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(54) REFRIGERATION DEVICE

(57) The performing of wasteful defrosting, in which a defrosting operation is started when no frost has formed on the outdoor heat exchanger, is prevented. The refrigeration apparatus of the present invention is configured to start a defrosting operation for defrosting an outdoor heat exchanger (13) not only when a first necessary condition is met, which is that a state in which a continuous decrease of an indoor heat exchanger temperature is detected by an indoor heat exchanger temperature sensor (33) continues over a first set time, but also when a second necessary condition is met, which is that a state in which a continuous decrease of an outdoor heat exchanger temperature is detected by an outdoor heat exchanger temperature sensor (23) continues over a second set time.

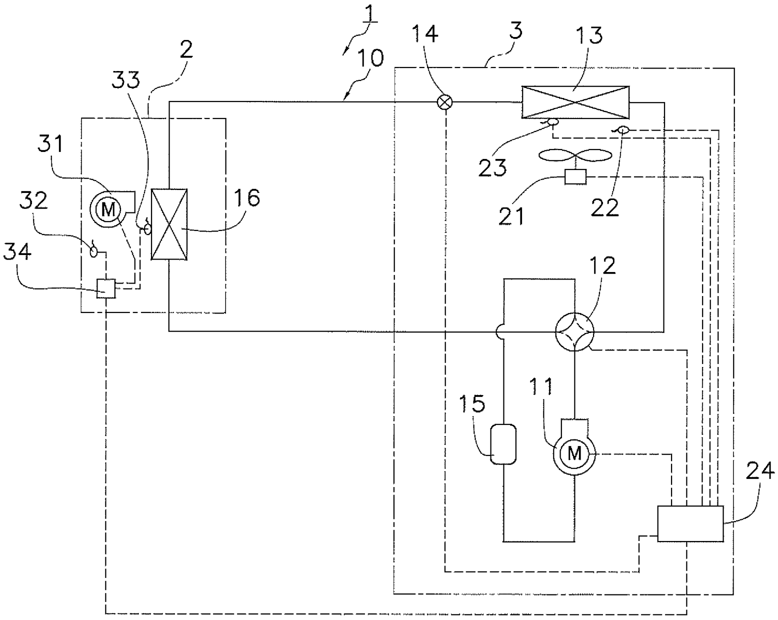

FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigeration apparatus provided with a refrigeration circuit.

BACKGROUND ART

[0002] Conventionally, in refrigeration apparatuses, a defrosting operation is performed in order to remove frost forming on an outdoor heat exchanger. For example, as disclosed in Patent Literature 1 (Japanese Laid-open Patent Publication No. 9-243210), Patent Literature 2 (Japanese Laid-open Patent Publication No. 10-103818), etc., the fact that the temperature of the outdoor heat exchanger has decreased to no higher than a predetermined value is sensed for the purpose of learning that frost has begun to form on an indoor heat exchanger in order to determine whether or not to start a defrosting operation for removing the frost on the outdoor heat exchanger.

SUMMARY OF THE INVENTION

<Technical Problem>

[0003] In the refrigeration apparatus disclosed in Patent Literature 1 or Patent Literature 2, other than the condition that the temperature of the outdoor heat exchanger be a predetermined value or lower, the condition that the indoor heat exchanger temperature be a predetermined value or lower, the condition that the operating frequency of a compressor be a predetermined value or lower, etc. are also added to the conditions for performing defrosting, and the outdoor heat exchanger temperature at which the defrosting operation is started is set with the operating frequency of the compressor, the outside air temperature, and/or the outside air humidity taken into account. However, even if control is performed so that the defrosting operation starts under the conditions such as those disclosed in Patent Literature 1 and/or Patent Literature 2, it is insufficient to prevent wasteful defrosting, in which the defrosting operation is started when no frost has formed on the outdoor heat exchanger. Wasteful defrosting is, in other words, erroneous defrosting.

[0004] An object of the present invention is to prevent the performing of wasteful defrosting, in which the defrosting operation is started when no frost has formed on the outdoor heat exchanger.

<Solution to Problem>

[0005] A refrigeration apparatus according to a first aspect of the present invention comprises: a refrigeration circuit configured to repeat a vapor-compression refrigeration cycle by channeling refrigerant sequentially through a compressor, an indoor heat exchanger, an expansion mechanism, and an outdoor heat exchanger; a first sensor configured to detect an indoor heat exchanger temperature of the indoor heat exchanger; and a second sensor configured to detect an outdoor heat exchanger temperature of the outdoor heat exchanger, wherein the refrigeration apparatus is configured to start a defrosting operation to defrost the outdoor heat exchanger when a first necessary condition and a second condition is met, is the first condition being that a continuous decrease of the indoor heat exchanger temperature detected by the first sensor continues over a first set time, the second necessary condition being that a continuous decrease of the outdoor heat exchanger temperature detected by the second sensor continues over a second set time.

[0006] In this refrigeration apparatus, the conditions to start the defrosting operation are not only the first necessary condition, which is that a state in which a continuous decrease of the indoor heat exchanger temperature is detected by the first sensor continues over a first set time, but also a second necessary condition which is that a state in which a continuous decrease of the outdoor heat exchanger temperature is detected by the second sensor continues over a second set time, therefore cases of the temperature of the outdoor heat exchanger increasing due to no frost having formed on the outdoor heat exchanger in spite of the temperature of the indoor heat exchanger decreasing for reasons other than frost forming on the outdoor heat exchanger can be excluded from cases of starting a defrosting operation.

[0007] A refrigeration apparatus according to a second aspect of the present invention is the refrigeration apparatus according to the first aspect, wherein the second necessary condition is determined to have been met when average values of sampling values of the outdoor heat exchanger temperature within respective predetermined sampling times, detected by the second sensor, continues to not increase for at least a predetermined number of times.

[0008] Because an average value of the outdoor heat exchanger temperature within a predetermined sampling time is used in this refrigeration apparatus, it is possible to suppress error in determining that the second necessary condition has been met due to noise encountered in measuring the outdoor heat exchanger temperature.

[0009] A refrigeration apparatus according to a third aspect of the present invention is the refrigeration apparatus according to the first aspect, further comprising a third sensor configured to detect an outside air temperature at a location where the outdoor heat exchanger is installed, wherein a third necessary condition is that the outdoor heat exchanger temperature detected by the second sensor is lower than a defrosting start temperature set according to the outside air temperature detected by the third sensor and an operating frequency of the compressor, and the refrigeration apparatus is configured to start the defrosting operation when the first necessary condition, the second necessary condition, and the third necessary condition have been simultaneously met.

[0010] Because a third necessary condition, which is that the outdoor heat exchanger temperature be lower than the defrosting start temperature set according to the outside air temperature and the operating frequency of the compressor, is used in this refrigeration apparatus, whether or not to start the defrosting operation can be determined additionally taking environments where frost forms into account.

[0011] A refrigeration apparatus according to a fourth aspect of the present invention is the refrigeration apparatus according to the third aspect, wherein the third necessary condition is a condition that a time period during which the outdoor heat exchanger temperature is lower than the defrosting start temperature continues over a third set time.

[0012] In this refrigeration apparatus, when the time period during which the outdoor heat exchanger temperature is lower than the defrosting start temperature does not continue over the third set time, the defrosting operation is not started even if the first necessary condition and the second necessary condition are met, and therefore the outside air temperature and the operating status of the compressor can be reflected in the determination of whether or not to start the defrosting operation.

<Advantageous Effects of Invention>

[0013] With the refrigeration apparatus according to the first aspect of the present invention, it is possible to prevent the performing of wasteful defrosting, in which the defrosting operation is started when no frost has formed on the outdoor heat exchanger.

[0014] With the refrigeration apparatus according to the second aspect of the present invention, the performing of wasteful defrosting can be consistently prevented.

[0015] With the refrigeration apparatus according to the third aspect of the present invention, it is easy to prevent wasteful defrosting from being performed by also taking environments where frost forms into account.

[0016] With the refrigeration apparatus according to the fourth aspect of the present invention, the effect of preventing wasteful defrosting from being performed is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a perspective view showing the outward appearance of an air conditioner according to an embodiment;
FIG. 2 is a circuit diagram showing a summary of the configuration of an air conditioner according to an embodiment;
FIG. 3 is a cross-sectional view of FIG. 1 sectioned along line I-I;
FIG. 4 is a timing chart showing a summary of the exchanging of main signals between the outdoor unit and the indoor unit;
FIG. 5 is a graph showing an example of the change of time in the outdoor heat exchanger temperature;
FIG. 6 is a flowchart for describing a summary of the method to determine that the defrosting operation will be started;
FIG. 7 is a flowchart for describing an example of the method to determine that the defrosting operation will be started;
FIG. 8 is a flowchart for describing another example of the method to determine that the defrosting operation will be started;
FIG. 9 is a graph showing an example of the relationship of the defrosting start determination to the change over time in the temperature difference between the indoor heat exchanger temperature and the indoor temperature; and
FIG. 10 is a graph showing another example of the relationship of the defrosting start determination to the change over time in the temperature difference between the indoor heat exchanger temperature and the indoor temperature.

