Further, after the time count accumulating the heat storage cumulative time tac is interrupted at step ST4, in the case in which the heat storage operation satisfies the heat storage time count reset condition, the processes of step ST1 are returned to, and the time for accumulation of heat storage cumulative time tac is reset. Here, the heat storage time reset condition is the condition for judging whether it is necessary to redo the counting of time accumulating the heat storage cumulative time tac because the condition in which it cannot be said that heat storage to the heat storage material is in effect performed has continued for a long duration. Here, the heat storage time reset condition is satisfied when for a duration that continues beyond a predetermined time tac4 (for example, 15 minutes), the condensation temperature Tc continues to be greater than or equal to a fourth heat storage condensation temperature Tcc4 that is slightly less than the first heat storage condensation temperature Tcc1 (here substantially the same temperature as the heat storage material phase change temperature, for example 35°C). Moreover, in the event that the defrosting operation has commenced, even in the course of the processes of step ST2 and step ST4, a return to the processes of step ST1 is forced, and the time for accumulation of the heat storage cumulative time tac is reset.

[0096] In this way, during the heat storage operation, whether the condition in which heat storage to the heat storage material is in effect performed is judged based on whether the condensation temperature Tc is greater than or equal to the first heat storage condensation temperature Tcc1, as the heat storage completion condensation temperature, and whether this heat storage operation is in effect performed for a sufficient time is judged on whether the heat storage cumulative time tac is greater than or equal to the heat storage completion cumulative time tace. Thus, the timing of the ending of the heat storage operation can be properly judged. When using heat storage material that undergoes phase change, while properly judging the timing of the ending of the heat storage operation may present difficulties, here, a proper judgment of the timing of the end of the heat storage operation can be made as the indicator of judging the heat storage cumulative time tac has been added.

- Heat retention operation after the heat storage operation -

[0097] Further, when the above-mentioned heat storage to the heat storage material by performance of the heat storage operation during the heating operation (refer FIG. 6) is ended, it could be considered that the heat storage operation only is ended, (that is, by closing the heat storage expansion valve 29 such that the refrigerant does not flow into the stored-heat exchanger 28), and only the above-mentioned heating operation (refer FIG. 5) is to be performed. However, after the heat storage operation during the heating operation ends, simply switching such that only the heating operation is performed engenders concern that heat release of the heat storage material will occur due to the effects of the outdoor air temperature Ta of the outdoor space in which the stored-heat heat exchanger 28 is installed, causing a decrease in the quantity of heat that can be used in the subsequent stored-heat usage operation during the defrosting operation.

[0098] Thus here, after the heat storage operation during the heating operation ends, while performing the heating operation, the heat retention operation for retaining heat of the heat storage material can be performed.

[0099] More specifically, the heat retention operation after the heat storage operation is performed in accordance with steps ST5, ST6 shown in the flowchart of FIG. 11. That is, at step ST5, if the heat storage operation during the heating operation has ended, (determination that the heat storage operation has ended of FIG. 10), the heat retention operation of step ST6 is transitioned to. The heat retention operation is performed by slightly opening the heat storage expansion valve 29 (taking the opening degree when the heat storage expansion valve 29 is in the fully open condition as 100%, an opening degree of not greater than approximately 15%).

[0100] In this way, by performing the heat retention operation after the heat storage operation has ended, a decrease in heat quantity through heat release from the heat storage material occurring after the heat storage operation ends can be compensated for. In this way decrease in the quantity of heat that can be used in the stored-heat usage operation during the defrosting operation can be suppressed. Further, the heat retention operation is performed by slightly opening the heat storage expansion valve 29 to flow a small quantity of the refrigerant to the stored-heat heat exchanger 28. Accordingly it becomes difficult for the quantity of the refrigerant flowing into the indoor heat exchangers 42a, 42b during the heating operation to decrease, such that the adverse impact on the heating operation can be suppressed to the minimum. Thus the heat retention operation can be performed while minimizing the adverse impact to the heating operation.

[0101] As described above, by controlling the opening degree of the heat storage expansion valve 29, the heat storage operation is performed while appropriately controlling the opening degree of the heat storage expansion valve 29, and through judging the ending of the heat storage operation and performing the heat retention operation after the heat storage operation as described above, it becomes possible to suppress the decrease in heat quantity that can be used in the stored-heat usage operation during the defrosting operation while properly judging the timing of the ending of the heat storage operation.

(4) Modification 1

[0102] In the above described embodiment, in the case in which the defrosting operation ends normally, that is, in the case in which the defrosting operation ends with the outdoor heat exchanger outlet temperature Tol2 being greater than or equal to the defrosting operation finish temperature Tdefe, it is possible to judge that there has not been an insufficiency in the quantity of heat stored to the heat storage material in the heat storage operation performed prior to the defrosting operation. Thus for the heat storage operation performed after the defrosting operation, it is suitable that the opening degree of the heat storage expansion valve 29 be controlled so as to be the setting heat storage operation opening degree MVacs determined by a function based on the above-mentioned condensation pressure Pc, the liquid pipe pressure P1, and the enthalpy hi, ho of the refrigerant at the inlet and the outlet of the stored-heat heat exchanger 28. However, in the case that the defrosting operation finishes abnormally, that is, the case in which the defrosting operation ends with the outdoor heat exchanger outlet temperature Tol2 not being greater than or equal to the defrosting operation finish temperature Tdefe, it is possible to judge that an insufficiency has been occurring in the quantity of heat stored to the heat storage material in the heat storage operation performed prior to the defrosting operation. Thus, for the heat storage operation performed after the defrosting operation, when simply controlling the opening degree of the heat storage expansion valve 29 so as to be the setting heat storage operation opening degree MVacs determined by a function based on the condensation pressure Pc, the liquid pipe pressure P1, and the enthalpy hi, ho of the refrigerant at the inlet and the outlet of the stored-heat heat exchanger 28, insufficiency in the quantity of heat stored to the heat storage material may occur again, raising concerns of abnormal completion of the defrosting operation occurring repeatedly.

[0103] Thus here, for the heat storage operation after the defrosting operation finishes abnormally as above, the setting heat storage operation opening degree MVacs is corrected so as to be greater than the opening degree of the heat storage operation after the defrosting operation completes normally.

[0104] Specifically here, correction of the setting heat storage operation opening degree MVacs is performed as follows. Here, the opening degree of the heat storage expansion valve 29 is expressed in formula 6 using setting heat storage operation opening degree MVacs and correction coefficient α.

[0105] Formula 6: Opening degree of the heat storage expansion valve = MVacs $\times$ α

[0106] When the heat storage operation commences the correction coefficient α for the setting heat storage operation opening degree MVacs is determined. In the case in which the defrosting operation finishes normally, the correction coefficient α = 1, thus the opening degree of the heat storage expansion valve 29 becomes the same as the setting heat storage operation opening degree MVacs (that is, opening degree of the heat storage expansion valve 29 = setting heat storage operation opening degree MVacs $\times$1). On the other hand, when the defrosting operation finishes abnormally, the correction coefficient is made $\alpha \geqq 1.1$, thus the opening degree of the heat storage expansion valve 29 becomes at least α times (for example, $\alpha \geqq 1.1$) the setting heat storage operation opening degree MVacs (that is, opening degree of the heat storage expansion valve 29 = setting heat storage operation opening degree MVacs $\times$ α), being greater than the opening degree of the heat storage operation after the defrosting operation finishes normally. By doing this, in the heat storage operation after the defrosting operation finishes abnormally, an insufficiency in the quantity of heat being stored to the heat storage material occurs less readily.

[0107] In this way, by ascertaining whether the defrosting operation performed prior to the heat storage operation finished normally or abnormally, the opening degree of the heat storage expansion valve 29 in the heat storage operation can be controlled as appropriate, enabling repeated occurrence of abnormal completion of the defrosting operation to be suppressed.

(5) Modification 2

[0108] In the above described embodiment and modification 1, the stored-heat heat exchanger 28, as shown in FIG. 2, has primarily the heat storage tank 281 in which the heat storage material is stored and the heat-transfer tube group 282 arranged so as to be immersed in the heat storage material. The heat-transfer tube group 282 has a configuration in which a plurality of heat-transfer tubes 285 are branched and connected via a header pipe 283 and a distributor 284 provided at the refrigerant outlet and inlet. Thus, in the heat storage operation, there is concern that uneven flow of refrigerant may occur between the heat-transfer tubes 285 comprising the heat-transfer tube group 282 of the stored-heat heat exchanger 28. If uneven flow of refrigerant between the heat-transfer tubes 285 occurs, the unevenness occurs to the extent that heat is stored to the heat storage material in the heat storage tank 281, a condition of coexistence arising having the heat-transfer tubes 285 in the vicinity of heat storage material in the condition in which the temperature is higher than the phase change temperature of the heat storage material (that is, the heat-transfer tubes 285 in the vicinity of the heat storage material for which phase change has completed), and the heat-transfer tubes 285 in the vicinity of heat storage material in the condition in which the temperature is lower than the phase change temperature of the heat storage material (that is, the heat-transfer tubes in the vicinity of the heat storage material for which phase change has not completed). In this condition, a phenomenon readily occurs in which the refrigerant in the gas state flows to the heat-transfer tubes 285 in the vicinity of the heat storage material for which phase change has completed, while the liquid refrigerant accumulates in the heat-storage tubes 285 in the vicinity of the heat storage material for which phase change has not completed (a phenomenon of refrigerant accumulating in the stored-heat heat exchanger 28). This phenomenon of refrigerant accumulating in the stored-heat heat exchanger 28 occurs readily because each of the plurality of heat-transfer tubes 285 is of a form folding up and down. Accordingly, uneven flow to the extent that heat is stored to the heat storage material is difficult to be solved, even leading to insufficient heat being stored to the heat storage material when the heat storage operation has finished.

[0109] Thus, in the heat storage operation, as described above, each time the normal opening degree heat storage time tacn passes, a correction is applied such that the setting heat storage operation opening degree MVacs increases, for just the duration of the refrigerant discharge opening degree time tacd (that is, regularly).

[0110] Specifically, the setting heat storage operation opening degree MVacs is corrected following steps ST11-ST13 shown in the flow chart of FIG. 12. Here, formula 7 shows the opening degree of the heat storage expansion valve 29 using the setting heat storage operation opening degree MVacs and the correction coefficient β.

$$\text{Formula 7: Opening degree of heat storage expansion valve} = \text{MVacs} \times \beta$$

[0111] At step ST11, when the heat storage operation commences, the correction coefficient P for the setting heat storage operation opening degree MVacs is determined. Firstly, at step ST12, the correction coefficient $\beta = 1$, and from this, the opening degree of the heat storage expansion valve 29 becomes the same as the setting heat storage operation opening degree MVacs (that is opening degree of the heat storage expansion valve 29 = the setting heat storage operation opening degree MVacs $\times$ 1). Taking correction coefficient $\beta = 1$, when the normal opening degree heat storage time tacn has elapsed, at step ST13, correction coefficient β is taken as $\geqq 1.5$, thus the opening degree of the heat storage expansion valve 29 becomes not less than β (for example, $\beta \geqq 1.5$) times the setting heat storage operation opening degree MVacs (that is, opening degree of the heat storage expansion valve 29 = the setting heat storage operation opening degree MVacs $\times$ β), becoming greater than the opening degree at step 12. Then, as correction coefficient $\beta \geqq 1.5$, when the time in which the opening degree of the refrigerant discharge tacd has elapsed, step ST12 is returned to, becoming correction coefficient $\beta = 1$. In this way, in the heat storage operation, each time the normal opening degree heat storage time tacn passes, for just the passing of the refrigerant discharge opening degree time tacd (that is regularly), the setting heat storage operation opening degree MVacs is corrected so as to increase. Doing this enables the liquid refrigerant accumulating in the heat-transfer tubes 285 in the vicinity of the heat storage material for which phase change has not completed to be regularly discharged at the outlet side of the stored-heat heat exchanger 28. Note that here, immediately after the heat storage operation is commenced, we have correction coefficient $\beta = 1$, and thereafter, this becomes correction coefficient $\beta \geqq 1.5$, however this is illustrative and not restrictive, and it is also suitable immediately after commencement of the heat storage operation, to make correction coefficient $\beta \geqq 1.5$, and thereafter correction coefficient $\beta = 1$.

