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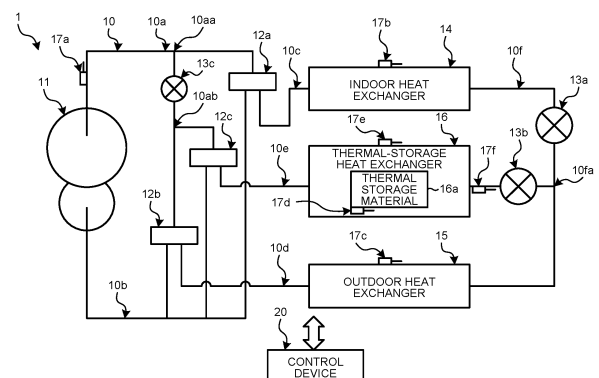
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(54) **AIR CONDITIONER**

(57) In an air conditioner, to a refrigerant circuit in which a refrigerant is circulated, a compressor configured to compress the refrigerant, an indoor heat exchanger, an outdoor heat exchanger, a thermal-storage heat exchanger configured to exchange heat between a thermal storage material and the refrigerant, a plurality of expansion valves, an opening degree of which is adjustable, and a plurality of switching valves configured to switch a circulation path of the refrigerant in the refrigerant circuit between a thermal-storage heating operation in which the indoor heat exchanger and the thermal-storage heat exchanger function as a condenser and the outdoor heat exchanger functions as the evaporator, and a defrosting heating operation in which the indoor heat exchanger and the outdoor heat exchanger function as the condenser and the thermal-storage heat exchanger functions as the evaporator are connected, one of the expansion valves is arranged upstream to the outdoor heat exchanger when the outdoor heat exchanger functions as the condenser, and this one of the expansion valves depressurizes the refrigerant that flows into the outdoor heat exchanger.

**FIG.1A**



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**Description**

[Technical Field]

**[0001]** The present invention relates to an air conditioner.

[Background Art]

**[0002]** An air conditioning system that is equipped with a thermal storage heat exchanger that allows a refrigerant discharged from a compressor to exchange heat with a thermal storage material has conventionally been known. For this air conditioner, there is a related technique that switches between thermal-storage heating operation and defrosting heating operation to melt frost that forms on an outdoor heat exchanger while continuing heating operation.

**[0003]** In this related technique, during thermal-storage heating operation, an indoor heat exchanger and the thermal storage heat exchanger function as condensers, while the outdoor heat exchanger functions as an evaporator. During defrosting heating operation, the indoor heat exchanger and the outdoor heat exchanger function as condensers, and the thermal storage heat exchanger functions as an evaporator.

[Citation List]

[Patent Citation]

**[0004]** Patent Literature 1: Japanese Laid-open Patent Publication No.2016-17738

[Summary of Invention]

[Technical Problem]

**[0005]** However, in the related technique described above, the pressure (condensation temperature in two-phase region) of the refrigerant flowing into the indoor heat exchanger and outdoor heat exchanger during the defrosting heating operation is the same. To provide indoor heating, the condensation temperature is set to approximately 40°C, but because the temperature of frost on the outdoor heat exchanger is 0°C or lower, the temperature of the refrigerant supplied to the outdoor heat exchanger becomes excessively higher than the temperature necessary for defrosting. As a result, a large amount of supercooled liquid refrigerant accumulates in the outdoor heat exchanger, and there has been a problem that the flow of refrigerant into the indoor heat exchanger is reduced, causing reduction in heating capacity.

**[0006]** The disclosed technique has been achieved in view of the above problems, and it is an object to provide an air conditioner that can suppress a decrease in the indoor heating capacity during the defrosting heating

operation.

[Solution to Problem]

**[0007]** An air conditioner according to an aspect of the present disclosure is an air conditioner, wherein to a refrigerant circuit in which a refrigerant is circulated, a compressor configured to compress the refrigerant, an indoor heat exchanger configured to exchange heat between indoor air and the refrigerant, an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant, a thermal-storage heat exchanger configured to exchange heat between a thermal storage material and the refrigerant, a plurality of expansion valves, an opening degree of which is adjustable, and a plurality of switching valves to switch a circulation path of the refrigerant in the refrigerant circuit between a thermal-storage heating operation in which the indoor heat exchanger and the thermal-storage heat exchanger function as a condenser and the outdoor heat exchanger functions as an evaporator, and a defrosting heating operation in which the indoor heat exchanger and the outdoor heat exchanger function as the condenser and the thermal-storage heat exchanger functions as the evaporator are connected, and one of the expansion valves is arranged upstream to the outdoor heat exchanger when the outdoor heat exchanger functions as a condenser, and a refrigerant that flows into the outdoor heat exchanger is depressurized by the one of the expansion valves.

[Advantageous Effects of Invention]

**[0008]** A disclosed air conditioner can suppress a decrease in heating capacity for indoor space during defrosting heating operation.

[Brief Description of Drawings]

**[0009]**

[Fig. 1A] FIG. 1A is a circuit diagram illustrating an example of an air conditioner according to an embodiment.

[Fig. 1B] FIG. 1B is a circuit diagram illustrating an example of an air conditioner according to an embodiment.

[Fig. 2] FIG. 2 is a block diagram illustrating an example of an air conditioner according to an embodiment.

[Fig. 3] FIG. 3 is a flowchart illustrating an operation example of the air conditioner according to the embodiment.

[Fig. 4] FIG. 4 is an explanatory diagram explaining a state during thermal-storage heating operation of the air conditioner according to the embodiment.

[Fig. 5] FIG. 5 is a diagram illustrating an example of a timing chart at the time of start of defrosting operation

of the air conditioner according to the embodiment.  
[Fig. 6] FIG. 6 is an explanatory diagram explaining switching of operation states of the air conditioner according to the embodiment.

[Fig. 7] FIG. 7 is an explanatory diagram explaining a state during defrosting heating operation of the air conditioner according to the embodiment.

[Fig. 8] FIG. 8 is a diagram illustrating an example of a timing chart at the time of stopping the defrosting operation of the air conditioner according to the embodiment.

#### [Embodiments for Carrying Out the Invention]

**[0010]** Hereinafter, an air conditioner according to an embodiment will be explained with reference to the drawings. In the embodiment, identical reference signs are assigned to components having an identical function, and duplicated explanation will be omitted. Note that the air conditioner explained in the following embodiment is only an example, and is not intended to limit the embodiment. Moreover, respective embodiments below may be combined within a range not causing a contradiction.

**[0011]** FIG. 1A, FIG. 1B are circuit diagrams illustrating an example of the air conditioner according to the embodiment. As illustrated in FIG. 1A, an air conditioner 1 is, for example, a device that heats and cools indoor space under control of a control device 20. The air conditioner 1 includes a compressor 11 that compresses a refrigerant such as R32, an indoor heat exchanger 14 that exchanges heat between indoor air and the refrigerant, an outdoor heat exchanger 15 that exchanges heat between outdoor air and the refrigerant, and a thermal-storage heat exchanger 16 that exchanges heat between a thermal storage material 16a and the refrigerant. By connecting the respective devices described above with flow paths (refrigerant pipes), a refrigerant circuit 10 through which the refrigerant circulates is formed.

**[0012]** The refrigerant circuit 10 has flow paths 10a to 10f through which the refrigerant flows formed therein. To the flow paths 10a to 10f, a first three-way valve 12a, a second three-way valve 12b, and a third three-way valve 12c that switch circulation path of the refrigerant, a first expansion valve 13a, a second expansion valve 13b, and a third expansion valve 13c, an opening degree of which can be adjusted are connected. The first three-way valve 12a, the second three-way valve 12b, and the third three-way valve 12c are an example of a switching valve, and is replaceable with a four-way valve or the like.

**[0013]** In the following explanation, the first three-way valve 12a, the second three-way valve 12b, the third three-way valve 12c, and the like are referred to as three-way valve 12 when not particularly distinguished from one another. Similarly, the first expansion valve 13a, the second expansion valve 13b, the third expansion valve 13c, and the like are referred to as expansion valve 13 when not particularly distinguished from one another.

**[0014]** The flow path 10a of the refrigerant circuit 10 connects a discharge side of the compressor 11 with each of the first three-way valve 12a, the second three-way valve 12b, and the third three-way valve 12c. Specifically, the flow path 10a branches into a path through which the refrigerant flows into the first three-way valve 12a, and a path through which the refrigerant flows to the second three-way valve 12b and the third three-way valve 12c. The path through which the refrigerant flows to the second three-way valve 12b and the third three-way valve 12c is branched by a second branch 10ab to paths through which the refrigerant flows to each of the second three-way valve 12b and the third three-way valve 12c. Moreover, between a first branch 10aa and a second branch 10ab, the third expansion valve 13c is connected.

**[0015]** In the circuit example of the air conditioner 1 illustrated in FIG. 1A, in the flow path 10a on the discharge side of the compressor 11, the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16 are configured to use the common third expansion valve 13c. On the other hand, as the circuit example of an air conditioner 1a illustrated in FIG. 1B, in each of flow paths of the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16 by a branch 10ac and a branch 10ad, a third expansion valve 13ca, a fourth expansion valve 13cb corresponding to the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16, respectively, may be provided. However, because the configuration in which the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16 uses the common third expansion valve 13c only requires a single expansion valve, it can reduce cost.

**[0016]** A flow path 10b in the refrigerant circuit 10 connects a suction side of the compressor 11 with the each of the first three-way valve 12a, the second three-way valve 12b, and the third three-way valve 12c. A flow path 10c connects the first three-way valve 12a and the indoor heat exchanger 14. A flow path 10d connects the second three-way valve 12b and the outdoor heat exchanger 15. A flow path 10e connects the third three-way valve 12c and the thermal-storage heat exchanger 16.