DESCRIPTION OF EMBODIMENTS

(1) Summary of Configuration of Air Conditioner

[0018] An air conditioner is described below as an example of a refrigeration apparatus according to an embodiment of the present invention. First, a summary of the configuration of an air conditioner according to an embodiment of the present invention is described using FIGS. 1 and 2. An air conditioner 1 shown in FIG. 1 is provided with an indoor unit 2 attached to a wall surface WL or the like indoors, and an outdoor unit 3 installed outdoors. FIG. 2 is a circuit diagram of the air conditioner 1. This air conditioner 1 is provided with a refrigeration circuit 10, and is able to perform a vapor-compression refrigeration cycle by causing a refrigerant inside the refrigeration circuit 10 to circulate. To cause the refrigerant to circulate in the refrigeration circuit 10, the indoor unit 2 and the outdoor unit 3 are connected by a communication pipe 4.

(1-1) Refrigeration Circuit 10

[0019] The refrigeration circuit 10 is provided with a compressor 11, a four-way switching valve 12, an outdoor heat exchanger 13, an expansion mechanism 14, an accumulator 15, and an indoor heat exchanger 16. The compressor 11, which takes in refrigerant from an intake port and discharges compressed refrigerant from a discharge port, blows the refrigerant discharged from the discharge port toward a first port of the four-way switching valve 12.

[0020] When the air conditioner 1 is in an air-warming operation, the four-way switching valve 12 allows refrigerant to flow between the first port and a fourth port while simultaneously allowing refrigerant to flow between a second port and a third port, as shown by the dashed lines. When the air conditioner 1 is in an air-cooling operation and also when the air conditioner 1 is in a reverse-cycle defrosting operation, the four-way switching valve 12 allows refrigerant to flow between the first port and the second port while simultaneously allowing refrigerant to flow between the third port and the fourth port, as shown by the solid lines.

[0021] The outdoor heat exchanger 13 has a gas-side outlet/inlet for mainly allowing gas refrigerant to flow between the outdoor heat exchanger 13 and the second port of the four-way switching valve 12, and also has a liquid-side outlet/inlet for mainly allowing liquid refrigerant to flow between the outdoor heat exchanger 13 and the expansion mechanism 14. The outdoor heat exchanger 13 allows heat to be exchanged between outdoor air and refrigerant flowing through heat transfer tubes (not shown) connected between the liquid-side outlet/inlet and the gas-side outlet/inlet of the outdoor heat exchanger 13.

[0022] The expansion mechanism 14 is disposed between the outdoor heat exchanger 13 and the indoor heat exchanger 16. The expansion mechanism 14 has the function of expanding and decompressing the refrigerant flowing between the outdoor heat exchanger 13 and the indoor heat exchanger 16.

[0023] The indoor heat exchanger 16 has a liquid-side outlet/inlet for mainly allowing liquid refrigerant to flow between the indoor heat exchanger 16 and the expansion mechanism 14, and also has a gas-side outlet/inlet for mainly allowing gas refrigerant to flow between the indoor heat exchanger 16 and the fourth port of the four-way switching valve 12. The indoor heat exchanger 16 allows heat to be exchanged between indoor air and the refrigerant flowing through heat transfer tubes 16a (see FIG. 3) connected between the liquid-side outlet/inlet and the gas-side outlet/inlet of the indoor heat exchanger 16.

[0024] An accumulator 15 is disposed between the third port of the four-way switching valve 12 and the intake port of the compressor 11. In the accumulator 15, refrigerant flowing from the third port of the four-way switching valve 12 to the compressor 11 is separated into gas refrigerant and liquid refrigerant. Mainly gas refrigerant is supplied from the accumulator 15 to the intake port of the compressor 11.

(1-2) Configuration other than refrigeration circuit 10

[0025] The outdoor unit 3 is provided with an outdoor fan 21 for generating an air flow of outdoor air through the outdoor heat exchanger 13. The outdoor unit 3 is also provided with an outdoor temperature sensor 22 for measuring the temperature of outdoor air, and an outdoor heat exchanger temperature sensor 23 for measuring the temperature of the outdoor heat exchanger 13. Furthermore, the outdoor unit 3 is provided with an outdoor-side control device 24 that controls the compressor 11, the four-way switching valve 12, the expansion mechanism 14, and the outdoor fan 21. This outdoor-side control device 24 includes, e.g., a CPU (not shown) and memory (not shown), and the outdoor-side control device 24 is configured to be able to control the outdoor unit 3 in accordance with stored programs and the like. The outdoor-side control device 24 is connected to the outdoor temperature sensor 22 and the outdoor heat exchanger temperature sensor 23 in order to receive signals pertaining to the temperatures measured by the outdoor temperature sensor 22 and the outdoor heat exchanger temperature sensor 23.

[0026] The indoor unit 2 is provided with an indoor fan 31 for generating an air flow of indoor air through the indoor heat exchanger 16. The indoor unit 2 is also provided with an indoor temperature sensor 32 for measuring the temperature of indoor air, and an indoor heat exchanger temperature sensor 33 for measuring the temperature of the indoor heat exchanger 16. Furthermore, the indoor unit 2 is provided with an indoor-side control device 34 that controls the indoor fan 31. This indoor-side control device 34 includes, e.g., a CPU (not shown) and memory (not shown), and the indoor-side control device 34 is configured to be able to control the outdoor unit 3 in accordance with stored programs and the like. The indoor-side control device 34 is connected to the indoor temperature sensor 32 and the indoor heat exchanger temperature sensor 33 in order to receive signals pertaining to the temperatures measured by the indoor temperature sensor 32 and the indoor heat exchanger temperature sensor 33.

[0027] The outdoor-side control device 24 and the indoor-side control device 34 are connected to each other by a signal line, and are configured to be able to send and receive signals to and from each other.

(1-3) Detailed Configuration of Indoor Unit 2

[0028] FIG. 3 shows a cross-section of the indoor unit, sectioned along line I-I in FIG. 1. The indoor unit 2 is provided with a casing 41, the indoor heat exchanger 16, the indoor fan 31, an air filter 42, a horizontal flap 43, and a vertical flap 49.

[0029] An upper-surface intake port 44 is provided to the upper-surface of the casing 41. Indoor air in the proximity to the upper-surface intake port 44 is taken into the casing 41 from the upper-surface intake port 44 due to the driving of the indoor fan 31, and is sent to the indoor heat exchanger 16, which is shaped like an upside-down "V" in cross-section. The dashed-line arrows A in FIG. 3 represent the flow of indoor air sent from the upper-surface intake port 44 to the indoor fan 31 via the indoor heat exchanger 16.

[0030] A lower-surface intake port 45 and a blow-out port 46 are formed in the lower-surface of the casing 41. The lower-surface intake port 45 is provided nearer to the wall than the blow-out port 46, and is connected to the interior of the casing 41 by an intake flow channel 47. Indoor air in proximity to the lower-surface intake port 45 is taken into the casing 41 from the lower-surface intake port 45 by the driving of the indoor fan 31, and is sent through the intake flow channel 47 to the indoor heat exchanger 16. The dashed-line arrow B in FIG. 3 represents the flow of indoor air sent from the lower-surface intake port 45 to the indoor heat exchanger 16.

[0031] The blow-out port 46 is provided nearer to the front-surface side of the indoor unit 2 than the lower-surface intake port 45, and is connected to the interior of the casing 41 by a blow-out flow channel 48. Indoor air taken in from the upper-surface intake port 44 and the lower-surface intake port 45 exchanges heat in the indoor heat exchanger 16, after which the indoor air is passed through the blow-out flow channel 48 and blown out from the blow-out port 46 into the room. The dashed-line arrow C in FIG. 3 represents the flow of air sent from the blow-out flow channel 48 into the room via the blow-out port 46.

[0032] Two horizontal flaps 43 are turnably attached to the casing 41 in proximity to the blow-out port 46. The horizontal flaps 43, turned by a flap-driving motor (not shown), open and close the blow-out port 46 in accordance with the operating state of the indoor unit 2. Furthermore, the horizontal flaps 43 have the function of varying the blow-out direction of indoor air up and down so that indoor air blown out from the blow-out port 46 is guided in the direction desired by the user. In addition, the vertical flap 49 is turnably attached to the casing 41 in proximity to the blow-out port 46. The vertical flap 49, turned by a flap-driving motor (not shown), has the function varying the blow-out direction of indoor air left and right.

(2) Summary of Air-Warming Operation, Air-Cooling Operation, and Reverse-Cycle Defrosting operation

(2-1) Air-Warming Operation

[0033] When the air conditioner 1 is in the air-warming operation, the four-way switching valve 12 switches to the state of the dashed lines shown in FIG. 2. Specifically, high-temperature, high-pressure gas refrigerant discharged from the compressor 11 flows into the indoor heat exchanger 16 via the four-way switching valve 12. At this time, the indoor heat exchanger 16 functions as a condenser. Therefore, as the refrigerant flows through the indoor heat exchanger 16, the refrigerant warms the indoor air while being cooled by exchanging heat with the indoor air, and the refrigerant condenses and changes from gas refrigerant to liquid refrigerant. Having lost temperature in the indoor heat exchanger 16, the low-temperature, high-pressure refrigerant is decompressed by the expansion mechanism 14 and changed to low-temperature, low-pressure refrigerant. Having flowed into the outdoor heat exchanger 13 via the expansion mechanism 14, the refrigerant is warmed by exchanging heat with outdoor air, and the refrigerant evaporates and changes from liquid refrigerant to gas refrigerant. At this time, the outdoor heat exchanger 13 functions as an evaporator. Refrigerant composed mainly of low-temperature gas refrigerant is then drawn into the compressor 11 from the outdoor heat exchanger 13 via the four-way switching valve 12 and the accumulator 15. The refrigerant is channeled sequentially through the compressor 11, the indoor heat exchanger 16, the expansion mechanism 14, and the outdoor heat exchanger 13, and the repetition of this vapor-compression refrigeration cycle is the forward cycle.