[0112] In this way, the occurrence of the phenomena of refrigerant accumulating in the stored-heat heat exchanger 28 is suppressed, and the unevenness to the extent that heat is stored to the heat storage material can be solved.

[0113] Further, in the case of modification 2 being used in combination with the correction for the setting heat storage operation opening degree MVacs in modification 1, the opening degree of the heat storage expansion valve 29 uses the setting heat storage operation opening degree MVacs and the correction coefficients a, β as shown in formula 7'.

$$\text{Formula 7': Opening degree of heat storage expansion valve} = \text{MVacs} \times \alpha \times \beta$$

[0114] In this case, in the heat storage operation, the correction for the setting heat storage operation opening degree MVacs is performed using the correction coefficients α, β, enabling control of the opening degree of the heat storage expansion valve 29 taking account of the phenomenon of refrigerant accumulating in the stored-heat heat exchanger 28 and the condition in which the defrosting operation has ended.

(6) Modification 3

[0115] In the above described embodiment and modifications 1 and 2, the heat storage operation comes to be performed during the heating operation. In this heat storage operation during the heating operation it occurs that the condensation temperature Tc decreases. However the decrease of the condensation temperature Tc in the heat storage operation during the heating operation means that the quantity of heat released to the heat storage material from the refrigerant via the stored-heat heat exchanger 28 decreases, heat storage to the heat storage material becoming more difficult. As heat storage to the heat storage material becomes more difficult, the problem of insufficiency of heat stored to the heat storage material when the heat storage operation has finished occurs more readily.

[0116] Thus here, in the heat storage operation during the heating operation, the heating capacity of the indoor heat exchangers 42a, 42b is restricted so as to decrease in stages as the condensation temperature Tc decreases.

[0117] Specifically here, heating capacity restriction of the indoor heat exchangers 42a, 42b during the heat storage operation is restricted following steps ST21-ST24 shown in the flow chart of FIG. 13.

[0118] Once the heat storage operation during the heating operation commences, firstly, at step ST21 the heat storage capacity of the stored-heat heat exchanger 28 is maintained by the opening degree of the heat storage expansion valve 29 being controlled so as to be the setting heat storage operation opening degree MVacs determined by the function based on the condensation pressure Pc, the liquid pipe pressure P1 and the enthalpy hi, ho of the refrigerant, (or further, the opening degree as corrected by the correction coefficients α, β). Further, in the same manner as applies when only the heating operation is performed, the heating capacity of the indoor heat exchangers 42a, 42b is maintained by the opening degree of the indoor expansion valves 41a, 41b being controlled such that the subcooling degrees SCra, SCrb of the refrigerant in the outlets of the indoor heat exchangers 42a, 42b are the target subcooling degrees SCras, SCrbs (for example, 3°C). Accordingly, the heating capacity of the indoor heat exchangers 42a, 42b comes to be controlled by the indoor-side control parts 48a, 42b, with no relation to the heat storage capacity of the stored-heat heat exchanger 28.

[0119] However, if by maintaining the heating capacity of the indoor heat exchangers 42a, 42b, the condensation temperature Tc decreases, concerns arise of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. Thus, during the processes of step ST21, if the subcooling degree restriction conditions are satisfied, step ST22 is transitioned to and the target subcooling degrees SCras, SCrbs (both being generically referred to as SCr) of subcooling degree control by the indoor expansion valves 41a, 41b is increased. Here, the subcooling degree restriction conditions are the conditions for judging whether the condition is such that there is concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. The subcooling degree restriction conditions are satisfied when the heat storage operation during the heating operation is performed, moreover the outdoor temperature Ta is less than a predetermined indoor capacity restriction outdoor temperature Tpa (for example, 4°C), moreover the condensation temperature Tc is less than a predetermined first indoor capacity restriction condensation temperature Tpc1 (a temperature higher than the phase change temperature of the heat storage material, for example 41°C), moreover the operating capacity of the compressor 21 is greater than a predetermined first indoor capacity restriction capacity fp1 (for example, that the frequency of the compressor 21 is 98% of the maximum frequency). If the subcooling degree restriction conditions are satisfied in the processes of step ST21, the target subcooling degree SCs of subcooling degree control by the indoor expansion valves 41a, 41b is greater than in the case in which the heating operation only is performed (for example, the target subcooling degree SCs is made 9°C). Here, the instruction to increase the target subcooling degree SCrs of the subcooling degree control by the indoor expansion valves 41a, 41b is performed from the outdoor-side control part 38, unlike in the case in which the heating operation only is performed. By doing this, the opening degree of the indoor expansion valves 41a, 41b decreases, the heating capacity of the indoor heat exchangers 42a, 42b decreases, and the heat storage capacity of the stored-heat heat exchanger 28 is able to be increased by just a corresponding extent.

[0120] After transitioning from step ST21 to step ST22, if the subcooling degree restriction release conditions are satisfied, the processes of step ST21 are transitioned to, and the target subcooling degree SCrs for subcooling degree control by the indoor expansion valves 41a, 41b is reduced. Here, the subcooling degree restriction release conditions are the conditions for judging whether the condition is that there is no concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. The subcooling degree restriction release conditions are satisfied when the condensation temperature Tc is greater than a predetermined second indoor capacity restriction condensation temperature Tpc2 (a temperature slightly higher than the first indoor capacity restriction condensation temperature Tpc1, for example 42°C), moreover the operating capacity of the compressor 21 is less than a predetermined second indoor capacity restriction capacity fp2 (for example, that the frequency of the compressor 21 is 90% of the maximum frequency), moreover when a predetermined time tp2 from transition to step ST22 (for example, 3 minutes) has elapsed, or when the condensation temperature Tc is higher than a temperature that is higher (here, a temperature sufficiently higher than the phase change temperature of the heat storage material, for example 50°C) just by a predetermined temperature ΔTpc2 (for example, 8°C) than the second indoor capacity restriction condensation temperature Tpc2. If the subcooling degree restriction release conditions are satisfied in the processes of step ST22, the instruction to increase the target subcooling degree SCs for subcooling by the indoor expansion valves 41a, 41b in step ST22 is canceled, and the target subcooling degree SCrs is the same as when the heating operation only is performed (for example, 3°C). By doing this, the opening degree of the indoor expansion valves 41a, 41b increases, and while maintaining the heat storage capacity of the stored-heat heat exchanger 28, the heating capacity of the indoor heat exchangers 42a, 42b can be increased.

[0121] Further, even during the processes of step ST22, in the case that there is insufficient heat storage capacity of the stored-heat heat exchanger 28 and the indoor fan restriction conditions are satisfied, the processes of step ST23 are transitioned to, and the rotational speed of the indoor fans 43a, 43b is reduced, reducing the air flow rate. Here, the indoor fan restriction conditions are, even when the processes of step ST22 are performed, the conditions for judging whether the condition is that there is concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. Thus here, the indoor fan restriction conditions are satisfied when the condensation temperature Tc is less than a predetermined third condensation temperature for indoor capacity restriction Tpc3 (a temperature slightly higher than the phase change temperature of the heat storage material, for example 41°C), moreover a predetermined time tp3 from transition to step ST22 (for example, 5 minutes) has elapsed, moreover the operating capacity of the compressor 21 is greater than a predetermined third indoor capacity restriction capacity fp3 (for example, that the frequency of the compressor 21 is 98% of the maximum frequency). Then if the indoor fan restriction conditions are satisfied during the processes of step ST22, the rotational speed of the indoor fans 43a, 43b is reduced, reducing the air flow rate (a reduction for example to the minimum rotational speed of the indoor fans 43a, 43b). Here, the instruction to reduce the rotational speed of the indoor fans 43a, 43b is performed by the outdoor-side control part 38, unlike in the case in which the heating operation only is performed. By doing this, heat exchange in the indoor heat exchangers 42a, 42b is suppressed, the heating capacity of the indoor heat exchangers 42a, 42b is reduced, and the heat storage capacity of the stored-heat heat exchanger 28 is able to be increased by just a corresponding extent.

[0122] After the transition from step ST22 to step ST23, if the indoor fan restriction release conditions are satisfied, the processes of step ST22 are transitioned to, and the rotational speed of the indoor fans 43a, 43b is increased, increasing the air flow rate. Here, the indoor fan restriction release conditions are the conditions for judging whether the condition is that there is no concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. The indoor fan restriction release conditions are satisfied when the condensation temperature Tc is greater than a predetermined fourth condensation temperature for indoor capacity restriction Tpc4 (a temperature slightly higher than the first indoor capacity restriction condensation temperature Tpc1, for example 42°C), moreover the operating capacity of the compressor 21 is less than a predetermined fourth indoor capacity restriction capacity fp4 (for example, that the frequency of the compressor 21 is 90% of the maximum frequency), moreover when a predetermined time tp4 from transition to step ST23 (for example, 3 minutes) has elapsed, or when the condensation temperature Tc is higher than a temperature that is higher (here, a temperature sufficiently higher than the phase change temperature of the heat storage material, for example 48°C) just by a predetermined temperature ΔTpc4 (for example, 6°C) than the fourth indoor capacity restriction condensation temperature Tpc4. If the indoor fan restriction release conditions are satisfied in the processes of step ST23, the instruction to decrease the rotational speed of the indoor fans 43a, 43b in step ST23 is canceled, making the rotational speed of the indoor fans 43a, 43b the same as in the case when the heating operation only is performed. By doing this, heat exchange in the indoor heat exchangers 42a, 42b is promoted, and while maintaining the heat storage capacity of the stored-heat heat exchanger 28, the heating capacity of the indoor heat exchangers 42a, 42b can be increased.

[0123] Further, even during the processes of step ST23, in the case that there is insufficient heat storage capacity of the stored-heat heat exchanger 28 and the upper limit opening degree restriction conditions are satisfied, the processes of step ST24 are transitioned to, and an upper limit opening degree is instructed to the indoor expansion valves 41a, 41b. Here, the upper limit opening degree restriction conditions, even when the processes of step ST23 are performed, are the conditions for judging whether the condition is that there is concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. Thus here, the upper limit opening degree restriction conditions are satisfied when the condensation temperature Tc is less than a predetermined fifth condensation temperature for indoor capacity restriction Tpc5 (a temperature higher than the phase change temperature of the heat storage material, for example 41°C), moreover a predetermined time tp5 (for example, 5 minutes) from transition to step ST23 has elapsed, moreover the operating capacity of the compressor 21 is greater than a predetermined fifth indoor capacity restriction capacity fp5 (for example, that the frequency of the compressor 21 is 98% of the maximum frequency). Then if the upper limit opening degree restriction conditions are satisfied during the processes of step ST23, an upper limit opening degree restriction instruction is issued to the indoor expansion valves 41a, 41b, and the quantity of refrigerant flowing into the indoor heat exchangers 42a, 42b is reduced (for example, making the upper limit 50% of the maximum opening degree of the indoor expansion valves 41a, 41b). Here, the instruction to the indoor expansion valves 41a, 41b to restrict the upper limit opening degree is performed by the outdoor-side control part 38, unlike in the case in which the heating operation only is performed. By doing this, the quantity of refrigerant flowing into the indoor heat exchangers 42a, 42b is reduced, the heating capacity of the indoor heat exchangers 42a, 42b is reduced, and the heat storage capacity of the stored-heat heat exchanger 28 is able to be increased by just a corresponding extent.