**[0017]** A flow path 10f in the refrigerant circuit 10 connects the indoor heat exchanger 14, the outdoor heat exchanger 15, and the thermal-storage heat exchanger 16. Between the indoor heat exchanger 14 in the flow path 10f and a branch 10fa that diverges from or merges with the indoor heat exchanger 14, the first expansion valve 13a is connected. Similarly, between the thermal-storage heat exchanger 16 and the branch 10fa that diverges therefrom or merges therewith, the second expansion valve 13b is connected.

**[0018]** Moreover, the air conditioner 1 includes temperature sensors 17a to 17f that detect a temperature of respective parts. The temperature sensor 17a is a sensor that detects a temperature of the refrigerant discharged from the compressor 11. The temperature sensor 17b is a sensor that detects a temperature of the indoor heat

exchanger 14. The temperature sensor 17c is a sensor that detects a temperature of the outdoor heat exchanger 15.

[0019] The temperature sensor 17d is a sensor that detects a temperature of the thermal storage material 16a. The temperature sensor 17e is a sensor that detects a temperature of the thermal-storage heat exchanger 16. The temperature sensor 17f is a sensor that detects a temperature (liquid pipe temperature) of the refrigerant flowing between the thermal-storage heat exchanger 16 and the second expansion valve 13b in the flow path 10f. In the following explanation, the temperature sensors 17a to 17f and the like are referred to as temperature sensor 17 when not particularly distinguished from one another. Note that the temperature sensor 17 includes a temperature sensor to detect a temperature of indoor space and the like although not specifically illustrated.

[0020] A refrigerant circulation path during thermal-storage heating operation and a refrigerant circulation path during the defrosting heating operation in the refrigerant circuit 10 will be explained.

[0021] During the thermal-storage heating operation, the control device 20 of the air conditioner 1 circulates the refrigerant so as to make the indoor heat exchanger 14 and the thermal-storage heat exchanger 16 function as a condenser, and to make the outdoor heat exchanger 15 function as the evaporator by switching of the multiple three-way valves 12.

[0022] Specifically, the control device 20 switches the first three-way valve 12a such that the refrigerant discharged from the compressor 11 flows through the flow paths 10a, 10c, to the indoor heat exchanger 14. Similarly, the control device 20 switches the third three-way valve 12c such that the refrigerant discharged from the compressor 11 flows through the flow path 10a, the third expansion valve 13c, and the flow path 10e and to the thermal-storage heat exchanger 16. Furthermore, the control device 20 switches the second three-way valve 12b such that the refrigerant that has entered the flow path 10f from the indoor heat exchanger 14 and the thermal-storage heat exchanger 16, and has been depressurized by the first expansion valve 13a and the second expansion valve 13b returns, after passing through the outdoor heat exchanger 15, to the compressor 11 through the flow paths 10d, 10b.

[0023] During the defrosting heating operation, the control device 20 of the air conditioner 1 circulates the refrigerant such that the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser, and the thermal-storage heat exchanger 16 functions as the evaporator by switching the multiple three-way valves 12.

[0024] Specifically, the control device 20 switches the first three-way valve 12a such that the refrigerant discharged from the compressor 11 flows through the flow paths 10a, 10c to the indoor heat exchanger 14. Similarly, the control device 20 switches the second three-way valve 12b such that the refrigerant discharged from the

compressor 11 flows to the outdoor heat exchanger 15 through the flow paths 10a, 10d. At this time, the refrigerant flowing into the outdoor heat exchanger 15 is depressurized by the third expansion valve 13c arranged in the flow path 10a. Moreover, the control device 20 switches the third three-way valve 12c such that the refrigerant that has entered the flow path 10f from the indoor heat exchanger 14 and the outdoor heat exchanger 15 returns, after passing through the thermal-storage heat exchanger 16, to the compressor 11 through the flow paths 10e, 10b. At this time, the refrigerant that has entered the flow path 10f from the indoor heat exchanger 14 is depressurized by the first expansion valve 13a.

[0025] FIG. 2 is a block diagram illustrating an example of the air conditioner 1 according to the embodiment. As illustrated in FIG. 2, the air conditioner 1 includes the compressor 11, the three-way valve 12, the expansion valve 13, an outdoor fan 31, an indoor fan 32, and the control device 20 that is electrically connected to the temperature sensor 17 to control various components.

[0026] The outdoor fan 31 is arranged inside an outdoor unit (not specifically illustrated) in which the outdoor heat exchanger 15 is provided. The outdoor fan 31 is controlled by the control device 20, and blows outdoor air such that outside air comes into thermal contact with the outdoor heat exchanger 15. The indoor fan 32 is arranged inside an indoor unit (not specifically illustrated). The indoor fan 32 is controlled by the control device 20, and blows indoor air such that indoor air comes into thermal contact with the indoor heat exchanger 14 and that the indoor air that has come into thermal contact with the indoor heat exchanger 14 is blown out of the indoor unit to the room.

[0027] The control device 20 is a computer as an example of a control unit, and includes a storage device 21 and a central processing unit (CPU) 22. The storage device 21 stores a computer program to be installed in the control device 20, and stores information used by the CPU 22. The CPU 22 performs information processing by executing the computer program to be installed in the control device 20, and controls the operation of the air conditioner 1.

[0028] The control device 20 accepts various kinds of settings (the heating operation or the cooling operation and its set temperature and the like) configured through an operating unit (not illustrated) and a detection result of the temperature sensor 17, to control the compressor 11, the three-way valve 12, the expansion valve 13, the outdoor fan 31, and the indoor fan 32.

[0029] Specifically, the storage device 21 stores information, such as parameters, calculation formulas, and tables, for the CPU 22 to calculate control values used for control of the compressor 11, the three-way valve 12, the expansion valve 13, the outdoor fan 31, and the indoor fan 32 based on a detection result of the temperature sensor 17 and the like. The CPU 22 controls the compressor 11, the three-way valve 12, the expansion valve 13, the outdoor fan 31, and the indoor fan 32 using the

control value calculated from the detection result of the temperature sensor 17 and the like based on the information stored in this storage device 21.

**[0030]** FIG. 3 is a flowchart illustrating an operation example of the air conditioner 1 according to the embodiment. As illustrated in FIG. 3, the control device 20 starts the thermal-storage heating operation when a start instruction for the heating operation is received and processing is started (S11).

**[0031]** Specifically, the control device 20 switches the first three-way valve 12a to connect the flow paths 10a, 10c, to make the indoor heat exchanger 14 function as the compressor. Moreover, the control device 20 switches 12b to connect the flow paths 10d, 10b, to make the outdoor heat exchanger 15 function as the evaporator. Furthermore, the control device 20 switches the third three-way valve 12c to connect the flow paths 10a, 10e, to make the thermal-storage heat exchanger 16 function as the compressor. Moreover, the control device 20 performs initial opening control so that opening degrees of the first expansion valve 13a, the second expansion valve 13b, and the third expansion valve 13c become initial values during the heating operation. The initial value is set to ensure reliability (and startup performance) at the time of start. For the first expansion valve 13a, an opening degree that enables to prevent liquid backflow to the compressor while preventing the discharge temperature from becoming excessively high is set. For the second expansion valve 13b, such an opening degree that an amount of flow of the refrigerant to the thermal-storage heat exchanger 16 does not become excessive while avoiding liquid accumulation in the thermal-storage heat exchanger 16 is set. For the third expansion valve, an opening degree to maintain the operating differential pressure of the second three-way valve 12b while preventing excessive flow of the refrigerant to the thermal-storage heat exchanger 16 is set. Furthermore, the control device 20 starts the indoor fan 32, the outdoor fan 31, and the compressor 11.

**[0032]** Subsequently, the control device 20 performs control (adjustment) of the opening degree of the expansion valve 13 using the control value calculated from the detection result of the temperature sensor 17 (S12).

**[0033]** Specifically, the control device 20 performs target discharge-temperature control so that discharge temperature of the compressor 11 becomes a target discharge temperature, for the opening degree of the first expansion valve 13a. Moreover, the control device 20 performs target subcooling-temperature control of the thermal-storage heat exchanger so that a subcooling temperature at an outlet of the thermal-storage heat exchanger 16 becomes a target subcooling temperature, for the opening degree of the second expansion valve 13b. Furthermore, the control device 20 performs target condensation-temperature control of the thermal-storage heat exchanger so that a condensation temperature of the thermal-storage heat exchanger 16 becomes a target condensation temperature, for the opening degree

of the third expansion valve 13c.

**[0034]** FIG. 4 is an explanatory diagram explaining a state during the thermal-storage heating operation of the air conditioner according to the embodiment. As illustrated in FIG. 4, during the thermal-storage heating operation, the control device 20 controls the opening degree of the first expansion valve 13a, the second expansion valve 13b, and the third expansion valve 13c based on a control value calculated based on an input of a detection result of the temperature sensor 17.

**[0035]** Specifically, the control device 20 calculates a target discharge temperature based on a temperature (condensation temperature) of the indoor heat exchanger 14 detected by the temperature sensor 17b and a temperature (evaporation temperature) of the outdoor heat exchanger 15 detected by the temperature sensor 17c. Subsequently, the control device 20 adjusts the opening degree of the first expansion valve 13a so that the discharge temperature of the refrigerant detected by the temperature sensor 17a becomes close to the calculated target discharge temperature.

**[0036]** Moreover, the control device 20 calculates the subcooling temperature of the thermal-storage heat exchanger based on a liquid pipe temperature of the thermal-storage heat exchanger 16 detected by the temperature sensor 17f and a temperature (condensation temperature) of the thermal-storage heat exchanger 16 detected by the temperature sensor 17e. Subsequently, the control device 20 controls the opening degree of the second expansion valve 13b so that the calculated subcooling temperature of the thermal-storage heat exchanger becomes close to the target subcooling temperature of the thermal-storage heat exchanger 16 stored in advance.

