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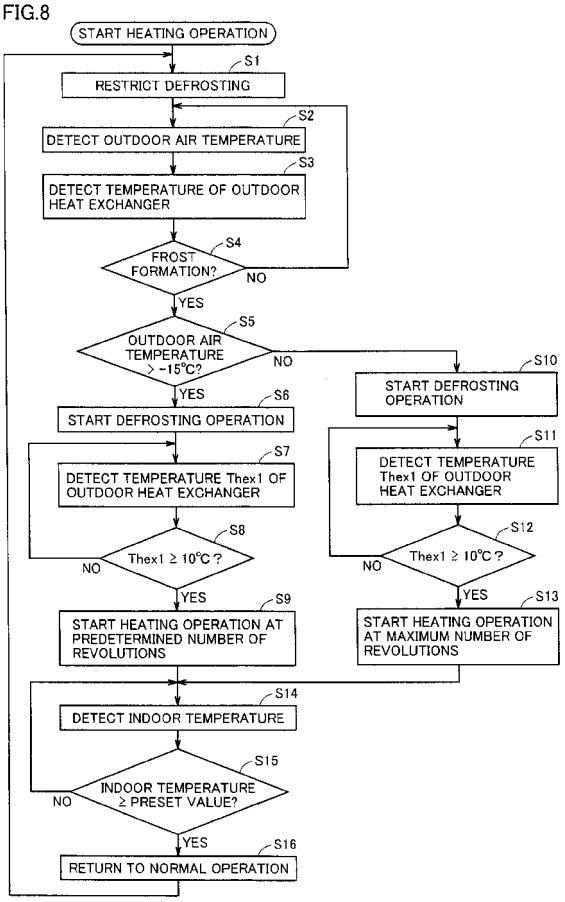
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(54) AIR CONDITIONER

(57) When a defrosting operation is switched to a heating operation, a control unit (32) of an air conditioner (30) instructs a four-way valve (10) to switch and revolves a compressor (11) at a first number of revolutions, in the case where the outdoor air temperature detected by a temperature sensor (12) is a predetermined reference value or less. In contrast, when the detected outdoor air temperature is higher than the reference value, the control unit (32) sets the number of revolutions of the compressor (11) to a second number of revolutions smaller than the first number of revolutions and causes the heating operation to start. Preferably, the first number of revolutions is the maximum number of revolutions that can be set, and the second number of revolutions is set based on the number of revolutions of the compressor (11) in a heating operation immediately before the defrosting operation is started.

FIG.8



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Description

TECHNICAL FIELD

[0001] The present invention relates to a heat-pump-type air conditioner, and particularly to an air conditioner performing a heating operation and a defrosting operation by switching them to each other.

BACKGROUND ART

[0002] When a heat-pump-type air conditioner is heating the indoor air in a heating cycle, an outdoor heat exchanger absorbs heat from the outdoor air and thus its temperature decreases. If the outdoor air temperature is low, the moisture in the air condenses to form frost that accumulates on the outdoor heat exchanger. When frost forms on the surface of the outdoor heat exchanger to a certain extent or more, the frost must be removed and this process is generally called defrosting.

[0003] For a defrosting operation, a four-way valve is switched to thereby change the heating cycle to a cooling cycle. Consequently, a refrigerant having been heated by a compressor flows to the outdoor heat exchanger to thereby remove the frost accumulating on the surface of the outdoor heat exchanger. During the defrosting operation, an indoor fan and an outdoor fan are stopped.

[0004] Japanese Patent Laying-Open No. 58-115235 (PTL 1) discloses a technique for shortening the time taken by the defrosting operation. According to the technique of this document, for a certain period of time in a span of the defrosting operation and its preceding and following heating operations, the number of revolutions of the compressor is set larger than a preset number of revolutions that is calculated based on the indoor temperature and a preset value of the indoor temperature.

[0005] Japanese Patent Laying-Open No. 2007-278536 (PTL 2) discloses an air conditioner in which a bypass circuit having a refrigerant heater is provided in a heat-pump-type refrigerating cycle. When a heating operation ends, the air conditioner of this document causes a refrigerant having been overheated by the refrigerant heater to flow to an outdoor heat exchanger to thereby remove frost on the outdoor heat exchanger, without switching a four-way valve.

CITATION LIST

PATENT LITERATURE

[0006]

PTL 1: Japanese Patent Laying-Open No. 58-115235

PTL 2: Japanese Patent Laying-Open No. 2007-278536

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] The time required for the defrosting operation using the cooling cycle to end is less than 15 minutes if the outdoor air temperature is -8°C or higher. If the outdoor air temperature is -15°C or lower, however, it takes a considerable time for the temperature of the outdoor heat exchanger to increase. Therefore, if the defrosting operation is continued under a low-outdoor-air-temperature condition until frost is completely removed, the indoor temperature will be decreased to an excessive extent.

[0008] If the number of revolutions of the compressor is set larger for a certain period of time in a span of a defrosting operation and its preceding and following heating operations, as done in the above-referenced Japanese Patent Laying-Open No. 58-115235 (PTL 1), the decrease of the indoor temperature can be reduced.

[0009] If, however, the number of revolutions of the compressor is raised to a maximum number of revolutions to cause an excessively sharp rise of the indoor temperature, it may take a considerable time for a subsequent feedback operation to stabilize the indoor temperature. On the contrary, if the number of revolutions of the compressor is insufficient, the refrigerant pressure could be insufficient to cause the four-way valve to switch, since the refrigerant pressure is low under a low-outdoor-air-temperature condition. This is because switching of the four-way valve requires the help of the refrigerant pressure from the compressor.

[0010] If a bypass circuit having a refrigerant heater is provided as done in Japanese Patent Laying-Open No. 2007-278536 (PTL 2), the energies from both the high-pressure refrigerant discharged from the compressor and the refrigerant heater can all be used for defrosting the outdoor heat exchanger. Accordingly, the time taken by the defrosting operation can be shortened. It is, however, necessary to provide the refrigerant heater and the bypass circuit in addition to the ordinary refrigerant circuit, resulting in an increased size of the outdoor unit and complicated control.

[0011] An object of the present invention is to provide an air conditioner that is capable of stably performing a heating operation after a defrosting operation, even if the outdoor air temperature is low, by means of a method of performing a defrosting operation by switching a heating cycle to a cooling cycle.

SOLUTION TO PROBLEM

[0012] In summary, the present invention is an air conditioner including: a compressor having a variable number of revolutions; an outdoor heat exchanger; an indoor heat exchanger; a four-way valve; a first temperature sensor; and a control unit controlling the compressor and the four-way valve. The four-way valve switches

a flow of a refrigerant compressed by the compressor in such a manner that allows the compressed refrigerant to flow to the indoor heat exchanger in a heating operation, and allows the compressed refrigerant to flow to the outdoor heat exchanger in a defrosting operation. The first temperature sensor detects an outdoor air temperature. In a case where the outdoor air temperature is equal to or lower than a predetermined reference value of the outdoor air temperature when a defrosting operation is switched to a heating operation, the control unit gives an instruction to switch to the four-way valve and causes the compressor to revolve at a first number of revolutions. In a case where the outdoor air temperature is higher than the reference value of the outdoor air temperature when the defrosting operation is switched to the heating operation, the control unit gives an instruction to switch to the four-way valve and causes the compressor to revolve at a second number of revolutions smaller than the first number of revolutions.

[0013] Preferably, the first number of revolutions is a maximum number of revolutions among numbers of revolutions that can be set for the compressor. The second number of revolutions is set based on the number of revolutions of the compressor in a heating operation immediately before the defrosting operation is started.

[0014] Preferably, the air conditioner further includes a second temperature sensor detecting an indoor temperature. In this case, when the detected indoor temperature reaches a range that meets a preset value of the indoor temperature after the heating operation is started, the control unit causes the number of revolutions of the compressor to change from the first or second number of revolutions to a third number of revolutions, and thereafter performs feedback control of the number of revolutions of the compressor so that the detected indoor temperature is kept at the preset value of the indoor temperature. Here, the third number of revolutions is set based on the number of revolutions of the compressor in a heating operation immediately before the defrosting operation is started.

[0015] Preferably, the air conditioner further includes a third temperature sensor detecting a temperature of the outdoor heat exchanger. In this case, the control unit causes the defrosting operation to end, when a first condition is met that the detected temperature of the outdoor heat exchanger is equal to or higher than a predetermined reference defrosting-end temperature, or a second condition is met that a predetermined maximum defrosting time has passed since start of the defrosting operation.

[0016] Preferably, when the control unit causes the defrosting operation to end as the second condition is met, the control unit restricts the third number of revolutions and restricts an upper limit value of the number of revolutions for the feedback control of the number of revolutions of the compressor, to a value smaller than a maximum number of revolutions that can be set.

[0017] Preferably, the control unit causes a defrosting operation to start, when a predetermined defrosting-restricted time has passed since start of the heating operation and the detected temperature of the outdoor heat exchanger is equal to or lower than a reference defrosting start-temperature that is set in advance depending on the outdoor air temperature. In this case, when the control unit causes the defrosting operation to end as the second condition is met, the control unit sets the defrosting-restricted time which is a condition based on which a subsequent defrosting operation is started, shorter than the defrosting-restricted time when the defrosting operation is caused to end as the first condition is met.

[0018] Preferably, the air conditioner further includes an outdoor fan having a variable number of revolutions for blowing air to the outdoor heat exchanger. In this case, when the detected temperature of the outdoor heat exchanger is higher than the reference defrosting-start temperature and equal to or lower than a preset reference frost formation temperature that is set in advance depending on the outdoor air temperature, the control unit increases the number of revolutions of the outdoor fan so that the number of revolutions is larger than that when the detected temperature of the outdoor heat exchanger is higher than the reference frost formation temperature.