[0124] After the transition from step ST23 to step ST24, if the upper limit opening degree restriction release conditions are satisfied, the processes of step ST23 are transitioned to, and the opening degree of the indoor expansion valves 41a, 41b is increased. Here, the upper limit opening degree restriction release conditions are the conditions for judging whether the condition is that there is no concern of an insufficiency of heat storage capacity of the stored-heat heat exchanger 28. The upper limit opening degree restriction release conditions are satisfied when the condensation temperature Tc is greater than a predetermined sixth condensation temperature for indoor capacity restriction Tpc6 (a temperature slightly higher than the first indoor capacity restriction condensation temperature Tpc1, for example 42°C), moreover the operating capacity of the compressor 21 is less than a predetermined sixth indoor capacity restriction capacity fp6 (for example, that the frequency of the compressor 21 is 90% of the maximum frequency), moreover when a predetermined time tp6 from transition to step ST24 (for example, 3 minutes) has elapsed, or when the condensation temperature Tc is higher than a temperature that is higher (here, a temperature sufficiently higher than the phase change temperature of the heat storage material, for example 46°C) just by a predetermined temperature ΔTpc6 (for example, 4°C) than the sixth indoor capacity restriction condensation temperature Tpc6. If the upper limit opening degree restriction release conditions are satisfied in the processes of step ST24, the instruction to the indoor expansion valves 41a, 41b in step ST24 to restrict the upper limit opening degree is canceled, making the condition in which there is no upper limit opening restriction to the indoor expansion valves 41a, 41b, in the same manner as when the heating operation only is performed. By doing this, the quantity of refrigerant flowing into the indoor heat exchangers 42a, 42b is increased, and while maintaining the heating capacity of the stored-heat heat exchanger 28, the heating capacity of the indoor heat exchangers 42a, 42b can be increased.

[0125] In this way, taking account of the condensation temperature Tc in the heat storage operation during the heating operation, the heating capacity of the indoor heat exchangers 42a, 42b is restricted, enabling suppression of the occurrence of an insufficiency of heat storage to the heat storage material when the heat storage operation has finished.

[0126] Further, the restriction of the heating capacity of the indoor heat exchangers 42a, 42b in the heat storage operation during the heating operation can be performed with a combination of the three techniques of the instruction for the target subcooling degree SCrs, the air flow rate instruction to the indoor fans 43a, 43b and the upper limit opening degree instruction to the indoor expansion valves 41a, 41b. Note that this kind of heating capacity restriction can be performed not only through the combination of the above three techniques, and it is also suitable to combine any two of those instructions, moreover, it is also suitable to use any one of those instructions. For example, when using only the instruction for the target subcooling degree SCrs, the target subcooling degree SCrs can be increased in stages.

(7) Modification 4

[0127] In the above described embodiment and the modifications 1 through 3, the heat retention operation is performed after the heat storage operation. However, the heat retention operation is an operation that becomes necessary when it is necessary to perform the defrosting operation with the stored-heat usage operation. Thus when the outdoor temperature Ta is high and the defrosting operation itself is not required, it is not necessary to perform the heat retention operation. Further, the heat retention operation is an operation that becomes possible when the condensation temperature Tc in the heating operation after the heat storage operation, is maintained at a temperature that can compensate for decreased heat quantity due to heat release of the heat storage material. Accordingly, in the case that the condensation temperature Tc in the heating operation after the heat storage operation is low, for example, when the condensation temperature Tc is lower than the phase change temperature of the heat storage material, even if the heat retention operation were to be performed, the refrigerant could not release heat to the heat storage material, to the contrary, the heat storage material would come to release heat.

[0128] Thus if in the heat retention operation, the outdoor temperature Ta of the outdoor space in which the stored-heat heat exchanger 28 is arranged is greater than or equal to a heat retention interrupt outdoor temperature Tka, or the condensation temperature Tc is less than or equal to a heat retention interrupt condensation temperature Tkc, the heat retention operation is interrupted.

[0129] Specifically here, the heat retention operation after the heat storage operation is performed in accordance with steps ST31-ST33 shown in the flowchart of FIG. 14.

[0130] Firstly, at step ST31, if the heat storage operation during the heating operation finishes, the heat retention operation of step ST32 (here, operation with the heat storage expansion valve 29 open slightly) commences.

[0131] If the heat retention operation satisfies the conditions to interrupt the heat retention operation, the processes of step ST33 are transitioned to, and the heat retention operation is interrupted. Here, the heat retention operation interrupt conditions are satisfied when the outdoor temperature Ta is greater than or equal to the heat retention interrupt outdoor temperature Tka (a temperature at which there is little concern of frosting in the outdoor heat exchanger 23, for example 6°C), or the condensation temperature Tc is less than or equal to the heat retention interrupt condensation temperature Tkc (a temperature slightly lower than the phase change temperature of the heat storage material, for example 38°C). The heat retention operation is interrupted by completely closing the expansion valve 29.

[0132] After the heat retention operation is interrupted at step ST33, if the outdoor temperature Ta or the condensation temperature Tc have ceased to satisfy the heat retention operation interrupt conditions (heat retention operation interrupt condition exclusion), the processes of step ST32 are returned to, and the heat retention operation recommences.

[0133] Thus here, if the outdoor temperature Ta becomes greater than or equal to the heat retention interrupt outdoor temperature Tka, by interrupting the heat retention operation, the process finishes without needlessly performing the heat retention operation. Further, if the condensation temperature Tc becomes less than or equal to the heat retention interrupt condensation temperature Tkc, by interrupting the heat retention operation, the problem of the heat storage material releasing heat to the refrigerant and needless reduction in the quantity of heat in the heat storage material is suppressed. Thus the heat retention operation is not needlessly performed.

(8) Modification 5

[0134] In the above described embodiment and modifications 1 through 4, after the heat storage operation during the heating operation ends, it may happen that, notwithstanding that the heat retention operation is performed, heat release from the heat storage material occurs to an extent that cannot be compensated for by the heat retention operation.

[0135] Here, after the heat storage operation during the heating operation has finished, whether the condition is of heat release from the heat storage material, is judged according to whether the condensation temperature Tc is less than or equal to a first heat storage recommence condensation temperature Trc, while whether such heat release from the heat storage material is for an extent of time requiring recommencement of the heat storage operation is judged according to whether a heat retention cumulative time trc, that is an integrated value for time at which the condensation temperature Tc is less than or equal to the first heat storage recommence condensation temperature Trc, is greater than or equal to a heat storage recommence cumulative time trce.

[0136] Specifically, the determination to recommence heat storage after the heat storage operation is performed in accordance with steps ST41-ST44 shown in the flowchart of FIG. 15.

[0137] Once the heat storage operation finishes (that is transition to heating operation with heat retention operation), firstly at step ST41, the time that accumulates heat retention cumulative time trc is reset.

[0138] In the case that the heating operation with heat retention operation satisfies the conditions for commencing a time count for heat storage recommencement, the processes of step ST42 is transitioned to, and a count of the time of accumulating the heat retention cumulative time trc commences. Here, the conditions to commence the heat storage recommence time count are the conditions for judging whether the condition is that release of heat from the heat storage material has in effect occurred, notwithstanding performance of the heat retention operation. The conditions to commence the heat storage recommence time count are satisfied when the heat storage operation has ended, moreover, the condensation temperature Tc is lower than a first predetermined heat storage recommence condensation temperature Trc1 (a temperature slightly less than the phase change temperature of the heat storage material, for example 37°C).

[0139] In the case that the condition for completing the time count for heat storage recommencement is satisfied, this condition being that the heat retention cumulative time trc from commencement of the counting of time accumulating the heat retention cumulative time trc at step ST42 is greater than or equal to the predetermined heat storage recommence cumulative time trce, the processes of step ST43 are transitioned to, the counting of time accumulating the heat retention cumulative time trc is ended (count up), and the heat storage operation recommences.

[0140] Further, when, after commencement of the counting of time accumulating the heat retention cumulative time trc at step ST42, the heating operation with the heat retention operation satisfies the conditions for holding the time count for heat storage recommencement (heat storage recommence time count hold condition), step ST44 is transitioned to, and the counting of time accumulating the heat retention cumulative time trc is interrupted (hold). Here, the heat storage recommence time count hold condition is the condition for judging whether the condition recovers in which it cannot be said that heat release from the heat storage material has in effect. Here, the heat storage recommence time count hold condition is satisfied when the condensation temperature Tc is greater than the second heat storage recommence condensation temperature Trc2 (for example, 38°C) that is slightly higher than the first heat storage recommence condensation temperature Trc1.

[0141] Moreover, after interruption of the counting of the time accumulating the heat retention cumulative time trc at step ST44, if the heating operation with the heat retention operation satisfies the condition for recommencing the heat storage recommence time count, the processes of step ST42 are returned to, and the counting of time accumulating the heat retention cumulative time trc recommences. The condition for recommencing the heat storage recommence time count is the condition for judging whether the condition in which heat release from the heat storage material has in effect occurred again. The condition for recommencing the heat storage recommence time count is satisfied when the condensation temperature Tc becomes lower than the first heat storage recommence condensation temperature Trc1. In this way, the counting of time accumulating the heat retention cumulative time trc is only performed when the condensation temperature Tc is greater than or equal to the first heat storage recommence condensation temperature Trc1. Moreover, in the case that the heat storage operation has commenced or the case that the condensation temperature Tc continues to be a third heat storage recommence condensation temperature Trc3 (a temperature higher than the phase change temperature of the heat storage material, for example 41°C) for a predetermined time trc3 (for example, 30 minutes), even during the processes of step ST42 and step ST44, there is a forced return to the processes of step ST41, and the time for accumulating the heat retention cumulative time trc is reset.

[0142] Thus here, during the heating operation with the heat retention operation, it is possible to suitably determine whether it is necessary to recommence the heat storage operation. By recommencing the heat storage operation, it is possible to suppress the problem of heat release from the heat storage material occurring to an extent that cannot be compensated for by the heat retention operation. Thus, it is possible to suppress the occurrence of decrease in the quantity of heat that can be used in the stored-heat usage operation during the defrosting operation.

INDUSTRIAL APPLICABILITY

[0143] The present invention is provided with a refrigerant circuit having a stored-heat heat exchanger for performing heat exchange between a refrigerant and a heat storage material, and is broadly applicable to an air conditioning apparatus that performs a heat storage operation by storing heat to the heat storage material through causing the stored-heat heat exchanger to function as a radiator of the refrigerant during a heating operation, and performs a stored-heat usage operation by releasing heat from the heat storage material by causing the stored-heat heat exchanger to function as an evaporator of refrigerant during a defrosting operation.

REFERENCE SIGNS LIST

[0144]

1	Air conditioning apparatus
10	Refrigerant circuit
21	Compressor
23	Outdoor heat exchanger
28	Stored-heat heat exchanger
29	Heat storage expansion valve
41a, 41b	Indoor expansion valve
42a, 42b	Indoor heat exchanger
43a, 43b	Indoor fan

PATENT LITERATURE

Patent document 1

[0145] 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), an indoor heat exchanger (42a, 42b), and a stored-heat heat exchanger (28) for exchanging heat

between a refrigerant and a heat storage material, being capable of performing a heat storage operation for storing heat to the heat storage material by causing the stored-heat heat exchanger to function as a radiator of the refrigerant during a heating operation in which the indoor heat exchanger is caused to function as a radiator of the refrigerant, and a stored-heat usage operation for releasing heat from the heat storage material by causing the stored-heat heat exchanger to function as an evaporator of the refrigerant during a defrosting operation for defrosting the outdoor heat exchanger by causing the outdoor heat exchanger to function as a radiator of the refrigerant: wherein
the refrigerant circuit further comprises a heat storage expansion valve (29) configured to vary the quantity of the refrigerant flowing into the stored-heat heat exchanger, and
the opening degree of the heat storage expansion valve is configured to be controlled in the heat storage operation so as to be a setting heat storage operation opening degree determined according to a function based on a condensation pressure that is a saturation pressure that corresponds to a condensation temperature of the refrigerant in the refrigerant circuit, a liquid pipe pressure that is a pressure of the refrigerant at an outlet of the heat storage expansion valve, and an enthalpy of the refrigerant at an inlet and outlet of the stored-heat heat exchanger.

