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(71) Applicant: **Hitachi-Johnson Controls Air Conditioning, Inc.**
Tokyo 105-0022 (JP)

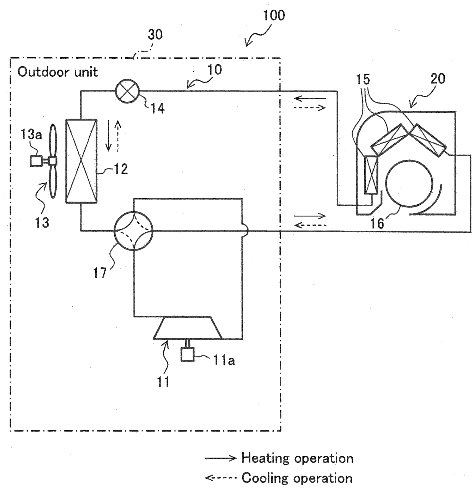
(72) Inventors:
- **KATO, Tomohiro**
  Tokyo 105-0022 (JP)
- **XIE, Yingmei**
  Tokyo 105-0022 (JP)

(74) Representative: **MERH-IP Matias Erny Reichl Hoffmann**
Patentanwälte PartG mbB
Paul-Heyse-Strasse 29
80336 München (DE)

(54) **AIR CONDITIONER**

(57) An air conditioner is provided that cleans an indoor heat exchanger and additionally purify air. The air conditioner (100) includes: a compressor (11); an outdoor heat exchanger (12); an expansion valve (14); an indoor heat exchanger (15); an indoor fan (16); and a controller to make the indoor heat exchange (15) work as an evaporator and execute processing of making the indoor heat exchanger (15) frosted, wherein the controller makes the indoor fan (16) driven during at least a part of the processing, and executes control of keeping temperature of the indoor heat exchanger (15) below freezing but higher than a predetermined value, wherein the predetermined value indicates a temperature below freezing, at which gaps between fins of the indoor heat exchanger (15) are not completely filled with frost.

FIG. 1



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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] A technique of cleaning a heat exchanger in an air conditioner includes one disclosed in Patent Literature 1. That is, Patent Literature 1 describes that a control unit operates to make temperature of a heat exchanger decreased to frost or ice surfaces of fins.

PRIOR ART LITERATURES

Patent Literatures

[0003] Patent Literature 1: Japanese Patent Application Publication No. 2018-189270

SUMMARY OF THE INVENTION

Problems to be Solved

[0004] Patent Literature 1 describes the technique of cleaning an indoor heat exchanger with frost or ice adhered to the indoor heat exchanger, but is silent about a technique of purifying air in an air-conditioned room.

[0005] The present invention is then intended to provide an air conditioner to clean an indoor heat exchanger and additionally purify air.

Solution to Problems

[0006] In order to solve the above-described problem, an air conditioner according to the present invention includes: a compressor; an outdoor heat exchanger; an expansion valve; an indoor heat exchanger; an indoor fan; and a controller to make the indoor heat exchange work as an evaporator and execute processing of making the indoor heat exchanger frosted, wherein the controller makes the indoor fan driven during at least a part of the processing, and executes control of keeping temperature of the indoor heat exchanger below freezing but higher than a predetermined value, wherein the predetermined value indicates a temperature below freezing, at which gaps between fins of the indoor heat exchanger are not completely filled with frost.

Advantageous Effects of the Invention

[0007] The present invention provides an air conditioner to clean the indoor heat exchanger and additionally purify air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 shows a configuration of an air conditioner according to a first embodiment;
FIG. 2 is a vertical cross-sectional view of an indoor unit of the air conditioner according to the first embodiment;
FIG. 3 is a perspective view of an outdoor unit of the air conditioner according to the first embodiment, with side plates and a top plate of a housing thereof moved;
FIG. 4 is a functional block diagram of the air conditioner according to the first embodiment;
FIG. 5 is a flowchart of cleaning operation for the indoor heat exchanger in the air conditioner according to the first embodiment;
FIG. 6 illustrates the indoor heat exchanger of the air conditioner according to the first embodiment, while being defrosted;
FIG. 7 is a timing chart, in the air conditioner according to the first embodiment, of states of a compressor and a four-way valve, degree of opening of an expansion valve, rotation speeds of an indoor fan and an outdoor fan, and change in temperature of the indoor heat exchanger;
FIG. 8A is a partially enlarged view of a frosted indoor heat exchanger of an air conditioner according to a comparative case;
FIG. 8B is a partially enlarged view of the frosted indoor heat exchanger of the air conditioner according to the first embodiment;
FIG. 9 is a flowchart of cleaning operation for the indoor heat exchanger in an air conditioner according to a second embodiment;
FIG. 10 is a flowchart of cleaning operation for the indoor heat exchanger in an air conditioner according to a third embodiment;
FIG. 11 is a vertical cross-sectional view of an indoor unit of an air conditioner according to a fourth embodiment;
FIG. 12 is a functional block diagram of the air conditioner according to the fourth embodiment;
FIG. 13 is a flowchart of cleaning operation for an indoor heat exchanger in the air conditioner according to the fourth embodiment;
FIG. 14 is a timing chart, in the air conditioner according to the fourth embodiment, of states of the compressor and four-way valve, degree of opening of the expansion valve, the rotation speeds of the indoor fan and outdoor fan, states of a sterilizing substance generator, and change in temperature of the indoor heat exchanger; and
FIG. 15 shows a configuration of an air conditioner according to a fifth embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

First Embodiment

<Configuration of Air Conditioner>

[0009] FIG. 1 shows a configuration of an air conditioner 100 according to a first embodiment. Note that solid line arrows in FIG. 1 indicate refrigerant flow during heating operation. In contrast, dashed line arrows in FIG. 1 indicate refrigerant flow during cooling operation. The air conditioner 100 is a device to execute air conditioning such as cooling operation and heating operation. As shown in FIG. 1, the air conditioner 100 includes a compressor 11, an outdoor heat exchanger 12, an outdoor fan 13, and an expansion valve. The air conditioner 100 also includes an indoor heat exchanger 15, an indoor fan 16, and a four-way valve 17, in addition to those described above.

[0010] The compressor 11 is a device to compress a low-temperature, low-pressure gas refrigerant and discharge a high-temperature, high-pressure gas refrigerant, and includes a compressor motor 11a as a drive source. The compressor 11 is selected from a scroll compressor, a rotary compressor, and the like. Note that the compressor 11 has an accumulator 9 (see FIG. 3) connected thereto at a suction end thereof, although not shown in FIG. 1, for separating gas and liquid in the refrigerant.

[0011] The outdoor heat exchanger 12 is a heat exchanger to exchange heat between the refrigerant flowing through heat transfer tubes 12b thereof (see FIG. 3) and ambient air blown by the outdoor fan 13. The outdoor fan 13 is a fan to blow ambient air to the outdoor heat exchanger 12. The outdoor fan 13 includes an outdoor fan motor 13a as a drive source and is provided around the outdoor heat exchanger 12. The expansion valve 14 is a valve to depressurize the refrigerant condensed in a "condenser" (one of the outdoor heat exchanger 12 and the indoor heat exchanger 15). Note that the refrigerant depressurized by the expansion valve 14 is guided to an "evaporator" (the other of the outdoor heat exchanger 12 and the indoor heat exchanger 15).

[0012] The indoor heat exchanger 15 is a heat exchanger to exchange heat between the refrigerant flowing through heat transfer pipes 15b thereof (see FIG. 2) and indoor air (air in an air-conditioned room) blown by the indoor fan 16. The indoor fan 16 is a fan to blow the indoor air to the indoor heat exchanger 15. The indoor fan 16 includes an indoor fan motor 16a (see FIG. 4) as a drive source, and is provided around the indoor heat exchanger 15.

[0013] The four-way valve 17 is a valve to switch a refrigerant flow path according to an operation mode of the air conditioner 100. The air conditioner 100 includes a refrigerant circuit 10 having the compressor 11 connected with the outdoor heat exchanger 12, expansion valve 14, and indoor heat exchanger 15 via the four-way valve 17.

[0014] During cooling operation (see the dashed line arrows in FIG. 1), for instance, the refrigerant circulates in the refrigerant circuit 10 sequentially through the compressor 11, outdoor heat exchanger 12 (condenser), expansion valve 14, and indoor heat exchanger 15 (evaporator). In contrast, during heating operation (see the solid line arrows in FIG. 1), the refrigerant circulates in the refrigerant circuit 10 sequentially through the compressor 11, indoor heat exchanger 15 (condenser), expansion valve 14, and outdoor heat exchanger 12 (evaporator).

[0015] Note that FIG. 1 shows a case where the compressor 11, outdoor heat exchanger 12, outdoor fan 13, expansion valve 14, and four-way valve 17 are installed in an outdoor unit 30. The indoor heat exchanger 15 and indoor fan 16 are installed in an indoor unit 20.

[0016] FIG. 2 is a vertical cross-sectional view of the indoor unit 20. As shown in FIG. 2, the indoor unit 20 includes a drain pan 18, a casing 19, and filters 21a and 21b, in addition to the indoor heat exchanger 15 and indoor fan 16. The indoor unit 20 further includes a front panel 22, a horizontal louver 23 and a vertical louver 24.

[0017] The indoor heat exchanger 15 includes fins 15a and the heat transfer tubes 15b penetrating the fins 15a. From another point of view, the indoor heat exchanger 15 includes a front indoor heat exchanger 15c arranged in front of the indoor fan 16, and a rear indoor heat exchanger 15d arranged behind the indoor fan 16. In a case of FIG. 2, an upper end of the front indoor heat exchanger 15c is connected with an upper end of the rear indoor heat exchanger 15d so as to form an inverted V-shape, in vertical cross-sectional view. Note that the configuration of the indoor heat exchanger 15 in FIG. 2 is just an example, and the configuration is not limited thereto.

[0018] The indoor fan 16 is a cylindrical cross-flow fan, for example, and is provided around the indoor heat exchanger 15. The indoor fan 16 includes fan blades 16b and ring-shaped end plates 16c to which the fan blades 16b are attached, in addition to the indoor fan motor 16a (see FIG. 4) as described above. The drain pan 18 receives dew water from the indoor heat exchanger 15 and is arranged under the indoor heat exchanger 15. The casing 19 accommodates the indoor heat exchanger 15, the indoor fan 16, and the like.

[0019] The filters 21a and 21b collect dust from the air flowing to the indoor heat exchanger 15 and are provided around the indoor heat exchanger 15. One of them, the filter 21a, is arranged in front of the indoor heat exchanger 15, while the other of them, the filter 21b, is arranged above the indoor heat exchanger 15.

[0020] The front panel 22 is a panel installed so as to cover the front filter 21a, and is pivotable forward about a lower end thereof. Note that the front panel 22 may be configured so as not to be pivoted. The horizontal louver 23 is a plate-like member used to adjust a right-left orientation of the air blown out from the indoor fan 16. The horizontal louver 23 is arranged in a blown-out air path 26, and is horizontally pivoted by a horizontal louver motor 34 (see FIG. 4). The vertical louver 24 is a plate-shaped member used to adjust an up-down orientation of the air blown out from the indoor fan 16. The vertical louver 24 is arranged at an air outlet 27 and is vertically pivoted by a vertical louver motor 35 (see FIG. 4).

[0021] Air sucked in through air inlets 25a and 25b exchanges heat with the refrigerant flowing through the heat transfer tubes 15b of the indoor heat exchanger 15, and the heat-exchanged air is guided to the blown-out air path 26. The air flowing through the blown-out air path 26 is guided in a predetermined orientation by the horizontal louver 23 and vertical louver 24, and is further blown out through an air outlet 27 into the air-conditioned room.

[0022] Note that the dust flowing toward the air inlets 25a and 25b along with the air flow is mostly collected by the filters 21a and 21b. However, fine dust may pass through the filters 21a and 21b and adhere to the indoor heat exchanger 15. Accordingly, the indoor heat exchanger 15 is desirably cleaned periodically. Purifying air in the air-conditioned room additionally, while the indoor heat exchanger 15 being cleaned, would further improve user comfort.

[0023] Then, the first embodiment is designed to clean the indoor heat exchanger 15 with the frost involved in making the indoor heat exchanger 15 frosted, and to purify the air in the air-conditioned room with the frost. The frost on the indoor heat exchanger 15 is made to work as if it were a filter for purifying air, to have dust in the air adhered to the frost and flushed away, although the details are described below. Note that a series of processes relating to cleaning the indoor heat exchanger 15 is referred to as "cleaning operation."

[0024] FIG. 3 is a perspective view of the outdoor unit 30, with side plates and a top plate of a housing 31 removed. Note that FIG. 3 does not show the expansion valve 14 (see FIG. 1) and the four-way valve 17 (see FIG. 1). As shown in FIG. 3, the housing 31 of the outdoor unit 30 houses an electric component box 32, in addition to the compressor 11, outdoor heat exchanger 12, and outdoor fan 13. In the case in FIG. 3, the outdoor heat exchanger 12 having an L-shape in planar view is installed on a bottom plate 31a of the housing 31. The outdoor heat exchanger 12 includes a large number of fins 12a aligned at predetermined intervals and the heat transfer tubes 12b penetrating the fins 12a. In the case in FIG. 3, a propeller fan is used as the outdoor fan 13.