ADVANTAGEOUS EFFECTS OF INVENTION

[0019] In accordance with the present invention, the number of revolutions of the compressor at the time when a heating operation is started after a defrosting operation is ended is changed depending on the outdoor air temperature. Therefore, when the outdoor air temperature is lower than a reference value, the four-way valve can be prevented from failing to switch due to an insufficient discharge pressure of the compressor. When the outdoor air temperature is higher than the reference value, the number of revolutions of the compressor is set smaller than that when the outdoor air temperature is equal to or lower than the reference value, and the heating operation is then started. Thus, a sharp increase of the indoor temperature can be suppressed. Consequently, indoor temperature control by a subsequent feedback operation can stably be performed.

BRIEF DESCRIPTION OF DRAWINGS

[0020]

Fig. 1 is a refrigerant circuit diagram showing a configuration of an air conditioner 30 according to a first embodiment of the present invention.

Fig. 2 is a diagram for illustrating a flow of a refrigerant in a defrosting operation, in the refrigerant circuit diagram of Fig. 1.

Fig. 3 is an external view of an indoor unit 7.

Fig. 4 is a cross section schematically showing an internal configuration of indoor unit 7 in Fig. 3.

Fig. 5 is an external view of an outdoor unit 14.

Fig. 6 is a diagram schematically showing an internal configuration of outdoor unit 14 in Fig. 5.
Fig. 7 is a functional block diagram of air conditioner 30.
Fig. 8 is a flowchart showing an operation of a control unit 32 in Fig. 7.
Fig. 9 is a diagram for illustrating how it is determined that frost forms on an outdoor heat exchanger 8.
Fig. 10 is a flowchart showing an operation of control unit 32 in a second embodiment of the present invention.
Fig. 11 is a flowchart showing an operation of control unit 32 in a third embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0021] Embodiments of the present invention will hereinafter be described in detail with reference to the drawings. The same or corresponding components are denoted by the same reference characters, and a description thereof will not be repeated.

[First Embodiment]

[0022] Fig. 1 is a refrigerant circuit diagram showing a configuration of an air conditioner 30 according to a first embodiment of the present invention. Fig. 1 shows a flow of a refrigerant in a heating operation.

[0023] Air conditioner 30 in Fig. 1 is a separate-type apparatus including an indoor unit 7 and an outdoor unit 14. Indoor unit 7 includes an indoor heat exchanger 3 and an indoor fan 4. Outdoor unit 14 includes an outdoor heat exchanger 8, an outdoor fan 9, a four-way valve 10, a compressor 11, a capillary tube 15 functioning as an expansion mechanism, a three-way valve 16, and a two-way valve 17. As the expansion mechanism, an expansion valve may also be used instead of capillary tube 15.

[0024] Indoor fan 4 supplies the indoor air to indoor heat exchanger 3. Indoor heat exchanger 3 transfers heat between the indoor air supplied from indoor fan 4 and the refrigerant. Outdoor fan 9 supplies the outdoor air to outdoor heat exchanger 8. Outdoor heat exchanger 8 transfers heat between the outdoor air supplied from outdoor fan 9 and the refrigerant. Four-way valve 10 switches the direction in which the refrigerant flows, between a heating operation and a defrosting operation. Compressor 11 compresses the refrigerant. Capillary tube 15 reduces the pressure of the refrigerant. Three-way valve 16 and two-way valve 17 are provided for introducing the refrigerant into the pipe system when indoor unit 7 and outdoor unit 14 are installed.

[0025] The direction of the flow of the refrigerant in the heating operation is indicated by arrows in Fig. 1. The gaseous refrigerant generated in outdoor heat exchanger 8 is fed via four-way valve 10 to compressor 11. The warm gaseous refrigerant having been compressed by compressor 11 releases heat to the indoor air and liquefies in indoor heat exchanger 3. In this way, the indoor air is heated. The liquid refrigerant generated in indoor heat exchanger 3 is decompressed in capillary tube 15 and fed to outdoor heat exchanger 8, and absorbs heat from the outdoor air to evaporate in outdoor heat exchanger 8.

[0026] Fig. 2 is a diagram for illustrating a flow of the refrigerant in a defrosting operation, in the refrigerant circuit diagram of Fig. 1. Referring to Fig. 2, frost formation on outdoor heat exchanger 8 causes the heat exchange efficiency of outdoor heat exchanger 8 to decrease. Therefore, when the temperature of outdoor heat exchanger 8 becomes equal to or lower than a predetermined value that depends on the outdoor air temperature, for example, it is determined that frost forms on outdoor heat exchanger 8 and the defrosting operation is performed. Details of the basis on which it is determined that frost forms will be explained in connection with Fig. 9.

[0027] The direction in which the refrigerant flows in the defrosting operation is indicated by arrows in Fig. 2. Indoor fan 4 and outdoor fan 9 are stopped from being driven. The gaseous refrigerant generated in indoor heat exchanger 3 is fed via four-way valve 10 to compressor 11. The warm gaseous refrigerant having been compressed in compressor 11 provides heat to outdoor heat exchanger 8 and liquefies. In this way, outdoor heat exchanger 8 is heated to be defrosted. The liquid refrigerant generated in outdoor heat exchanger 8 is decompressed in capillary tube 15 and fed to indoor heat exchanger 3, and absorbs heat from the indoor air to evaporate in indoor heat exchanger 3.

[0028] Fig. 3 is an external view of indoor unit 7.

[0029] Fig. 4 is a cross section schematically showing an internal configuration of indoor unit 7 in Fig. 3. Fig. 4 shows the cross section of indoor unit 7 as seen in the direction of the Y axis in Fig. 3.

[0030] In Fig. 4, indoor unit 7 includes, in addition to indoor heat exchanger 3 and indoor fan 4 shown in Figs. 1 and 2, temperature sensors 1, 2, a louver 5, and a louver motor 6. Temperature sensor 1 (second temperature sensor) detects the indoor temperature. Temperature sensor 2 detects the temperature of indoor heat exchanger 3. Louver 5 is a wind direction guide member provided in an air outlet of indoor unit 7. The louver motor is a motor for driving louver 5 so that louver 5 turns. A plurality of louvers are driven so that they are identically oriented.

[0031] Fig. 5 is an external view of outdoor unit 14.

[0032] Fig. 6 is a diagram schematically showing an internal configuration of outdoor unit 14 in Fig. 5. Referring to Fig. 6, outdoor unit 14 includes temperature sensors 12, 13, in addition to outdoor heat exchanger 8, outdoor fan 9, four-way valve 10, and compressor 11 shown in Figs. 1 and 2. Temperature sensor 12 (first temperature sensor) detects the outdoor air temperature. Temperature sensor 13 (third temperature sensor) detects the temperature of outdoor heat exchanger 8.

[0033] Fig. 7 is a functional block diagram of air con-

ditioner 30. In Fig. 7, air conditioner 30 includes an operation unit 31 and a control unit 32 in addition to the components shown in Figs. 1, 2, 4, and 6. Operation unit 31 includes a power switch, a temperature regulation key, an air volume regulation key, and a timer, for example. Control unit 32 is a computer incorporated in indoor unit 7. Based on user's instructions such as a preset value of the indoor temperature that is input by means of operation unit 31 and the results of detection by temperature sensors 1, 2, 12, 13, for example, control unit 32 controls the number of revolutions of compressor 11, switches four-way valve 10, and controls the number of revolutions of fans 4, 9, for example.

[0034] In air conditioner 30 of the first embodiment, the number of revolutions of compressor 11 is controlled in a multilevel manner by means of an FD value. The FD value is set to eight or more levels. By way of example, assuming that the maximum number of revolutions is FD = 10, the minimum number of revolutions is FD = 1, the number of revolutions when the compressor is stopped is FD = 0, and the rated number of revolutions is set to FD = 6.

[0035] In the heating operation, control unit 32 performs feedback control of the number of revolutions of compressor 11, so that a preset value of the indoor temperature that is input by a user and the indoor temperature are equal to each other. The lower the outdoor temperature is, the larger is the amount of heat (heat load) that is lost from the indoor space to the outdoor space. The FD value in the steady state is therefore larger. As for the compressor for super insulated houses that prevail in cold climate areas, the compressor is operated in some cases at the minimum number of revolutions of FD = 1 even if the outdoor air temperature is -8°C.

[0036] Fig. 8 is a flowchart showing an operation of control unit 32 in Fig. 7. Fig. 8 shows a procedure in which frost formation on outdoor heat exchanger 8 is detected during a heating operation, the operation is accordingly switched to a defrosting operation, and the operation is thereafter returned to the normal heating operation.

[0037] In step S1 which is immediately after the heating operation is started, control unit 32 does not switch the heating operation to the defrosting operation until a predetermined time (defrosting-restricted time) has passed since the start of the heating operation, even if frost forms on outdoor heat exchanger 8. This step S1 is performed for ensuring the time for the operating state of air conditioner 30 to become stable and the time for the indoor temperature to increase to a certain extent. This defrosting-restricted time is usually set to 20 to 40 minutes.

[0038] When the defrosting-restricted time has passed, control unit 32 determines, based on the outdoor air temperature detected by temperature sensor 12 (step S2) and the temperature of outdoor heat exchanger 8 detected by temperature sensor 13 (step S3), whether or not frost forms on indoor heat exchanger 3 (step S4). How it is determined that frost forms will be described in the following.