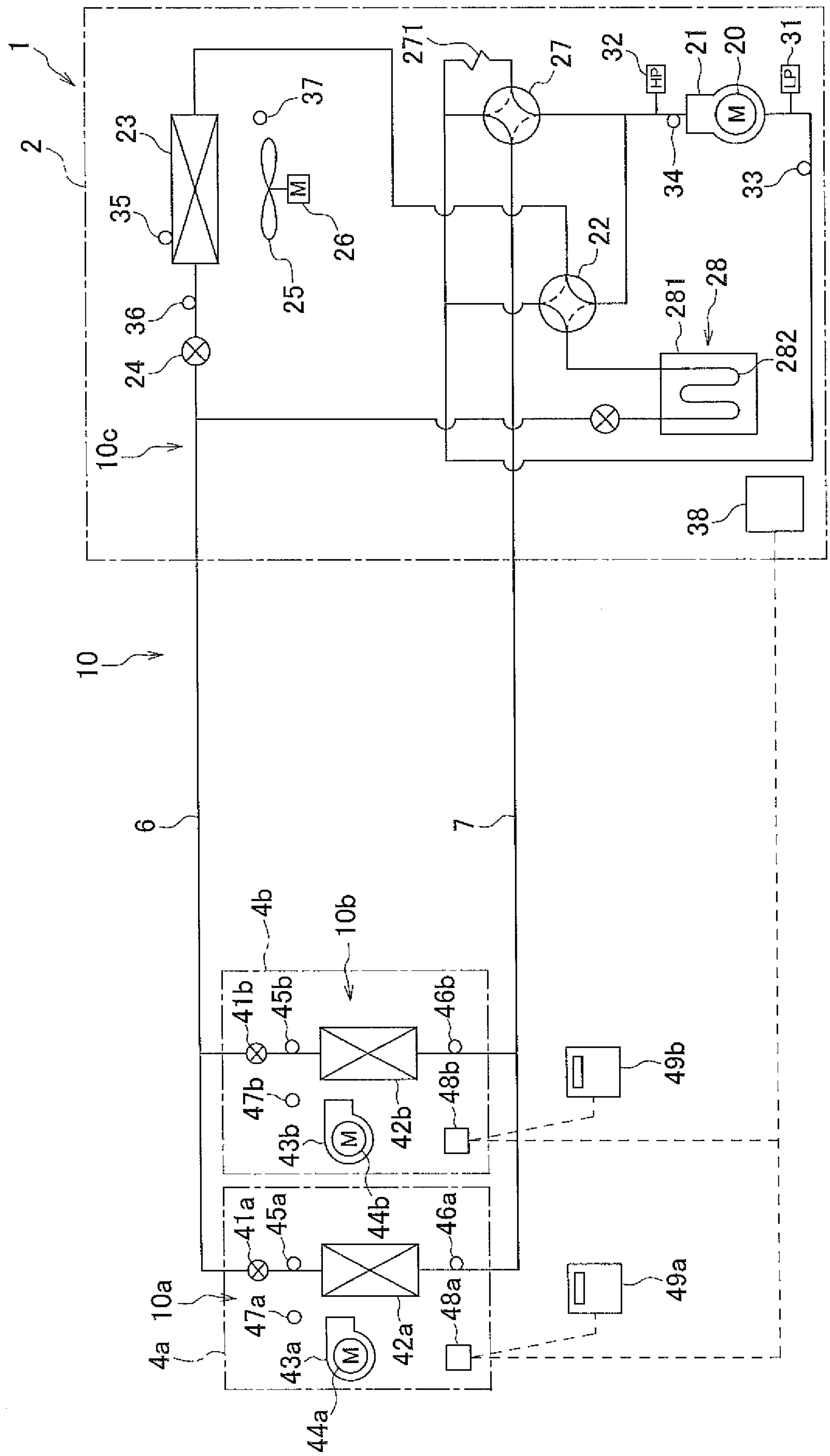
2. The air conditioning apparatus (1) according to claim 1 wherein;
the function for determining the setting heat storage operation opening degree further uses a density of the refrigerant in the outlet of the stored-heat heat exchanger (28).

3. The air conditioning apparatus (1) according to either of claim 1 or claim 2 wherein;
in the heat storage operation, each time a normal opening degree heat storage time passes, for just the duration of a refrigerant discharge opening degree time, the setting heat storage operation opening degree is corrected so as to be greater than during the normal opening degree heat storage time.

4. The air conditioning apparatus (1) according to any of claims 1 to 3 wherein;
whether the defrosting operation ended normally or ended abnormally is judged based on an outdoor heat exchange outlet temperature that is a temperature of the refrigerant at an outlet of the outdoor heat exchanger (23), and
in the heat storage operation after the defrosting operation ends abnormally, the setting heat storage operation opening degree is corrected so as to be greater than for the heat storage operation after the defrosting operation ends normally.

5. The air conditioning apparatus (1) according to any of claims 1 to 4 wherein;
the refrigerant circuit (10) is configured such that in the heat storage operation during the heating operation, the refrigerant discharged from the compressor (21) can be delivered in parallel to the indoor heat exchanger (42a, 42b) and the stored-heat heat exchanger (28), and
in the heat storage operation during the heating operation, a heating capacity of the indoor heat exchanger is restricted so as to decrease in stages as the condensation temperature decreases.

6. The air conditioning apparatus (1) according to claim 5 wherein;
the refrigerant circuit (10) further comprises an indoor expansion valve (41a, 41b) configured to vary the quantity of the refrigerant flowing into the indoor heat exchanger (42a, 42b),
the indoor expansion valve is configured to be controlled in the heating operation such that a subcooling degree of the refrigerant at the outlet of the indoor heat exchanger reaches a target subcooling degree for indoor heat exchange, an indoor fan (43a, 43b) is configured to supply air to the indoor heat exchanger, and
the heating capacity of the indoor heat exchanger is restricted in the heat storage operation during the heating operation, by increasing the target subcooling degree for indoor heat exchange through decreasing the rotational speed of the indoor fan, and/or by reducing an upper limit opening degree of the indoor expansion valve.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10c
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6
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4a
4b
10a
10b
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21
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28
281
282
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41a
41b
42a
42b
43a
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49a
49b

FIG. 1

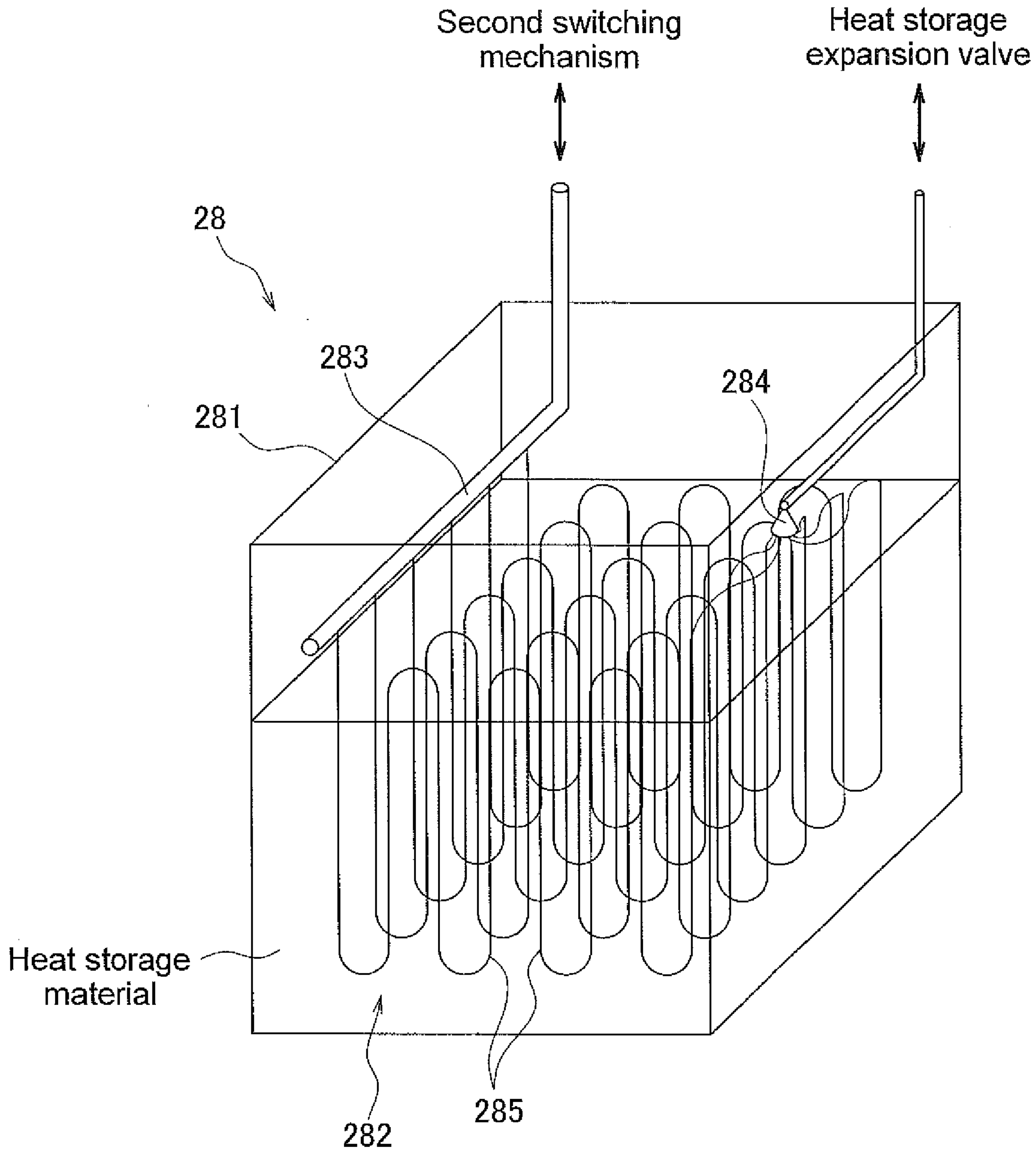

Second switching mechanism
Heat storage expansion valve
28
283
281
284
Heat storage material
282
285