**[0037]** Furthermore, the control device 20 calculates the target condensation temperature of the thermal-storage heat exchanger 16 based on the temperature of the thermal storage material 16a detected by the temperature sensor 17d. Subsequently, the control device 20 controls the opening degree of the third expansion valve 13c so that the temperature (condensation temperature) of the thermal-storage heat exchanger 16 detected by the temperature sensor 17e becomes close to the target condensation temperature.

**[0038]** Returning back to FIG. 3, after S12, the control device 20 determines whether a condition for starting defrosting has been met (S13). For example, the control device 20 determines that the condition for starting defrosting is met when a temperature of the outdoor heat exchanger 15 satisfies a predetermined temperature condition ( $-6^{\circ}\text{C}$  or lower when an outdoor temperature is  $2^{\circ}\text{C}$ , or the like). Furthermore, the control device 20 may determine that the condition for starting defrosting is met when not only the temperature of the outdoor heat exchanger 15 but also an elapsed time of the thermal-storage heating operation satisfies a predetermined condition (for example, a continuous operation time is equal to or longer than a predetermined duration, or the like).

**[0039]** When the condition for starting defrosting is not met (S13: NO), the control device 20 waits to start processing. When the condition for starting defrosting is met (S13: YES), the control device 20 performs processing at S14 to S19 and starts the defrosting heating operation.

**[0040]** Specifically, the control device 20 changes a rotation speed of the indoor fan 32 to a defrosting rotation speed (a), and changes a rotation speed of the compressor 11 to a defrosting-start rotation speed (b) (S14). The defrosting rotation speed (a) is set to a rotation speed of an air speed that does not make a user feel a cold draft. The defrosting-start rotation speed (b) is set to a rotation speed ensuring a refrigerant circulation amount while preventing abnormal noise during the switching of the three-way valve 12. Subsequently, the control device 20 fixes the opening degree of the first expansion valve 13a (discharge temperature control inactive), and switches the third three-way valve 12c to be connected to the flow paths 10e, 10b, causing the thermal-storage heat exchanger 16 to function as the evaporator (S15).

**[0041]** Subsequently, the control device 20 fixes the second expansion valve 13 to a defrosting pulse (c) (S16). For the defrosting pulse (c), a pulse that correspond to an opening degree ensuring a circulation amount for the defrosting heating operation is set. Thus, the second expansion valve 13b is fixed to the opening degree corresponding to the defrosting operation.

**[0042]** Subsequently, the control device 20 switches the second three-way valve 12b to be connected to the flow paths 10a, 10b, to cause the outdoor heat exchanger 15 to function as the condenser, and stops the outdoor fan 31 (S17).

**[0043]** Subsequently, the control device 20 changes the third expansion valve 13c to have a defrosting initial pulse (d), and changes the rotation speed of the compressor 11 to a defrosting rotation speed (e) (S18). For the defrosting initial pulse (d), a pulse corresponding to an opening degree that enables to exert a desired heating capacity even when the temperature of the outdoor heat exchanger 15 is low and a relatively large amount of the refrigerant flows to the outside is set. For the defrosting rotation speed (e), a rotation speed at which a low pressure remains above a lower specification limit of the compressor 11 during defrosting operation, and that minimizes the defrosting time is set. Thus, in the air conditioner 1, the defrosting heating operation is started, setting the third expansion valve 13c to have the initial opening degree at the start of the defrosting.

**[0044]** FIG. 5 is an example of a timing chart at a start of the defrosting operation of the air conditioner according to the embodiment. As illustrated in FIG. 5, when the defrosting operation is started, the air conditioner 1 changes the rotation speed of the indoor fan 32 to the defrosting rotation speed (a: Lo airflow) at time t1.

**[0045]** Subsequently, at time t2, the air conditioner 1 changes the rotation speed of the compressor 11 to the defrosting start rotation speed (87 rps in the illustrated example). Subsequently, at time t3, the air conditioner 1

switches the third three-way valve 12c to switch the thermal-storage heat exchanger 16 to function as the condenser (heat storage) to the evaporator (heat release). Subsequently, at time t4, in the air conditioner 1, the second expansion valve 13b is fixed to the defrosting pulse (200 pls in the illustrated example).

**[0046]** Subsequently, at time t5, the air conditioner 1 switches the second three-way valve 12b to make the outdoor heat exchanger 15 function as the condenser (heat release, defrosting), switched from the evaporator (heat absorption). Subsequently, at time t6, the air conditioner 1 stops the outdoor fan 31. Subsequently, at time t7, in the air conditioner 1, the third expansion valve 13c is changed to have the defrosting initial pulse (125 pls in the illustrated example). Subsequently, at time t8, the air conditioner 1 changes the rotation speed of the compressor 11 to the defrosting rotation speed (130 rps in the illustrated example).

**[0047]** Returning back to FIG. 3, after S18, the control device 20 controls the opening degree of the third expansion valve 13c according to the temperature of the outdoor heat exchanger 15 detected by the temperature sensor 17c (S19). Specifically, the control device 20 increases the opening degree of the third expansion valve 13c according to an increase of the temperature of the outdoor heat exchanger 15. Thus, the temperature of the refrigerant can be adjusted to a minimum necessary temperature for defrosting by adjusting the pressure of the refrigerant flowing into the outdoor heat exchanger 15. Therefore, it is possible to suppress excessive distribution of subcooled liquid refrigerant in the outdoor heat exchanger 15, and to prevent the flow of the refrigerant to the indoor heat exchanger 14 from being reduced to cause a decrease in the heating capacity.

**[0048]** FIG. 6 is an explanatory diagram explaining switching of the operational state of the air conditioner 1 according to the embodiment. In FIG. 6, hatching of the indoor heat exchanger 14, the outdoor heat exchanger 15, and the thermal-storage heat exchanger 16 indicates whether it functions as the condenser (with hatching) or as the evaporator (without hatching). The density of the hatching indicates a temperature state of the refrigerant when functioning as the condenser (the denser hatching represents a higher temperature). Similarly, a type of line in the flow paths 10a to 10f of the refrigerant circuit 10 indicates the temperature of the refrigerant flowing through the flow path (closer spacing of dashed lines represents a higher temperature), and a solid line is used in a part with no flow of the refrigerant.

**[0049]** As illustrated in FIG. 6, in the thermal-storage heating operation (S1), the air conditioner 1 circulates the refrigerant such that the indoor heat exchanger 14 and the thermal-storage heat exchanger 16 function as the condenser and the outdoor heat exchanger 15 functions as the evaporator. The first expansion valve 13a is adjusted its opening degree, to adjust the discharge temperature of the refrigerant to be discharged from the compressor 11. Moreover, the third expansion valve

13c that is positioned upstream and the second expansion valve 13b positioned downstream of the circulation path of the refrigerant relative to the thermal-storage heat exchanger 16 are adjusted their opening degrees, to respectively adjust the heat storage temperature (pressure) and the flow rate of the refrigerant.

**[0050]** When it is switched from the thermal-storage heating operation (S1) to the defrosting heating operation (S3), the air conditioner 1 first switches the thermal-storage heat exchanger 16 to the evaporator. Thus, the air conditioner 1 circulates the refrigerant such that the indoor heat exchanger 14 functions as the condenser, and the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16 function as the evaporator (S2). Subsequently, the air conditioner 1 switches the outdoor heat exchanger 15 to the condenser, to be in the defrosting heating operation state (S3). By thus switching, in the air conditioner 1, a circulation path in which the refrigerant discharged from the compressor 11 circulates the condenser and the evaporator, and returns to the compressor 11 is maintained all the time.

**[0051]** Moreover, the air conditioner 1 circulates, in the defrosting heating operation (S3), the refrigerant such that the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser and the thermal-storage heat exchanger 16 functions as the evaporator. The first expansion valve 13a is adjusted its opening degree, to adjust the condensation temperature.

**[0052]** Moreover, the third expansion valve 13c positioned upstream of the circulation path of the refrigerant relative to the outdoor heat exchanger 15 is adjusted its opening degree such that the temperature of the thermal-storage heat exchanger 16 (condensation temperature) detected by the temperature sensor 17e becomes close to the calculated target condensation temperature, thereby adjusting the flow rate (defrosting flow rate) and the temperature of the refrigerant flowing into the outdoor heat exchanger 15. Thus, in the air conditioner 1, it is possible to suppress supply of the refrigerant of an excessive temperature to the outdoor heat exchanger 15. Moreover, the second expansion valve 13b positioned upstream of the circulation path of the refrigerant relative to the thermal-storage heat exchanger 16 is adjusted its opening degree, thereby adjusting the entire flow rate of the refrigerant flowing through the refrigerant circuit 10.

**[0053]** Furthermore, in the third expansion valve 13c positioned upstream of the circulation path of the refrigerant relative to the outdoor heat exchanger 15, by increasing the opening degree during the defrosting heating operation from that in the thermal-storage heating operation (in the example in FIG. 5, 32 pls to 126 pls), the circulation amount of the refrigerant flowing per unit time becomes larger in the defrosting heating operation than that in the thermal-storage heating operation.

**[0054]** Moreover, during the defrosting heating operation, the opening degree (in the example in FIG. 5, 125 pls) of the third expansion valve 13c positioned upstream of the circulation path of the refrigerant relative to the

outdoor heat exchanger 15 is set to be smaller than the opening degree (in the example in FIG. 15, 200 pls) of the second expansion valve 13b positioned upstream relative to the thermal-storage heat exchanger 16. Thus, in the air conditioner 1, it is possible to adjust the flow rate of the refrigerant to be flow into the outdoor heat exchanger 15 during the defrosting heating operation to a minimum necessary flow rate for defrosting. Therefore, the flow rate of the refrigerant that can be supplied to the indoor heat exchanger 14 increases. Furthermore, it is possible to adjust the flow rate of the refrigerant to prevent the temperature of the thermal-storage heat exchanger 16 from dropping too low, and to perform more efficient defrosting and heating operation.