(2-2) Air-Cooling Operation

[0034] During the air-cooling operation of the air conditioner 1, the four-way switching valve 12 switches to the state of the solid lines shown in FIG. 2. Specifically, high-temperature, high-pressure gas refrigerant discharged from the compressor 11 flows into the outdoor heat exchanger 13 via the four-way switching valve 12. At this time, the outdoor heat exchanger 13 functions as a condenser. Therefore, as the refrigerant flows through the outdoor heat exchanger 13, the refrigerant is cooled by exchanging heat with the outdoor air, and the refrigerant condenses and changes from gas refrigerant to liquid refrigerant. Having lost temperature in the outdoor heat exchanger 13, the low-temperature, high-pressure refrigerant is decompressed by the expansion mechanism 14 and changed to low-temperature, low-pressure refrigerant. Having flowed into the indoor heat exchanger 16 via the expansion mechanism 14, the refrigerant cools the indoor air and is warmed by exchanging heat with the indoor air, and the refrigerant evaporates and changes from liquid refrigerant to gas refrigerant. At this time, the indoor heat exchanger 16 functions as an evaporator. Refrigerant composed mainly of low-temperature gas refrigerant is then drawn into the compressor 11 from the indoor heat exchanger 16 via the four-way switching valve 12 and the accumulator 15.

(2-3) Reverse-Cycle Defrosting operation

[0035] The reverse-cycle defrosting operation is performed in order to remove frost that has formed on the outdoor heat exchanger 13 due to the air-warming operation being performed. Therefore, operation switches to the reverse-cycle defrosting operation midway through the air-warming operation, and the air-warming operation is resumed when the reverse-cycle defrosting operation ends. In the reverse-cycle defrosting operation, as with the air-cooling operation, the four-way switching valve 12 switches to the state of the solid lines shown in FIG. 2. The same vapor-compression refrigeration cycle as the air-cooling operation is then repeated in the reverse-cycle defrosting operation as well. In other words, in reverse of the forward cycle during the air-warming operation, the cycle performed during the reverse-cycle defrosting operation is a reverse cycle, in which the vapor-compression refrigeration cycle is repeated with refrigerant being channeled sequentially through the compressor 11, the outdoor heat exchanger 13, the expansion mechanism 14, and the indoor heat exchanger 16.

[0036] When the reverse-cycle defrosting operation begins, the outdoor unit 3 concludes that defrosting will be performed by the outdoor-side control device 24 when air-warming control is being performed, as shown in FIG. 3. A defrosting start determination is described hereinafter. When the outdoor unit 3 concludes that defrosting will be performed, a defrosting request signal SG1 is transmitted from the outdoor-side control device 24 of the outdoor unit 3 to the indoor-side control device 34 of the indoor unit 2. When the indoor-side control device 34 receives the defrosting request signal SG1, the indoor unit 2 begins preparations for the defrosting operation. For example, in cases in which an electric heater (not shown) is installed to supplementarily warm the indoor air, the indoor-side control device 34 leaves the indoor fan 31 on for some time after turning the electric heater off, and completes preparations for the defrosting operation when the electric heater has been cooled.

[0037] When the indoor unit 2 has completed defrosting operation preparations, the indoor-side control device 34 transmits a defrosting permit signal SG2 to the outdoor-side control device 24. Upon receiving the defrosting permit signal SG2, the outdoor-side control device 24 begins defrosting control and transmits a signal SG3 indicating that defrosting is occurring to the indoor-side control device 34.

[0038] In the outdoor unit 3, when the outdoor-side control device 24 determines that defrosting has ended, a normal notification signal SG4 is transmitted from the outdoor-side control device 24 to notify the indoor-side control device 34 of the indoor unit 2 that the air conditioner will return to the normal air-warming operation. The indoor unit 2, having received the normal notification signal SG4, resumes air-warming control for the air-warming operation.

(3) Defrosting Start Determination

(3-1) Ending of Reverse-Cycle Defrosting operation

[0039] The outdoor heat exchanger temperature during the reverse-cycle defrosting operation and before and after this operation is shown in FIG. 5. The values shown on the time axis of FIG. 5 are one example for making the description easy to understand, and these values change due to the outside air temperature and/or the operating state of the air conditioner 1. When defrosting is started, the temperature of the outdoor heat exchanger 13 gradually increases until thirty seconds have elapsed since the start. During the period in which the frost melts, after thirty seconds have elapsed since the start and the temperature of the outdoor heat exchanger 13 has reached 0°C, the temperature of the outdoor heat exchanger 13 is maintained at 0°C. When the frost formed on the outdoor heat exchanger 13 has melted away, the temperature of the outdoor heat exchanger 13 begins to increase. In FIG. 5, the frost has completely melted at the timepoint when ninety seconds has elapsed, and a temperature increase is therefore observed after ninety seconds has elapsed. The outdoor-side control device 24 monitors the outdoor heat exchanger temperature using the outdoor heat exchanger temperature sensor 23. When the outdoor-side control device 24 senses that the outdoor heat exchanger temperature has reached Ta°C due to the increase in the outdoor heat exchanger temperature beyond ninety seconds, the outdoor-side control device 24 concludes to end the reverse-cycle defrosting operation.

[0040] As was already described, the defrosting time required from defrosting start to defrosting end changes due to the outside air temperature and/or the operating state of the air conditioner 1. In other words, there are cases of longer, as well as shorter, defrosting times. The outdoor-side control device 24 stores a threshold value tr, and discerns whether the defrosting time is longer or shorter than the threshold value tr every time the reverse-cycle defrosting operation is performed.

(3-2) Determination to Start Reverse-Cycle Defrosting operation

(3-2-1) Summary of Determination to Start

[0041] A summary of the determination to start the reverse-cycle defrosting operation is described using FIG. 6. First, the indoor-side control device 34 of the indoor unit 2 measures an indoor heat exchanger temperature Tei of the indoor heat exchanger 16 using the indoor heat exchanger temperature sensor 33 (step ST1), and the outdoor-side control device 24 of the outdoor unit 3 measures an outdoor heat exchanger temperature Teo of the outdoor heat exchanger 13 using the outdoor heat exchanger temperature sensor 23 (step ST2). FIG. 6 indicates that the indoor heat exchanger temperature Tei is measured prior to the outdoor heat exchanger temperature Teo measurement, but either one of these measurements may be performed first, or they may be performed simultaneously.

[0042] Next, a determination is made as to whether or not the indoor heat exchanger temperature Tei has continuously decreased over a first set time (step ST3), and a determination is made as to whether or not the outdoor heat exchanger temperature Teo has continuously decreased over a second set time (step ST4). The former of these determinations is a determination of a first necessary condition, and the latter is a determination of a second necessary condition. These determinations, which are performed separately by the indoor-side control device 34 and the outdoor-side control device 24, involve the exchange of information between the indoor-side control device 34 and the outdoor-side control device 24; the results alone can be compiled by either one of the control devices, and whether or not both the first necessary condition and the second necessary condition have been satisfied can be determined by the control device that has compiled the results. As another option, the outdoor heat exchanger temperature Teo and the indoor heat exchanger temperature Tei may be compiled in either one of the indoor-side control device 34 and the outdoor-side control device 24, and whether or not both the first necessary condition and the second necessary condition have been satisfied may be determined by the control device that has the data on both the outdoor heat exchanger temperature Teo and the indoor heat exchanger temperature Tei.

[0043] The indoor heat exchanger temperature Tei and the outdoor heat exchanger temperature Teo are repeatedly measured until the above-described first and second necessary conditions are met. When the above-described first and second necessary conditions are met, the air conditioner 1 concludes, through the indoor-side control device 34 or the outdoor-side control device 24, that the defrosting operation is to be started (step ST5).

(3-2-2) Determination of Continuous Decrease of Outdoor Heat Exchanger Temperature

[0044] Next, a specific example of a determination of the continuous decrease of the outdoor heat exchanger temperature is described using FIG. 7. The flowchart shown in FIG. 7 differs from the flowchart shown in FIG. 6 in that the step of determining whether or not the outdoor heat exchanger temperature Teo has continuously decreased over the second set time (step ST4) is carried out in step ST11 and step ST12. In step ST11, the outdoor-side control device 24 samples the outdoor heat temperature n times over a certain time using a built-in sampling timer, and calculates the average value of the outdoor heat exchanger temperature Teo (ΣTeo/n). The value n in this case is a predetermined natural number. As a result of calculating the average value of the outdoor heat exchanger temperature Teo a predetermined m+1 number of times, if the next subsequent average value continues to be equal to or less than the previous average value for m number of times, the outdoor-side control device 24 or the indoor-side control device 34, having received the information from the outdoor-side control device 24, determines that the outdoor heat exchanger temperature Teo has continually decreased over the second set time (step ST12).