[0025] FIG. 4 is a functional block diagram of the air conditioner 100. The indoor unit 20 shown in FIG. 4 includes a remote control transceiver 28, an indoor temperature sensor 29, an indoor heat exchanger temperature sensor 33, an indicator lamp 36, and an indoor control circuit 41, in addition to the components described above. The remote control transceiver 28 exchanges predetermined information with a remote controller 50 through infrared communication or the like. The indoor temperature sensor 29 is a sensor to detect temperature in the air-conditioned room, and is installed on a portion, closer to the air inlet, of the indoor heat exchanger 15, for example.

[0026] The indoor heat exchanger temperature sensor 33 is a sensor to detect temperature of the indoor heat exchanger 15 (see FIG. 2). Note that the indoor heat exchanger temperature sensor 33 may be installed on the indoor heat exchanger 15, or may be installed on a predetermined refrigerant pipe connected to the indoor heat exchanger 15. Values detected by the indoor temperature sensor 29 and indoor heat exchanger temperature sensor 33 are outputted to the indoor control circuit 41. The indicator lamp 36 is a lamp to show a predetermined indication regarding air conditioning.

[0027] The indoor control circuit 41 includes electronic circuits such as a CPU (Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory), and various interfaces, although not shown. The indoor control circuit 41 is configured to retrieve one or more programs stored in the ROM, load the program(s) into the RAM, and cause the CPU to execute various processes.

[0028] As shown in FIG. 4, the indoor control circuit 41 includes a storage 41a and an indoor controller 41b. The storage 41a stores data received via the remote control transceiver 28, detection values of the sensors, and the like, in addition to the one or more predetermined programs. The indoor controller 41b controls the indoor fan motor 16a, horizontal louver motor 34, vertical louver motor 35, indicator lamp 36, and the like, based on the data in the storage 41a.

[0029] The outdoor unit 30 includes an outdoor temperature sensor 37 and an outdoor control circuit 42, in addition to the components described above. The outdoor temperature sensor 37 is a sensor to detect temperature of ambient air and is installed at a predetermined location in the outdoor unit 30. Additionally, the outdoor unit 30 also includes a sensor to detect discharge temperature of the compressor 11 (see FIG. 1), although not shown in FIG. 4. Values detected by these sensors are outputted to the outdoor control circuit 42.

[0030] The outdoor control circuit 42 includes electronic circuits such as a CPU, a ROM, a RAM, and various interfaces, although not shown, and is connected to the indoor control circuit 41 via a communication line. As shown in FIG. 4, the outdoor control circuit 42 includes a storage 42a and an outdoor controller 42b.

[0031] The storage 42a stores data received from the indoor control circuit 41 and the like, in addition to the one or more predetermined programs. The outdoor controller 42b controls the compressor motor 11a, outdoor fan motor 13a, expansion valve 14, four-way valve 17, and the like, based on the data in the storage 42a. Note that the indoor control circuit 41 and outdoor control circuit 42 are collectively referred to as a controller 40.

<Processing of Controller>

[0032] Fig. 5 is a flowchart of the cleaning operation for the indoor heat exchanger (see FIGS. 1 and 4 as required). Note that a series of processing in FIG. 5 may be started when a value obtained by accumulating execution time of the air conditioning operation since completion of previous cleaning operation (the sum) has been amounted to a predetermined value, for example, although this condition is not shown in FIG. 5. Alternatively or additionally, the series of processing in FIG. 5 may be started when a user has executed predetermined operation on an operation terminal such as the remote controller 50 (see FIG. 4), a smart phone, and a mobile phone, for example.

[0033] In step S101 in FIG. 5, the controller 40 makes the indoor heat exchanger 15 frosted. That is, the controller 40 executes processing of making the refrigerant circulate in a cooling cycle in the refrigerant circuit 10 to have the indoor heat exchanger 15 working as an evaporator, to make the indoor heat exchanger 15 frosted. This causes moisture in the air to be condensed into dew and then frosted on the indoor heat exchanger 15. Note that the indoor heat exchanger 15 is assumed to remain frosted in steps S102 to S104 after step S101. The indoor fan 16 is driven during processing in steps S101 to S104.

[0034] Next, the controller 40 in step S102 determines whether or not a predetermined time Δta has elapsed since the beginning of processing of making the indoor heat exchanger 15 frosted. Note that the predetermined time Δta is a time required for the temperature of the indoor heat exchanger 15 to drop below a predetermined value Th below freezing (see FIG. 7), and is preset. Here, the predetermined value Th is a temperature below freezing at which the gaps between the fins 15a (see FIG. 2) of the indoor heat exchanger 15 are not completely filled with frost (and this state is kept). When the predetermined time Δta has not elapsed in step S102 (S102: No), processing of the controller 40 returns to step S101. On the contrary, when the predetermined time Δta has elapsed in step S102 (S102: Yes), processing of the controller 40 proceeds to step S103.

[0035] The controller 40 in step S103 makes the rotation speed of the compressor 11 decreased. For example, the controller 40 may make the compressor 11 driven at a speed lower than the average rotation speed of the compressor 11 during the predetermined time Δta (S102). This moderates frost growing on the indoor heat exchanger 15, to keep a condition of air flowing through minute gaps between crystals of the frost. As a result, the frost on the indoor heat exchanger 15 works as if it were an air purifying filter, so that dust in the air is collected by the frost on the indoor heat exchanger 15. In this manner, the controller 40 of the first embodiment makes the indoor heat exchanger 15 frosted and additionally makes the air in the air-conditioned room purified. Note that the example in FIG. 7 shows that the temperature of the indoor heat exchanger 15 is dropped to the predetermined value Th at time t2, at which the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted, and the controller 40 makes the rotation speed of the compressor 11 decreased after time t2, but the present invention is not limited thereto. For instance, the predetermined time Δta may be suitably set such that the controller 40 continues to make the compressor 11 rotated at a relatively high speed (e.g., rotation speed n1: see FIG. 7) for a while after the temperature of the indoor heat exchanger 15 has dropped to the predetermined value Th, and then makes the rotation speed of the compressor 11 decreased. In addition, the example in FIG. 7 shows that the base time for measuring the predetermined time Δta is set to the beginning of making the indoor heat exchanger 15 frosted (time t1), but the present invention is not limited thereto. That is, the base time for measuring the predetermined time Δta may be the time at which the temperature of the indoor heat exchanger 15 has dropped to 0 degrees Celsius or lower, or the time where the temperature of the indoor heat exchanger 15 has dropped to the predetermined value Th or lower, for example.

[0036] The controller 40 in step S104 determines whether or not a predetermined time Δtb has elapsed since the rotation speed of the compressor 11 was decreased. Note that the predetermined time Δtb is the time during which the compressor 11 continues to be driven at a low speed, and is preset. This allows for keeping the indoor heat exchanger 15 moderately covered with frost for a comparatively long time, while preventing the indoor heat exchanger 15 from being additionally frosted, to sufficiently purify the air in the air-conditioned room. Note that there is no specific need for the predetermined time Δtb described above to be a fixed value. For instance, the length of the predetermined time Δtb may be suitably set (changed) by the user operating an operation terminal, such as the remote controller 50 (see FIG. 4), a smart phone, a mobile phone, and a tablet, in a predetermined way. Additionally, when the operation terminal such as the remote controller 50 is operated in a predetermined way by the user, the cleaning operation involving air purification (control of making the compressor 11 driven at a low speed from halfway through the processing, to make the indoor heat exchanger 15 frosted, onwards) may be interrupted. This allows for suitably incorporating the user's intention of interrupting (canceling) the cleaning operation, involving air purification, in the middle of operation.

[0037] When the predetermined time Δtb has not elapsed in step S104 (S104: No), the controller 40 repeats processing in step S104. On the contrary, when the predetermined time Δtb has elapsed in step S104 (S104: Yes), processing of the controller 40 proceeds to step S105. In step S105, the controller 40 makes the indoor heat exchanger 15 defrosted. For example, the controller 40 makes the compressor 11 stopped and makes the opening of the expansion valve 14 increased. This causes the high-temperature refrigerant to flow from the outdoor heat exchanger 12, where the refrigerant is under high pressure, to the indoor heat exchanger 15, where the refrigerant is under low pressure, through the expansion valve 14, to make the indoor heat exchanger 15 defrosted. Note that there is no specific need for the opening of the expansion valve 14 to be increased while the indoor heat exchanger 15 is defrosted, as long as the refrigerant can flow through the expansion valve 14.

[0038] FIG. 6 illustrates the indoor heat exchanger 15 while being defrosted. When the controller 40 makes the indoor heat exchanger 15 defrosted (S105) after the indoor heat exchanger 15 has been frosted (S101 in FIG. 5), the high-temperature refrigerant flows through the heat transfer tubes 15b of the indoor heat exchanger 15. As a result, frost 61 on the indoor heat exchanger 15 is defrosted to have a large amount of water 62 streaming down the fins 15a and then flowing down into the drain pan 18, along with dust 63.

[0039] FIG. 7 is a timing chart of states of the compressor and four-way valve, the degree of opening of the expansion valve, the rotation speeds of the indoor fan and outdoor fan, and change in temperature of the indoor heat exchanger (see FIGS. 1 and 4, as required). Note that the horizontal axis in FIG. 7 indicates time. The vertical axis in FIG. 7 indicates states of the compressor 11 and four-way valve 17, and the like. In the example in FIG. 7, the air conditioner 100 is stopped (air conditioning is not executed) until time t1. It is assumed, for example, that heating operation was executed immediately before the air conditioner 100 has been stopped (see states of "four-way valve" in FIG. 7).

[0040] When the indoor heat exchanger 15 is frosted (S101 in FIG. 5), the controller 40 makes the four-way valve 17 switched to the cooling cycle at time t1, the expansion valve 14 throttled to a predetermined opening $\alpha 1$, and the compressor 11 driven at a rotation speed n1. Additionally, the controller 40 makes the indoor fan 16 driven at a predetermined rotation speed n3 and makes the outdoor fan 13 driven at a rotation speed n4.

[0041] Note that the predetermined opening $\alpha 1$ of the expansion valve 14 may be an opening smaller than that during normal air conditioning operation, for example. This causes the outdoor heat exchanger 12 to work as a condenser, while the indoor heat exchanger 15 to work as an evaporator, so that the low-pressure refrigerant having a saturation temperature lower than 0 degrees Celsius flows through the indoor heat exchanger 15. As a result, the temperature of the indoor heat exchanger 15 drops below freezing, as time passes (see FIG. 7), to cause moisture in the air to be condensed into dew and then frosted on the indoor heat exchanger 15.

[0042] Note that the controller 40 preferably makes the indoor fan 16 driven at a rotation speed n3 equal to or less than a predetermined value, while the indoor heat exchanger 15 being frosted (time t1 to t4). What is used as the predetermined value described above may be a value obtained by dividing the sum of an upper limit value and a lower limit value of the rotation speed of the indoor fan 16 by 2, for example. This is because if the rotation speed of the indoor fan 16 is too high, fresh air comes in before moisture contained in the air around the indoor heat exchanger 15 is changed into frost, to make the change difficult to proceed.

[0043] In addition, when the indoor fan 16 is being driven while the indoor heat exchanger 15 being frosted, the controller 40 preferably makes the vertical louver 24 (see FIG. 2) swung in a predetermined way. This causes the air purified with the frost on the indoor heat exchanger 15 (air from which fine dust has been removed) to be readily circulated in the air-conditioned room. Further, when the vertical louver 24 is swung while the indoor heat exchanger 15 being frosted, a swing range is preferably smaller than the full swing range of the vertical louver 24 (full range of the swing range). This reduces the user's discomfort due to chilly air blowing into the air-conditioned room.

[0044] When the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted (S102 in FIG. 5: Yes), the controller 40 makes the rotation speed of the compressor 11 decreased at time t2 (S103). This causes the compressor 11 to be driven at a low rotation speed n2, so that the temperature of the indoor heat exchanger 15 rises within a subzero range. In the example in FIG. 7, the temperature of the indoor heat exchanger 15 has dropped to a predetermined value Th below freezing, after the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted. Subsequently, the temperature of the indoor heat exchanger 15 is higher than the predetermined value Th from time t3 to time t4.

[0045] As described above, the controller 40 executes control of making the indoor fan 16 driven, during processing of making the indoor heat exchanger 15 frosted, to keep the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th (from time t2 to t4). In other words, the controller 40 executes control of making the indoor fan 16 driven, during processing of making the indoor heat exchanger 15 frosted, to purify the air in the air-conditioned room with the frost involved in making the indoor heat exchanger 15 frosted. Such control is implemented in the first embodiment that the controller 40 makes the rotation speed of the compressor 11 decreased from halfway through the processing, to make the indoor heat exchanger 15 frosted, (time t2) onwards. This moderates frost growing on the indoor heat exchanger 15.