FIG. 2

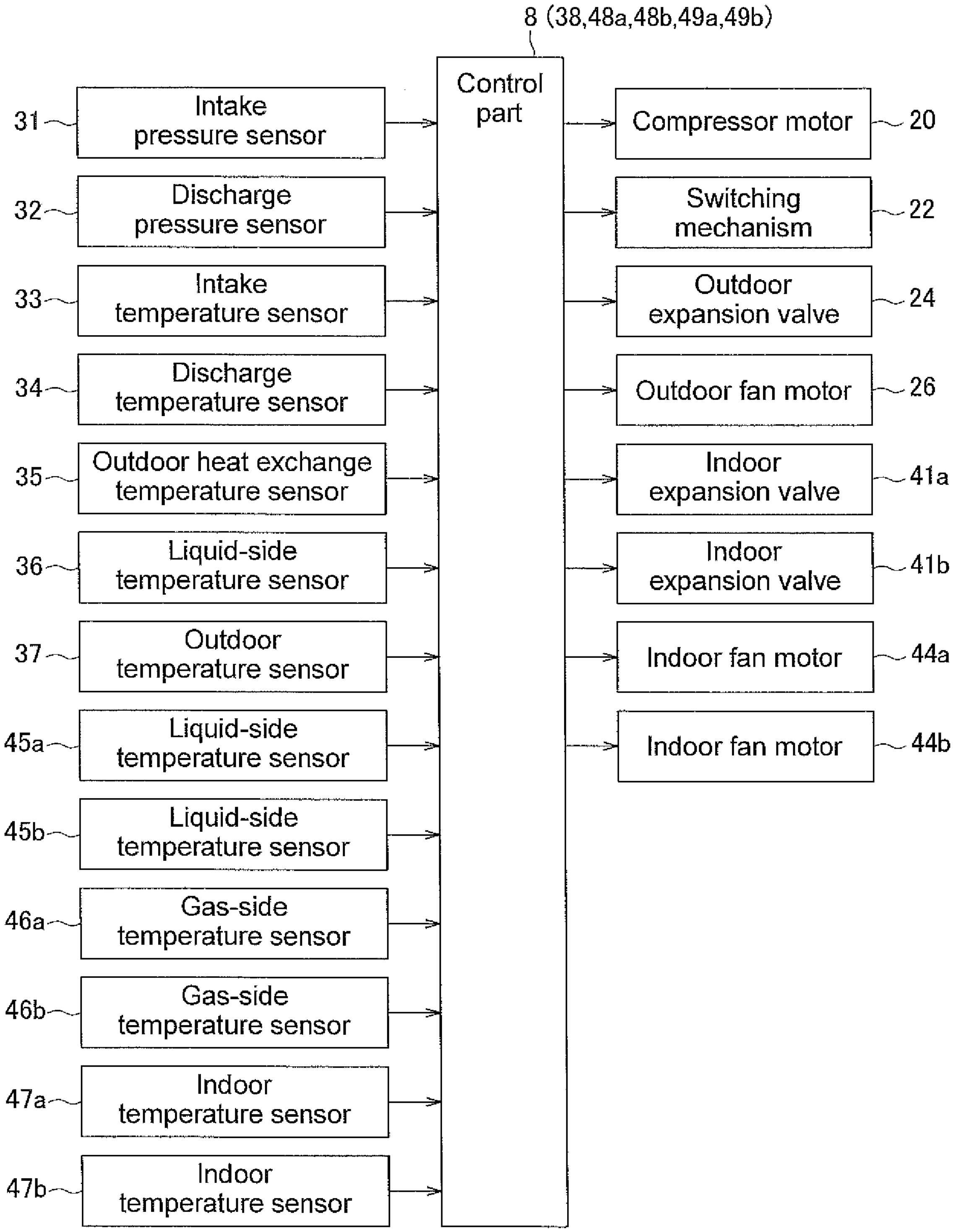
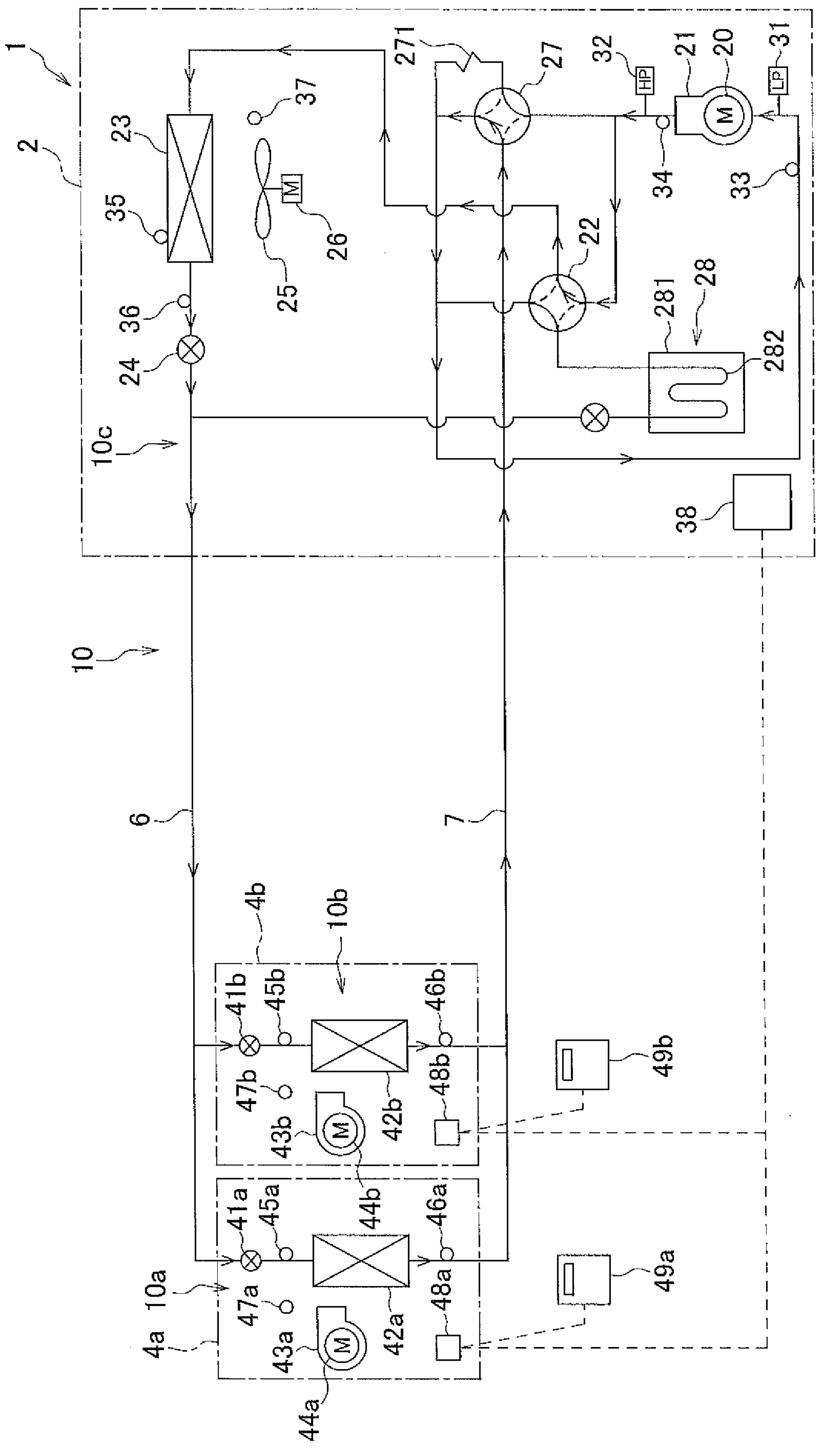

8 (38,48a,48b,49a,49b)
Control part
31
Intake pressure sensor
32
Discharge pressure sensor
33
Intake temperature sensor
34
Discharge temperature sensor
35
Outdoor heat exchange temperature sensor
36
Liquid-side temperature sensor
37
Outdoor temperature sensor
45a
Liquid-side temperature sensor
45b
Liquid-side 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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281
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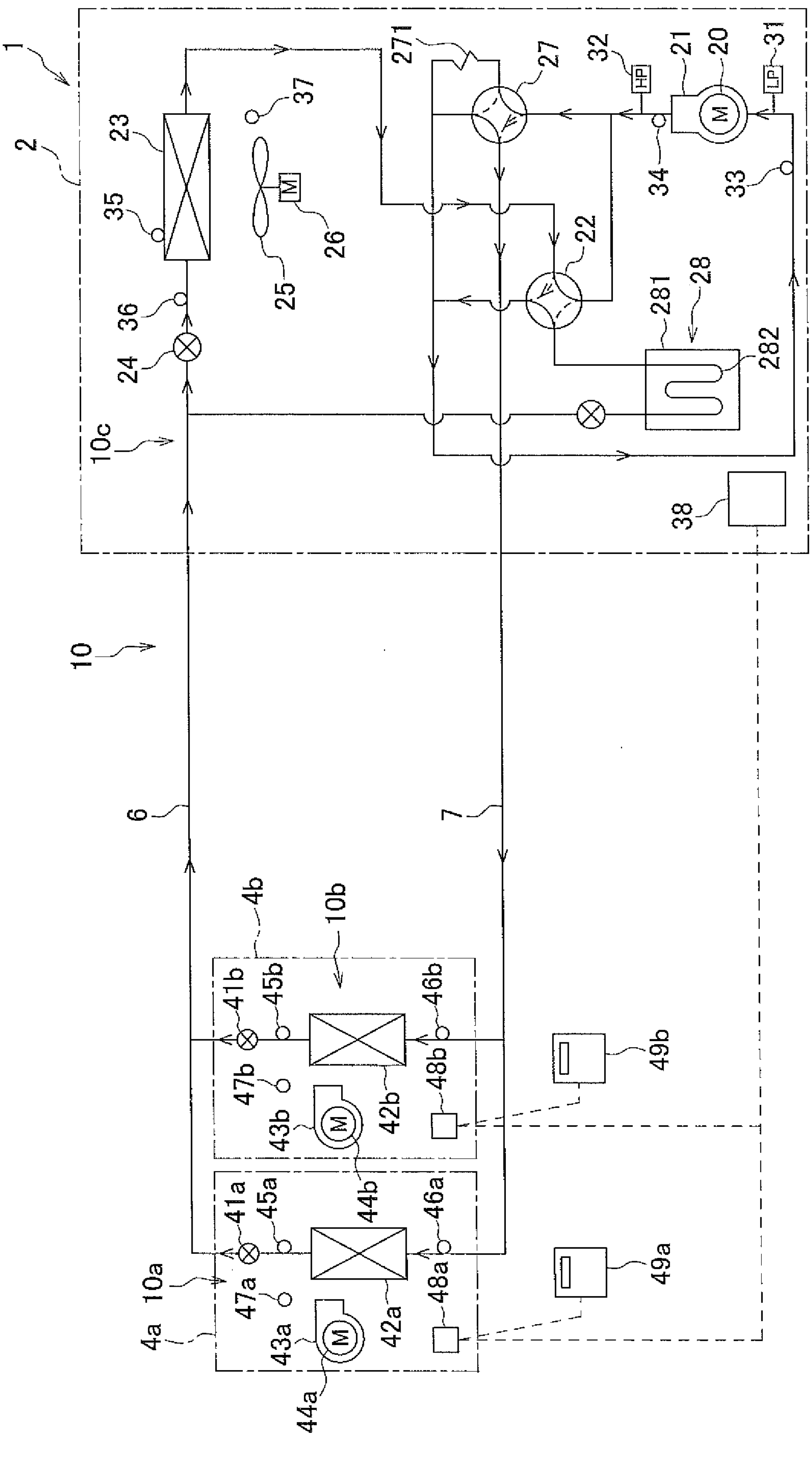
282
10c
38
10
6
7
4b
10b
41b
45b
46b
47b
48b
42b
43b
44b
49b
41a
45a
46a
47a
48a
42a
43a
44a
49a
4a
10a