[0039] Fig. 9 is a diagram for illustrating how it is determined that frost forms on outdoor heat exchanger 8. The horizontal axis and the vertical axis of Fig. 9 represent the outdoor air temperature and the temperature of outdoor heat exchanger 8, respectively.

[0040] Whether or not frost forms is determined based on the outdoor air temperature and the temperature of outdoor heat exchanger 8. In the case where no frost forms at all on the fins of outdoor heat exchanger 8, the outdoor air warms outdoor heat exchanger 8. Therefore, as shown by a graph 35 represented by a solid line in Fig. 9, the temperature of outdoor heat exchanger 8 is proportional to the outdoor air temperature. In contrast, as frost forms on outdoor heat exchanger 8, the frost hinders the outdoor air from passing through the outdoor heat exchanger and accordingly, as shown by a graph 36 represented by a short dashed line in Fig. 9, the temperature of outdoor heat exchanger 8 decreases. As frost further builds up, the temperature of outdoor heat exchanger 8 continues decreasing to finally reach a region (a point 39 in Fig. 9) below a reference line 38.

[0041] Control unit 32 utilizes this phenomenon to determine the state of frost formation. Specifically, when a state continues for approximately three minutes in which the temperature of outdoor heat exchanger 8 is equal to or lower than a reference temperature at which defrosting is to be started, which is set in advance depending on the outdoor air temperature, namely a state continues for approximately three minutes in which the temperature of outdoor heat exchanger 8 is equal to or lower than reference line 38 indicated by the dashed two-dotted line in Fig. 9, control unit 32 determines that outdoor heat exchanger 8 is completely frosted, and switches the operating mode to the defrosting operation. Reference line 38 varies depending on the type of air conditioner 30, and is therefore determined by actually conducting tests. In order to more accurately determine the state of frost formation, it is desirable to make corrections using the number of revolutions of compressor 11.

[0042] Referring again to Fig. 8, when control unit 32 detects frost formation (YES in step S4), it proceeds to step S5. The subsequent procedure varies depending on whether or not the outdoor air temperature measured in step S2 immediately before the procedure proceeds to step S5 is higher than a predetermined reference value (-15°C for example).

(i) The outdoor air temperature is not higher than the reference value (-15°C) (NO in step S5)

[0043] Since super insulated houses are increasing in these days, there is often the case where the number of revolutions of compressor 11 does not reach the maximum number of revolutions even if the heating operation is performed under the condition that the outdoor air temperature is -15°C or lower. For example, when it is assumed that the maximum FD value is 10, the indoor temperature may become equal to a preset value and the

steady state may be reached when the FD value is approximately equal to 5.

[0044] When control unit 32 detects frost formation, it causes the defrosting operation to start (step S10). Specifically, in order to switch four-way valve 10, control unit 32 temporarily stops compressor 11. After giving an instruction to switch to four-way valve 10, control unit 32 restarts compressor 11. At this time, in order to complete defrosting as quickly as possible, the number of revolutions of compressor 11 is set for example to the maximum number of revolutions (FD = 10).

[0045] When compressor 11 is started, four-way valve 10 is switched with the help of the discharge pressure of compressor 11. Since the number of revolutions of compressor 11 is the maximum number of revolutions, a refrigerant pressure that is sufficient for four-way valve 10 to switch is ensured even if the refrigerant temperature is low. Switching of four-way valve 10 can be confirmed by a decrease of the temperature of indoor heat exchanger 3 and an increase of the temperature of outdoor heat exchanger 8.

[0046] In the defrosting operation, control unit 32 stops indoor fan 4 and outdoor fan 9, in order to prevent cold air from blowing indoors, and further to prevent heat of the warm gaseous refrigerant supplied to outdoor heat exchanger 8 for defrosting, from being taken by the outdoor air.

[0047] After the defrosting operation starts, control unit 32 causes temperature sensor 13 to detect temperature Thex 1 of outdoor heat exchanger 8 (step S11), and determines whether or not detected temperature Thex1 is equal to or higher than a reference defrosting-end temperature (step S12). In principle, frost has been removed when the temperature of outdoor heat exchanger 8 is higher than 0°C. The reference defrosting-end temperature, however, is set to approximately 10°C in order to allow for a margin.

[0048] When temperature Thex 1 of outdoor heat exchanger 8 becomes equal to or higher than the reference defrosting-end temperature (10°C) (YES in step S12), control unit 32 causes the heating operation to restart (step S13). Specifically, in order to switch four-way valve 10, control unit 32 temporarily stops compressor 11. After giving an instruction to switch to four-way valve 10, compressor 11 is restarted. At this time, in the case where the outdoor air temperature is not higher than the reference value (-15°C), the number of revolutions of compressor 11 is set to the maximum number of revolutions (FD = 10). It is assumed here that the outdoor air temperature almost remains the same during the defrosting operation of at most approximately 15 minutes. If the outdoor air temperature can be detected by temperature sensor 12 even while outdoor fan 9 is stopped, the outdoor air temperature may be detected again in step S13 and the number of revolutions of compressor 11 at the time the heating operation is started may be set based on the detected outdoor air temperature.

[0049] After compressor 11 is started, four-way valve 10 is switched with the help of the discharge pressure of compressor 11. Since the number of revolutions of compressor 11 is the maximum number of revolutions, a refrigerant pressure that is sufficient for four-way valve 10 to switch is ensured even if the refrigerant temperature is low.

[0050] Control unit 32 confirms that four-way valve 10 has been switched, by respective temperatures of indoor heat exchanger 3 and outdoor heat exchanger 8, and then causes indoor fan 4 and outdoor fan 9 to rotate. Switching of four-way valve 10 can be confirmed by an increase of the temperature of indoor heat exchanger 3 and a decrease of the temperature of outdoor heat exchanger 8.

[0051] After the heating operation is restarted, control unit 32 causes temperature sensor 1 to detect the indoor temperature (step S14), and determines whether or not the detected indoor temperature has reached a predetermined range that meets a preset value of the indoor temperature that has been input by a user (step S15). In the example of Fig. 8, it is determined whether or not the detected indoor temperature has become equal to or higher than the preset value.

[0052] When the indoor temperature has become equal to or higher than the preset value (YES in step S15), control unit 32 causes the operating mode to return to the usual feedback operation (step S16). Specifically, control unit 32 sets the number of revolutions of compressor 11 to the number of revolutions (FD = 6) which is larger by a predetermined value (+1) than the number of revolutions (FD = 5) in the heating operation immediately before the start of the defrosting operation. After this, control unit 32 performs feedback control of the number of revolutions of compressor 11 so that the indoor temperature detected by temperature sensor 1 is equal to the preset value of the indoor temperature having been input by the user.

[0053] Subsequently, the procedure is repeated from step S1. In the case of the heating operation after the defrosting operation as well, in order to stabilize the operating state of air conditioner 30, switching to the defrosting operation is restricted for a predetermined time (defrosting-restricted time) (step S1) immediately after the heating operation is started.

(ii) The outdoor air temperature is higher than the reference value (-15°C) (YES in step S5)

[0054] In the case for example where air conditioner 30 is installed in a super insulated house and the outdoor air temperature is approximately 2°C, the heating operation is performed with the preset minimum number of revolutions (FD = 1) of the compressor.

[0055] When control unit 32 detects frost formation, it causes the defrosting operation to start (step S6). Specifically, in order to switch four-way valve 10, control unit 32 temporarily stops compressor 11. After giving an instruction to switch to four-way valve 10, control unit 32

restarts compressor 11. At this time, the number of revolutions of the compressor is set to the rated number of revolutions (FD = 6) or a number slightly larger than it. When the outdoor air temperature is high, four-way valve 10 receives the discharge pressure from compressor 11 to be easily switched. During the defrosting operation, control unit 32 stops indoor fan 4 and outdoor fan 9.

[0056] As the defrosting operation is started, control unit 32 causes temperature sensor 13 to detect temperature Thex1 of outdoor heat exchanger 8 (step S7), and determines whether or not detected temperature Thex 1 is equal to or higher than the reference defrosting-end temperature (10°C) (step S8).

[0057] When temperature Thex 1 of outdoor heat exchanger 8 becomes equal to or higher than the reference defrosting-end temperature (10°C) (YES in step S8), control unit 32 causes the heating operation to restart (step S9). Specifically, in order to switch four-way valve 10, control unit 32 temporarily stops compressor 11. After giving an instruction to switch to four-way valve 10, control unit 32 restarts compressor 11.

[0058] At this time, in the case where the outdoor air temperature is higher than the reference value (-15°C), the number of revolutions of compressor 11 is not set to the maximum number of revolutions, for the following reason. If the number of revolutions of compressor 11 is raised to the maximum number of revolutions under the condition that the outdoor air temperature is high, the indoor temperature will sharply increase. Thus, when the operation is returned to the feedback operation, a large overshoot of the indoor temperature occurs and it takes a considerable time for the indoor temperature to become stable.

[0059] In view of this, the number of revolutions of compressor 11 is set to a value (FD = 4 to 5) which is larger by a predetermined value (+3 to 4) than the number of revolutions (FD =1) in the heating operation immediately before the defrosting operation. In this way, control can be performed stably without causing a sharp increase of the indoor temperature. Since the outdoor air temperature is high, a refrigerant pressure sufficient for four-way valve 10 to switch can be ensured while the number of revolutions of compressor 11 is small.

[0060] The procedure from the subsequent step S14 is the same as the one in the case where the outdoor air temperature is equal to or lower than the reference value (-15°C), and thus the description thereof will not be repeated.