[0046] FIG. 8A is a partially enlarged view the frosted indoor heat exchanger 15 of the air conditioner according to a comparative case. In a case where the compressor 11 is continuously driven at a comparatively high speed, while the indoor heat exchanger 15 being frosted, for example, the frost 61 on the indoor heat exchanger 15 grows too far (too many number of crystals, or too much amount, of the generated frost 61), resulting in the close-packed frost 61 as shown in FIG. 8A. In this state, gaps between the fins 15a are mostly filled with frost 61, to make air less likely flow through the gaps.

[0047] FIG. 8B is a partially enlarged view of the frosted indoor heat exchanger 15 of the air conditioner according to the first embodiment. With the first embodiment, the controller 40 makes the rotation speed of the compressor 11 decreased, when the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted (time t2 in FIG. 7), as described above. This causes the number of crystals, or an amount, of the generated frost 61 to be reduced (the frost becomes sparse), as compared with the case where the rotation speed of the compressor 11 is high (see FIG. 8A). That is, as shown in FIG. 8B, the degree of the gaps between the fins 15a of the indoor heat exchanger 15 being filled with the frost 61 is small, to allow for keeping the fins moderately frosted with the frost 61. There is another advantage that a surface area of each crystal of the frost 61 readily increases, as the frost 61 grows slowly. As a result, dust mixed in the air adheres to the frost 61 while the air flows through the gaps between the fins 15a, so that purified air is blown out into the air-conditioned room.

[0048] In the example in FIG. 7, the temperature of the indoor heat exchanger 15 from time t2 to t3 is lower than (has undershot) the predetermined value Th, even after the controller 40 has made the rotation speed of the compressor 11 decreased at time t2. The temperature of the indoor heat exchanger 15 from time t3 to time t4 stays within a range of below freezing but higher than the predetermined value Th (e.g., minus 10 degrees Celsius). The controller 40 executes the above-described control (control of keeping the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th) so as to keep an amount of frost on the indoor heat exchanger 15 at the beginning of the control. More in detail, when the predetermined time Δta has elapsed since the beginning of the processing to make the indoor heat exchanger 15 frosted, the controller 40 switches from control of increasing the amount of frost on the indoor heat exchanger 15 (that is, the number of crystals, or an amount, of the frost) to control of keeping the amount of frost on the indoor heat exchanger 15. This allows for keeping the indoor heat exchanger 15 moderately frosted for a predetermined period of time (time t2 to t4 in FIG. 7) required for purifying the air in the air-conditioned room.

[0049] Note that FIG. 7 shows merely an example, and there is no specific need for the rotation speed of the compressor 11 and the opening of the expansion valve 14 to be constant from time t1 to time t2. The same holds true for the period from time t2 to time t4. For instance, the controller 40 may suitably make the rotation speed of the compressor 11 and the opening of the expansion valve 14 changed, based on the temperature in the air-conditioned room, the temperature of the indoor heat exchanger 15, and the like.

[0050] Then, when the predetermined time Δtb has elapsed since the rotation speed of the compressor 11 was decreased (S104 in FIG. 5: Yes), the controller 40 makes the indoor heat exchanger 15 defrosted (S105 in FIG. 5). In the example in FIG. 7, the controller 40 makes the compressor 11, outdoor fan 13, and indoor fan 16 stopped at time t4, and makes the opening of the expansion valve 14 increased (e.g., makes the expansion valve 14 fully opened). This causes the high-temperature refrigerant to flow from the outdoor heat exchanger 12, where the refrigerant is under high pressure, to the indoor heat exchanger 15, where the refrigerant is under low pressure, through the expansion valve 14. As a result, frost and/or ice on the indoor heat exchanger 15 is/are melted, and dust on the indoor heat exchanger 15 is flushed away (see FIG. 6). That is, not only the dust, already landed on the indoor heat exchanger 15 before frosting, but also the dust, collected by the frost on the indoor heat exchanger 15 during frosting, is flushed away. Note that there is no specific need for the opening of the expansion valve 14 to be increased at time t4 in FIG. 7, as long as the refrigerant can flow through the expansion valve 14.

<Advantageous Effects>

[0051] According to the first embodiment, when the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted (S102 in FIG. 5: Yes), the controller 40 makes the rotation speed of the compressor 11 decreased (S103), and makes the temperature of the indoor heat exchanger 15 higher than the predetermined value Th, while keeping said temperature below freezing. This moderates frost growing on the indoor heat exchanger 15 (that is, moderates the number of crystals, or an amount, of the frost), to keep the amount of frost (see FIG. 8B). As a result, dust is adhered to the frost while the air flowing through the indoor heat exchanger 15, to purify the air in the air-conditioned room. Additionally, dust on the indoor heat exchanger 15 is flushed away such as through making the indoor heat exchanger 15 frosted. In this manner, the first embodiment provides the air conditioner 100 to clean the indoor heat exchanger 15 and additionally purify air.

Second Embodiment

[0052] A second embodiment is different from the first embodiment on the point that the controller 40 (see FIG. 4) makes the rotation speed of the compressor 11 decreased, while the indoor heat exchanger 15 (see FIG. 1) being frosted, based on the temperature of the indoor heat exchanger 15. Note that other points (such as the configuration of the air conditioner: see FIGS. 1 to 4) are the same as those of the first embodiment. Therefore, a description is given of differences from the first embodiment, and duplicate descriptions are not given here.

[0053] FIG. 9 is a flowchart of the cleaning operation for the indoor heat exchanger in an air conditioner according to the second embodiment (see FIGS. 1 and 4 as required). Note that processing in step S101 and steps S103 to S105 in FIG. 9 is the same as that of the first embodiment (see FIG. 5), and detailed description thereof is not given here. After making the indoor heat exchanger 15 frosted in step S101, the controller 40 determines in step S202 whether the temperature of the indoor heat exchanger 15 is equal to or less than the predetermined value Th. The predetermined value Th (see also FIG. 7) is a subzero temperature at which the gaps between the fins 15a of the indoor heat exchanger 15 are not completely filled with frost (and this state is kept), and is preset as a value lower than zero degree Celsius. Note that a value of the predetermined Th is minus 10 degrees Celsius, for example.

[0054] In step S202, when the temperature of the indoor heat exchanger 15 is higher than the predetermined value Th (S202: No), processing of the controller 40 returns to step S101. On the contrary, when the temperature of the indoor heat exchanger 15 is equal to or less than the predetermined value Th in step S202 (S202: Yes), processing of the controller 40 proceeds to step S103. Then, the controller 40 in step S103 makes the rotation speed of the compressor 11 decreased.

[0055] In this manner, when the temperature of the indoor heat exchanger 15 becomes equal to or less than the predetermined value Th (S202: Yes), during processing of making the indoor heat exchanger 15 frosted, the controller 40 executes control of making the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th (S103). That is, the controller 40 switches from control of increasing the amount of frost (the number of crystals, or an amount, of the frost) on the indoor heat exchanger 15 to control of keeping the amount of frost on the indoor heat exchanger 15. This allows for keeping the amount of frost suitable for purifying air, while moderating frost growing on the indoor heat exchanger 15 (see FIG. 8B).

[0056] Note that FIG. 9 shows such an example that when the predetermined time Δtb has elapsed since the controller 40 made the rotation speed of the compressor 11 decreased (S104: Yes), the controller 40 ends processing of driving the compressor 11 at a low speed (that is, ends processing of purifying air), but the present invention is not limited thereto. For example, after making the rotation speed of the compressor 11 decreased (S103), the controller 40 may make the indoor fan 16 stopped (that is, ends processing of purifying air), on the condition that the temperature of the indoor heat exchanger 15 has stayed within a predetermined range of below freezing but higher than the predetermined value Th for a certain period of time. This facilitates keeping the indoor heat exchanger 15 moderately frosted.

[0057] In addition, after purifying air by making the indoor heat exchanger 15 frosted, while the indoor fan 16 being driven, the controller 40 may make the rotation speed of the compressor 11 increased, with the indoor fan 16 stopped, and continue to make the indoor heat exchanger 15 frosted. This allows for preventing chilly air from being blown into the air-conditioned room for a long time and causing the indoor heat exchanger 15 to be frosted in enormous amounts, until defrosted, resulting in dust on the indoor heat exchanger 15 being flushed away with enormous amounts of water.

<Advantageous Effects>

[0058] According to the second embodiment, the controller 40 makes the rotation speed of the compressor 11 decreased (S103), when the temperature of the indoor heat exchanger 15 has dropped below the predetermined value Th (S202 in FIG. 9: Yes), while the indoor heat exchanger 15 being frosted. This moderates frost growing on the indoor heat exchanger 15, to allow for purifying the air in the air-conditioned room.

Third Embodiment

[0059] A third embodiment is different from the first embodiment on the point that the controller 40 makes the rotation speed of the compressor 11 decreased, while the indoor heat exchanger 15 (see FIG. 1) being frosted, based on the magnitude of inputted power to the indoor fan motor 16a (see FIG. 4). Note that other points (such as the configuration of the air conditioner: see FIGS. 1 to 4) are the same as those of the first embodiment. Therefore, a description is given of differences from the first embodiment, and duplicate descriptions are not given here.

[0060] FIG. 10 is a flowchart of the cleaning operation for the indoor heat exchanger in an air conditioner according to the third embodiment (see FIGS. 1 and 4 as required). Note that processing in step S101 and steps S103 to S105 in FIG. 10 is the same as that of the first embodiment (see FIG. 5), and detailed description thereof is not given here. After making the indoor heat exchanger 15 frosted in step S101, the controller 40 determines in step S302 whether the inputted power to the indoor fan motor 16a is equal to or less than a predetermined value. The predetermined value indicates a threshold to serve as a criterion for determining whether or not to decrease the rotation speed of the compressor 11, while the indoor heat exchanger 15 being frosted, and is preset.

[0061] Note that the inputted power to the indoor fan motor 16a may be calculated based on a voltage command value and/or current command value to the indoor fan motor 16a, or may be calculated based on a detected voltage value and/or detected current value at the indoor fan motor 16a. According to the results of experiments and simulations by the inventors, the inputted power to the indoor fan motor 16a tends to decrease as the amount of frost on the indoor heat exchanger 15 increases.

[0062] In step S302, when the inputted power to the indoor fan motor 16a is higher than the predetermined value (S302: No), processing of the controller 40 returns to step S101. On the contrary, when the inputted power to the indoor fan motor 16a has become equal to or less than the predetermined value in step S302 (S302: Yes), processing of the controller 40 proceeds to step S103.

Then, the controller 40 in step S103 makes the rotation speed of the compressor 11 decreased.

[0063] In this manner, when the inputted power to the indoor fan motor 16a, as a drive source of the indoor fan 16, has become equal to or less than the predetermined value (S302: Yes), during processing of making the indoor heat exchanger 15 frosted, the controller 40 executes control of making the temperature of the indoor heat exchanger 15 higher than the predetermined value Th, while keeping said temperature below freezing (S103). That is, the controller 40 switches from control of increasing the amount of frost on the indoor heat exchanger 15 to control of keeping the amount of frost on the indoor heat exchanger 15. This moderates frost growing on the indoor heat exchanger 15, to allow for keeping the amount of frost suitable for purifying air.

[0064] Note that the threshold of the inputted power to the indoor fan motor 16a ("predetermined value" in S302), as a criterion for determining whether or not to decrease the rotation speed of the compressor 11, may be suitably set depending on installation environment of the air conditioner 100. For example, when executing the above-described control (S103) based on the inputted power to the indoor fan motor 16a, the controller 40 preferably sets the "predetermined value" as the threshold of the inputted power to the indoor fan motor 16a, based on the inputted power to the indoor fan motor 16a at the beginning of the processing to make the indoor heat exchanger 15 frosted. In particular, the controller 40 may set a value obtained by multiplying the inputted power to the indoor fan motor 16a at the beginning of making the indoor heat exchanger 15 frosted by a predetermined coefficient smaller than 1, as the "predetermined value," for example. This allows for suitably setting the "predetermined value" as a criterion for determining whether or not to decrease the rotation speed of the compressor 11, depending on installation environment of the air conditioner 100.

[0065] Note that FIG. 10 shows such an example that when the predetermined time Δtb has elapsed since the controller 40 made the rotation speed of the compressor 11 decreased (S104: Yes), the controller 40 ends processing of making the compressor 11 driven at a low speed (that is, ends processing of purifying air), but the present invention is not limited thereto. For example, after making the rotation speed of the compressor 11 decreased (S103), the controller 40 may make the indoor fan 16 stopped (that is, ends processing of purifying air), on the condition that the inputted power to the indoor fan motor 16a has stayed within a predetermined range for a certain period of time. The predetermined range is a range of the inputted power to the indoor fan motor 16a, suitable for keeping the amount of frost on the indoor heat exchanger 15, and is preset. This facilitates keeping the indoor heat exchanger 15 moderately frosted.

<Advantageous Effects>

[0066] According to the third embodiment, the controller 40 makes the rotation speed of the compressor 11 decreased (S103), when the inputted power to the indoor fan motor 16a has become equal to or less than a predetermined value (S302 in FIG. 10: Yes), while the indoor heat exchanger 15 being frosted. This allows for purifying the air in the air-conditioned room, while moderating frost growing on the indoor heat exchanger 15.