(4) Modifications

(4-1) Modification A

[0045] In the above embodiment, the condition of the determination to start the defrosting operation is that two conditions, the first necessary condition and the second necessary condition, are met, but another necessary condition may be added in order to make the determination to start the defrosting operation.

[0046] In the flow of making the determination to start the defrosting operation shown in FIG. 8, the difference with the above embodiment is the inclusion of step ST21, in which a defrosting start temperature is calculated from the outdoor heat exchanger temperature, and step ST22, in which a determination of whether or not to avoid starting the defrosting operation is made using the defrosting start temperature.

[0047] An example of the method of calculating the defrosting start temperature in step ST21 is described. The outdoor-side control device 24 measures the outside air temperature Tout using the outdoor temperature sensor 22. The outdoor-side control device 24 then determines if the outside air temperature Tout is either below a defrosting determination outside air temperature Tdd, or equal to or greater than the defrosting determination outside air temperature Tdd.

Additionally, the outdoor-side control device 24 determines whether the previous defrosting time tdf is longer or shorter than the threshold value tr, as was described in (3-1) above. The defrosting start temperature Tp is calculated according to these circumstances, using any of the following four formulas (1) to (4). In formulas (1) to (4), f denotes the operating frequency of the compressor 11, and β, $\varepsilon 1$, $\varepsilon 0$, $\alpha 1$, $\alpha 0$, and v are positive constants. The value Tp is set within a predetermined range. Additionally, the constants of formulas (1) to (4) have been concluded from the results of measuring the outdoor heat exchanger temperature that prompts starting the defrosting operation (the defrosting start temperature Tp), outside air temperature Tout and operating frequency f.
when

$$\text{Tout} < \text{Tdd and tdf} < \text{tr},\ \text{Tp} = -\beta \times f + \varepsilon 1 \times \text{Tout} - \alpha 1 \qquad (1)$$

when

$$\text{Tout} \geq \text{Tdd and tdf} < \text{tr},\ \text{Tp} = -\beta \times f + \varepsilon 0 \times \text{Tout} - \alpha 0 \qquad (2)$$

when

$$\text{Tout} < \text{Tdd and tdf} \geq \text{tr},\ \text{Tp} = -\beta \times f + \varepsilon 1 \times \text{Tout} - \alpha 1 + v \qquad (3)$$

when

$$\text{Tout} \geq \text{Tdd and tdf} \geq \text{tr},\ \text{Tp} = -\beta \times f + \varepsilon 0 \times \text{Tout} - \alpha 0 + v \qquad (4)$$

[0048] A comparison is made between the defrosting start temperature Tp calculated with appropriate use of the above formulas (1) to (4) and the outdoor heat exchanger temperature Teo sensed by the outdoor heat exchanger temperature sensor 23, and if the state Teo ≤ Tp continues over a third set time, the outdoor-side control device 24 concludes that the reverse-cycle defrosting operation will be started (step ST22).

(4-2) Modification B

[0049] In the above embodiment, a case of the indoor heat exchanger temperature Tei continuously decreasing over the first set time is described as an example of the first necessary condition when the determination is made to start the defrosting operation. However, when the indoor heat exchanger temperature Tei is determined to have continuously decreased, the indoor heat exchanger temperature Tei is affected by the indoor temperature Tin, and rectifications may therefore be made using the indoor temperature Tin. In other words, the aspect in which the indoor heat exchanger temperature Tei has continuously decreased over the first set time includes, e.g., the aspect in which a temperature difference ΔTei has continuously decreased over the first set time, the temperature difference ΔTei being defined as the difference between the indoor heat exchanger temperature Tei and the indoor temperature Tin (= Tei -Tin).
[0050] Specifically, first, the indoor-side control device 34 calculates the average value of temperature differences ΔTei sampled over a certain time. When the average value of temperature differences ΔTei has continued to decrease for k number of times, the indoor-side control device 34 determines that the first necessary condition has been met. Due to such a determination being made, a continuous decrease in the indoor heat exchanger temperature Tei can be determined while taking the effect of the indoor temperature Tin into account.

(4-3) Modification C

[0051] In Modification B described above, a case was described in which the first necessary condition is that the average value AvΔTei of temperature differences ΔTei continues to decrease for k times. However, using an example of k = 5 for such a determination, the first necessary condition for starting defrosting is met at the timepoint of time t22, at which the average value AvΔTei of temperature differences ΔTei has continually decreased five times since time t21, as shown in FIG. 9.
[0052] However, depending on the type of the apparatus, there are cases in which a first condition for starting defrosting should be met at point Q shown in FIG. 9. In view of this, in Modification C, the first necessary condition to be met is

either that the average value Av∆Tei of temperature differences ∆Tei continues to decrease for k number of times, or that the average value Av∆Tei of temperature differences ∆Tei does not increase over a first set time Ts1. In this case, even if the former condition is not met, the average value Av∆Tei of temperature differences ∆Tei does not increase but either remains at the same value or decreases from time t31 to time t32, as shown in FIG. 10. Thus, the first necessary condition for starting defrosting is met at a comparatively earlier timing than in FIG. 9.

(5) Characteristics

(5-1)

[0053] As described above, in the air conditioner 1, which is an example of the refrigeration apparatus according to the embodiment, the first necessary condition for the air conditioner to start the defrosting operation is that a state in which a continuous decrease in the indoor heat exchanger temperature Tei of the indoor heat exchanger 16 is detected by the indoor heat exchanger temperature sensor 33 continues over a first set time. The second necessary condition is that a state in which a continuous decrease in the outdoor heat exchanger temperature Teo of the outdoor heat exchanger 13 is detected by the outdoor heat exchanger temperature sensor 23 continues over the second set time. In this case, the indoor heat exchanger temperature sensor 33 is a first sensor, and the outdoor heat exchanger temperature sensor 23 is a second sensor. The first necessary condition is not the only condition for the air conditioner to start the defrosting operation; the second necessary condition is a condition as well. Therefore, but cases of the temperature of the outdoor heat exchanger 13 increasing due to no frost having formed on the outdoor heat exchanger 13 in spite of the temperature of the indoor heat exchanger 16 decreasing for reasons other than frost forming on the outdoor heat exchanger 13 can be excluded from cases of starting the defrosting operation.

(5-2)

[0054] In the air conditioner 1 described above, the average sampling values, within respective predetermined sampling times, of the outdoor heat exchanger temperature Teo of the outdoor heat exchanger 13; i.e., the average values (ΣTeo/n) of sampling values of the outdoor heat exchanger temperature sampled a predetermined n times, are used. As a result, it is possible to suppress error in determining that the second necessary condition has been met due to noise encountered in measuring the outdoor heat exchanger temperature Teo, and the performing of wasteful defrosting can be consistently prevented.

(5-3)

[0055] In the air conditioner 1 described above, a third necessary condition is that the outdoor heat exchanger temperature Teo of the outdoor heat exchanger 13 be lower than the defrosting start temperature Tp set according to the outside air temperature Tout and the operating frequency f of the compressor 11. Because such a third necessary condition is used, whether or not to start the defrosting operation can be determined with account also taken for environments where frost forms, and therefore the performing of wasteful defrosting is easily prevented.

(5-4)

[0056] The air conditioner 1 described above is configured so that when the time period during which the outdoor heat exchanger temperature Teo is lower than the defrosting start temperature Tp does not continue over the third set time, the defrosting operation does not start even if the first necessary condition and the second necessary condition are met. As a result, the outside air temperature Tout and the operating status of the compressor 11 can be reflected in the determination of whether or not to start the defrosting operation, and the effect of preventing wasteful defrosting from being performed is increased.

REFERENCE SIGNS LIST

[0057]

1 Air conditioner
2 Indoor unit
3 Outdoor unit
10 Refrigeration circuit
11 Compressor

12 Four-way switching valve
13 Outdoor heat exchanger
14 Expansion mechanism
16 Indoor heat exchanger
21 Outdoor fan
22 Outdoor temperature sensor
23 Outdoor heat exchanger temperature sensor
24 Outdoor-side control device
31 Indoor fan
32 Indoor temperature sensor
33 Indoor heat exchanger temperature sensor
34 Indoor-side control device

CITATION LIST

PATENT LITERATURE

[0058]

[Patent Literature 1] Japanese Laid-open Patent Publication No. 9-243210
[Patent Literature 2] Japanese Laid-open Patent Publication No. 10-103818

Claims

1. A refrigeration apparatus comprising:

a refrigeration circuit (10) configured to repeat a vapor-compression refrigeration cycle by channeling refrigerant sequentially through a compressor (11), an indoor heat exchanger (16), an expansion mechanism (14), and an outdoor heat exchanger (13);
a first sensor (33) configured to detect an indoor heat exchanger temperature of the indoor heat exchanger; and
a second sensor (23) configured to detect an outdoor heat exchanger temperature of the outdoor heat exchanger, wherein
the refrigeration apparatus is configured to start a defrosting operation to defrost the outdoor heat exchanger when a first necessary condition and a second necessary condition are met, the first necessary condition being that a state in which a continuous decrease of the indoor heat exchanger temperature is detected by the first sensor continues over a first set time, the second necessary condition being that a state in which a continuous decrease of the outdoor heat exchanger temperature is detected by the second sensor continues over a second set time.