FIG. 4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10c
38
10
6
7
4b
10b
41b
45b
46b
47b
48b
49b
42b
43b
44b
41a
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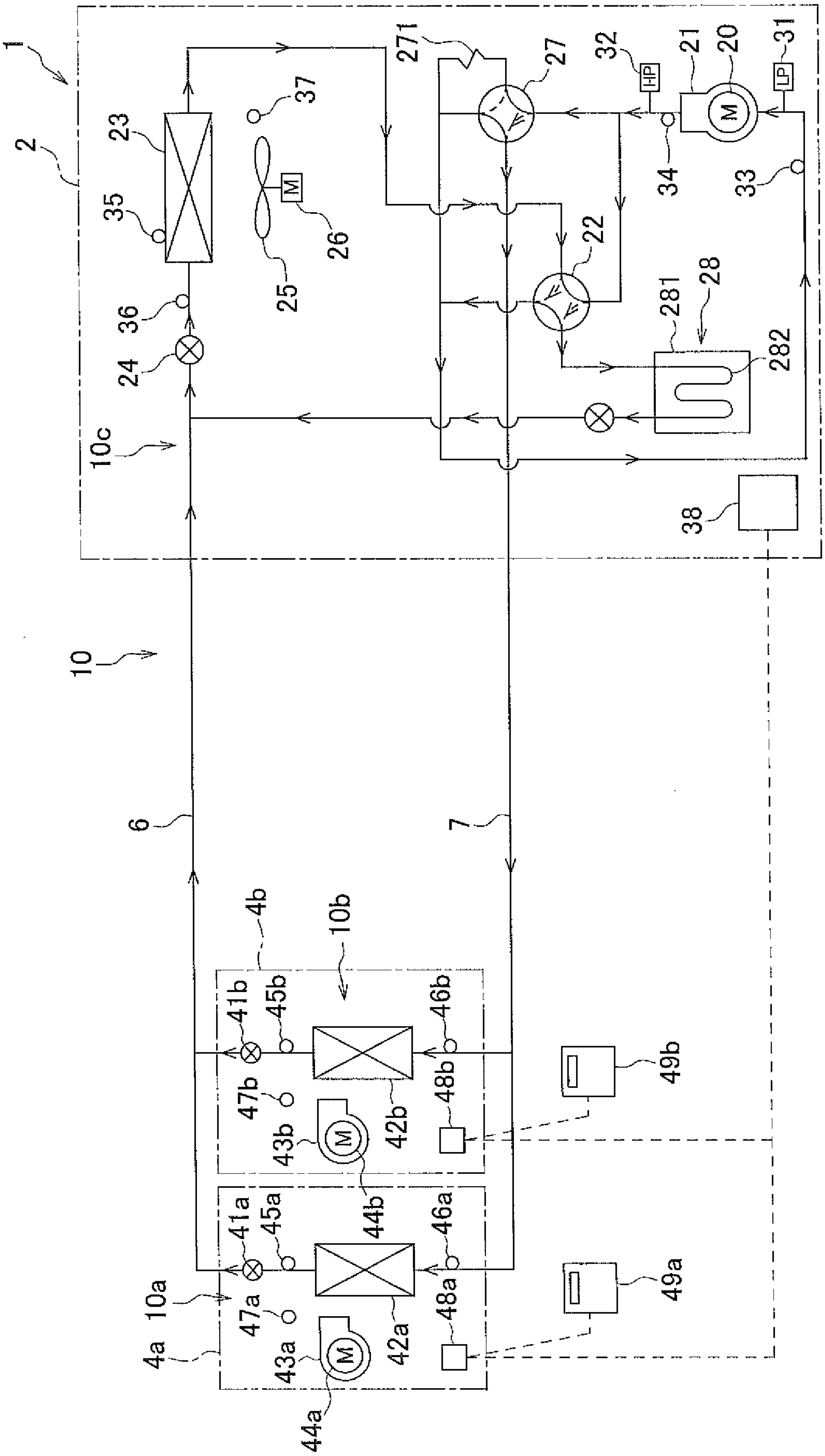
46a
10a
47a
48a
49a
4a
43a
42a
44a
M

FIG. 5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38
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6
7
4b
10b
41b
45b
46b
47b
48b
49b
42b
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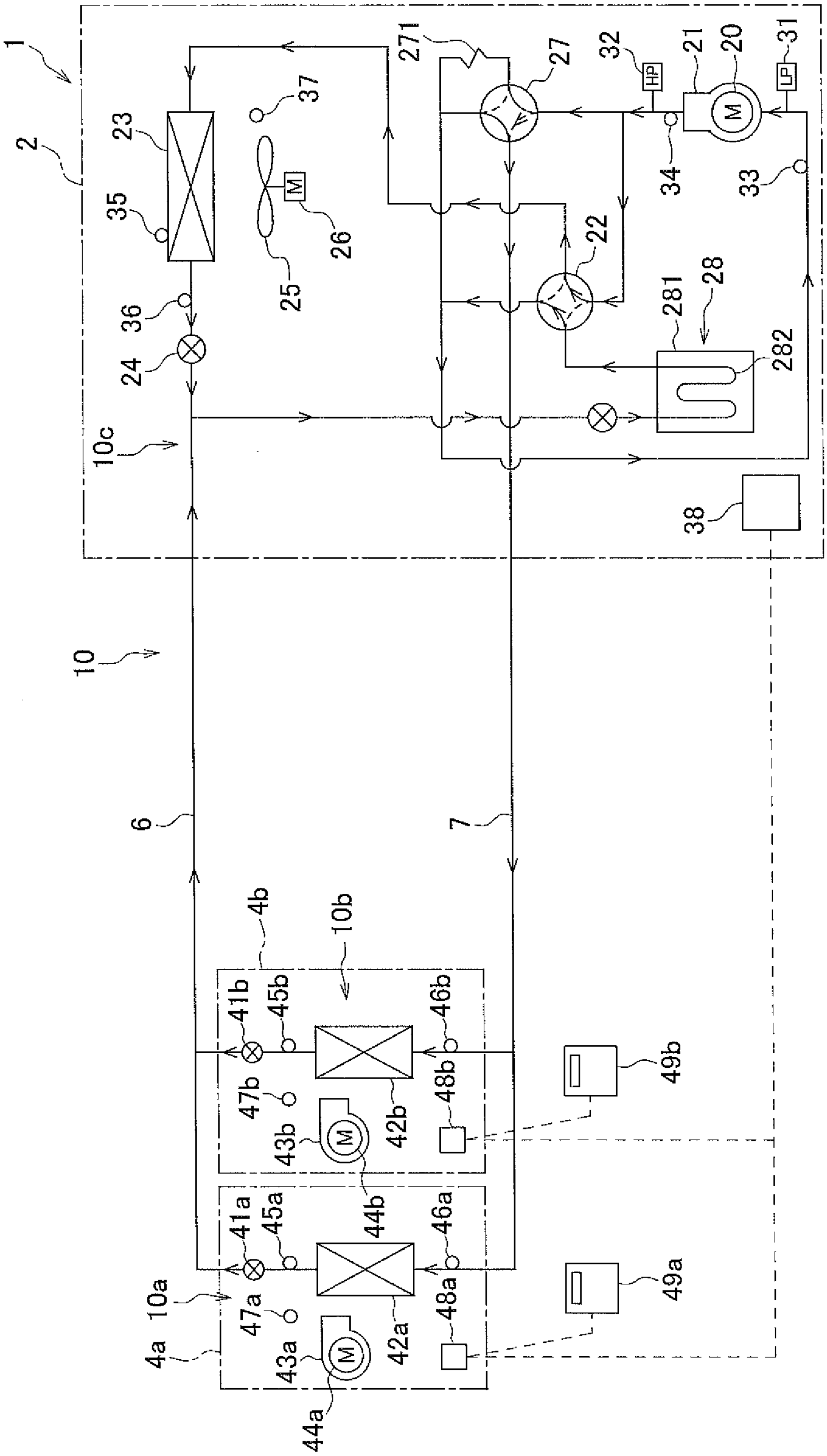
41a
45a
46a
47a
48a
49a
42a
43a
44a

FIG. 6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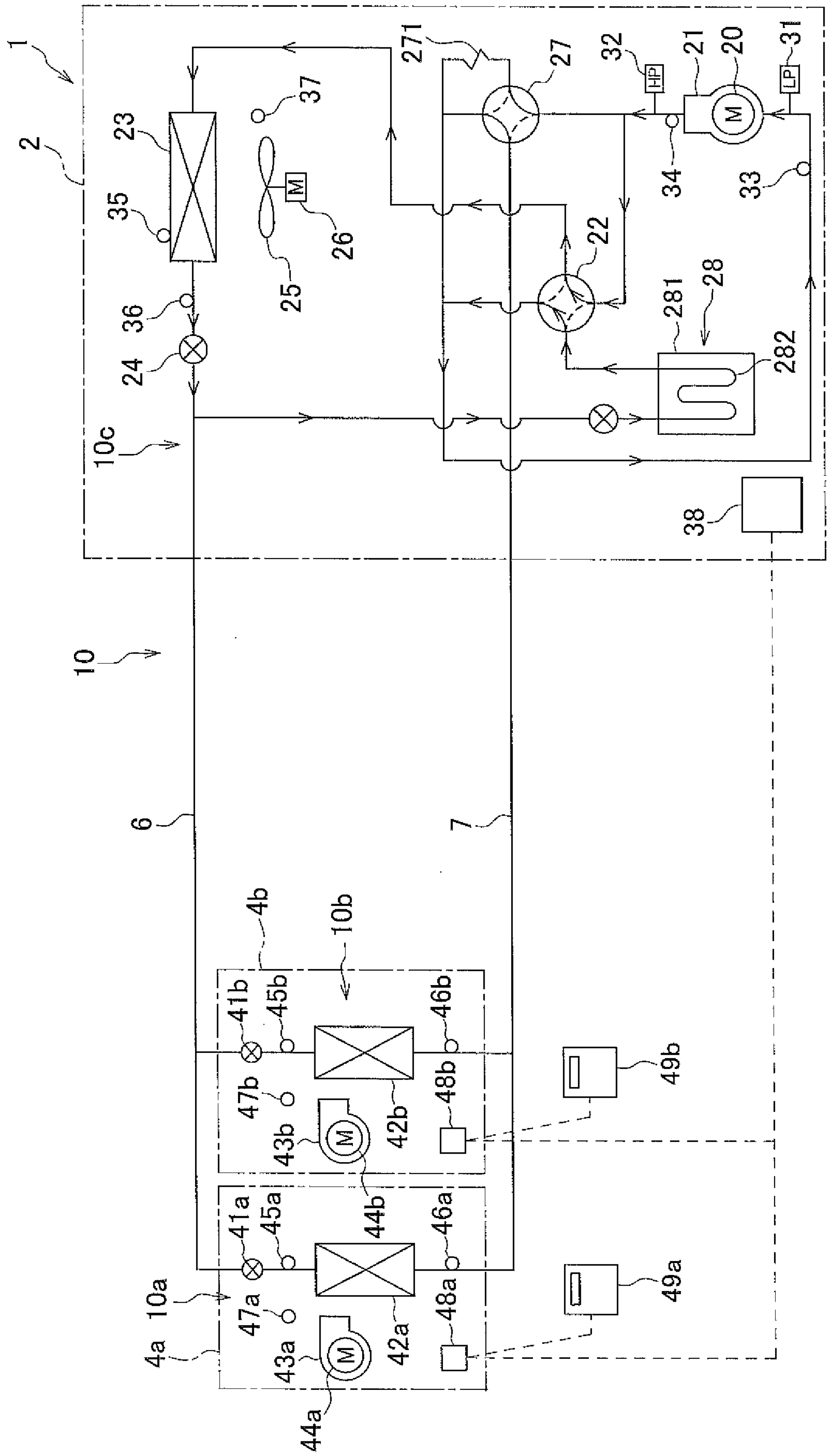
28
281
282
38
10
6
7
4b
10b
41b
45b
46b
47b
48b
42b
43b
44b
49b
4a
10a
41a
45a
46a
47a
48a
42a
43a
44a
49a