Fourth Embodiment

[0067] A fourth embodiment is different from the first embodiment on the point that an indoor unit 20A (see FIG. 11) is provided with a sterilizing substance generator 71 and the sterilizing substance generator 71 generates an intended sterilizing substance, while purifying air using the frost on the indoor heat exchanger 15. Note that other points are the same as those of the first embodiment. Therefore, a description is given of differences from the first embodiment, and duplicate descriptions are not given here.

[0068] FIG. 11 is a vertical cross-sectional view of the indoor unit 20A included in an air conditioner according to the fourth embodiment. The indoor unit 20A in FIG. 11 includes the sterilizing substance generator 71 in addition to the components described in the first embodiment (see FIG. 2). The sterilizing substance generator 71 is an ionizer to generate intended ions (e.g., OH-) as a sterilizing substance, and is provided inside the indoor unit 20A. In the example in FIG. 11, the sterilizing substance generator 71 is provided around the air outlet 27 of the indoor unit 20A. Once the indoor fan 16 is driven and the sterilizing substance generator 71 is energized, a sterilizing substance is supplied to the air-conditioned room.

[0069] The sterilizing substance generator 71 includes a needle-like discharge electrode and an induction electrode curved to surround the discharge electrode, although not shown. The sterilizing substance generator 71 applies high voltage across the discharge electrode and the induction electrode to generate corona discharge, so that OH- as a sterilizing substance and the like are generated. A sterilizing substance generated in this manner is guided to the air outlet 27 through a slit 19a shown in FIG. 11. Note that the indoor unit 20A may be provided, in a right-left direction thereof, with the two or more sterilizing substance generators 71.

[0070] FIG. 12 is a functional block diagram of an air conditioner 100A according to the fourth embodiment. As shown in FIG. 12, the sterilizing substance generator 71 is connected to the indoor control circuit 41 via wiring. The sterilizing substance generator 71 is energized, as intended, by way of a command from the indoor controller 41b (that is, the controller 40).

[0071] FIG. 13 is a flowchart of the cleaning operation for the indoor heat exchanger. Note that processing in steps S101 to S105 in FIG. 13 is the same as that of the first embodiment (see FIG. 5), and detailed description thereof is not given here. After making the indoor heat exchanger 15 frosted in step S101, the controller 40 makes the rotation speed of the compressor 11 decreased (S103), when the predetermined time Δta has elapsed (S102: Yes). Note that it is assumed that the indoor fan 16 is driven while the indoor heat exchanger 15 being frosted.

[0072] Next, the controller 40 in step S120 generates a sterilizing substance. That is, the controller 40 makes the sterilizing substance generator 71 (see FIG. 11) generate a sterilizing substance (e.g., OH-). This causes a sterilizing substance to be supplied into the air-conditioned room, to kill viruses and bacteria in the air with ions, so that purifying air is promoted.

[0073] When the predetermined time Δtb has elapsed since the beginning of generating a sterilizing substance (S104: Yes), the controller 40 in step S105 makes the indoor heat exchanger 15 defrosted. This causes dust adhered to the indoor heat exchanger 15 to be flushed away. Note that when the predetermined time Δtb has elapsed since the beginning of generating a sterilizing substance (S104: Yes), the controller 40 may continue to make the indoor heat exchanger 15 frosted, with the indoor fan 16 stopped and the energization of the sterilizing substance generator 71 stopped. After making the indoor heat exchanger 15 frosted in this way, the controller 40 makes the indoor heat exchanger 15 defrosted.

[0074] FIG. 14 is a timing chart of states of the compressor and four-way valve, the degree of opening of the expansion valve, the rotation speeds of the indoor fan and outdoor fan, states of the sterilizing substance generator, and change in temperature of the indoor heat exchanger (see FIGS. 11 and 12 as required). In the example in FIG. 14, when the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted (time t1) (S102 in FIG. 13: Yes), the controller 40 makes the compressor 11 driven at a low speed, and makes the sterilizing substance generator 71 generate a sterilizing substance from time t2 to time t4. That is, the controller 40 executes control of making the temperature of the indoor heat exchanger 15 below freezing but higher than a predetermined value Th (control of making the rotation speed of the compressor 11 decreased), and makes the sterilizing substance generator 71 generate a sterilizing substance. This allows for purifying air in the air-conditioned room with a sterilizing substance, while purifying the air with the frost on the indoor heat exchanger 15.

[0075] Note that FIG. 14 shows such an example that generation of a sterilizing substance is started at time t2 when the predetermined time Δta has elapsed since the beginning of making the indoor heat exchanger 15 frosted (time t1), but the present invention is not limited thereto. For instance, generation of a sterilizing substance may be started at the beginning of making the indoor heat exchanger 15 frosted (time t1). Similar effects are obtained even with such control.

<Advantageous Effects>

[0076] According to the fourth embodiment, the controller 40 executes control of purifying the air in the air-conditioned room with the frost involved in making the indoor heat exchanger 15 frosted, and makes the sterilizing substance generator 71 generate a sterilizing substance. This allows for both purifying the air with the frost on the indoor heat exchanger 15 and purifying the air by way of generating a sterilizing substance.

Fifth Embodiment

[0077] A fifth embodiment is different from the first embodiment on the point that an indoor heat exchanger 15B (see FIG. 15) includes a first heat exchange unit 15e and a second heat exchange unit 15f, and a two-way valve 38 is provided between the first and second heat exchange units 15e, 15f. Additionally, the fifth embodiment is different from the first embodiment on the point that the controller 40 (see FIG. 4) makes the second heat exchange unit 15f frosted for making the indoor heat exchanger 15B frosted. Note that other points are the same as those of the first embodiment. Therefore, a description is given of differences from the first embodiment, and duplicate descriptions are not given here.

[0078] FIG. 15 shows a configuration of an air conditioner 100B according to the fifth embodiment. As shown in FIG. 15, an indoor unit 20B of the air conditioner 100B includes the indoor heat exchanger 15B and the indoor fan 16. The indoor heat exchanger 15B has the first heat exchange unit 15e connected with the second heat exchange unit 15f via the two-way valve 38 (depressurizing means).

[0079] During normal air conditioning operation (cooling operation, heating operation, and the like), for example, the two-way valve 38 is fully opened while the expansion valve 14 is suitably throttled. Alternatively, when so-called dehumidification and reheating is executed, the expansion valve 14 is fully opened while the two-way valve 38 is controlled to a predetermined opening. Note that the two-way valve 38 may be configured to be switchable between a fully opened state and a predetermined degree of opening, for example. When the dehumidification and reheating is executed, there is no specific need for the expansion valve 14 to be fully opened, as long as the refrigerant can flow through the expansion valve 14.

[0080] While the indoor heat exchanger 15B being frosted, the controller 40 (see FIG. 4) executes dehumidification and reheating, to make the outdoor heat exchanger 12 and first heat exchange unit 15e work as condensers, and make the second heat exchange unit 15f work as an evaporator. That is, in processing of making the indoor heat exchanger 15B frosted, the controller 40 makes one of the first heat exchange unit 15e and second heat exchange unit 15f, situated upstream in the refrigerant flow (the first heat exchange unit 15e), work as a condenser, and makes the other of the two (second heat exchange section 15f), situated downstream in the refrigerant flow, work as an evaporator, for the processing. Note that the expansion valve 14 is controlled to be substantially fully opened, while the indoor heat exchanger 15 being frosted,.

[0081] Incidentally, the first heat exchange unit 15e is situated downstream of the second heat exchange unit 16f in the air flow resulting from the indoor fan 16 being driven. Then, the air cooled by releasing heat to the second heat exchange unit 16f (evaporator) is warmed by the first heat exchange unit 16e (condenser). This prevents chilly air from blowing into the air-conditioned room, while the indoor heat exchanger 15 being frosted, to improve user comfort. Note that other points than making the indoor heat exchanger 15 frosted (such as purifying air and defrosting) are the same as those of the first embodiment (see FIG. 5), the descriptions thereof are not given here.

<Advantageous Effects>

[0082] According to the fifth embodiment, the controller 40 executes dehumidification and reheating, while the indoor heat exchanger 15B being frosted, to prevent chilly air from blowing into the air-conditioned room. Thus, user comfort is improved.

Modifications

[0083] Hereinabove, the air conditioner 100 and the like according to the present invention have been described with the embodiments, but the present invention is not limited hereto and various modifications can be made. For example, the case has been described in the first embodiment, where the controller 40 makes the indoor fan 16 driven, while the indoor heat exchanger 15 being frosted (from time t1 to t4 in FIG. 7), but the present invention is not limited thereto. That is, the controller 40 may make the indoor fan 16 driven during at least a part of the processing of making the indoor heat exchanger 15 frosted and execute control of keeping the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th (that is, the control of purifying the air in the air-conditioned room with the frost involved in making the indoor heat exchanger 15 frosted). Here, the period during which the controller 40 makes the indoor fan 16 driven, while the indoor heat exchanger 15 being frosted, need not coincide with the period during which the temperature of the indoor heat exchanger 15 is below freezing but higher than the predetermined value Th. For example, one of the two periods described above may include the other of the two, or a portion of said one of the two may overlap with a portion of said the other of the two (the rest does not overlap). Alternatively, the controller 40 may make the indoor fan 16 driven during at least a part of the period (from time t2 to t4 in FIG. 7) after making the rotation speed of the compressor 11 decreased, while the indoor heat exchanger 15 being frosted. Note that the same holds true for the second to fifth embodiments.

[0084] In addition, as the control of keeping the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th, the processing has been described in the first embodiment in which the controller 40 makes the rotation speed of the compressor 11 decreased from halfway through the processing, to make the indoor heat exchanger 15 frosted, onwards, but the present invention is not limited thereto. For example, as the control of keeping the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th, the controller 40 may make the compressor 11 stopped from halfway through the processing, to make the indoor heat exchanger 15 frosted, onwards. In such a case, the controller 40 may make the compressor 11 driven when the temperature of the indoor heat exchanger 15 has become equal to or greater than a predetermined value higher than 0 degrees Celsius, to resume making the indoor heat exchanger 15 frosted. Further, the description has been given in the first embodiment that the controller 40 executes control of making the temperature of the indoor heat exchanger 15 equal to or less than the predetermined value Th and then making the temperature increased so as to be higher than the predetermined value Th, while keeping the temperature below freezing, but the present invention is not limited thereto. For example, the controller 40 may start processing, to make the indoor heat exchanger 15f frosted, and then keep the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th, immediately after the temperature of the indoor heat exchanger 15 has dropped below freezing.

[0085] Further, when the temperature (or humidity) in the air-conditioned room is equal to or less than a predetermined value, it is preferable that the controller 40 does not execute control of making the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th. In other words, when the temperature in the air-conditioned room is equal to or less than the predetermined value, it is preferable that the controller 40 does not execute control of purifying the air in the air-conditioned room with the frost involved in making the indoor heat exchanger 15 frosted. This is because an amount of moisture containable in the air per unit volume is small when the temperature in the air-conditioned room is too low, to have the indoor heat exchanger 15 less likely frosted. The above-described predetermined value indicates a threshold as a criterion for determining whether or not to purify the air with the frost on the indoor heat exchanger 15, and is preset. Note that when the temperature (or humidity) in the air-conditioned room is equal to or less than the predetermined value, the controller 40 may not execute processing of making the indoor heat exchanger 15 frosted (inclusive of purifying air using frost). In a case where the indoor heat exchanger 15 is not frosted as described above, the controller 40 may instead make the indoor fan 16 driven and make the sterilizing substance generator 71 (see FIG. 11) energized to purify the air in the air-conditioned room.

[0086] Still further, the case has been described in the first embodiment, where the expansion valve 14 is fully opened after the controller 40 has made the indoor heat exchanger 15 frosted (after time t4 in FIG. 7), to make the indoor heat exchanger 15 defrosted, but the present invention is not limited thereto. For example, the controller 40 may make the refrigerant circulated in the heating cycle in the refrigerant circuit 10 to have the indoor heat exchanger 15 working as a condenser, to make the indoor heat exchanger 15 defrosted. Alternatively, the controller 40 may make the compressor 11 stopped and make the indoor fan 16 suitably driven, to make the indoor heat exchanger 15 defrosted. Note that the same holds true for the second to fifth embodiments.

[0087] Still further, the case has been described in the first embodiment, where making the indoor heat exchanger 15 frosted and defrosted are sequentially executed as the cleaning operation (see FIG. 5), but making the indoor heat exchanger 15 defrosted (S105 in FIG. 5) may not be executed. This is because the frost and/or ice on the indoor heat exchanger 15 is/are naturally defrosted/thawed by the heat of the air, even if the indoor heat exchanger 15 is left as it is after it has been frosted. Note that the same holds true for the second to fifth embodiment.

[0088] Still further, the control has been described in the first embodiment such that the controller 40 makes the rotation speed of the compressor 11 decreased (S103 in FIG. 5) from halfway through the processing, to make the indoor heat exchanger 15 frosted, onwards, but the present invention is limited thereto. For example, as control of keeping the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th, the controller 40 may make the opening of the expansion valve 14 increased. Other than that, as control of making the temperature of the indoor heat exchanger 15 below freezing but higher than the predetermined value Th, the controller 40 may make the rotation speed of the indoor fan 16 increased, or make the rotation speed of the outdoor fan 13 decreased. Two or more of the above-described cases of control over the compressor 11, expansion valve 14, indoor fan 16, and outdoor fan 13 may be suitably combined with one another. Note that the same holds true for the second to fifth embodiments.