[0061] As seen from the above, air conditioner 30 of the first embodiment sets the number of revolutions of compressor 11 when the heating operation is to be started after the defrosting operation is ended, to the maximum number of revolutions in the case where the outdoor air temperature is equal to or lower than the reference value. Accordingly, it can be avoided that four-way valve 10 fails to switch due to an insufficient discharge pressure of compressor 11. If the outdoor air temperature is higher than the reference value, the number of revolutions of the compressor is set smaller than that in the case where the outdoor air temperature is equal to or lower than the reference value. Therefore, a sharp increase of the indoor temperature can be suppressed. Consequently, the indoor temperature control by the subsequent feedback operation can be performed stably.

[Second Embodiment]

[0062] In the first embodiment, when temperature Thex1 of outdoor heat exchanger 8 is equal to or higher than the reference defrosting-end temperature (10°C) in steps S8 and S12 of Fig. 8 (first defrosting-end condition), the defrosting operation is ended. In the case, however, where the outdoor air temperature is equal to or lower than -20°C, it takes a considerable time for the temperature of outdoor heat exchanger 8 to increase even if the defrosting operation is performed. Therefore, if the defrosting operation is continued until the frost on outdoor heat exchanger 8 is completely removed, the indoor temperature will become excessively low.

[0063] In view of this, according to a second embodiment, the defrosting operation is also ended when the time for which the defrosting operation is performed exceeds an upper limit value (maximum defrosting time) (second defrosting-end condition). The maximum defrosting time is set to approximately 15 minutes. Since indoor fan 4 is stopped during the defrosting operation, temperature sensor 1 cannot correctly detect the indoor temperature. Therefore, control is performed based on the time for which the defrosting operation is done, rather than the indoor temperature.

[0064] If the second defrosting-end condition is met and accordingly the defrosting operation is ended, the heating operation is restarted before perfect completion of defrosting of outdoor heat exchanger 8. It is therefore necessary to perform special control in order to avoid the situation where the frost which could not be removed completely accumulates to cause outdoor unit 14 to be frozen, as described specifically in the following.

[0065] Fig. 10 is a flowchart showing an operation of control unit 32 in the second embodiment of the present invention. The operational procedure of control unit 32 in Fig. 10 differs from the operational procedure in Fig. 8 in that the former includes step S12A between step S11 and step S12. Step S12A corresponds to the second defrosting-end condition. Further, the operational procedure of control unit 32 in Fig. 10 includes steps S20 to S27 that are performed when the second defrosting-end condition is met (YES in step S12A). In terms of other respects, the operational procedure in Fig. 10 is identical to that in Fig. 8, the same or corresponding steps are denoted by the same reference characters, and the description thereof will not be repeated.

[0066] In step S12A, control unit 32 determines whether or not a maximum defrosting time.(15 minutes for example) has passed since the start of the defrosting operation. When the maximum defrosting time has not

passed (NO in step S12A), the procedure proceeds to step S12 in which control unit 32 determines whether or not temperature Thex1 of outdoor heat exchanger 8 is equal to or higher than the reference defrosting-end temperature (10°C), namely whether or not the first defrosting-end condition is satisfied.

[0067] When the maximum defrosting time has passed (YES in step S12A), control unit 32 forces the defrosting operation to end, and causes the heating operation to restart (step S20). Specifically, control unit 32 temporarily stops compressor 11, gives an instruction to switch to four-way valve 10, and thereafter restarts compressor 11. At this time, since the outdoor air temperature is equal to or lower than the reference value (-15°C), the number of revolutions of compressor 11 is set to the maximum number of revolutions (FD = 10). As compressor 11 is started, four-way valve 10 is switched with the help of the discharge pressure from compressor 11. Control unit 32 confirms switching of four-way valve 10 by the temperature of indoor heat exchanger 3 and the temperature of outdoor heat exchanger 8, and causes indoor fan 4 and outdoor fan 9 to rotate.

[0068] After the heating operation is restarted, control unit 32 causes temperature sensor 1 to detect the indoor temperature (step S21), and confirms whether or not the detected indoor temperature has reached a predetermined range that meets a preset value of the indoor temperature that has been input by a user (step S22). In the example of Fig. 10, it is confirmed whether or not the detected indoor temperature is equal to or higher than the preset value of the indoor temperature.

[0069] When the indoor temperature has become equal to or higher than the preset value (YES in step S22), control unit 32 causes the operation mode to return to the feedback operation (step S23). Specifically, control unit 32 sets the number of revolutions of compressor 11 to a number of revolutions which is larger by a predetermined value (+1) than the number of revolutions in the heating operation immediately before the start of the defrosting operation. After this, control unit 32 performs feedback control of the number of revolutions of compressor 11, so that the indoor temperature detected by temperature sensor 1 is equal to the preset value of the indoor temperature having been input by the user.

[0070] It should be noted that, in the case of step S23, the upper limit value of the number of revolutions of compressor 11 is restricted to a value that is smaller than the maximum number of revolutions. For example, even if the number of revolutions of compressor 11 immediately before the start of the defrosting operation is FD = 9, the number of revolutions at the start of the feedback operation is not raised to the maximum number of revolutions (FD = 10) but restricted to a smaller value (FD = 9). In this way, the speed at which frost forms can be made slow.

[0071] As described above, in order to stabilize the operating state of air conditioner 30, the heating operation is not switched to the defrosting operation for a predetermined time (defrosting-restricted time) immediately after the start of the heating operation.

[0072] In step S24, control unit 32 sets this defrosting-restricted time shorter than the usual one. For example, if the usual defrosting-restricted time is approximately 30 minutes, the defrosting-restricted time is shortened in step S24 to approximately 20 minutes. Thus, the determination as to whether or not frost forms on outdoor heat exchanger 8 is made earlier than usual, so that the defrosting operation is performed before frost builds up.

[0073] Further, the reference defrosting-start temperature explained in connection with Fig. 9 may be set higher than usual to thereby cause the defrosting operation to start under the condition that the amount of formed frost is smaller than usual. By the above-described procedure, frost can be prevented from building up to cause outdoor unit 14 to be frozen.

[0074] After this, based on the outdoor air temperature detected by temperature sensor 12 (step S25) and the temperature of outdoor heat exchanger 8 detected by temperature sensor 13 (step S26), control unit 32 determines whether or not frost forms on indoor heat exchanger 3 (step S27). When frost formation is detected, the procedure returns to step S10 in which control unit 32 causes the defrosting operation to start. When defrosting has been completed within the maximum defrosting time (YES in step S12), control unit 32 executes steps S13 to S16 explained in connection with Fig. 8, and causes the operation to return to the normal feedback operation.

[Third Embodiment]

[0075] As the number of revolutions of outdoor fan 9 is larger, the amount of heat used as sensible heat is larger and therefore outdoor heat exchanger 8 is less likely to be frosted. Outdoor fan 9, however, is installed outdoors, and thus an excessively large number of revolutions causes noise. Accordingly, outdoor fan 9 is usually operated at a number of revolutions smaller than an operable maximum number of revolutions.

[0076] In contrast, if outdoor heat exchanger 8 starts being frosted, the part between fins is covered with frost and therefore noise does not increase to a significant level even if the number of revolutions of outdoor fan 9 is increased. In view of this, according to a third embodiment, control unit 32 detects the state where outdoor heat exchanger 8 is not completely frosted, namely the state where outdoor heat exchanger 8 starts being partially frosted. When outdoor heat exchanger 8 starts being partially frosted, control unit 32 increases the number of revolutions of outdoor fan 9 so that the number of revolutions is larger by approximately 100 to 200 rpm than the normal number of revolutions. Accordingly, the amount of heat used as sensible heat increases, frost is thus less likely to form, and the heat exchange efficiency of outdoor heat exchanger 8 increases. Since frost starts forming, the frost makes noise of outdoor fan 9 smaller than that generated in a non-frost state.

[0077] Whether outdoor heat exchanger 8 starts being frosted can be determined based on the outdoor air temperature and the temperature of outdoor heat exchanger 8 detected by means of temperature sensors 12, 13. Specifically, with reference to Fig. 9, control unit 32 increases the number of revolutions of outdoor fan 9 in the case where the temperature of outdoor heat exchanger 8 is higher than the above-described reference defrosting-start temperature (dashed two-dotted line 38 in Fig. 9) and equal to or lower than a reference frost formation temperature at which frost forms (dashed dotted line 37 in Fig. 9) which has been set in advance depending on the outdoor air temperature. The difference between the reference frost formation temperature and the reference defrosting-start temperature is set to approximately 1°C.

[0078] Fig. 11 is a flowchart showing an operation of control unit 32 in the third embodiment of the present invention. The operational procedure of control unit 32 in Fig. 11 differs from the operational procedure in Fig. 10 in that the former includes step S4A of determining the state of frost formation of outdoor heat exchanger 8 instead of step S4. Further, the operational procedure in Fig. 11 includes step S30 executed in the case where it is determined in step S4A that outdoor heat exchanger 8 is partially frosted. In terms of other respects, the operational procedure in Fig. 11 is identical to that in Fig. 10, the same or corresponding steps are thus denoted by the same reference characters, and the description thereof will not be repeated.