2. The refrigeration apparatus according to claim 1, wherein
the second necessary condition is determined to have been met when average values of sampling values of the outdoor heat exchanger temperature within respective predetermined sampling times, detected by the second sensor, continues to not increase for at least a predetermined number of times.

3. The refrigeration apparatus according to claim 1, further comprising a third sensor (22) configured to detect an outside air temperature at a location where the outdoor heat exchanger is installed, wherein
a third necessary condition is that the outdoor heat exchanger temperature detected by the second sensor is lower than a defrosting start temperature set according to the outside air temperature detected by the third sensor and an operating frequency of the compressor, and the refrigeration apparatus is configured to start the defrosting operation when the first necessary condition, the second necessary condition, and the third necessary condition have been simultaneously met.

4. The refrigeration apparatus according to claim 3, wherein
the third necessary condition is a condition that a time period during which the outdoor heat exchanger temperature is lower than the defrosting start temperature continues over a third set time.

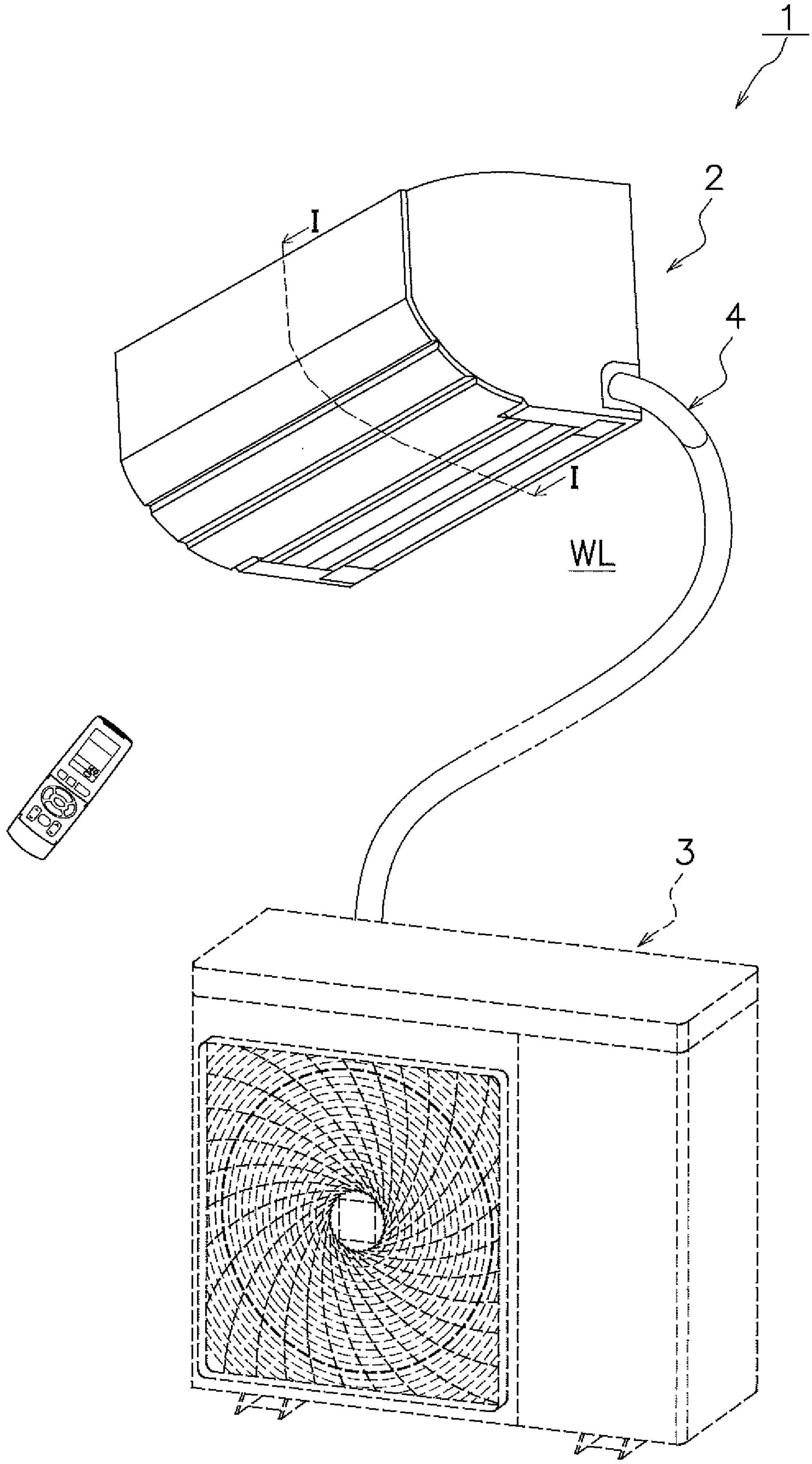


FIG. 1

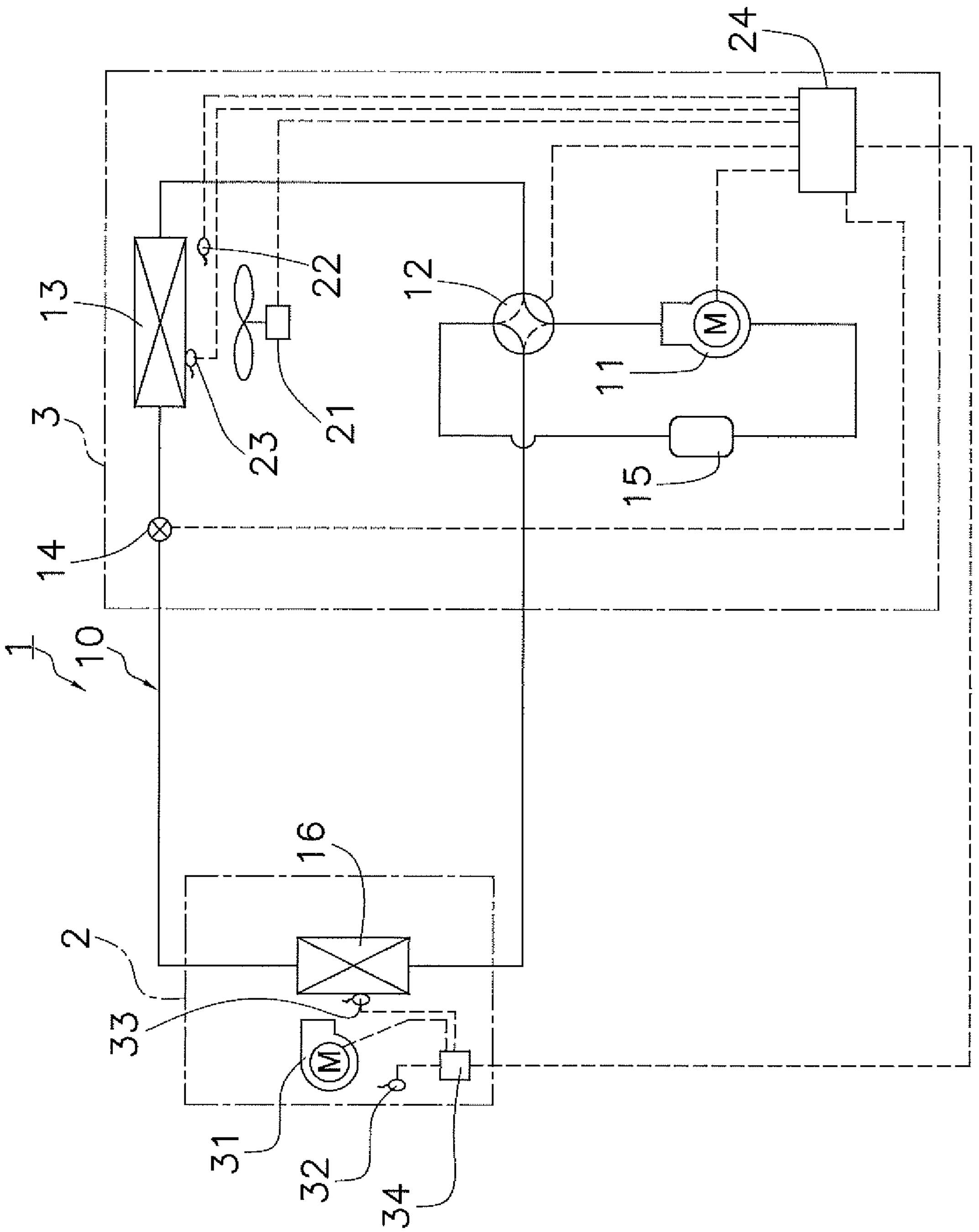
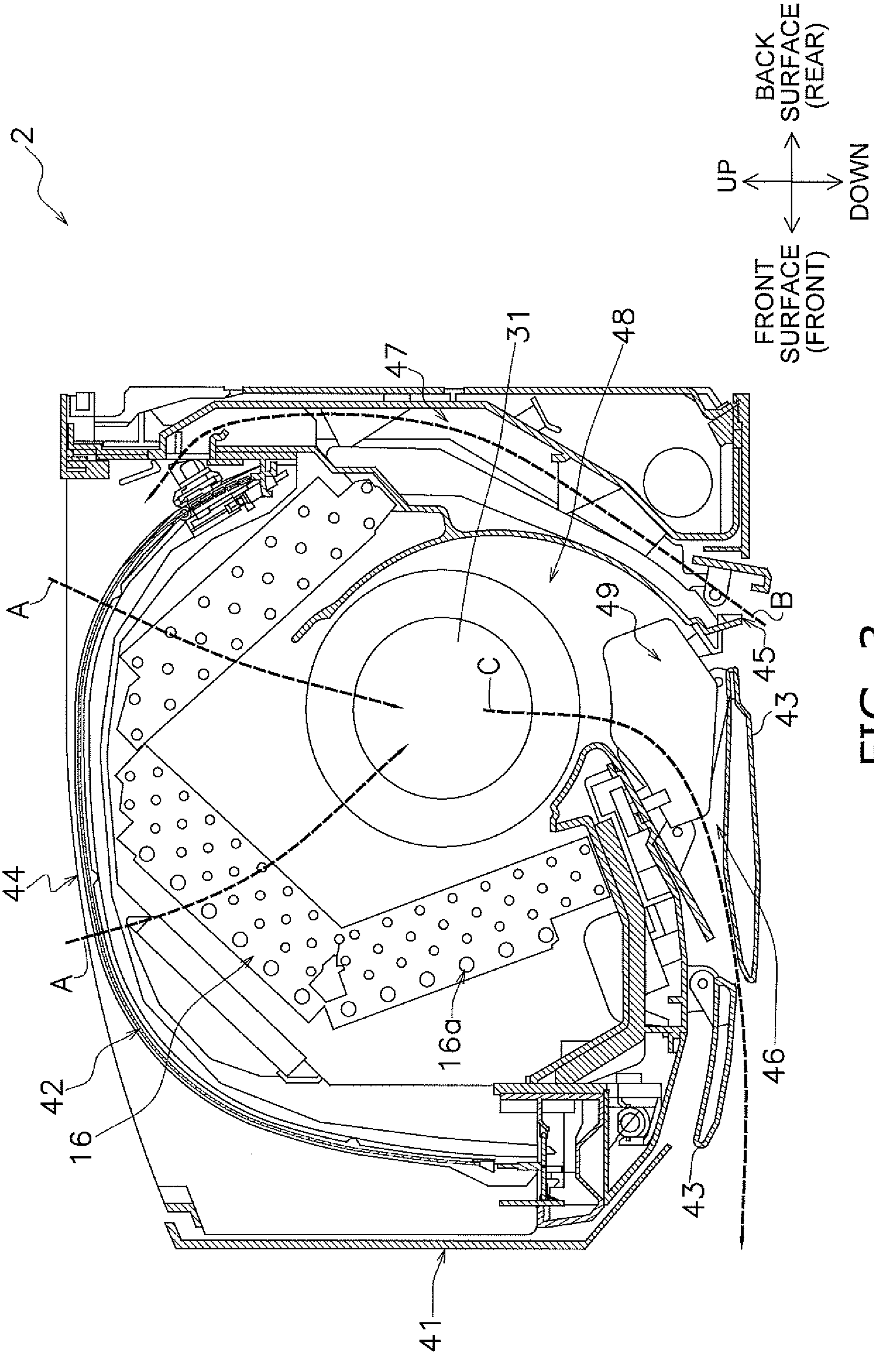