FIG. 7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24
282
10c
38
10
6
7
4b
10b
41b
45b
46b
47b
48b
43b
42b
49b
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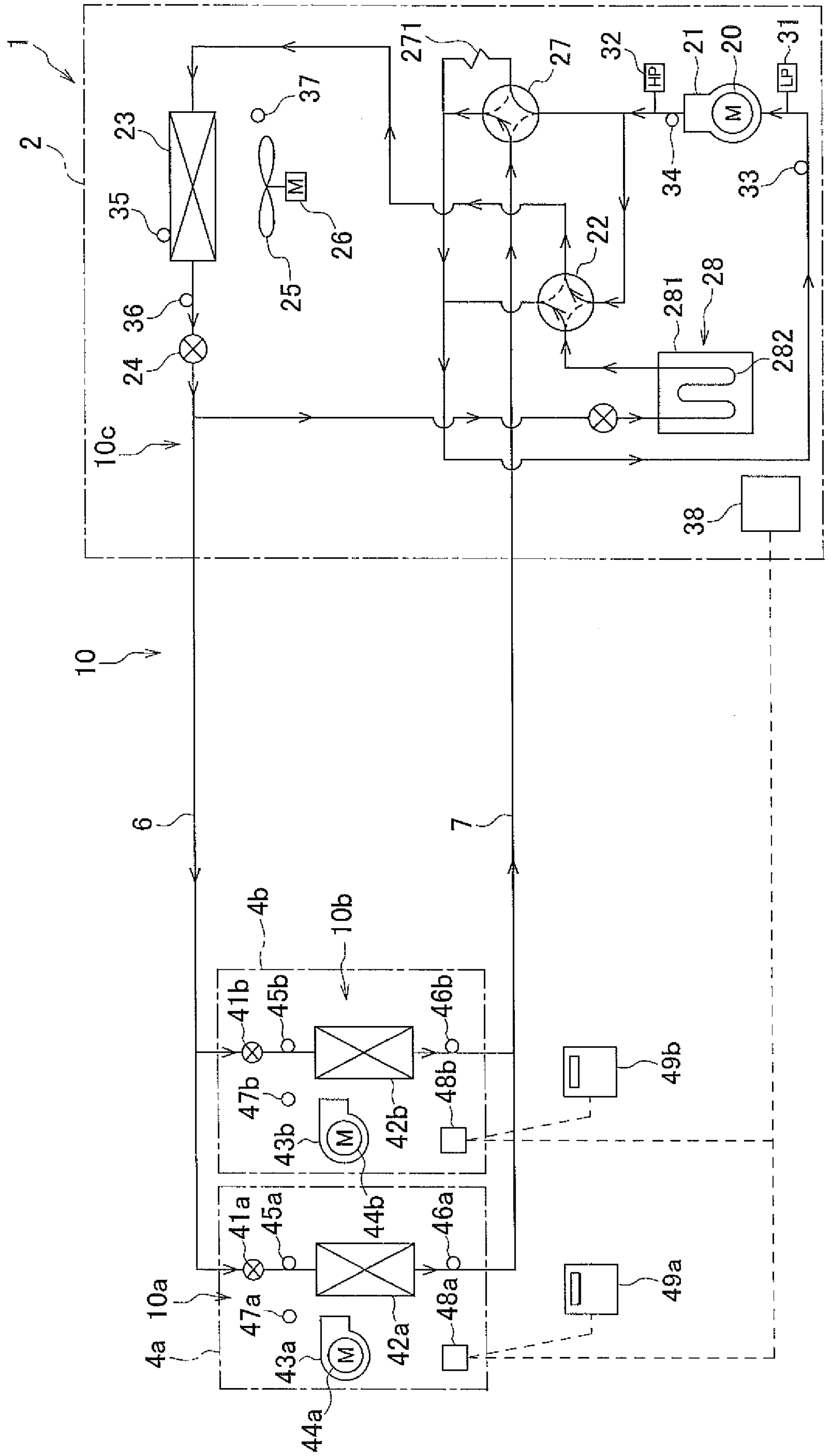
41a
45a
46a
4a
10a
47a
48a
43a
42a
49a
44a

FIG. 8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10c
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271
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HP
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M
31
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33
22
28
281
282
38
10
6
7
4b
10b
41b
45b
46b
47b
42b
43b
M
44b
48b
49b
4a
10a
41a
45a
46a
47a
42a
43a
M
44a
48a
49a

FIG. 9

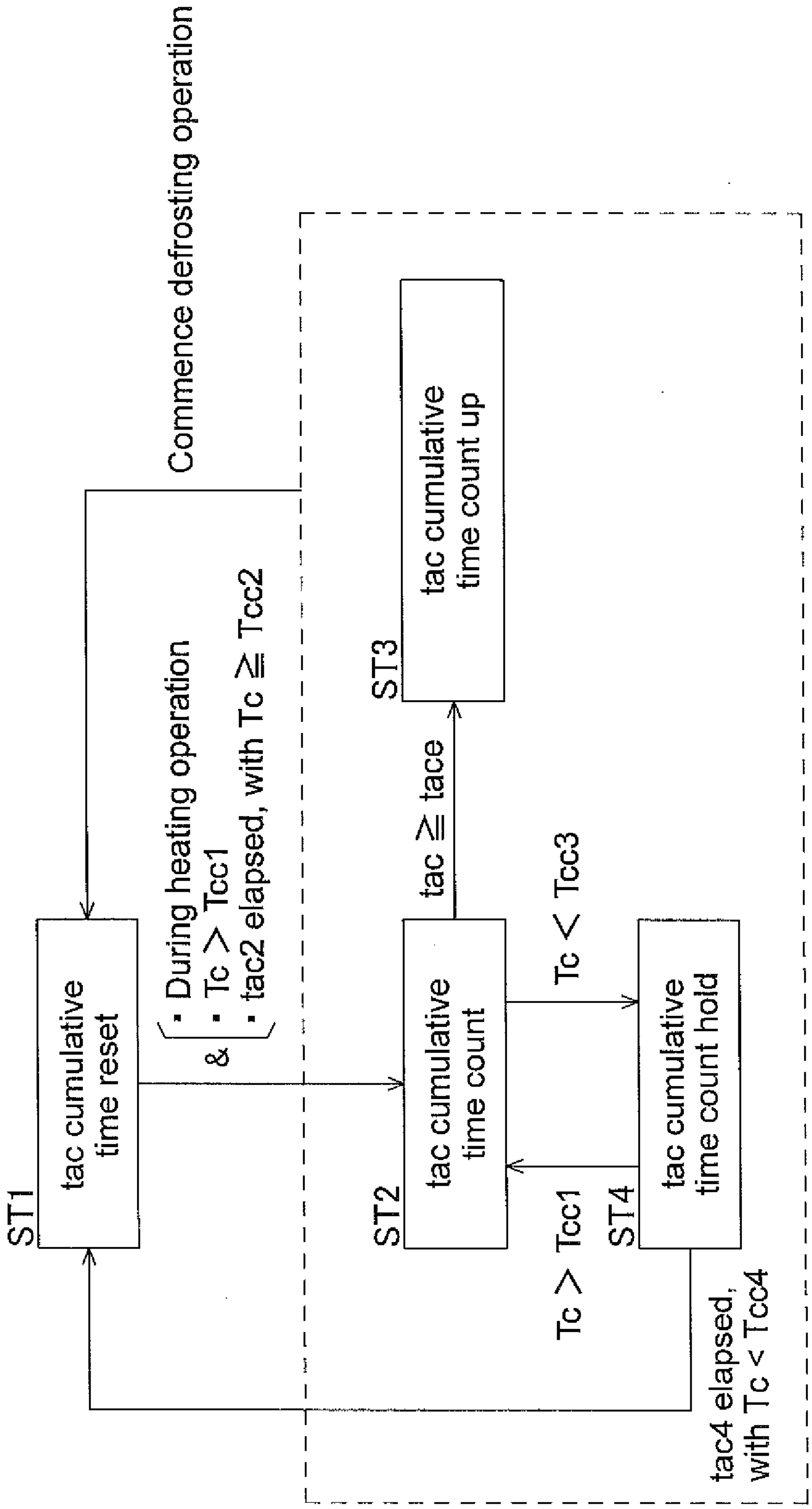
Commence defrosting operation
ST1
tac cumulative time reset
&
· During heating operation
· Tc > Tcc1
· tac2 elapsed, with Tc ≧ Tcc2
ST2
tac cumulative time count
tac ≧ tace
ST3
tac cumulative time count up
Tc < Tcc3
Tc > Tcc1
ST4
tac cumulative time count hold
tac4 elapsed, with Tc < Tcc4

FIG. 10

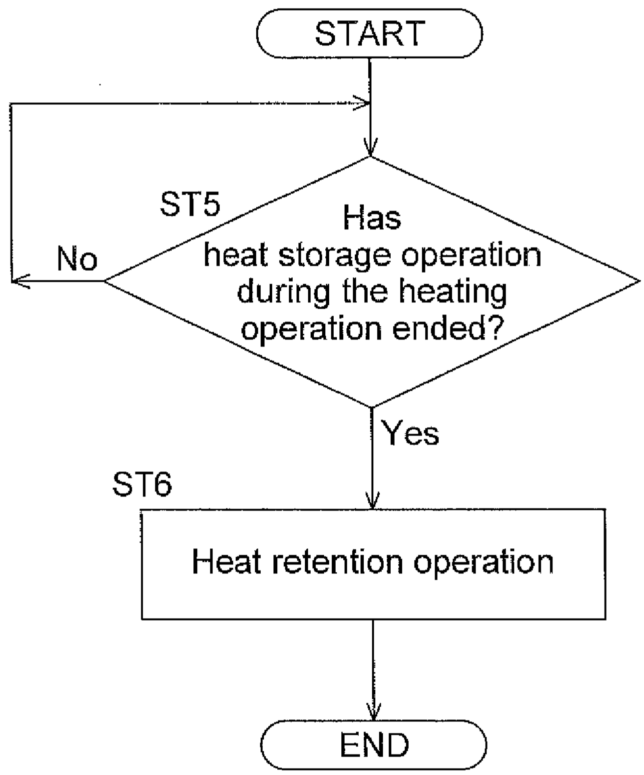
START
ST5
Has
heat storage operation
during the heating
operation ended?
No
Yes
ST6
Heat retention operation
END

FIG. 11

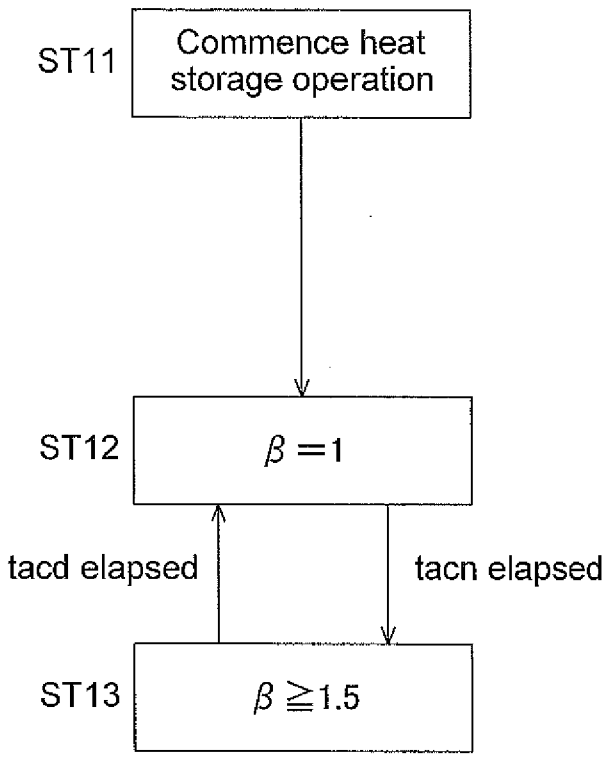
ST11
Commence heat storage operation
ST12
β =1
tacd elapsed
tacn elapsed
ST13
β ≧1.5