[0089] Still further, the configuration has been described in the fifth embodiment, in which the indoor unit 20B (see FIG. 15) includes the two-way valve 38 (see FIG. 15), but the present invention is not limited thereto. For example, an expansion valve (depressurizing means: not shown) may be provided between the first and second heat exchange units 15e and 15f, in place of the two-way valve 38. Then, the controller 40 may make the second heat exchange unit 15f (see FIG. 15) on the downstream side of said expansion valve (not shown) work as an evaporator, while the indoor heat exchanger 15 being frosted. Even such a configuration accomplishes the same advantageous effects as with the fifth embodiment.

[0090] Still further, the case has been described in the fifth embodiment (see FIG. 15), where dehumidification and reheating is used to make the indoor heat exchanger 15 frosted, but the present invention is not limited thereto. For example, the compressor motor 11a may be controlled, when the indoor heat exchanger 15 is frosted, so as to decrease a flow rate of the refrigerant in the indoor heat exchanger 15 as compared with normal air conditioning operation. This causes the refrigerant to fully evaporate halfway through the flow path in the indoor heat exchanger 15, so that the refrigerant works for frosting on an upstream side of a halfway point while the refrigerant is gasified on a downstream side of the halfway point to provide a superheated area (where the moisture contained in the air is not frosted). This prevents chilly air from blowing into the air-conditioned room, while a part (upstream side) of the indoor heat exchanger 15 being frosted. Additionally, as the rotation speed of the compressor motor 11a is comparatively low, power consumption of the air conditioner 100 is reduced.

[0091] Still further, the embodiments can be suitably combined with one another. For example, the second embodiment may be combined with the fourth embodiment, so that the controller 40 makes the rotation speed of the compressor 11 decreased and making the sterilizing substance generator 71 energized (see FIG. 13 in the fourth embodiment), when the temperature of the indoor heat exchanger 15 has dropped equal to or less than the predetermined value Th, while the indoor heat exchanger 15 being frosted (see FIG. 9 in the second embodiment). Alternatively, the third embodiment may be combined with the fifth embodiment, for example, so that the controller 40 makes the rotation speed of the compressor 11 decreased, when the inputted power to the indoor fan motor 16a becomes equal to or less than a predetermined value (see FIG. 10 in the third embodiment), while the second heat exchange unit 15f of the indoor heat exchanger 15B being frosted (see FIG. 15 in the fifth embodiment).

[0092] Still further, when a designated operation, corresponding to the control of purifying the air in the air-conditioned room with frost involved in making the indoor heat exchanger 15 frosted, is executed on the "operation terminal" such as the remote controller 50 (see FIG. 4), a smartphone, a mobile phone, and a tablet, the controller 40 preferably executes the above-described control from halfway through the processing, to make the indoor heat exchanger 15 frosted, onwards. This allows the user to operate the remote controller 50 or the like to clean the indoor heat exchanger 15, such as by making it frosted, and purify the air using the frost on the indoor heat exchanger 15.

[0093] Still further, the case has been described in the fourth embodiment, where the sterilizing substance generator 71 (see FIG. 11) generates OH- as a sterilizing substance, but the present invention is not limited thereto. For example, the sterilizing substance generator 71 may generate ions such as O^{2-} as a sterilizing substance. Additionally, a glow discharge ionizer or a plasma ionizer may be used as the sterilizing substance generator 71, in place of the corona discharge ionizer. The sterilizing substance generator 71 may generate OH radicals as a sterilizing substance. Other than that, the sterilizing substance generator 71 may generate ozone (Os) as a sterilizing substance. The sterilizing substance generator 71 may generate a "sterilizing substance" comprising at least one of predetermined ions, radicals, and ozone.

[0094] Still further, the embodiments has been described to have the single indoor unit 20 (see FIG. 1) and the single outdoor unit 30 (see FIG. 1), but the present invention is not limited thereto. That is, the two or more indoor units connected in parallel may be provided, and/or the two or more outdoor units connected in parallel may be provided. Additionally, the embodiments can also be applied to diverse types of air conditioners such as packaged air conditioners and multi-split air conditioners for buildings, other than room air conditioners.

[0095] Still further, the embodiments have been described in detail in order to illustrate the present invention, and are not necessarily limited to those having all the components as described above. Additionally, components of the embodiments may partly be deleted, or added/replaced with components of other embodiments. The mechanisms and components described above are those considered necessary for illustration, but all the mechanisms and components of the product may not have been shown.

LEGEND FOR REFERENCE NUMERALS

[0096] 110; 10B: refrigerant circuit, 11: compressor, 12: outdoor heat exchanger. 13: outdoor fan, 14: expansion valve, 15; 15B: indoor heat exchanger, 15a: fin, 15e: first heat exchange unit, 15f: second heat exchange unit, 16: indoor fan, 16a: indoor fan motor. 17: four-way valve, 18: drain pan, 19: housing, 21a; 21b: filter, 29: indoor temperature sensor, 33: indoor heat exchanger temperature sensor, 38: two-way valve (depressurizing means), 40: controller, 50: remote controller (operation terminal), 71: sterilizing substance generator, 100; 100A; 100B: air conditioner.

Claims

1. An air conditioner comprising:

a compressor;
an outdoor heat exchanger;
an expansion valve;
an indoor heat exchanger;
an indoor fan; and
a controller to make the indoor heat exchange work as an evaporator and execute processing of making the indoor heat exchanger frosted,
wherein the controller makes the indoor fan driven during at least a part of the processing, and executes control of keeping temperature of the indoor heat exchanger below freezing but higher than a predetermined value,
wherein the predetermined value indicates a temperature below freezing, at which gaps between fins of the indoor heat exchanger are not completely filled with frost.

2. An air conditioner comprising:

a compressor;
an outdoor heat exchanger;
an expansion valve;
an indoor heat exchanger;
an indoor fan; and
a controller to make the indoor heat exchange work as an evaporator and execute processing of making the indoor heat exchanger frosted,

wherein the controller makes the indoor fan driven during at least a part of the processing, and executes control of purifying air in an air-conditioned room with frost involved in making the indoor heat exchanger frosted.

3. The air conditioner according to claim 1, wherein the control is executed in such a way that the controller makes the temperature of the indoor heat exchanger equal to or less than the predetermined value and then makes the temperature of the indoor heat exchanger increased so as to become higher than the predetermined value, while keeping the temperature of the indoor heat exchanger below freezing.

4. The air conditioner according to claim 1 or 2, wherein the control is executed in such a way that the controller makes a rotation speed of the compressor decreased or makes the compressor stopped, from halfway through the processing, to make the indoor heat exchanger frosted, onwards.

5. The air conditioner according to claim 4, wherein the controller executes the control so as to keep an amount of frost on the indoor heat exchanger at the beginning of the control.

6. The air conditioner according to claim 1 or 2, further comprising:
an indoor heat exchanger temperature sensor to detect a temperature of the indoor heat exchanger,
wherein the controller executes the control

when a predetermined time has elapsed since the beginning of the processing to make the indoor heat exchanger frosted,
when temperature of the indoor heat exchanger has become equal to or less than a predetermined value during the processing, or
when inputted power to an indoor fan motor, as a drive source of the indoor fan, has become equal to or less than a predetermined value during the processing.

7. The air conditioner according to claim 6, wherein when executing the control based on the inputted power to the indoor fan motor, the controller sets the predetermined value as a threshold of the inputted power to the indoor fan motor, based on the inputted power to the indoor fan motor at the beginning of the processing to make the indoor heat exchanger frosted.

8. The air conditioner according to claim 1 or,2, further comprising:
a sterilizing substance generator provided inside an indoor unit, including the indoor heat exchanger and the indoor fan, and configured to generate a sterilizing substance,
wherein the controller executes the control and makes the sterilizing substance generator generate a sterilizing substance.

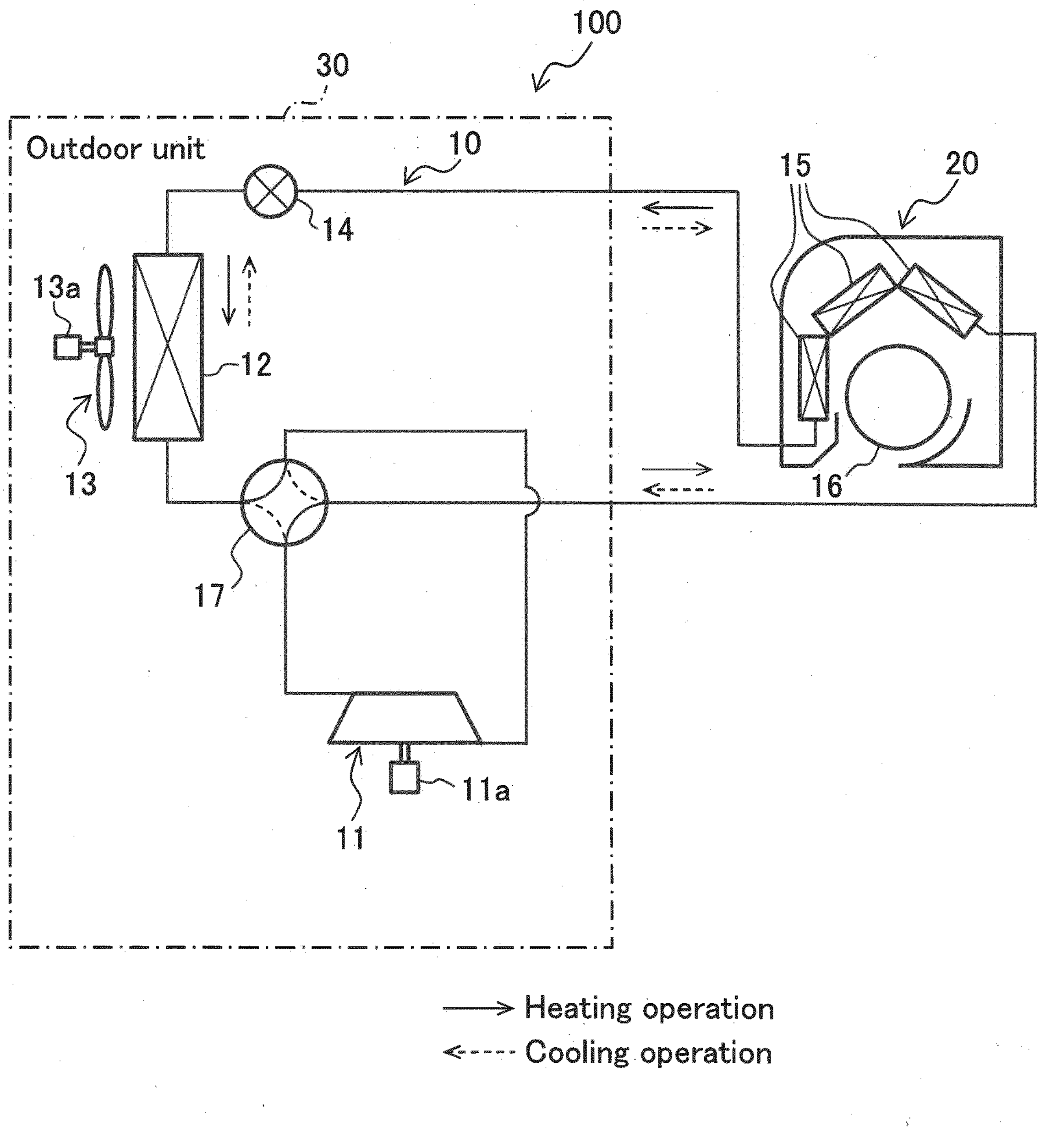
9. The air conditioner according to claim 1 or 2, further comprising:
an indoor temperature sensor to detect temperature in an air-conditioned room,
wherein the controller does not execute the control when the temperature in the air-conditioned room is equal to or less than a predetermined value.

10. The air conditioner according to claim 1 or 2, wherein when a designated operation, corresponding to the control, is executed on an operation terminal, the controller executes the control from halfway through the processing, to make the indoor heat exchanger frosted, onwards.

11. The air conditioner according to claim 1 or 2, wherein

the indoor heat exchanger has a first heat exchange unit connected with a second heat exchange unit via a depressurizing means, and
the controller, in the processing to make the indoor heat exchanger frosted, makes one of the first and second heat exchange units, situated upstream in a refrigerant flow, work as a condenser, and makes the other of the two, situated downstream in the refrigerant flow, work as an evaporator.