FIG. 2



2
UP
DOWN
BACK SURFACE (REAR)
FRONT SURFACE (FRONT)
47
31
48
A
A
44
49
B
45
C
43
43
42
16
16a
46
41

FIG. 3

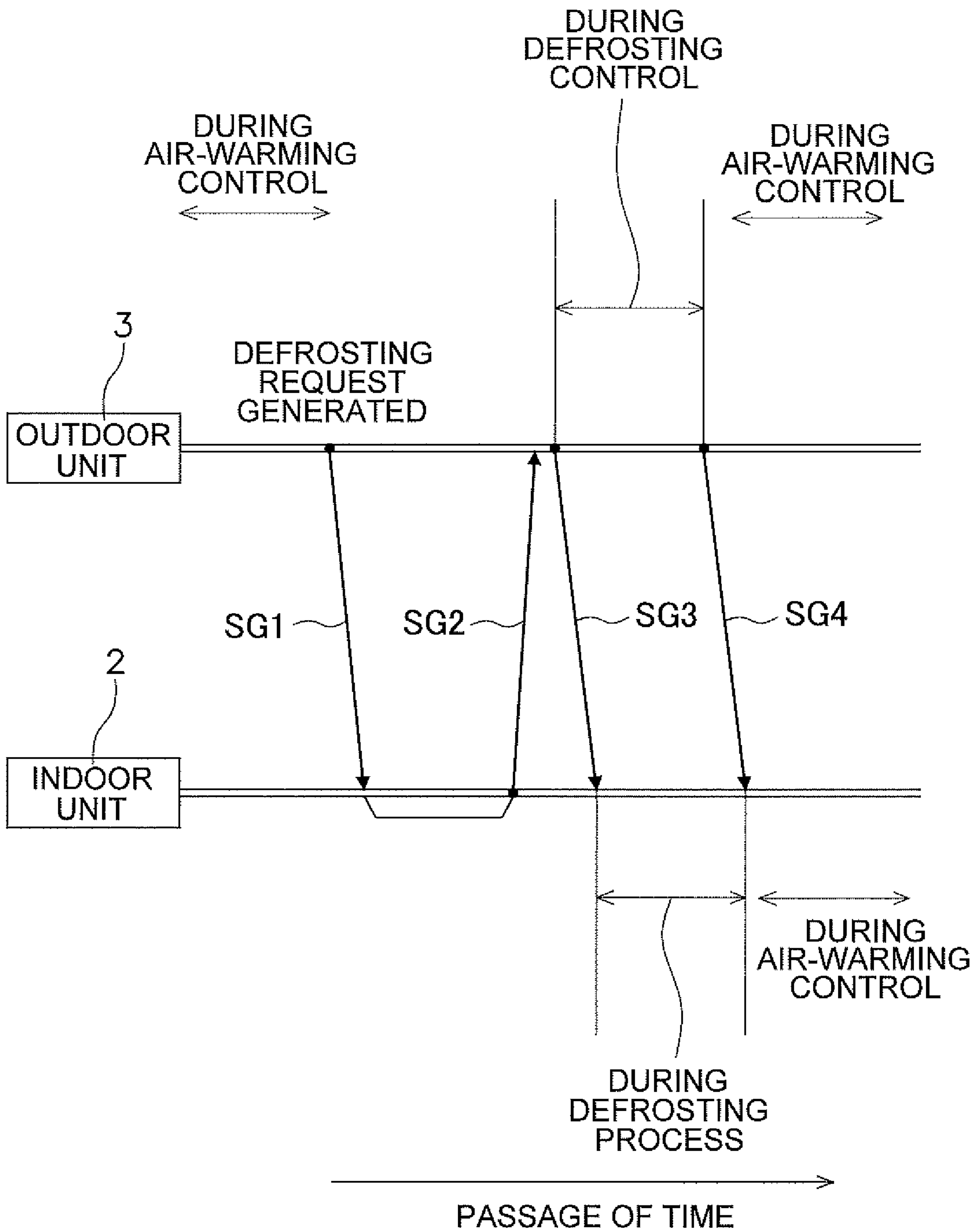

DURING
DEFROSTING
CONTROL
DURING
AIR-WARMING
CONTROL
DURING
AIR-WARMING
CONTROL
3
OUTDOOR
UNIT
DEFROSTING
REQUEST
GENERATED
SG1
SG2
SG3
SG4
2
INDOOR
UNIT
DURING
AIR-WARMING
CONTROL
DURING
DEFROSTING
PROCESS
PASSAGE OF TIME