[0079] In step S4A, control unit 32 determines the state of frost formation on outdoor heat exchanger 8 based on the outdoor air temperature detected in step S2 and the temperature of outdoor heat exchanger 8 detected in step S3. Specifically, when the temperature of outdoor heat exchanger 8 exceeds the reference frost formation temperature (dashed dotted line 37 in Fig. 9) depending on the outdoor air temperature, control unit 32 determines that this is the normal state and returns to step S2. When the temperature of outdoor heat exchanger 8 is equal to or lower than the reference defrosting-start temperature (dashed two-dotted line 38 in Fig. 9) depending on the outdoor air temperature, control unit 32 proceeds to step S5 and the following steps and causes the defrosting operation to start. When the temperature of outdoor heat exchanger 8 is equal to or lower than the reference frost formation temperature depending on the outdoor air temperature and exceeds the reference defrosting-start temperature, control unit 32 proceeds to step S30.

[0080] In step S30, control unit 32 increases the number of revolutions of outdoor fan 9 so that the number of revolutions is larger by approximately 100 to 200 rpm than the normal number of revolutions thereof.

[0081] It should be construed that the embodiments disclosed herein are by way of illustration in all respects, not by way of limitation. It is intended that the scope of the present invention is defined by claims, not by the description above, and encompasses all modifications and variations equivalent in meaning and scope to the claims.

REFERENCE SIGNS LIST

[0082] 1 temperature sensor (for indoor temperature); 2 temperature sensor (for indoor heat exchanger); 12 temperature sensor (for outdoor air temperature); 13 temperature sensor (for outdoor heat exchanger); 3 indoor heat exchanger; 4 indoor fan; 7 indoor unit; 8 outdoor heat exchanger; 9 outdoor fan; 10 four-way valve; 11 compressor; 14 outdoor unit; 15 capillary tube; 30 air conditioner; 31 operation unit; 32 control unit

Claims

1. An air conditioner (30) comprising:

a compressor (11) having a variable number of revolutions;
an outdoor heat exchanger (8);
an indoor heat exchanger (3);
a four-way valve (10) for switching a flow of a refrigerant compressed by said compressor (11) in such a manner that allows said compressed refrigerant to flow to said indoor heat exchanger (3) in a heating operation, and allows said compressed refrigerant to flow to said outdoor heat exchanger (8) in a defrosting operation;
a first temperature sensor (12) detecting an outdoor air temperature; and
a control unit (32) controlling said compressor (11) and said four-way valve (10),
in a case where the outdoor air temperature is equal to or lower than a predetermined reference value of the outdoor air temperature when a defrosting operation is switched to a heating operation, said control unit (32) giving an instruction to switch to said four-way valve (10) and causing said compressor (11) to revolve at a first number of revolutions, and
in a case where the outdoor air temperature is higher than said reference value of the outdoor air temperature when the defrosting operation is switched to the heating operation, said control unit (32) giving an instruction to switch to said four-way valve (10) and causing said compressor (11) to revolve at a second number of revolutions smaller than said first number of revolutions.

2. The air conditioner (30) according to claim 1, wherein said first number of revolutions is a maximum number of revolutions among numbers of revolutions that can be set for said compressor (11), and
said second number of revolutions is set based on the number of revolutions of said compressor (11) in a heating operation immediately before the de-

frosting operation is started.

3. The air conditioner (30) according to claim 1 or 2, further comprising a second temperature sensor (1) detecting an indoor temperature, wherein
when the detected indoor temperature reaches a range that meets a preset value of the indoor temperature after the heating operation is started, said control unit (32) causes the number of revolutions of said compressor (11) to change from said first or second number of revolutions to a third number of revolutions, and thereafter performs feedback control of the number of revolutions of said compressor (11) so that the detected indoor temperature is kept at said preset value of the indoor temperature, and said third number of revolutions is set based on the number of revolutions of said compressor (11) in a heating operation immediately before the defrosting operation is started.

4. The air conditioner (30) according to claim 3, further comprising a third temperature sensor (13) detecting a temperature of said outdoor heat exchanger (8), wherein
said control unit (32) causes the defrosting operation to end, when a first condition is met that the detected temperature of said outdoor heat exchanger (8) is equal to or higher than a predetermined reference defrosting-end temperature, or a second condition is met that a predetermined maximum defrosting time has passed since start of the defrosting operation.

5. The air conditioner (30) according to claim 4, wherein when said control unit (32) causes the defrosting operation to end as said second condition is met, said control unit (32) restricts said third number of revolutions and restricts an upper limit value of the number of revolutions for the feedback control of the number of revolutions of said compressor (11), to a value smaller than a maximum number of revolutions that can be set.

6. The air conditioner (30) according to claim 4, wherein said control unit (32) causes a defrosting operation to start, when a predetermined defrosting-restricted time has passed since start of the heating operation and the detected temperature of said outdoor heat exchanger (8) is equal to or lower than a reference defrosting start-temperature that is set in advance depending on the outdoor air temperature, and
when said control unit (32) causes the defrosting operation to end as said second condition is met, said control unit (32) sets said defrosting-restricted time which is a condition based on which a subsequent defrosting operation is started, shorter than said defrosting-restricted time when the defrosting operation is caused to end as said first condition is met.

7. The air conditioner (30) according to claim 6, further comprising an outdoor fan (9) having a variable number of revolutions for blowing air to said outdoor heat exchanger (8), wherein
when the detected temperature of said outdoor heat exchanger (8) is higher than said reference defrosting-start temperature and equal to or lower than a preset reference frost formation temperature that is set in advance depending on the outdoor air temperature, said control unit (32) increases the number of revolutions of said outdoor fan (9) so that the number of revolutions is larger than that when the detected temperature of said outdoor heat exchanger is higher than said reference frost formation temperature.