FIG. 1


100
30
Outdoor unit
10
14
15
20
13a
12
13
16
17
11a
11
Heating operation
Cooling operation

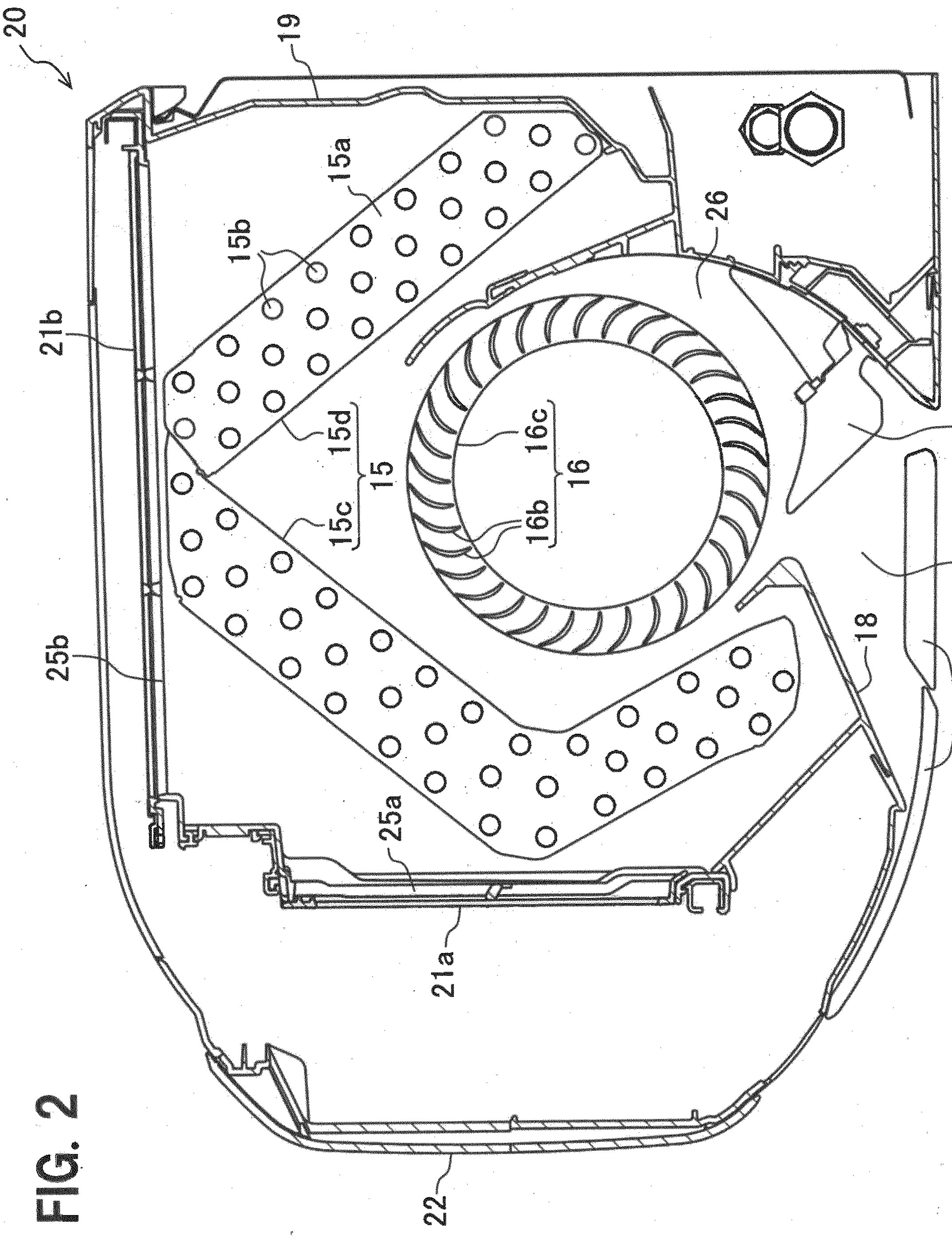

20
19
15a
15b
26
21b
15d
15c
15
16c
16b
16
23
27
25b
18
24
25a
21a
22

FIG. 2

FIG. 3

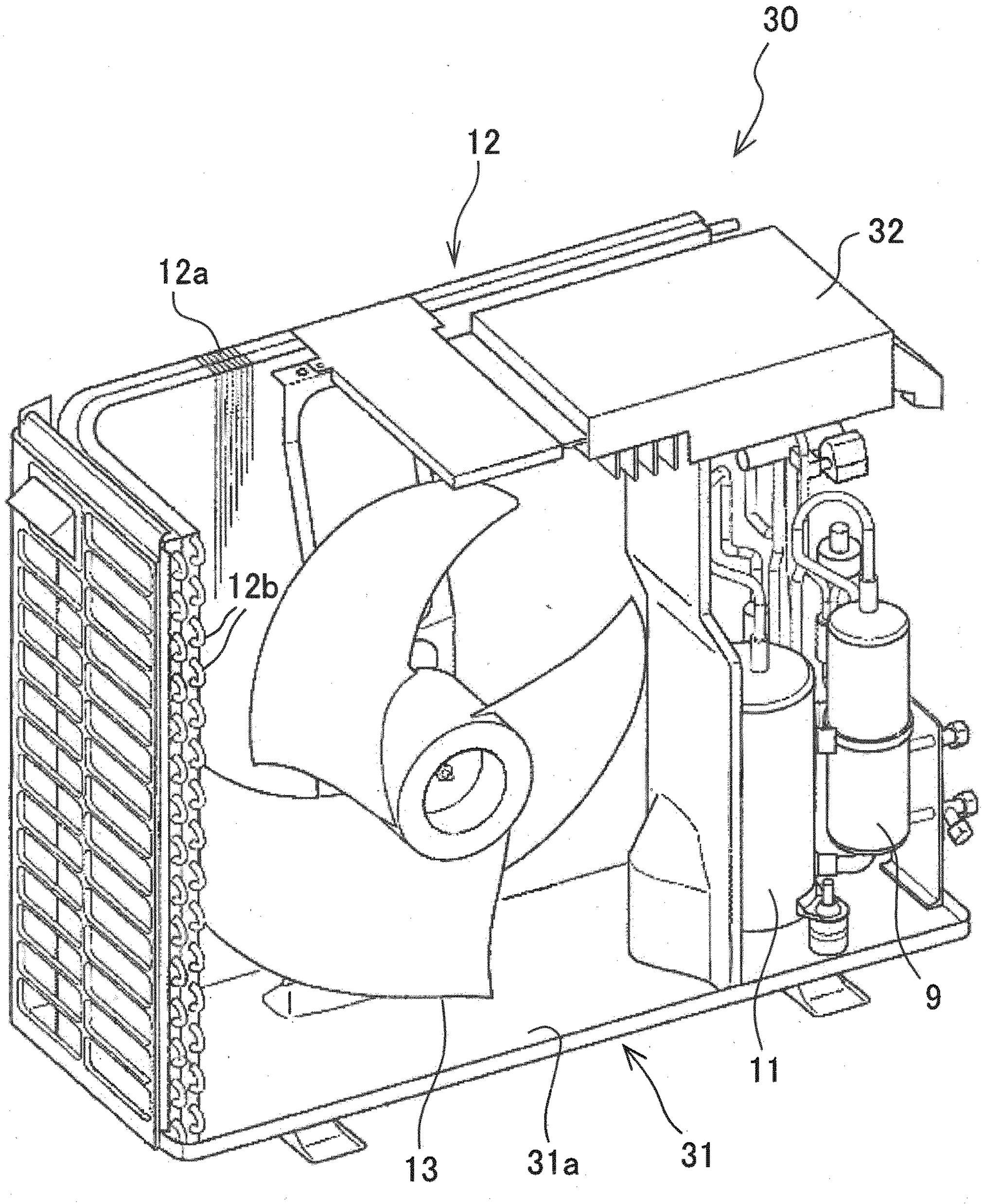


FIG. 4

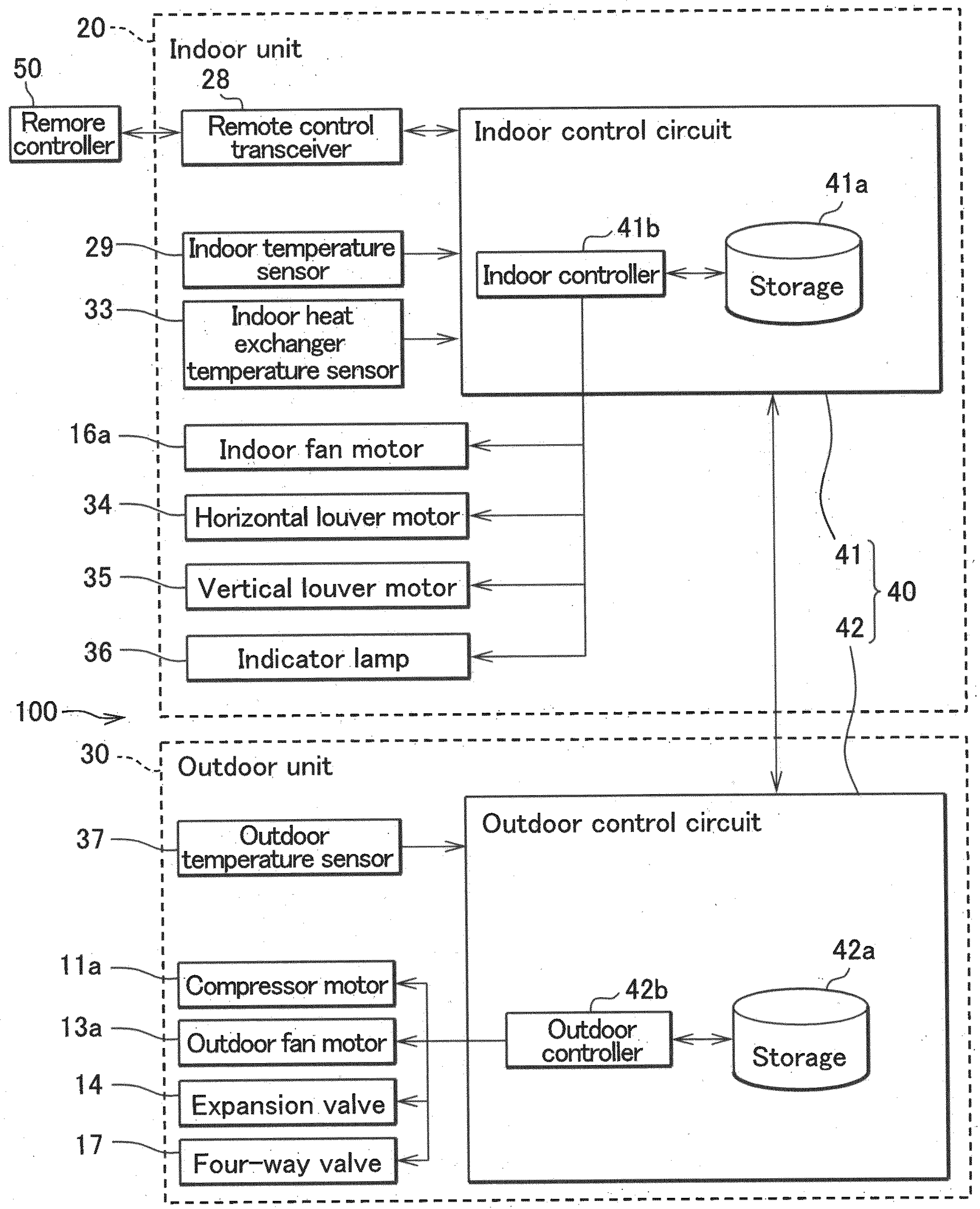

20
Indoor unit
50
Remore controller
28
Remote control transceiver
Indoor control circuit
41a
41b
Indoor controller
Storage
29
Indoor temperature sensor
33
Indoor heat exchanger temperature sensor
16a
Indoor fan motor
34
Horizontal louver motor
35
Vertical louver motor
36
Indicator lamp
41
40
42
100
30
Outdoor unit
37
Outdoor temperature sensor
Outdoor control circuit
42a
42b
11a
Compressor motor
13a
Outdoor fan motor
Outdoor controller
Storage
14
Expansion valve
17
Four-way valve