**[0055]** FIG. 7 is an explanatory diagram explaining a state of the air conditioner according to the embodiment during the defrosting heating operation. As illustrated in FIG. 7, during the defrosting heating operation, the control device 20 controls the opening degree of the third expansion valve 13c based on an input of a detection result of the temperature sensor 17.

**[0056]** Specifically, the control device 20 fixes the opening degree (for example, fully open) of the first expansion valve 13a and the second expansion valve 13b during the defrosting heating operation. Subsequently, the control device 20 controls the opening degree of the expansion valve 13 based on the temperature of the outdoor heat exchanger 15 detected by the temperature sensor 17c (for example, increase the opening degree of the third expansion valve 13c according to an increase in the temperature).

**[0057]** Returning back to FIG. 3, after S19, the control device 20 determines whether a condition for ending defrosting is met (S20). For example, the control device 20 determines that the condition for ending defrosting has been met when the temperature of the outdoor heat exchanger 15 satisfies a predetermined temperature condition (reach 16°C). Moreover, the control device 20 may determine that the condition for ending defrosting has been met when not only the temperature of the outdoor heat exchanger 15 but also an elapsed time of the defrosting heating operation satisfies a predetermined condition (for example, a continuous operation time is equal to or longer than a predetermined duration, or the like).

**[0058]** When the condition for ending defrosting is not met (S20: NO), the control device 20 returns the processing to S19. When the condition for starting defrosting is met (S20: YES), the control device 20 performs processing at S21 to S28 and switches from the defrosting heating operation to the thermal-storage heating operation.

**[0059]** Specifically, the control device 20 starts the outdoor fan 31 (S21). Subsequently, the control device 20 changes the third expansion valve 13c to have a post defrosting pulse (f) (S22). For the post defrosting pulse (f), a pulse corresponding to an opening degree to maintain the operating differential pressure of the three-way

valve 12b while preventing excessive flow of the refrigerant to the thermal-storage heat exchanger 16 is set. Thus, the opening degree of the third expansion valve 13c is adjusted to the opening degree after defrosting.

**[0060]** Subsequently, the control device 20 switches to connect the second three-way valve 12b to the flow paths 10d, 10b, to make the outdoor heat exchanger 15 function as the evaporator (S23). Subsequently, the control device 20 changes the second expansion valve 13b to have a post defrosting pulse (g) (S24). The post defrosting pulse (g) is set to a pulse corresponding to an opening degree to prevent excessive flow of the refrigerant to the thermal-storage heat exchanger 16 while avoiding liquid accumulation in the thermal-storage heat exchanger 16. Thus, the second expansion valve 13b is adjusted to have the opening degree after defrosting.

**[0061]** Subsequently, the control device 20 switches the third three-way valve 12c to be connected to the flow paths 10a 10e, and makes the thermal-storage heat exchanger 16 function as the condenser (S25). Subsequently, the control device 20 releases fixation of the opening degree of the first expansion valve 13a, and starts discharge-temperature control operation (S26).

**[0062]** Subsequently, the control device 20 controls the indoor fan 32 to shift to a user-specified airflow set through a remote control or the like, and shifts the compressor 11 to the rotation speed according to a requested capacity as the heating capacity (S27).

**[0063]** Subsequently, the control device 20 controls (adjusts) the opening degree of the second expansion valve 13b and the third expansion valve 13c using a control value calculated from a detection result of the temperature sensor 17 similarly to S12 (S28).

**[0064]** FIG. 8 is an example of a timing chart at the time of stopping the defrosting operation of the air conditioner 1 according to the embodiment. As illustrated in FIG. 8, when the defrosting heating operation is stopped, the air conditioner 1 starts the outdoor fan 31 at time t11.

**[0065]** Subsequently, at time t12, the air conditioner 1 changes the third expansion valve 13c to have the post defrosting pulse (f) (in the illustrated example, 125 pls to 32 pls). Subsequently, at time t13, the air conditioner 1 switches the second three-way valve 12b to switch the outdoor heat exchanger 15 to function as the evaporator (heat absorption), switched from the condenser (heat release, defrosting). Subsequently, at time t14, the air conditioner 1 switches the third three-way valve 12c to switch the thermal-storage heat exchanger 16 to function as the condenser (heat storage), switched from the evaporator (heat release).

**[0066]** Subsequently, at time t15, in the air conditioner 1, fixation of the opening degree of the first expansion valve 13a is released, and the operation of the discharge temperature control by adjustment of the opening degree of the first expansion valve 13a is started. Subsequently, at time t16, in the air conditioner 1, an airflow of the indoor fan 32 is shifted to a user-specified airflow (Hi airflow). Subsequently, at time t17, in the air conditioner 1, auto-

matic control (rotation speed control) of the compressor 11 according to a requested capacity as the heating capacity is started.

**[0067]** As illustrated in FIG. 6, the air conditioner 1 circulates the refrigerant such that the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser, and the thermal-storage heat exchanger 16 functions as the evaporator during the defrosting heating operation (S3).

**[0068]** When it is switched from the defrosting heating operation (S3) to the thermal-storage heating operation (S5), the air conditioner 1 first switches the outdoor heat exchanger 15 to the evaporator. Thus, the air conditioner 1 circulates the refrigerant such that the indoor heat exchanger 14 functions as the condenser and the outdoor heat exchanger 15 and the thermal-storage heat exchanger 16 function as the evaporator (S4). Subsequently, the air conditioner 1 switches the thermal-storage heat exchanger 16 to the condenser to bring it into the thermal-storage heating operation state (S5). By thus switching, in the air conditioner 1, the circulation path in which the refrigerant discharged from the compressor 11 circulates through the condenser and the evaporator, and returns to the compressor 11 is maintained all the time.

**[0069]** Returning back to FIG. 3, after S28, the control device 20 determines whether a condition of ending the operation is met, by determining whether an operation end instruction by a user operation or the like is present (S29). When the condition of ending the operation is not met (S29: NO), the control device 20 returns the processing to S13. When the condition of ending the operation is met (S29: YES), the control device 20 performs an ending operation (switching the three-way valve 12, adjusting the opening degree of the expansion valve 13, stop of the outdoor fan 31 and the indoor fan 32, and the like) to bring it into the operation end state, to end the processing.

**[0070]** As above, the embodiment of the air conditioner has been explained, but the embodiment is not limited to those explained previously. Moreover, the components described above include those easily thought of by a person skilled in the art, those substantially identical, and those falling in a so-called equivalent range. Furthermore, the components described above may be combined as appropriate. Moreover, at least one of various omissions, replacements and changes of the components may be possible within a range not departing from the gist of the embodiment.

**[0071]** As described above, in the air conditioner 1, to the refrigerant circuit 10 in which the refrigerant is circulated, the compressor 11, the indoor heat exchanger 14, the outdoor heat exchanger 15, the thermal-storage heat exchanger 16, the multiple expansion valves 13, and the multiple three-way valves 12 are connected. The compressor 11 compresses the refrigerant. The indoor heat exchanger 14 exchanges heat between indoor air and the refrigerant. The outdoor heat exchanger 15 exchanges heat between outdoor air and the refrigerant. The thermal-storage heat exchanger 16 exchanges heat

between the thermal storage material 16a and the refrigerant. Each of the multiple expansion valves 13 is a valve, the opening degree of which is adjustable. The multiple three-way valves 12 switch the circulation paths of the refrigerant in the refrigerant circuit 10 between the thermal-storage heating operation in which the indoor heat exchanger 14 and the thermal-storage heat exchanger 16 function as the condenser and the outdoor heat exchanger 15 functions as the evaporator, and the defrosting heating operation in which the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser and the thermal-storage heat exchanger 16 functions as the evaporator. In the air conditioner 1, one of the multiple expansion valves 13 (the third expansion valve 13c, 13ca) is arranged upstream to the outdoor heat exchanger 15 when the outdoor heat exchanger 15 functions as the condenser, and the refrigerant flowing into the outdoor heat exchanger 15 is depressurized by this one expansion valve 13.

**[0072]** As described, by depressurizing the refrigerant flowing into the outdoor heat exchanger 15, in the air conditioner 1, it is possible to suppress supply of the refrigerant of an excessive temperature to the outdoor heat exchanger 15 during the defrosting heating operation in which the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser. For example, during the defrosting heating operation in which the indoor heat exchanger 14 and the outdoor heat exchanger 15 function as the condenser, if the heating capacity used for defrosting becomes excessive, the indoor heating capacity decreases relatively. On the other hand, in the air conditioner 1, by suppressing supply of the refrigerant of an excessive temperature to the outdoor heat exchanger 15, a decrease in the heating capacity of indoor space during the defrosting heating operation can be suppressed.

**[0073]** In the air conditioner 1, one of the expansion valves 13 (the third expansion valve 13c) described above is arranged upstream to the thermal-storage heat exchanger 16 when the thermal-storage heat exchanger 16 functions as the condenser. Thus, in the air conditioner 1, when the outdoor heat exchanger 15 or the thermal-storage heat exchanger 16 is used as the condenser, it is possible to depressurize the refrigerant with a single expansion valve 13 (the third expansion valve 13c), without preparing an expansion valve for each, and to reduce cost.