FIG. 12

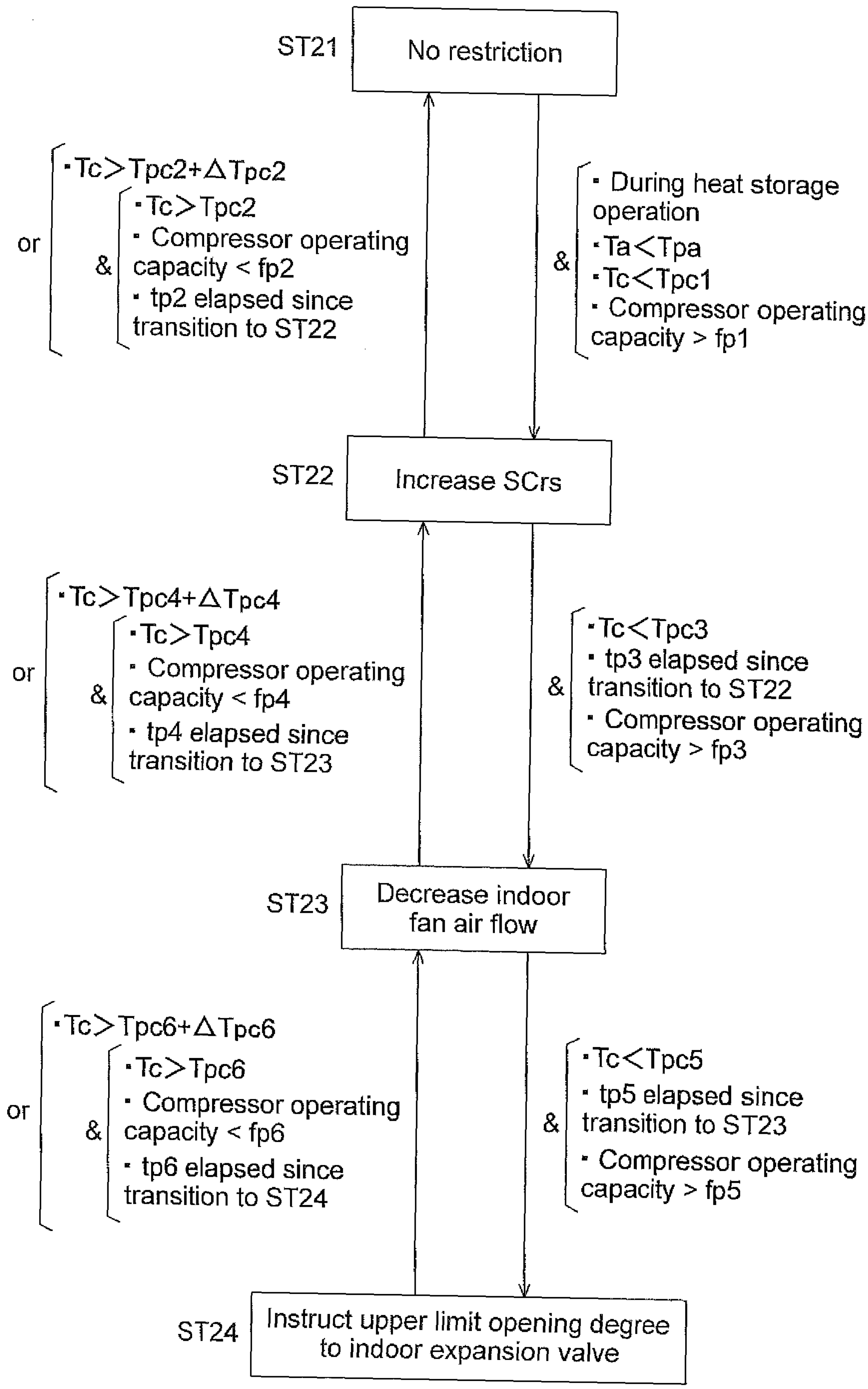
ST21
No restriction
or
・Tc>Tpc2+ΔTpc2
&
・Tc>Tpc2
・Compressor operating capacity < fp2
・tp2 elapsed since transition to ST22
&
・During heat storage operation
・Ta<Tpa
・Tc<Tpc1
・Compressor operating capacity > fp1
ST22
Increase SCrs
or
・Tc>Tpc4+ΔTpc4
&
・Tc>Tpc4
・Compressor operating capacity < fp4
・tp4 elapsed since transition to ST23
&
・Tc<Tpc3
・tp3 elapsed since transition to ST22
・Compressor operating capacity > fp3
ST23
Decrease indoor fan air flow
or
・Tc>Tpc6+ΔTpc6
&
・Tc>Tpc6
・Compressor operating capacity < fp6
・tp6 elapsed since transition to ST24
&
・Tc<Tpc5
・tp5 elapsed since transition to ST23
・Compressor operating capacity > fp5
ST24
Instruct upper limit opening degree to indoor expansion valve

FIG. 13

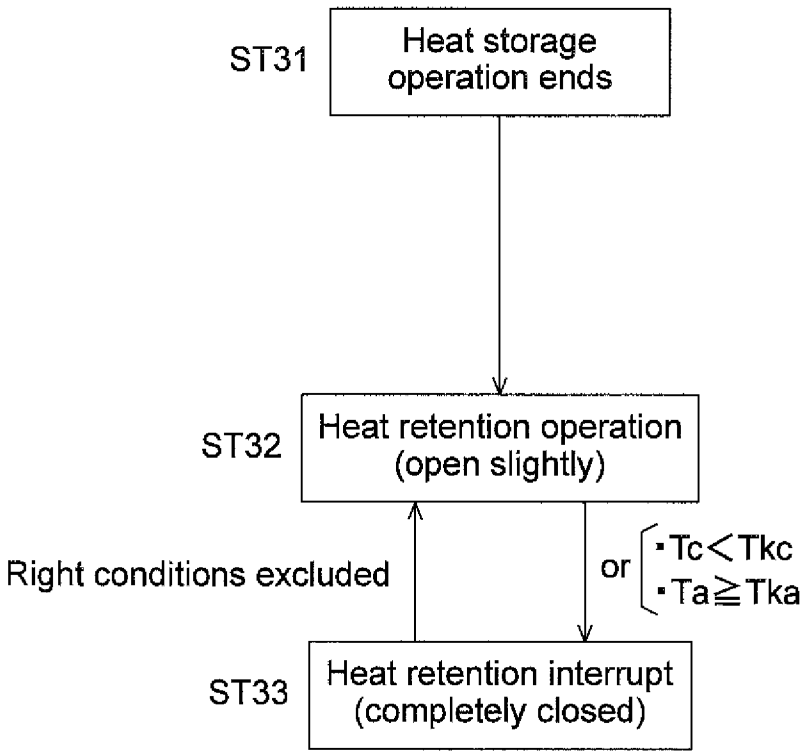
ST31
Heat storage operation ends
ST32
Heat retention operation (open slightly)
Right conditions excluded
or
・Tc＜Tkc
・Ta≧Tka
ST33
Heat retention interrupt (completely closed)

FIG. 14

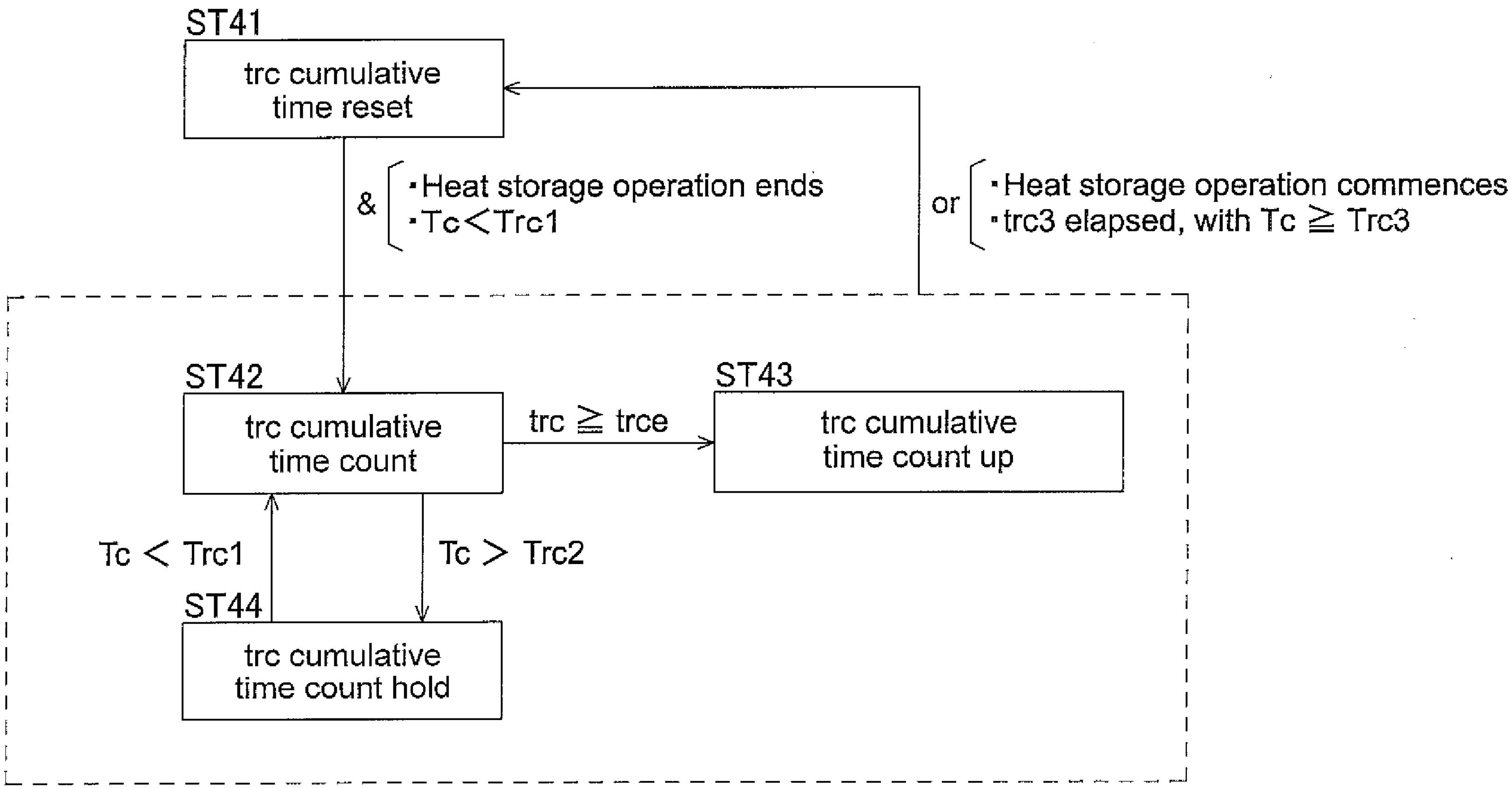
ST41
trc cumulative time reset
& ·Heat storage operation ends ·Tc<Trc1
or ·Heat storage operation commences ·trc3 elapsed, with Tc ≧ Trc3
ST42
trc cumulative time count
trc ≧ trce
ST43
trc cumulative time count up
Tc < Trc1
Tc > Trc2
ST44
trc cumulative time count hold

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/076938

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.
A	JP 63-306377 A (Matsushita Electric Industrial Co., Ltd.), 14 December 1988 (14.12.1988), fig. 1; page 3, upper right column, line 3 to lower right column, line 11 (Family: none)	1-6
A	JP 2010-145020 A (Mitsubishi Electric Corp.), 01 July 2010 (01.07.2010), claim 2; paragraphs [0012], [0033]; fig. 1 (Family: none)	1-6
A	JP 2007-10288 A (JFE Engineering Corp.), 18 January 2007 (18.01.2007), claim 1; paragraphs [0027] to [0033]; fig. 1 (Family: none)	1-6

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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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
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 November, 2012 (14.11.12)	27 November, 2012 (27.11.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/076938

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 2007-51805 A (Matsushita Electric Industrial Co., Ltd.), 01 March 2007 (01.03.2007), fig. 1; paragraphs [0026] to [0038] & CN 101382365 A & CN 101382366 A & CN 101382367 A	1-6
A	JP 2003-287311 A (Sanyo Electric Co., Ltd.), 10 October 2003 (10.10.2003), claim 3 (Family: none)	1-6
A	JP 2003-28520 A (Hitachi, Ltd.), 29 January 2003 (29.01.2003), paragraphs [0017] to [0020] (Family: none)	1-6

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Patent documents cited in the description

- JP 2005337657 A **[0002] [0145]**