FIG. 5

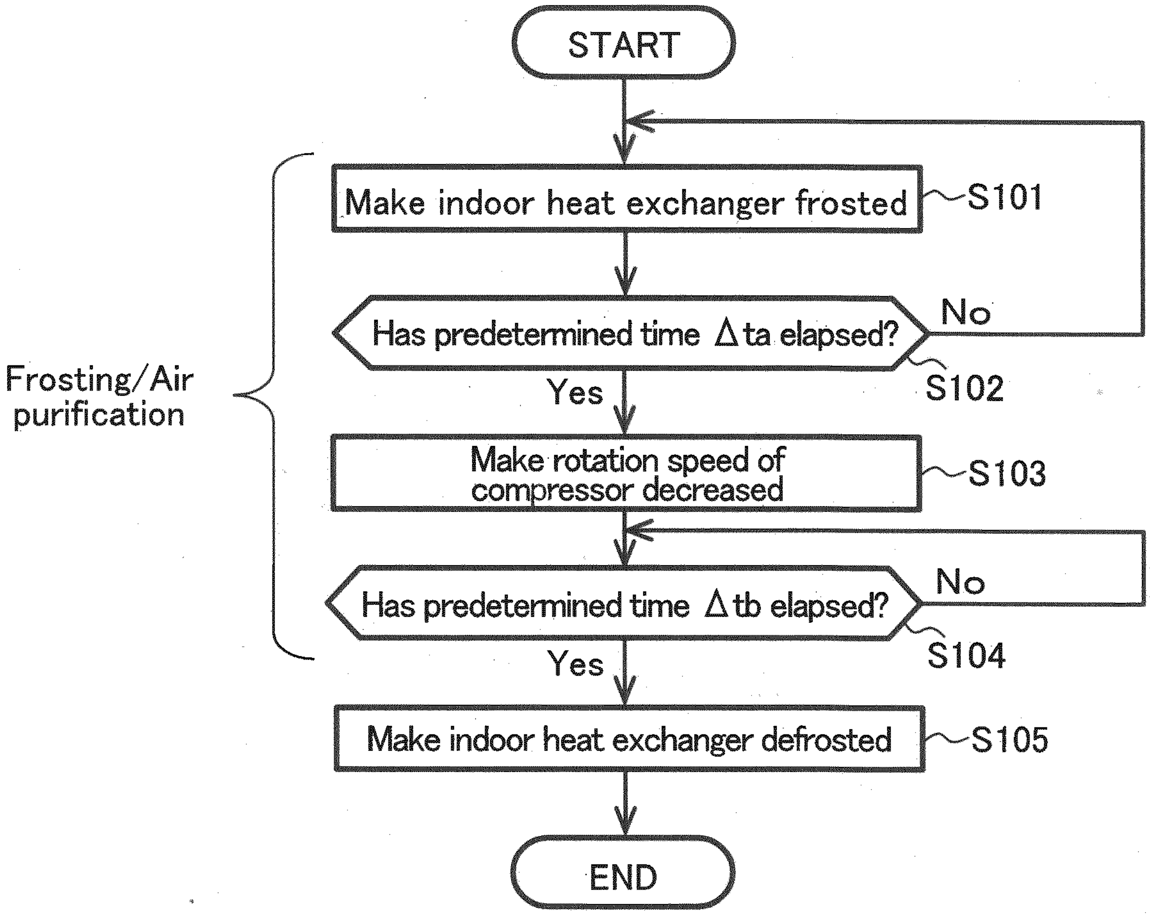

START
Make indoor heat exchanger frosted
S101
Has predetermined time Δta elapsed?
No
S102
Yes
Frosting/Air purification
Make rotation speed of compressor decreased
S103
Has predetermined time Δtb elapsed?
No
S104
Yes
Make indoor heat exchanger defrosted
S105
END

FIG. 6

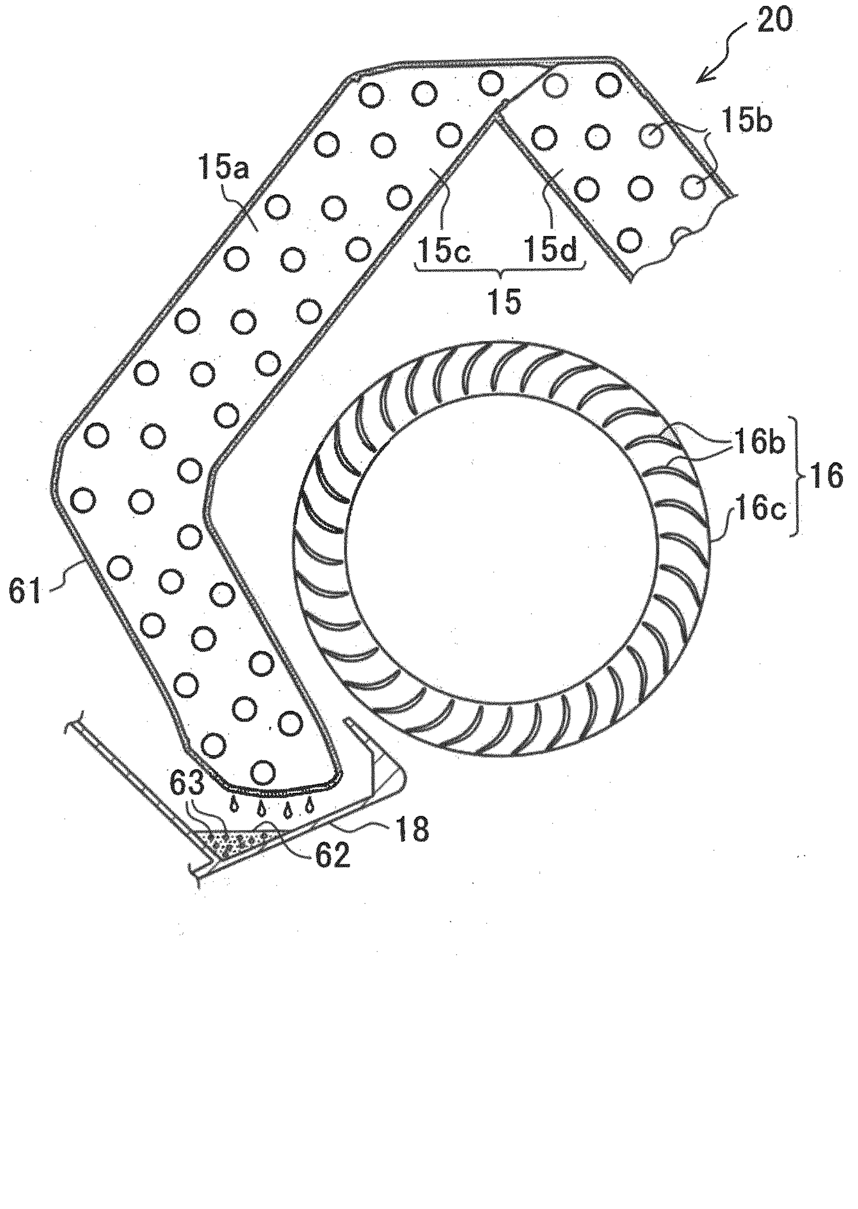
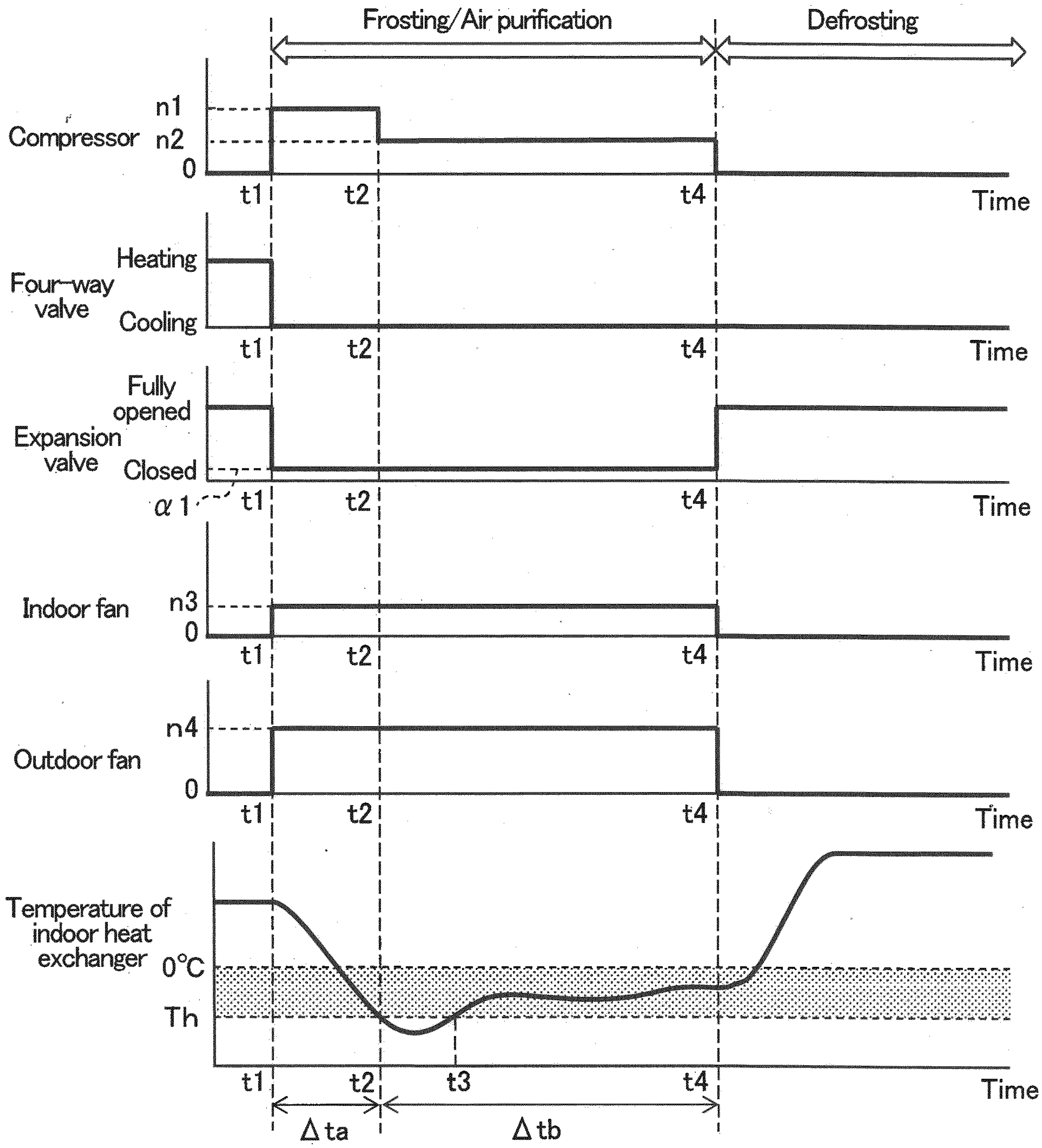


FIG. 7



Frosting/Air purification
Defrosting
Compressor
n1
n2
0
t1
t2
t4
Time
Four-way valve
Heating
Cooling
t1
t2
t4
Time
Expansion valve
Fully opened
Closed
α 1
t1
t2
t4
Time
Indoor fan
n3
0
t1
t2
t4
Time
Outdoor fan
n4
0
t1
t2
t4
Time
Temperature of indoor heat exchanger
0°C
Th
t1
t2
t3
t4
Time
Δ ta
Δ tb