**[0074]** In the air conditioner 1, a circulation amount of the refrigerant flowing through one of the expansion valves 13 (the third expansion valve 13c) described above per unit time is larger in the defrosting heating operation than in the thermal-storage heating operation. Thus, the air conditioner 1 can finish defrosting speedily while smoothing the heating capacity during the thermal-storage heating operation. For example, in the air conditioner 1, the circulation amount of the refrigerant to the thermal-storage heat exchanger 16 decreases during the thermal-storage heating operation, allowing heat to be

stored without significantly reducing the heating capacity for indoor space, thereby achieving a balance of heating capacity between the indoor area and the thermal storage material 16a. To the contrary, during the defrosting heating operation, the circulation amount of the refrigerant to the outdoor heat exchanger 15 increases, and rapid defrosting is enabled.

**[0075]** In the air conditioner 1, one of the expansion valves 13 (the third expansion valve 13c, 13ca) described above is adjusted its opening degree after the thermal-storage heat exchanger 16 is switched from the condenser to the evaporator when the defrosting heating operation is started, switched from the thermal-storage heating operation. Thus, in the air conditioner 1, when the thermal-storage heat exchanger 16 functions as the evaporator, a decrease in the heating capacity due to rapid flow of the refrigerant into the thermal-storage heat exchanger 16 can be suppressed.

**[0076]** In the air conditioner 1, one of the expansion valves 13 (the third expansion valve 13c, 13ca) described above is adjusted its opening degree before the function of the thermal-storage heat exchanger 16 is switched from the evaporator to the condenser when the thermal-storage heating operation is started, switched from the defrosting heating operation. Thus, in the air conditioner 1, when the thermal-storage heat exchanger 16 functions as the condenser, a decrease in the heating capacity due to rapid flow of the refrigerant into the thermal-storage heat exchanger 16 can be suppressed.

**[0077]** The air conditioner 1 includes the temperature sensor 17c that detects a temperature of the outdoor heat exchanger 15, and one of the expansion valves 13 (the third expansion valve 13c, 13ca) described above is adjusted its opening degree based on the temperature detected by the temperature sensor 17c during the defrosting heating operation. Thus, in the air conditioner 1, the refrigerant pressure of the outdoor heat exchanger 15 during the defrosting heating operation can be adjusted according to the temperature of the outdoor heat exchanger 15, and more efficient defrosting can be performed.

**[0078]** In the air conditioner 1, the flow rate of the refrigerant passing through one of the expansion valves 13 (the third expansion valve 13c, 13ca) described above per unit time during the defrosting heating operation is smaller than the flow rate of the refrigerant passing through the expansion valve 13 (the second expansion valve 13b) that is positioned upstream to the thermal-storage heat exchanger 16 among the multiple expansion valves 13 per unit time. Thus, in the air conditioner 1, it is possible to prevent the temperature of the outdoor heat exchanger 15 from becoming excessively high and the temperature of the thermal-storage heat exchanger 16 from dropping too low during the defrosting heating operation. Therefore, more efficient defrosting heating operation can be performed.

**[0079]** In the air conditioner 1, the flow rate of the refrigerant passing through the third expansion valve 13c, 13ca positioned upstream to the thermal-storage

heat exchanger 16 among the multiple expansion valves 13 per unit time is larger than the flow rate of the refrigerant passing through the second expansion valve 13b positioned downstream to the thermal-storage heat exchanger 16 per unit time during the thermal-storage heating operation. Thus, in the air conditioner 1, it is possible to increase the refrigerant pressure in the thermal-storage heat exchanger 16 during the thermal-storage heating operation, thereby increasing the heat storage capacity of the thermal storage material 16a and reducing the defrosting time.

#### Reference Signs List

#### [0080]

1, 1a AIR CONDITIONER  
 10 REFRIGERANT CIRCUIT  
 10a to 10f FLOW PATH  
 11 COMPRESSOR  
 12 THREE-WAY VALVE  
 12a FIRST THREE-WAY VALVE  
 12b SECOND THREE-WAY VALVE  
 12c THIRD THREE-WAY VALVE  
 13 EXPANSION VALVE  
 13a FIRST EXPANSION VALVE  
 13b SECOND EXPANSION VALVE  
 13c, 13ca THIRD EXPANSION VALVE  
 13cb FOURTH EXPANSION VALVE  
 14 INDOOR HEAT EXCHANGER  
 15 OUTDOOR HEAT EXCHANGER  
 16 THERMAL-STORAGE HEAT EXCHANGER  
 16a THERMAL STORAGE MATERIAL  
 17, 17a to 17f TEMPERATURE SENSOR  
 20 CONTROL DEVICE  
 21 STORAGE DEVICE  
 22 CPU  
 31 OUTDOOR FAN  
 32 INDOOR FAN  
 t1 to t8, t11 to t17 TIME

#### Claims

1. An air conditioner, wherein  
 to a refrigerant circuit in which a refrigerant is circulated,  
 a compressor configured to compress the refrigerant,  
 an indoor heat exchanger configured to exchange heat between indoor air and the refrigerant,  
 an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant,  
 a thermal-storage heat exchanger configured to exchange heat between a thermal storage ma-

terial and the refrigerant,  
 a plurality of expansion valves, an opening degree of which is adjustable, and  
 a plurality of switching valves to switch a circulation path of the refrigerant in the refrigerant circuit between a thermal-storage heating operation in which the indoor heat exchanger and the thermal-storage heat exchanger function as a condenser and the outdoor heat exchanger functions as an evaporator, and a defrosting heating operation in which the indoor heat exchanger and the outdoor heat exchanger function as the condenser and the thermal-storage heat exchanger functions as the evaporator are connected, and  
 one of the expansion valves is arranged upstream to the outdoor heat exchanger when the outdoor heat exchanger functions as a condenser, and a refrigerant that flows into the outdoor heat exchanger is depressurized by the one of the expansion valves.

2. The air conditioner according to claim 1, wherein the one of the expansion valves is arranged upstream to the thermal-storage heat exchanger when the thermal-storage heat exchanger functions as the condenser.
3. The air conditioner according to claim 2, wherein a flow rate of the refrigerant that flows through the one of the expansion valves per unit time is larger during the defrosting heating operation than that during the thermal-storage heating operation.
4. The air conditioner according to claim 1, wherein the one of the expansion valves is adjusted its opening degree after the thermal-storage heat exchanger is switched from the condenser to the evaporator, when the defrosting heating operation is started, switched from the thermal-storage heating operation.
5. The air conditioner according to claim 1, wherein the one of the expansion valves is adjusted its opening degree before a function of the thermal-storage heat exchanger is switched from the evaporator to the condenser, when the thermal-storage heating operation is started, switched from the defrosting heating operation.
6. The air conditioner according to claim 1, including  
 a temperature detecting unit configured to detect a temperature of the outdoor heat exchanger, wherein  
 the one of the expansion valves is adjusted its opening degree based on a temperature detected by the temperature detecting unit during

the defrosting heating operation.

7. The air conditioner according to claim 1, wherein  
a flow rate of the refrigerant passing through the one  
of the expansion valves per unit time during the  
defrosting heating operation is smaller than a flow  
rate of the refrigerant passing through an expansion  
valve that is positioned upstream to the thermal-  
storage heat exchanger out of the expansion valves  
per unit time. 5 10
8. The air conditioner according to claim 1, wherein  
a flow rate of the refrigerant passing through an  
expansion valve that is positioned upstream to the  
thermal-storage heat exchanger out of the expan-  
sion valves per unit time during the thermal-storage  
heating operation is larger than a flow rate of the  
refrigerant passing through an expansion valve that  
is positioned downstream to the thermal-storage  
heat exchanger per unit time. 15 20