FIG.1

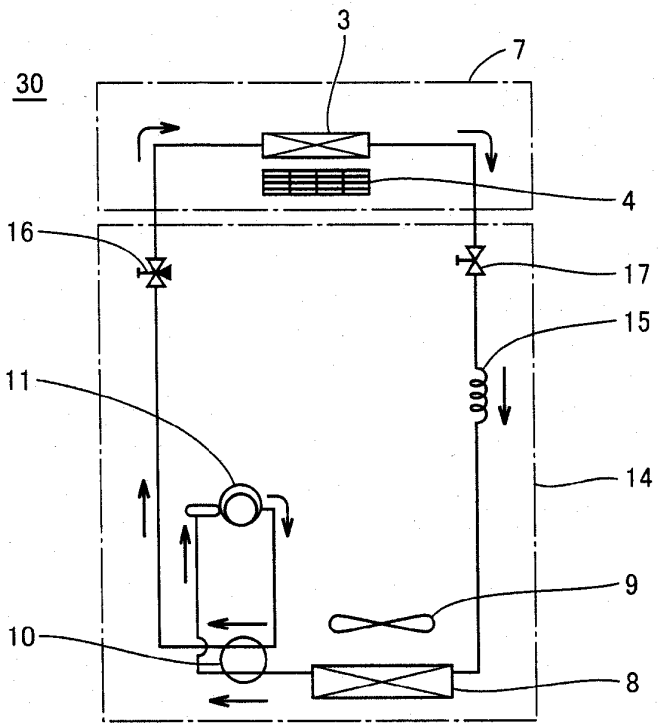


FIG.2

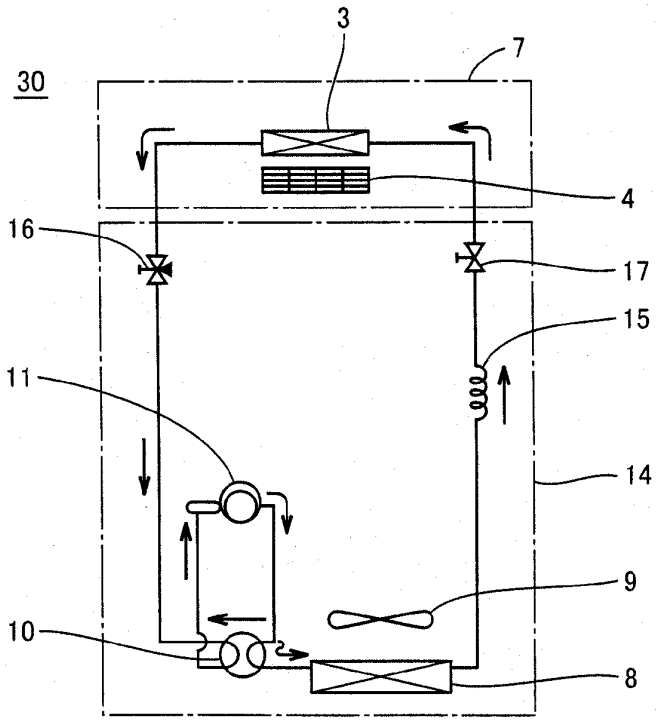


FIG.3

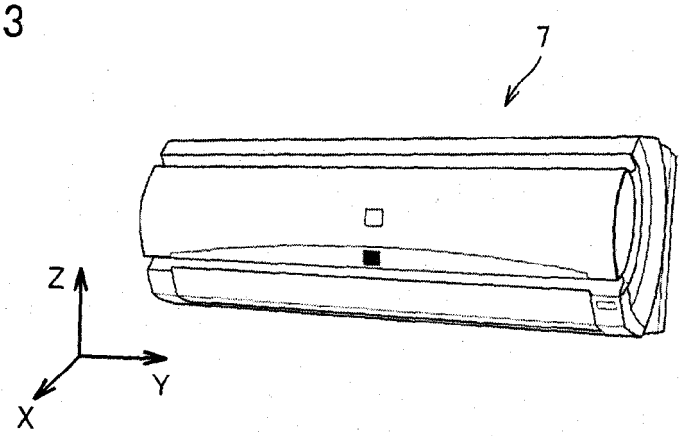


FIG.4

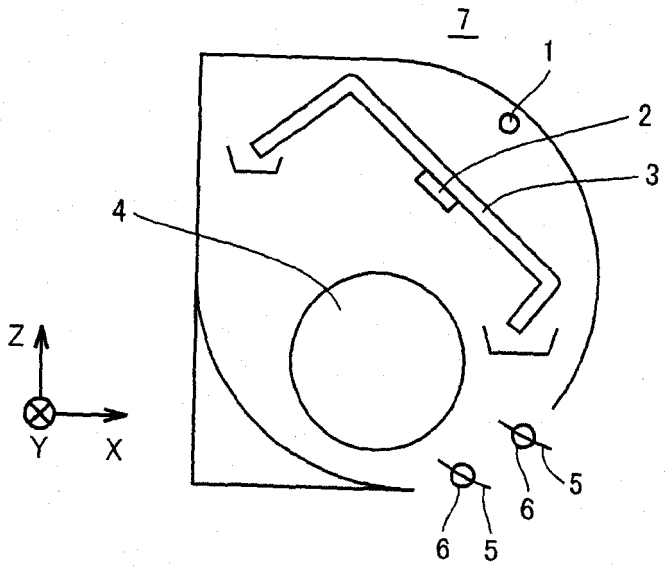


FIG.5

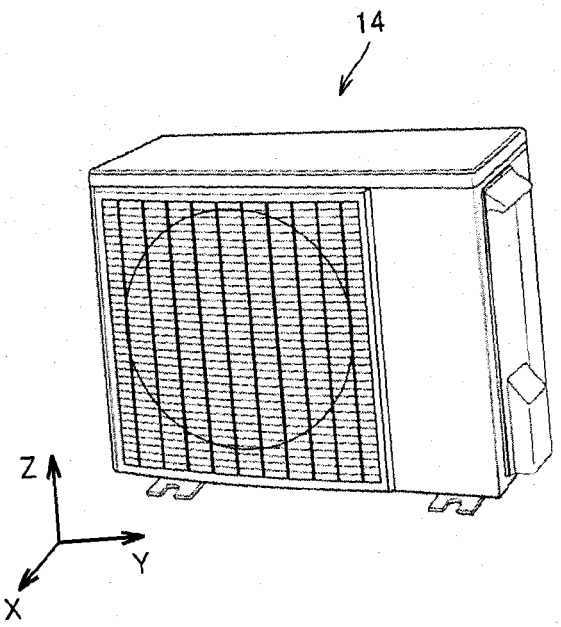


FIG.6

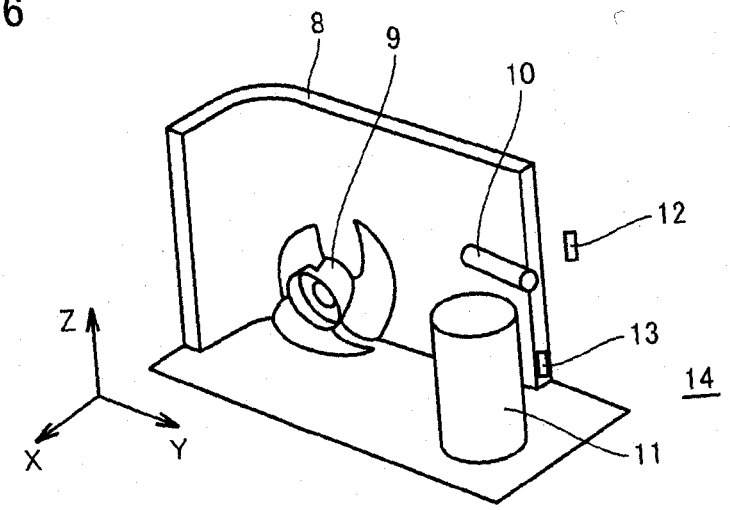


FIG.7

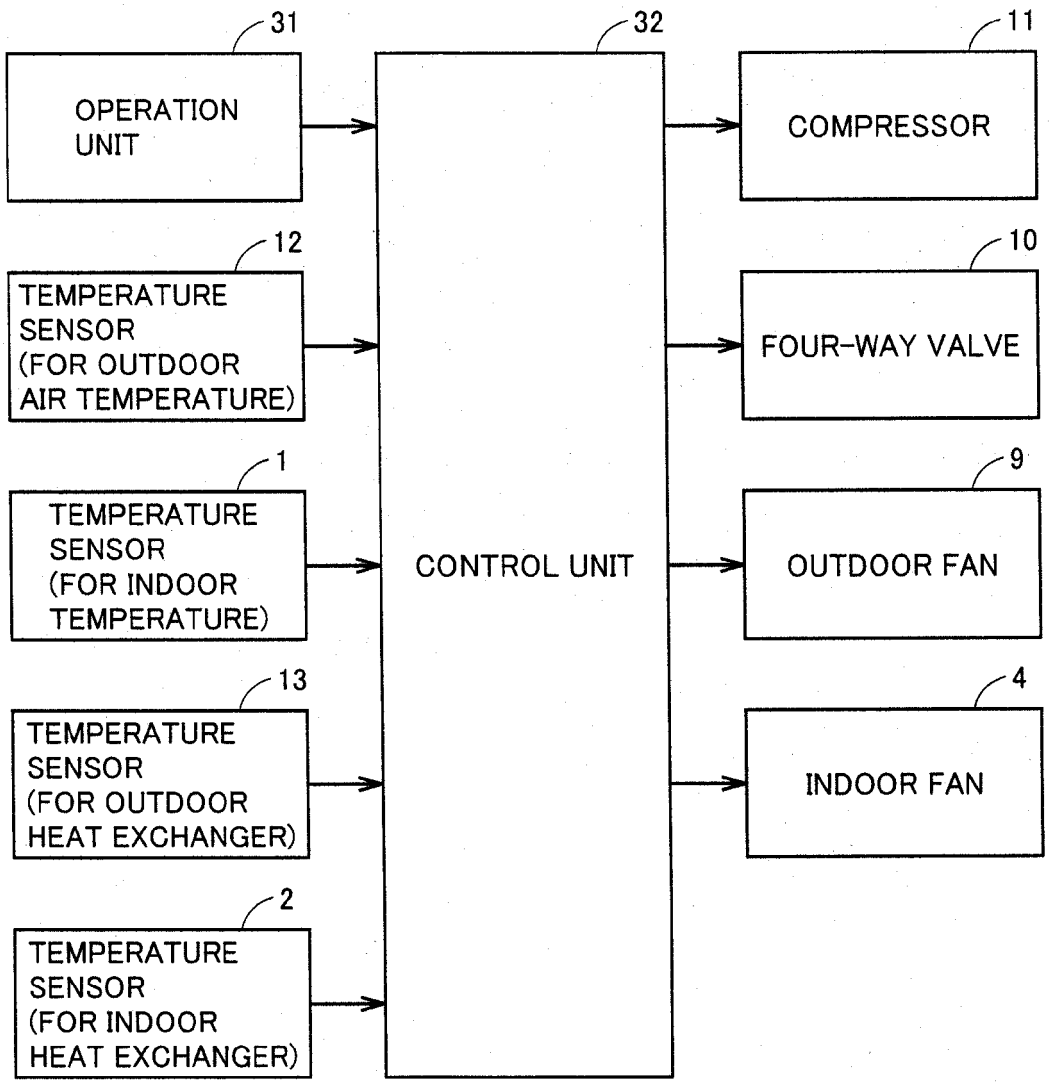

31
OPERATION UNIT
12
TEMPERATURE SENSOR (FOR OUTDOOR AIR TEMPERATURE)
1
TEMPERATURE SENSOR (FOR INDOOR TEMPERATURE)
13
TEMPERATURE SENSOR (FOR OUTDOOR HEAT EXCHANGER)
2
TEMPERATURE SENSOR (FOR INDOOR HEAT EXCHANGER)
32
CONTROL UNIT
11
COMPRESSOR
10
FOUR-WAY VALVE
9
OUTDOOR FAN
4
INDOOR FAN