FIG. 4

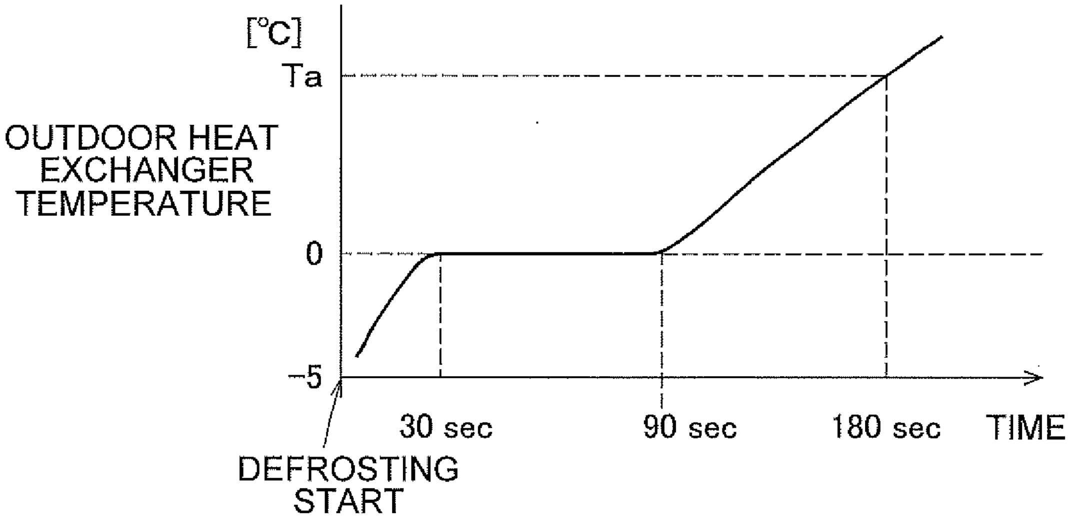

[°C]
Ta
OUTDOOR HEAT EXCHANGER TEMPERATURE
0
−5
30 sec
90 sec
180 sec
TIME
DEFROSTING START

FIG. 5

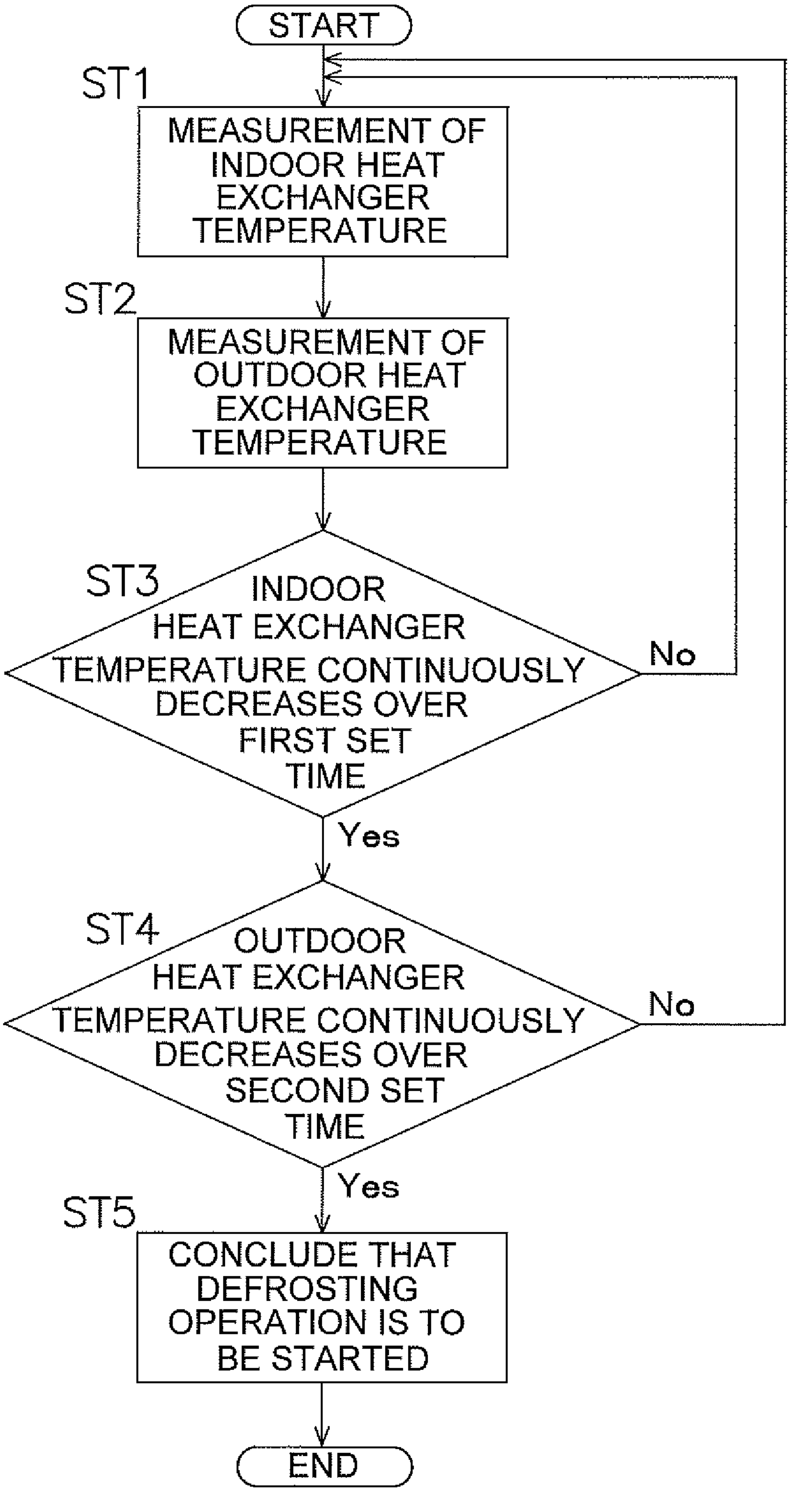

START
ST1
MEASUREMENT OF INDOOR HEAT EXCHANGER TEMPERATURE
ST2
MEASUREMENT OF OUTDOOR HEAT EXCHANGER TEMPERATURE
ST3
INDOOR HEAT EXCHANGER TEMPERATURE CONTINUOUSLY DECREASES OVER FIRST SET TIME
No
Yes
ST4
OUTDOOR HEAT EXCHANGER TEMPERATURE CONTINUOUSLY DECREASES OVER SECOND SET TIME
No
Yes
ST5
CONCLUDE THAT DEFROSTING OPERATION IS TO BE STARTED
END

FIG. 6

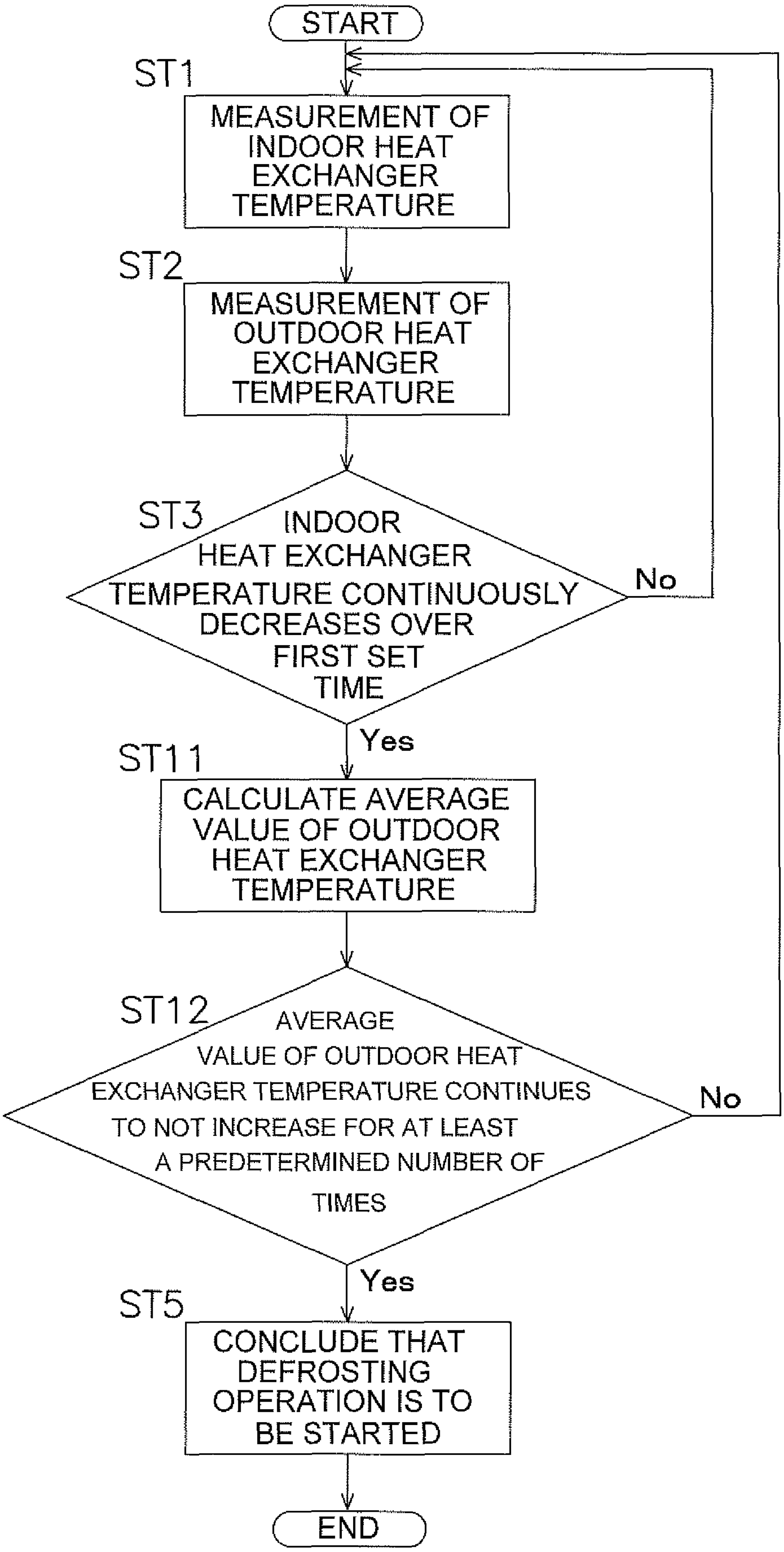

START
ST1
MEASUREMENT OF INDOOR HEAT EXCHANGER TEMPERATURE
ST2
MEASUREMENT OF OUTDOOR HEAT EXCHANGER TEMPERATURE
ST3
INDOOR HEAT EXCHANGER TEMPERATURE CONTINUOUSLY DECREASES OVER FIRST SET TIME
No
Yes
ST11
CALCULATE AVERAGE VALUE OF OUTDOOR HEAT EXCHANGER TEMPERATURE
ST12
AVERAGE VALUE OF OUTDOOR HEAT EXCHANGER TEMPERATURE CONTINUES TO NOT INCREASE FOR AT LEAST A PREDETERMINED NUMBER OF TIMES
No
Yes
ST5
CONCLUDE THAT DEFROSTING OPERATION IS TO BE STARTED
END