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FIG.1A

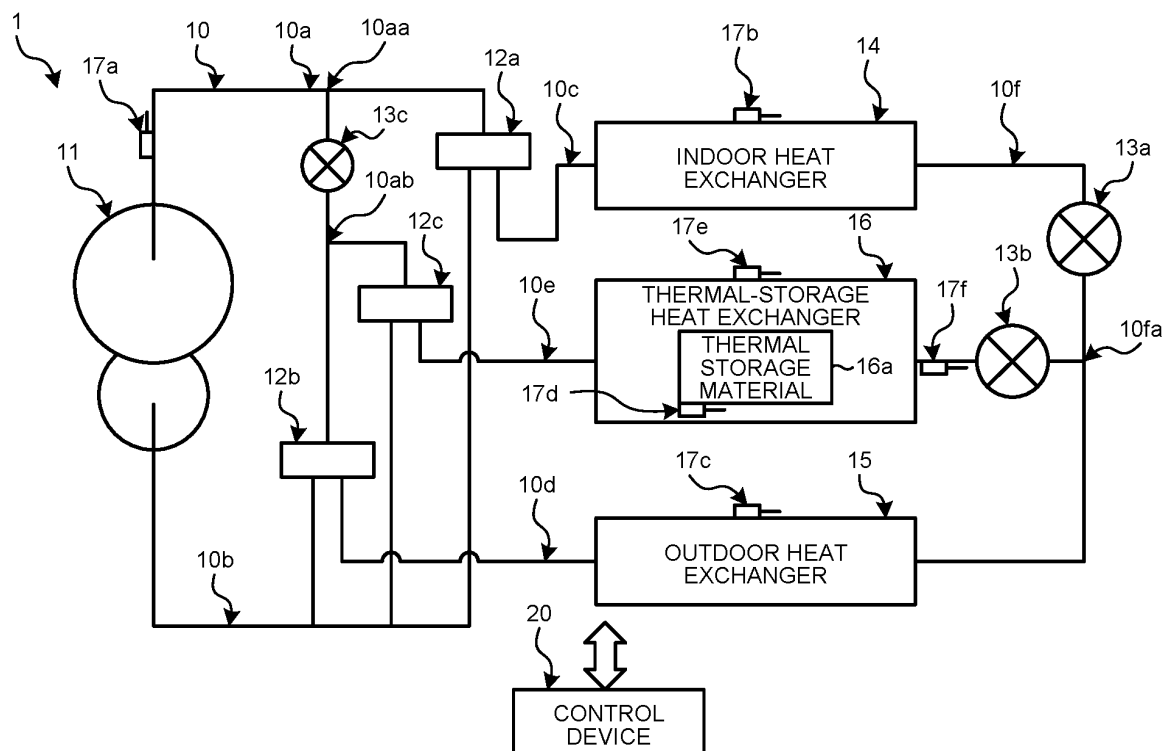


FIG.1B

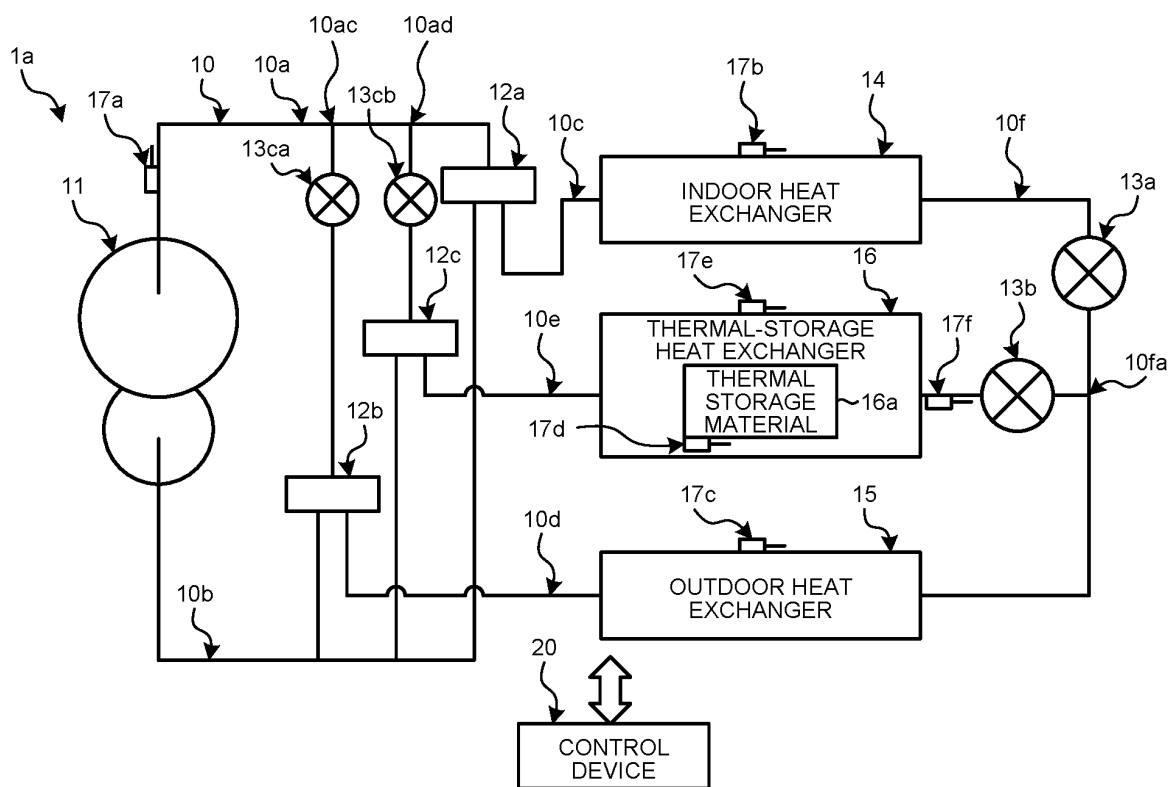


FIG.2

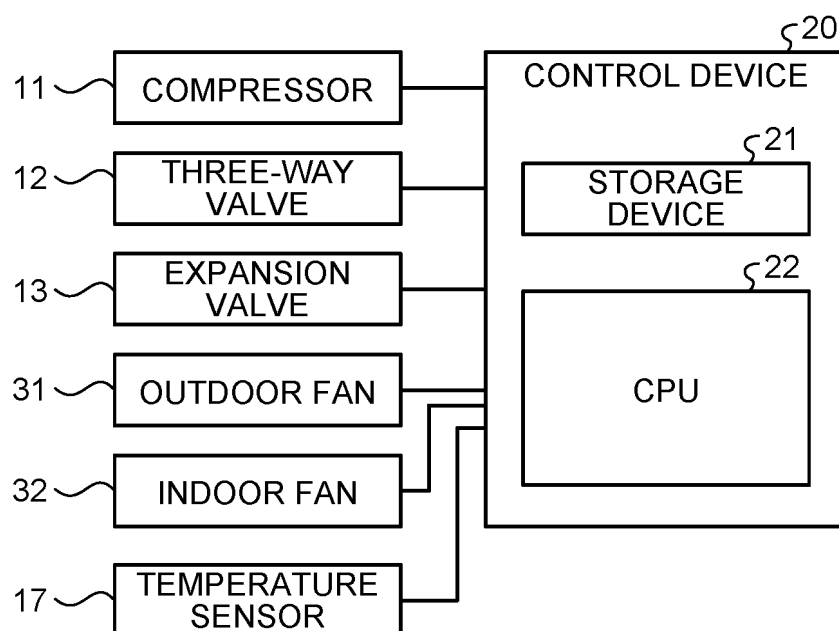


FIG.3

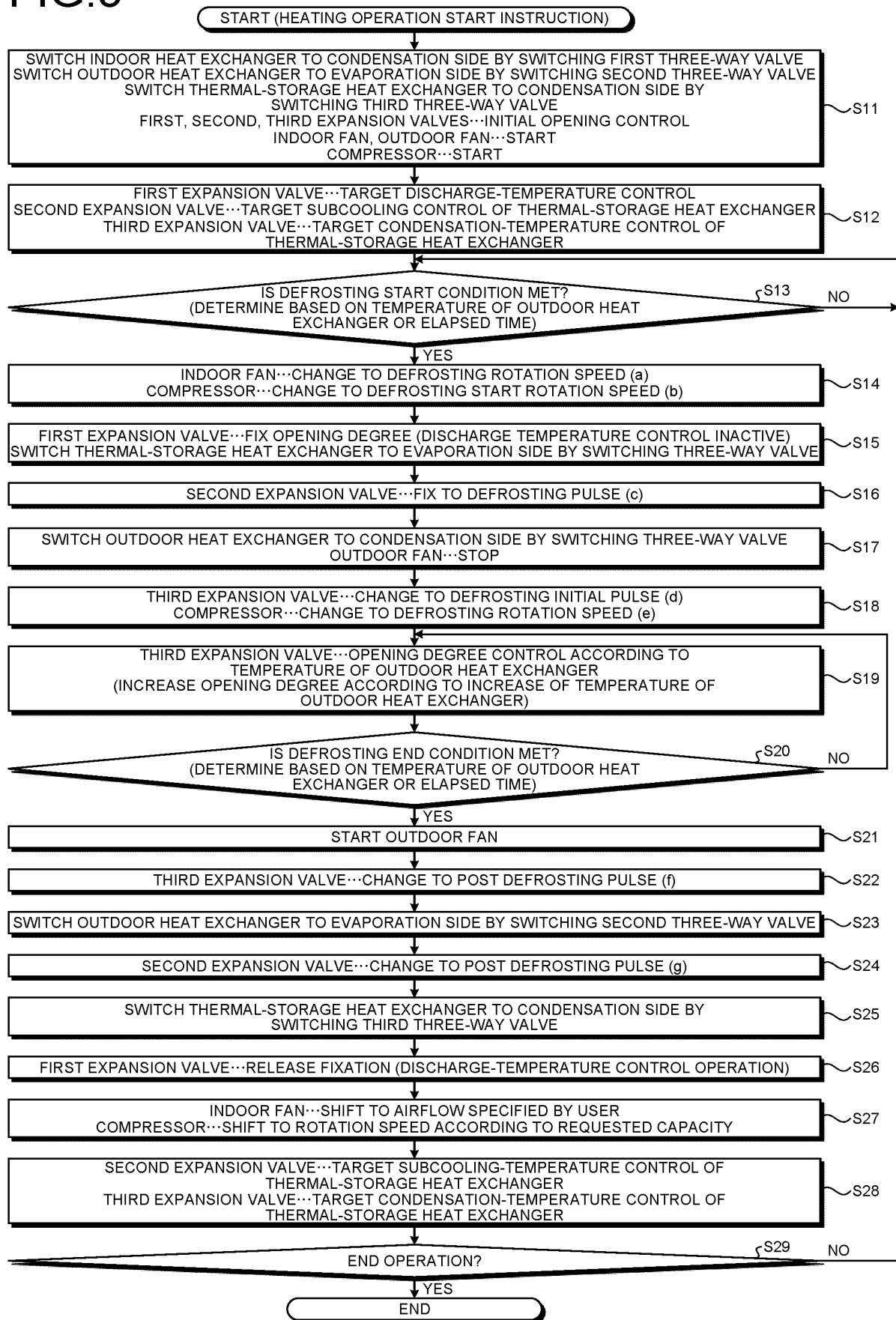


FIG.4

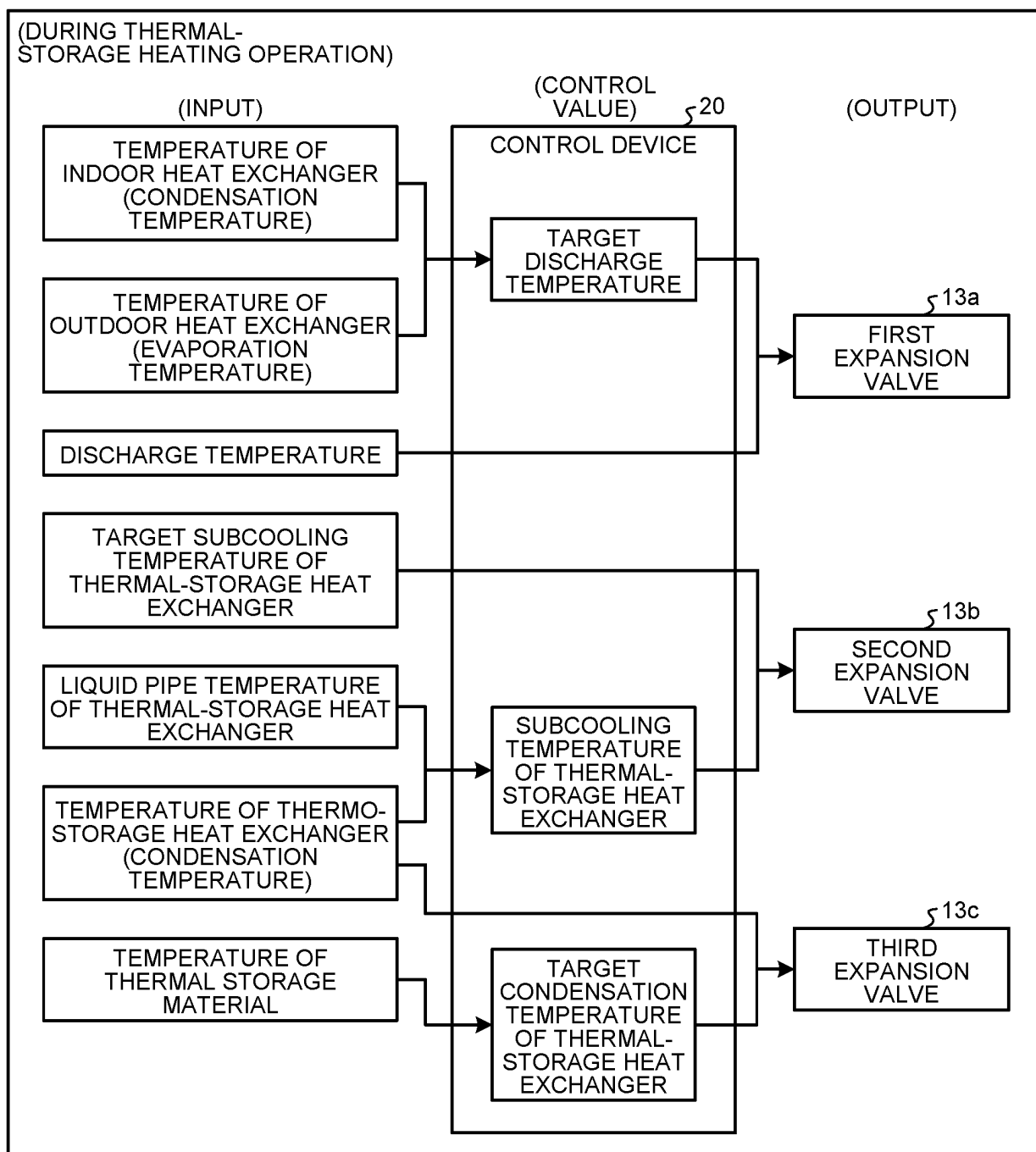


FIG.5

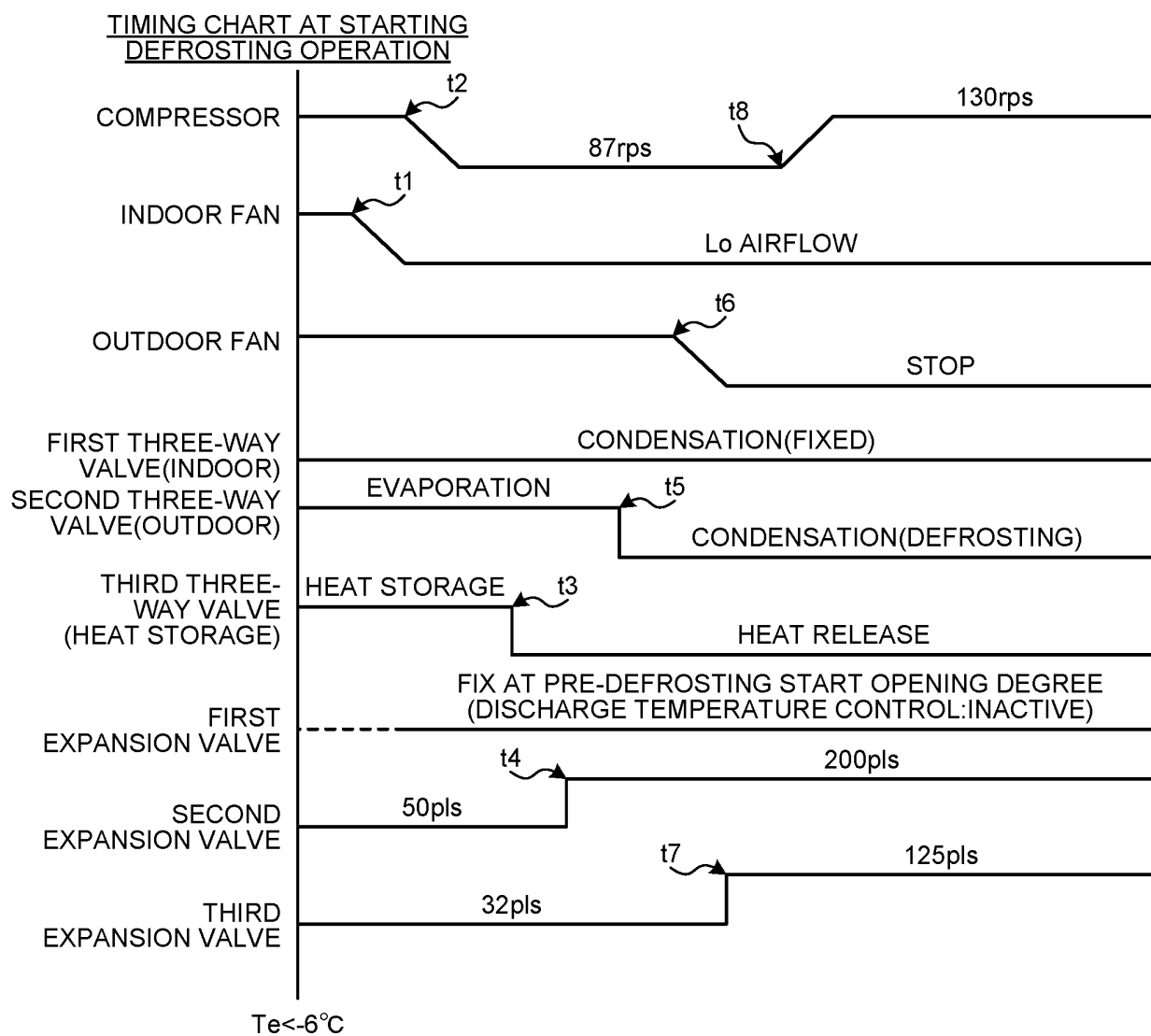


FIG.6

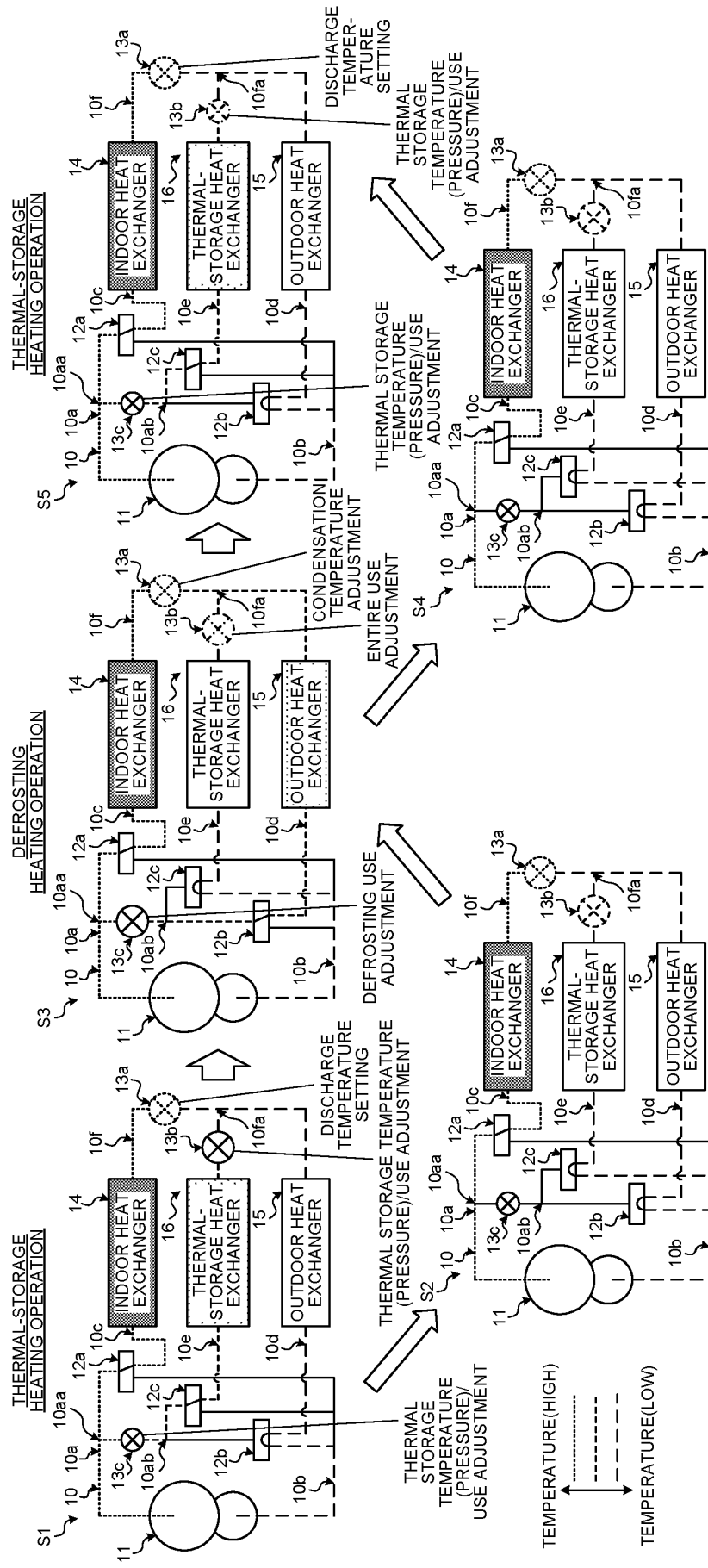


FIG.7

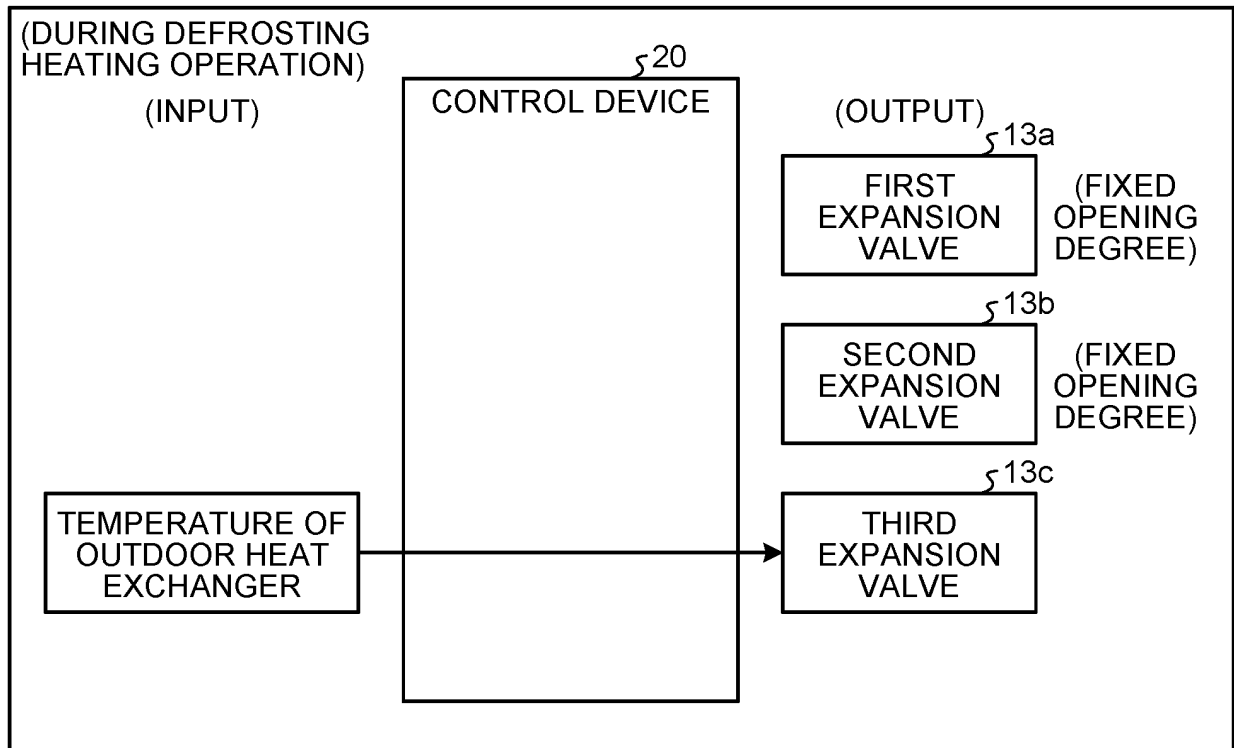
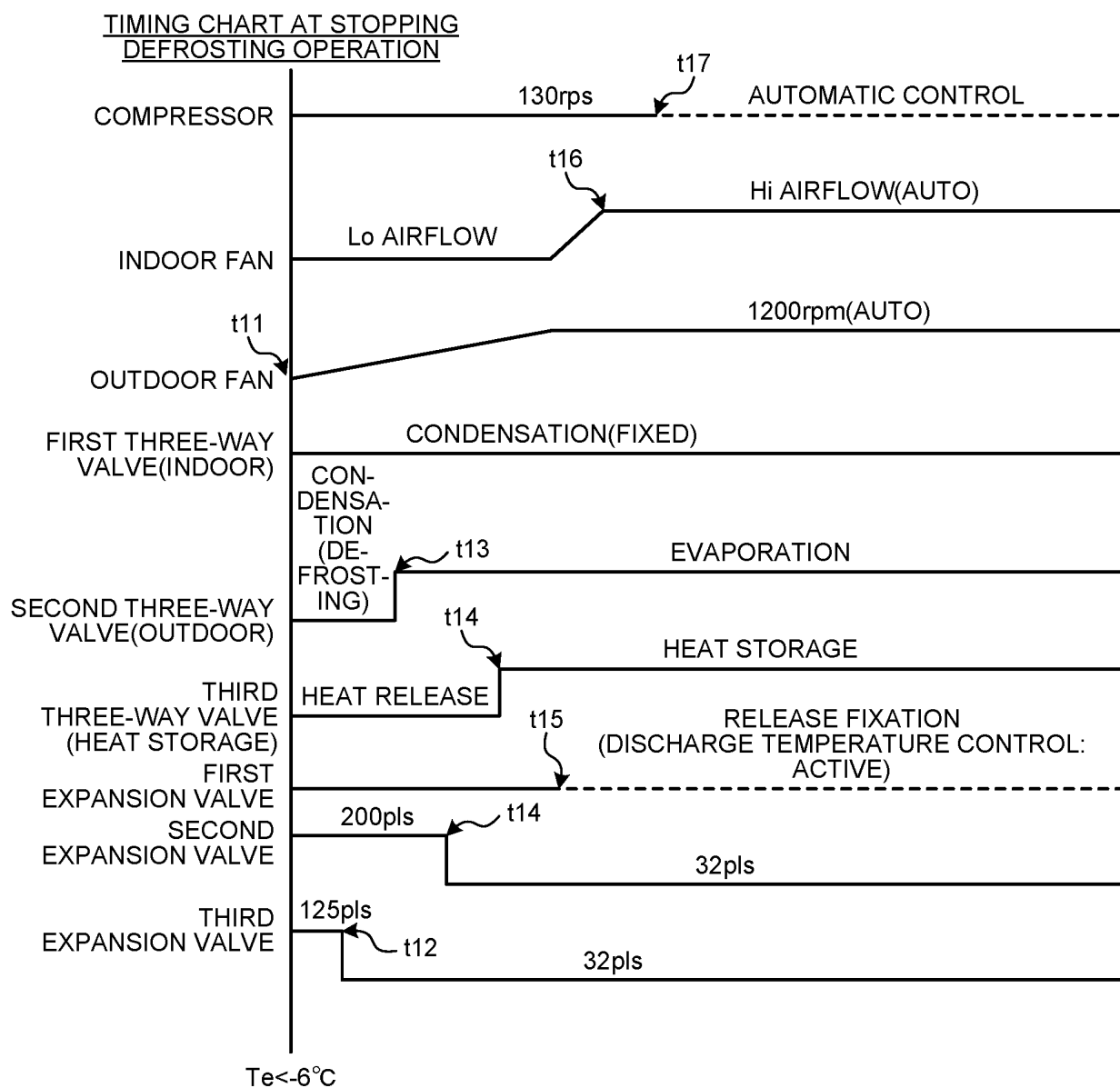


FIG.8



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/026736

## A. CLASSIFICATION OF SUBJECT MATTER

*F25B 13/00*(2006.01)i; *F25B 1/00*(2006.01)i; *F25B 47/02*(2006.01)i

FI: F25B47/02 550F; F25B13/00 351; F25B1/00 321C; F25B1/00 304Z; F25B13/00 N

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)

F25B13/00; F25B1/00; F25B47/02

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

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. |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2015/063846 A1 (MITSUBISHI ELECTRIC CORPORATION) 07 May 2015<br>(2015-05-07)<br>paragraphs [0009]-[0056], fig. 