FIG.8

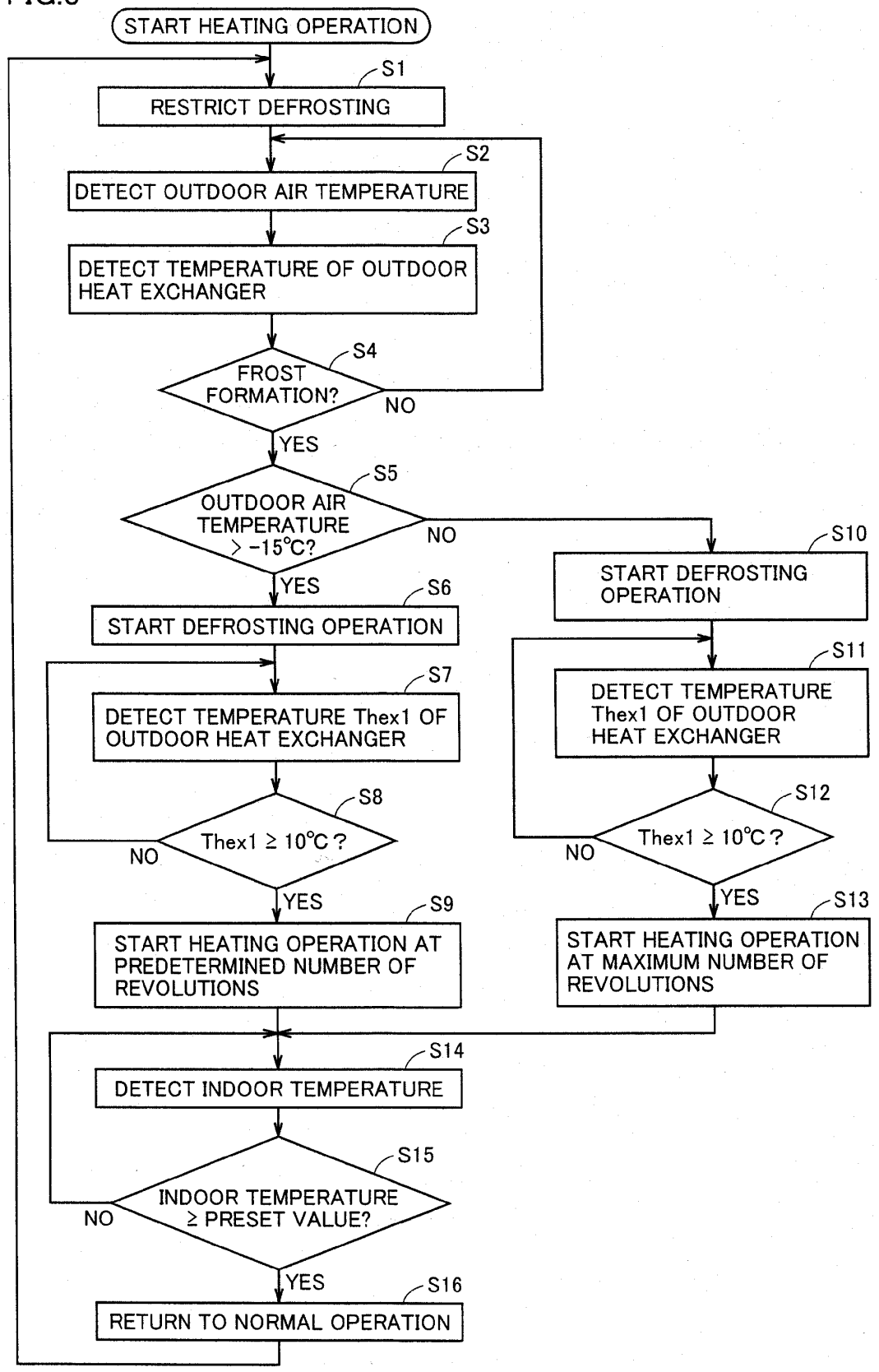

START HEATING OPERATION
S1
RESTRICT DEFROSTING
S2
DETECT OUTDOOR AIR TEMPERATURE
S3
DETECT TEMPERATURE OF OUTDOOR HEAT EXCHANGER
S4
FROST FORMATION?
NO
YES
S5
OUTDOOR AIR TEMPERATURE > -15°C?
NO
YES
S6
START DEFROSTING OPERATION
S7
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S8
Thex1 ≥ 10°C ?
NO
YES
S9
START HEATING OPERATION AT PREDETERMINED NUMBER OF REVOLUTIONS
S10
START DEFROSTING OPERATION
S11
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S12
Thex1 ≥ 10°C ?
NO
YES
S13
START HEATING OPERATION AT MAXIMUM NUMBER OF REVOLUTIONS
S14
DETECT INDOOR TEMPERATURE
S15
INDOOR TEMPERATURE ≥ PRESET VALUE?
NO
YES
S16
RETURN TO NORMAL OPERATION