FIG. 7

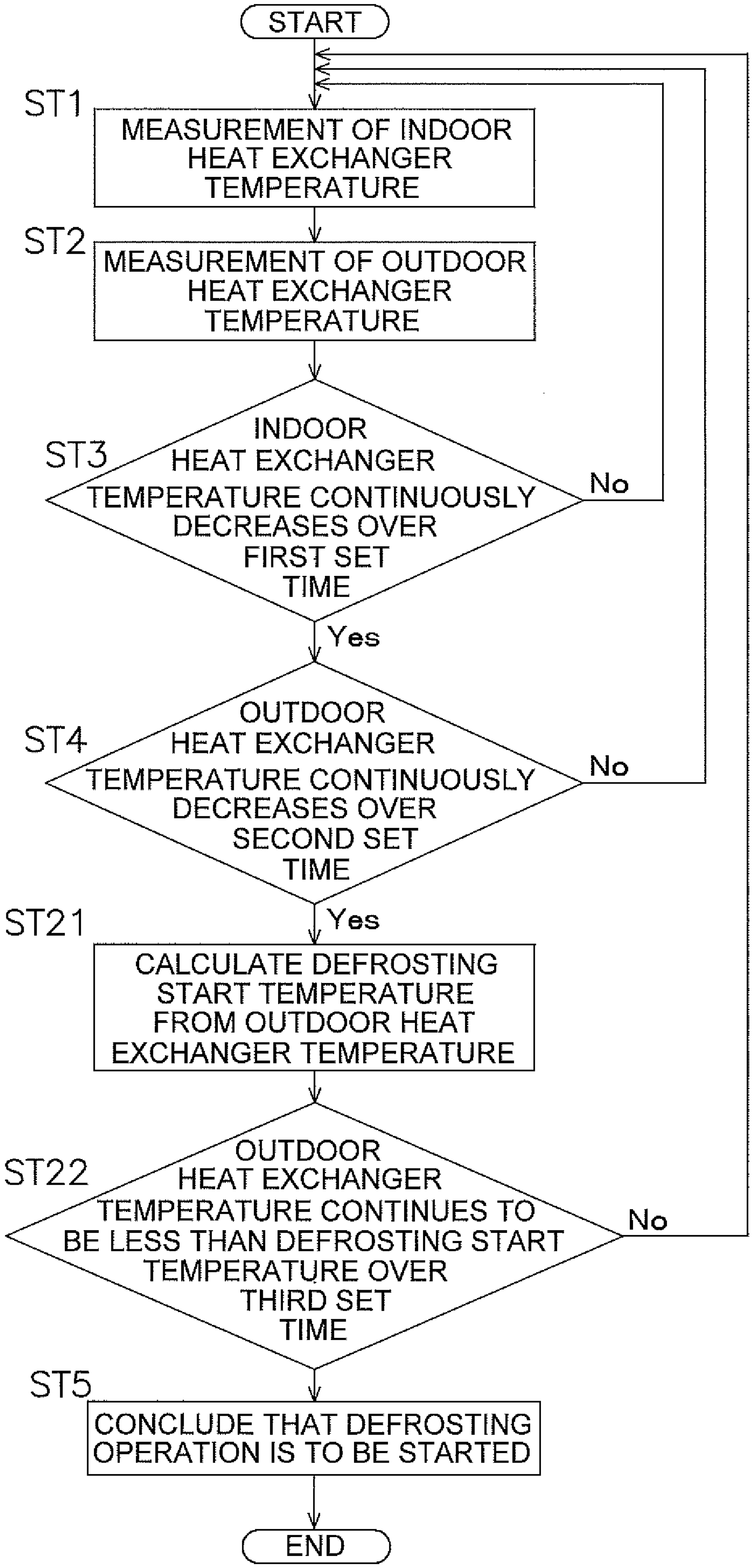

START
ST1
MEASUREMENT OF INDOOR HEAT EXCHANGER TEMPERATURE
ST2
MEASUREMENT OF OUTDOOR HEAT EXCHANGER TEMPERATURE
ST3
INDOOR HEAT EXCHANGER TEMPERATURE CONTINUOUSLY DECREASES OVER FIRST SET TIME
No
Yes
ST4
OUTDOOR HEAT EXCHANGER TEMPERATURE CONTINUOUSLY DECREASES OVER SECOND SET TIME
No
Yes
ST21
CALCULATE DEFROSTING START TEMPERATURE FROM OUTDOOR HEAT EXCHANGER TEMPERATURE
ST22
OUTDOOR HEAT EXCHANGER TEMPERATURE CONTINUES TO BE LESS THAN DEFROSTING START TEMPERATURE OVER THIRD SET TIME
No
ST5
CONCLUDE THAT DEFROSTING OPERATION IS TO BE STARTED
END

FIG. 8

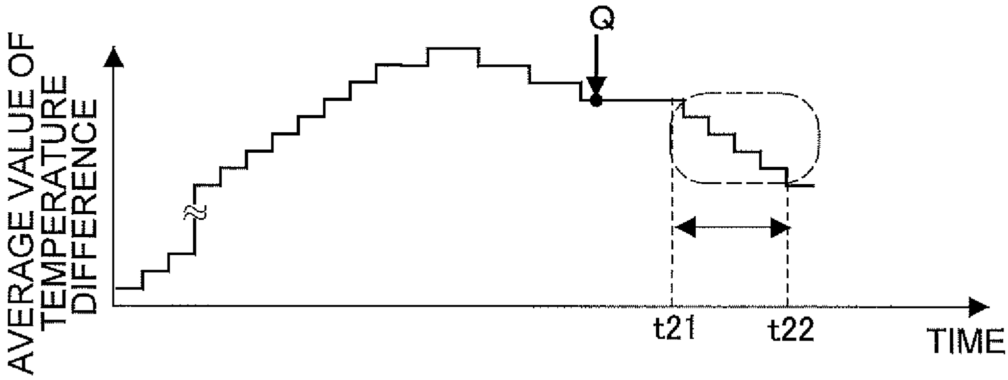

Q
AVERAGE VALUE OF TEMPERATURE DIFFERENCE
t21
t22
TIME

FIG. 9

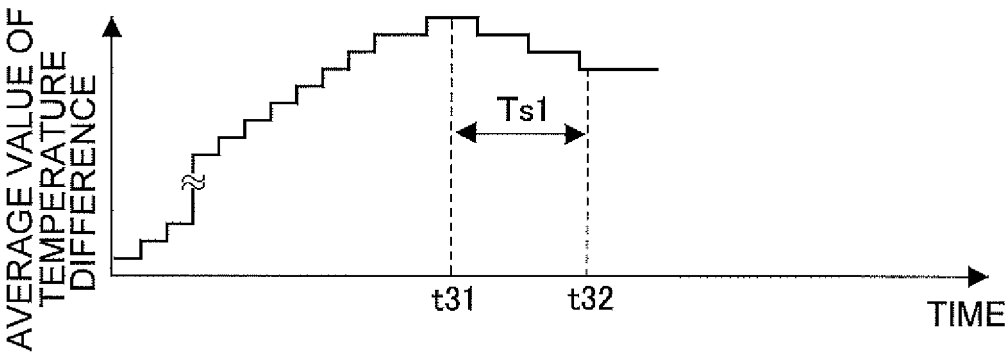

AVERAGE VALUE OF TEMPERATURE DIFFERENCE
Ts1
t31
t32
TIME

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/073565

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F11/02

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2008-128609 A (Mitsubishi Electric Corp.), 05 June 2008 (05.06.2008), paragraphs [0022] to [0028]; fig. 4 to 6 (Family: none)	1,3-4 2
Y	JP 2011-106771 A (Daikin Industries, Ltd.), 02 June 2011 (02.06.2011), paragraphs [0049] to [0053]; fig. 6 (Family: none)	1,3-4
Y	JP 2011-106743 A (Daikin Industries, Ltd.), 02 June 2011 (02.06.2011), paragraph [0023] (Family: none)	3-4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
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"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
28 September 2016 (28.09.16)	11 October 2016 (11.10.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 9243210 A **[0002] [0058]**
- JP 10103818 A **[0002] [0058]**