2-4                                                                                                                                                                                                                 | 1, 7                  |
| A         |                                                                                                                                                                                                                                                                                                                                       | 2-6, 8                |
| A         | JP 7-190534 A (TOHOKU ELECTRIC POWER CO INC, TOKYO ELECTRIC POWER CO INC, CHUBU ELECTRIC POWER CO INC, HOKURIKU ELECTRIC POWER CO INC, KANSAI ELECTRIC POWER CO INC, CHUGOKU ELECTRIC POWER CO INC, SHIKOKU ELECTRIC POWER CO INC, KYUSHU ELECTRIC POWER CO INC, TOSHIBA CORP) 28 July 1995 (1995-07-28)<br>entire text, all drawings | 1-8                   |

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

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
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Date of the actual completion of the international search

30 August 2023

Date of mailing of the international search report

12 September 2023

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)  
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Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT  
Information on patent family members

International application No.  
**PCT/JP2023/026736**

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| Patent document<br>cited in search report | Publication date<br>(day/month/year) | Patent family member(s)                                | Publication date<br>(day/month/year) |
|-------------------------------------------|--------------------------------------|--------------------------------------------------------|--------------------------------------|
| WO 2015/063846 A1                         | 07 May 2015                          | EP 3093586 A1<br>paragraphs [0009]-[0057], fig.<br>2-4 |                                      |
| JP 7-190534 A                             | 28 July 1995                         | (Family: none)                                         |                                      |

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2016017738 A [0004]