FIG.9

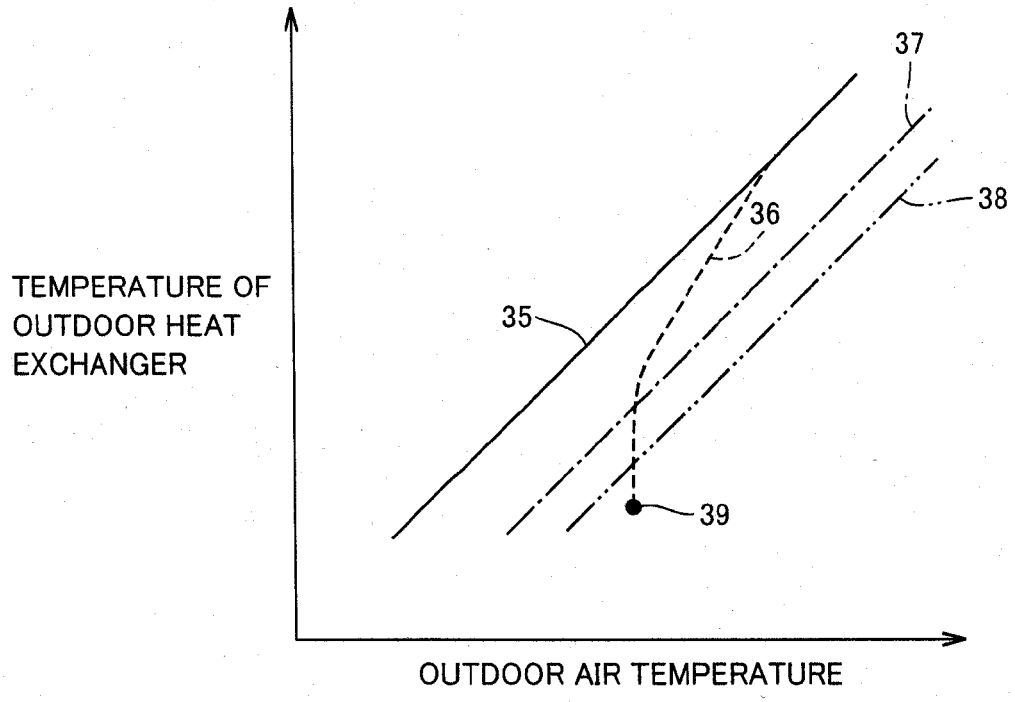

TEMPERATURE OF OUTDOOR HEAT EXCHANGER
35
36
37
38
39
OUTDOOR AIR TEMPERATURE

FIG.10

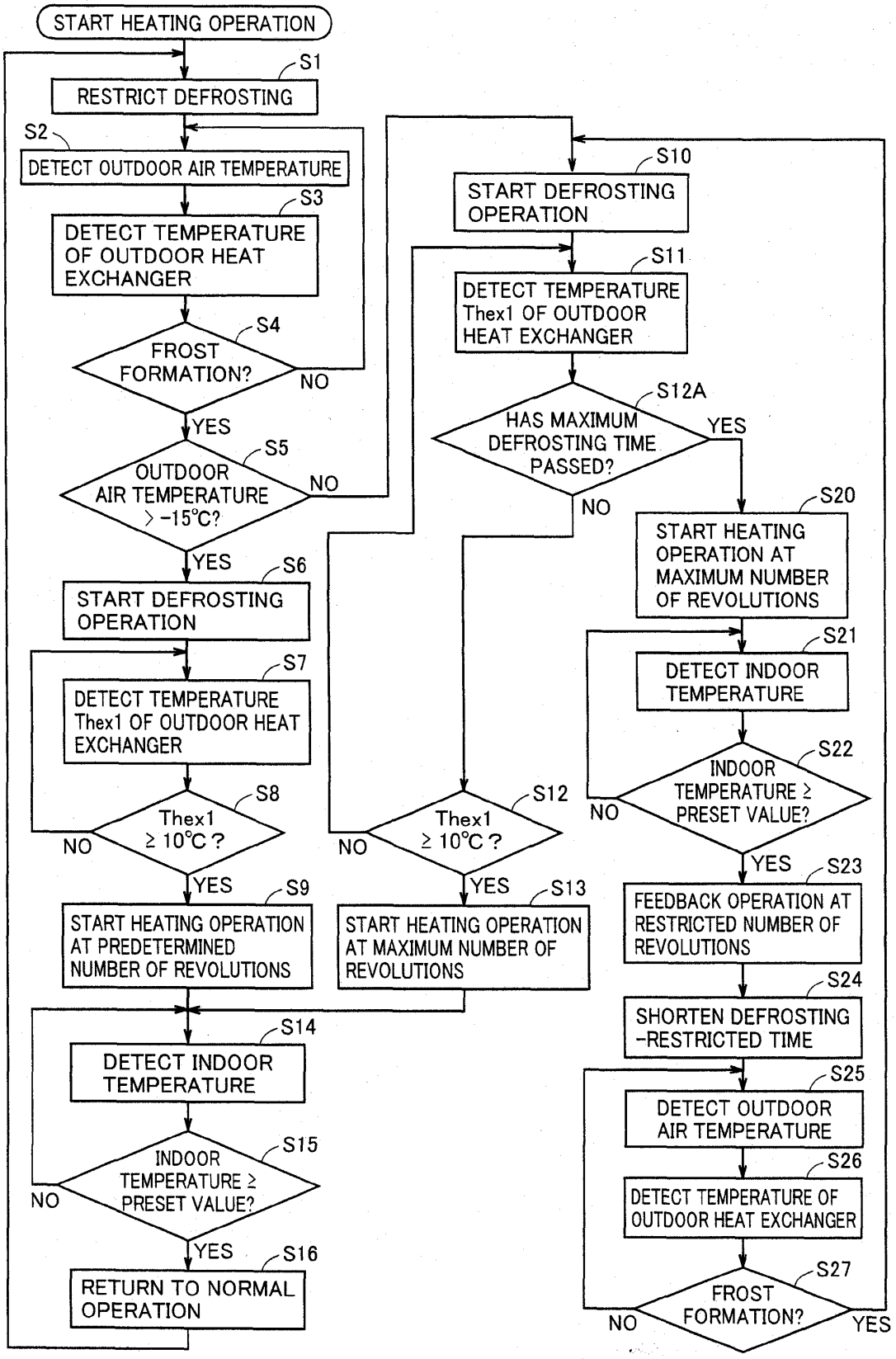
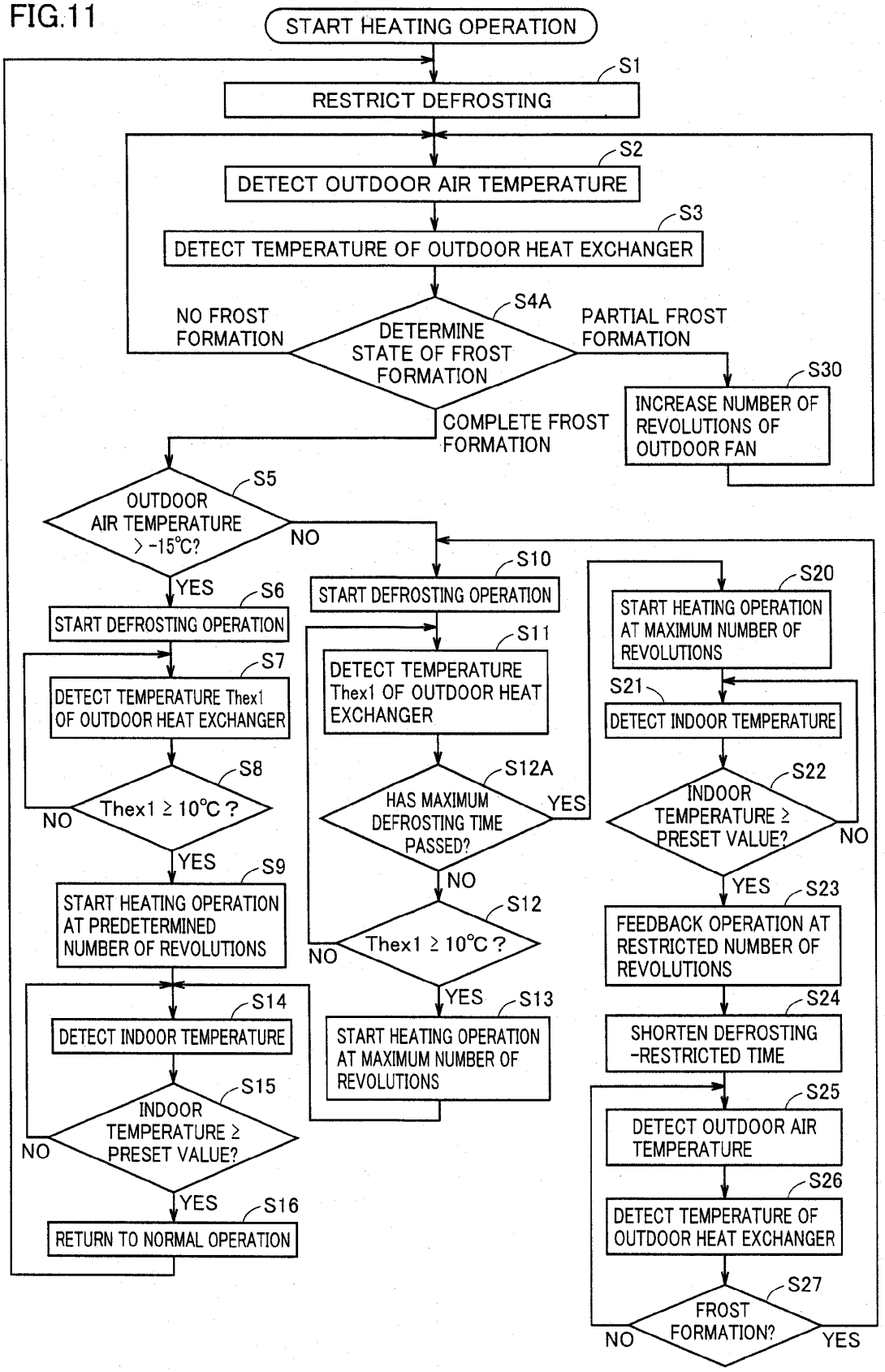

START HEATING OPERATION
S1
RESTRICT DEFROSTING
S2
DETECT OUTDOOR AIR TEMPERATURE
S3
DETECT TEMPERATURE OF OUTDOOR HEAT EXCHANGER
S4
FROST FORMATION?
NO
YES
S5
OUTDOOR AIR TEMPERATURE > -15°C?
NO
YES
S6
START DEFROSTING OPERATION
S7
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S8
Thex1 ≥ 10°C ?
NO
YES
S9
START HEATING OPERATION AT PREDETERMINED NUMBER OF REVOLUTIONS
S10
START DEFROSTING OPERATION
S11
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S12A
HAS MAXIMUM DEFROSTING TIME PASSED?
YES
NO
S12
Thex1 ≥ 10°C ?
NO
YES
S13
START HEATING OPERATION AT MAXIMUM NUMBER OF REVOLUTIONS
S14
DETECT INDOOR TEMPERATURE
S15
INDOOR TEMPERATURE ≥ PRESET VALUE?
NO
YES
S16
RETURN TO NORMAL OPERATION
S20
START HEATING OPERATION AT MAXIMUM NUMBER OF REVOLUTIONS
S21
DETECT INDOOR TEMPERATURE
S22
INDOOR TEMPERATURE ≥ PRESET VALUE?
NO
YES
S23
FEEDBACK OPERATION AT RESTRICTED NUMBER OF REVOLUTIONS
S24
SHORTEN DEFROSTING -RESTRICTED TIME
S25
DETECT OUTDOOR AIR TEMPERATURE
S26
DETECT TEMPERATURE OF OUTDOOR HEAT EXCHANGER
S27
FROST FORMATION?
NO
YES

FIG.11


START HEATING OPERATION
S1
RESTRICT DEFROSTING
S2
DETECT OUTDOOR AIR TEMPERATURE
S3
DETECT TEMPERATURE OF OUTDOOR HEAT EXCHANGER
S4A
NO FROST FORMATION
DETERMINE STATE OF FROST FORMATION
PARTIAL FROST FORMATION
S30
INCREASE NUMBER OF REVOLUTIONS OF OUTDOOR FAN
COMPLETE FROST FORMATION
S5
OUTDOOR AIR TEMPERATURE > -15°C?
NO
YES
S6
START DEFROSTING OPERATION
S7
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S8
Thex1 ≥ 10°C ?
NO
YES
S9
START HEATING OPERATION AT PREDETERMINED NUMBER OF REVOLUTIONS
S14
DETECT INDOOR TEMPERATURE
S15
INDOOR TEMPERATURE ≥ PRESET VALUE?
NO
YES
S16
RETURN TO NORMAL OPERATION
S10
START DEFROSTING OPERATION
S11
DETECT TEMPERATURE Thex1 OF OUTDOOR HEAT EXCHANGER
S12A
HAS MAXIMUM DEFROSTING TIME PASSED?
YES
NO
S12
Thex1 ≥ 10°C ?
NO
YES
S13
START HEATING OPERATION AT MAXIMUM NUMBER OF REVOLUTIONS
S20
START HEATING OPERATION AT MAXIMUM NUMBER OF REVOLUTIONS
S21
DETECT INDOOR TEMPERATURE
S22
INDOOR TEMPERATURE ≥ PRESET VALUE?
NO
YES
S23
FEEDBACK OPERATION AT RESTRICTED NUMBER OF REVOLUTIONS
S24
SHORTEN DEFROSTING -RESTRICTED TIME
S25
DETECT OUTDOOR AIR TEMPERATURE
S26
DETECT TEMPERATURE OF OUTDOOR HEAT EXCHANGER
S27
FROST FORMATION?
NO
YES

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059183

A. CLASSIFICATION OF SUBJECT MATTER
F25B47/02(2006.01)i, *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)
F25B47/02, 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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 136983/1983(Laid-open No. 43965/1985) (Daikin Industries, Ltd.), 28 March 1985 (28.03.1985), entire text; fig. 1 to 5 (Family: none)	1-7
Y	JP 9-236334 A (Daikin Industries, Ltd.), 09 September 1997 (09.09.1997), paragraphs [0037] to [0046]; fig. 5 to 6 (Family: none)	1-7

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search 05 August, 2010 (05.08.10)	Date of mailing of the international search report 17 August, 2010 (17.08.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/059183

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 58-115235 A (Sharp Corp.), 08 July 1983 (08.07.1983), column 6, line 16 to column 10, line 13; fig. 3 to 4 (Family: none)	2
Y	JP 4-174238 A (Toshiba Corp.), 22 June 1992 (22.06.1992), page 9, upper left column, line 10 to page 10, lower right column, line 16; fig. 8 to 9 & US 5186016 A & GB 2251318 A & KR 10-1995-0007285 B	2-7
Y	JP 2002-243276 A (Toshiba Carrier Corp.), 28 August 2002 (28.08.2002), paragraph [0081]; fig. 8 (Family: none)	2-7
Y	JP 59-145455 A (Daikin Industries, Ltd.), 20 August 1984 (20.08.1984), column 15, line 3 to column 20, line 10; fig. 4 to 7 (Family: none)	4-7
Y	JP 2005-300008 A (Matsushita Electric Industrial Co., Ltd.), 27 October 2005 (27.10.2005), paragraph [0081] (Family: none)	5
Y	JP 62-237255 A (Hitachi, Ltd.), 17 October 1987 (17.10.1987), page 2, upper right column, line 9 to lower right column, line 14; fig. 1 to 4 (Family: none)	7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 58115235 A **[0004] [0006] [0008]**
- JP 2007278536 A **[0005] [0006] [0010]**