FIG. 8A

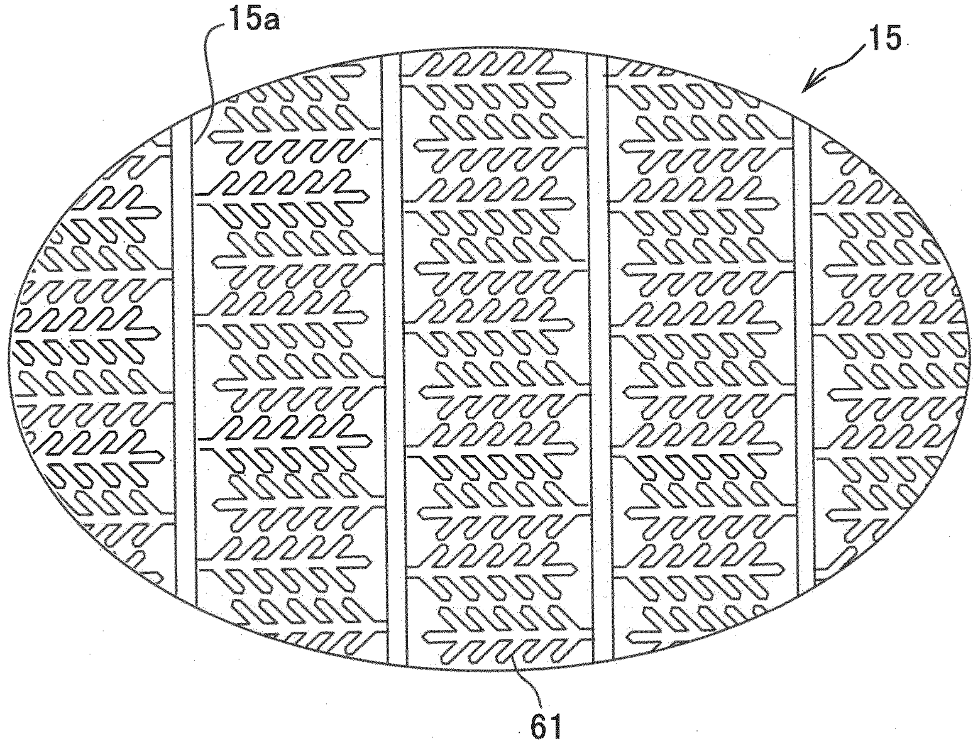


FIG. 8B

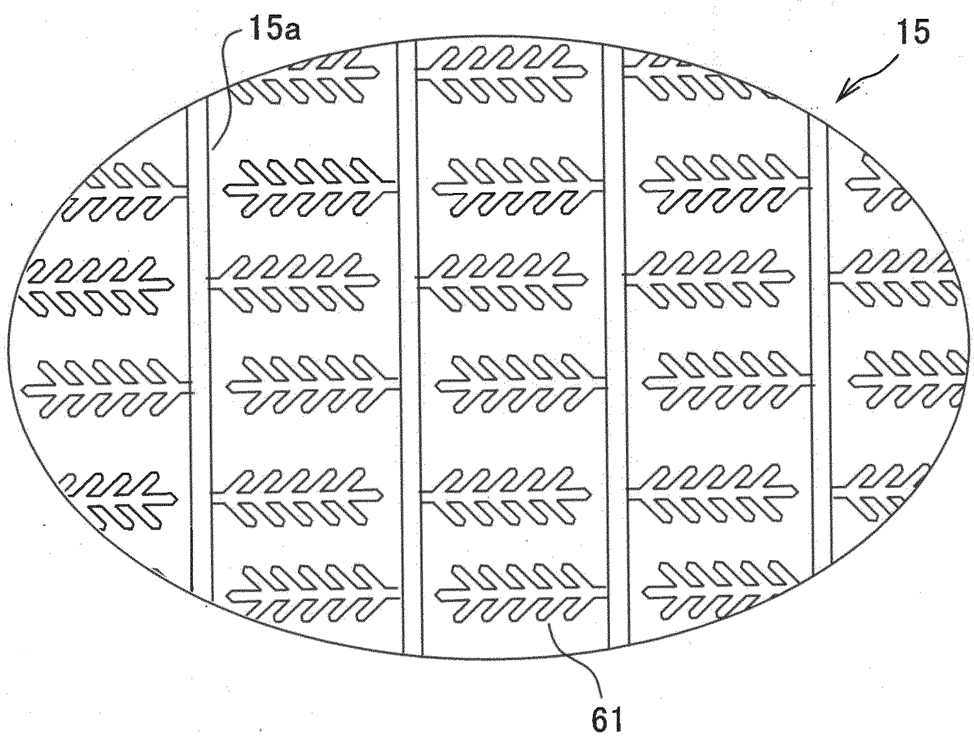


FIG. 9

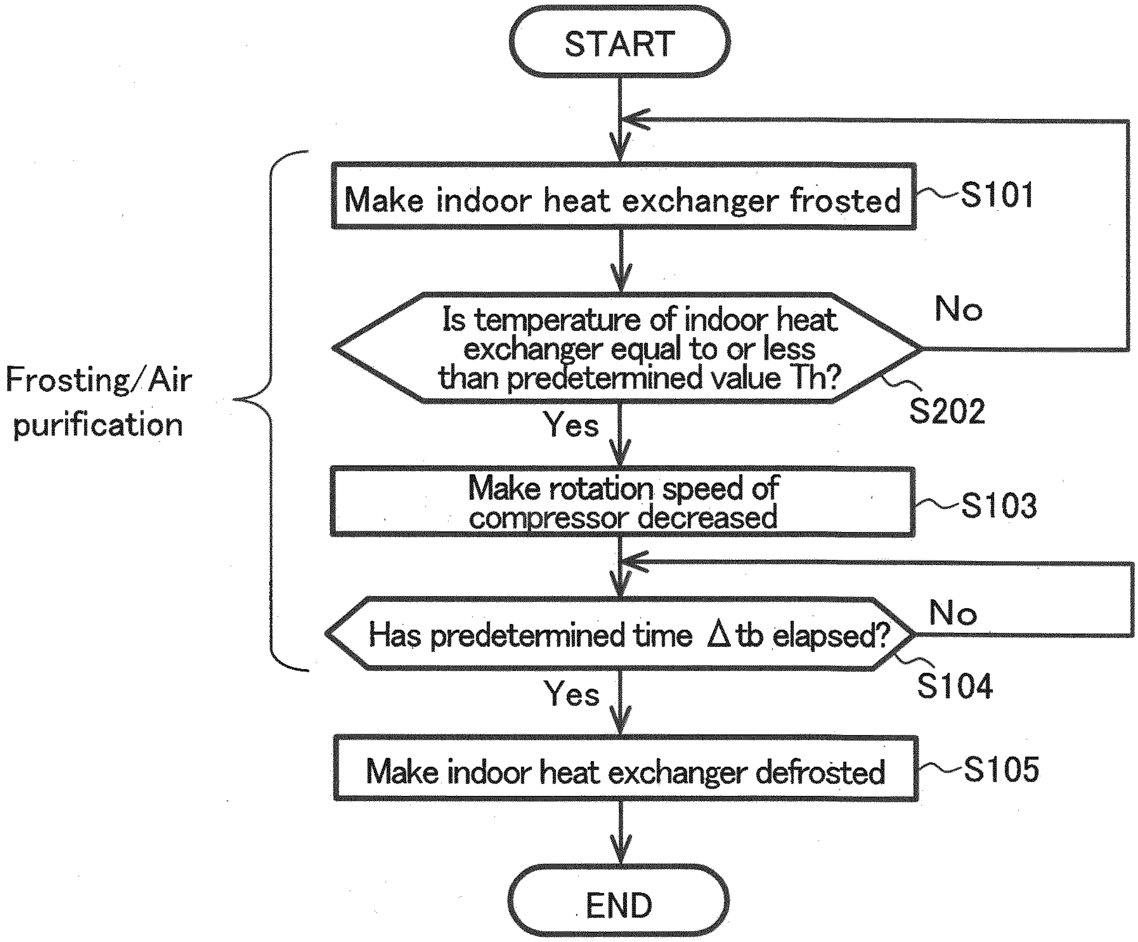

START
Make indoor heat exchanger frosted
S101
Is temperature of indoor heat exchanger equal to or less than predetermined value Th?
No
S202
Yes
Make rotation speed of compressor decreased
S103
Has predetermined time Δ tb elapsed?
No
S104
Yes
Make indoor heat exchanger defrosted
S105
END
Frosting/Air purification

FIG. 10

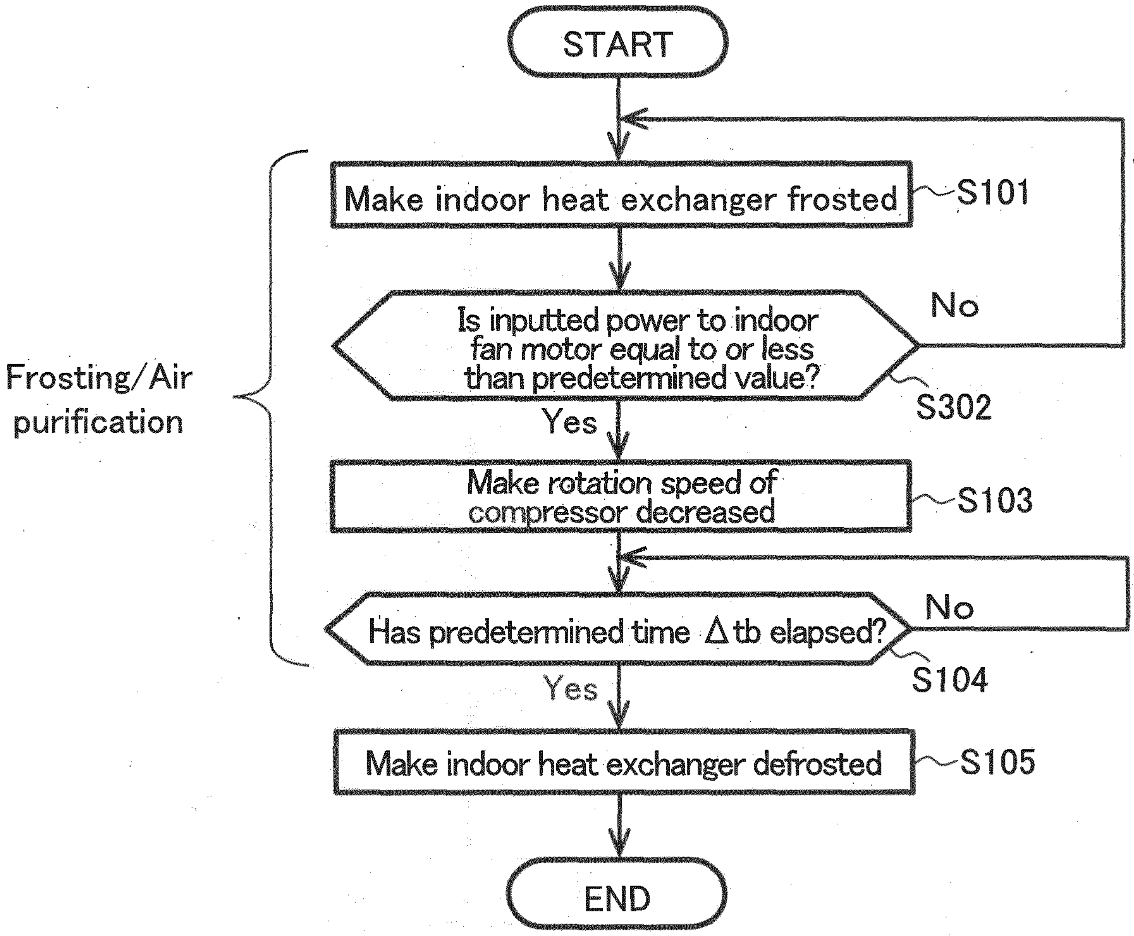

START
Make indoor heat exchanger frosted
S101
Is inputted power to indoor fan motor equal to or less than predetermined value?
No
S302
Yes
Make rotation speed of compressor decreased
S103
Has predetermined time Δtb elapsed?
No
S104
Yes
Make indoor heat exchanger defrosted
S105
END
Frosting/Air purification

FIG. 11

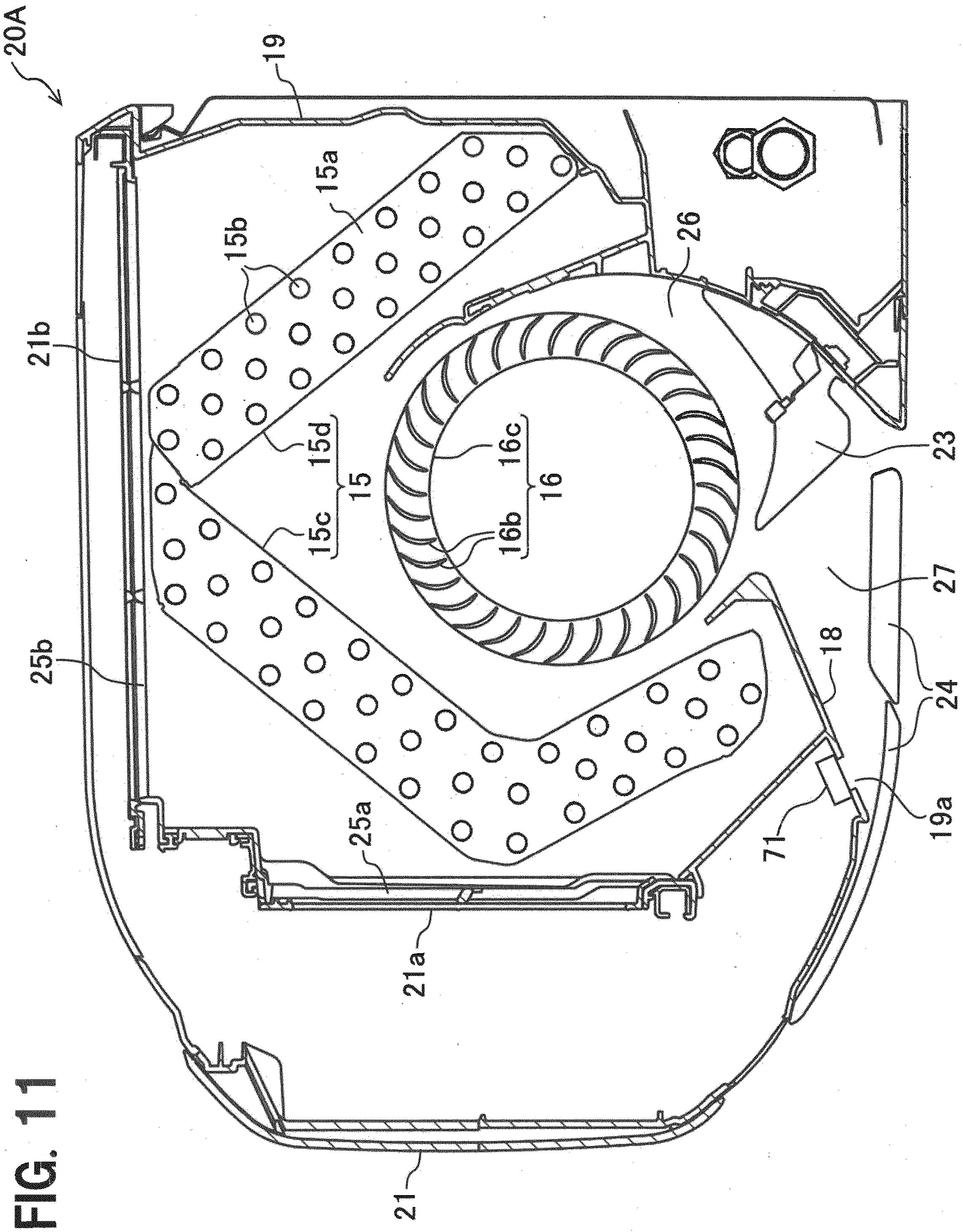

20A
19
15a
15b
26
21b
16c
15d
23
15
16
15c
16b
27
25b
18
24
19a
71
25a
21a
21

FIG. 12

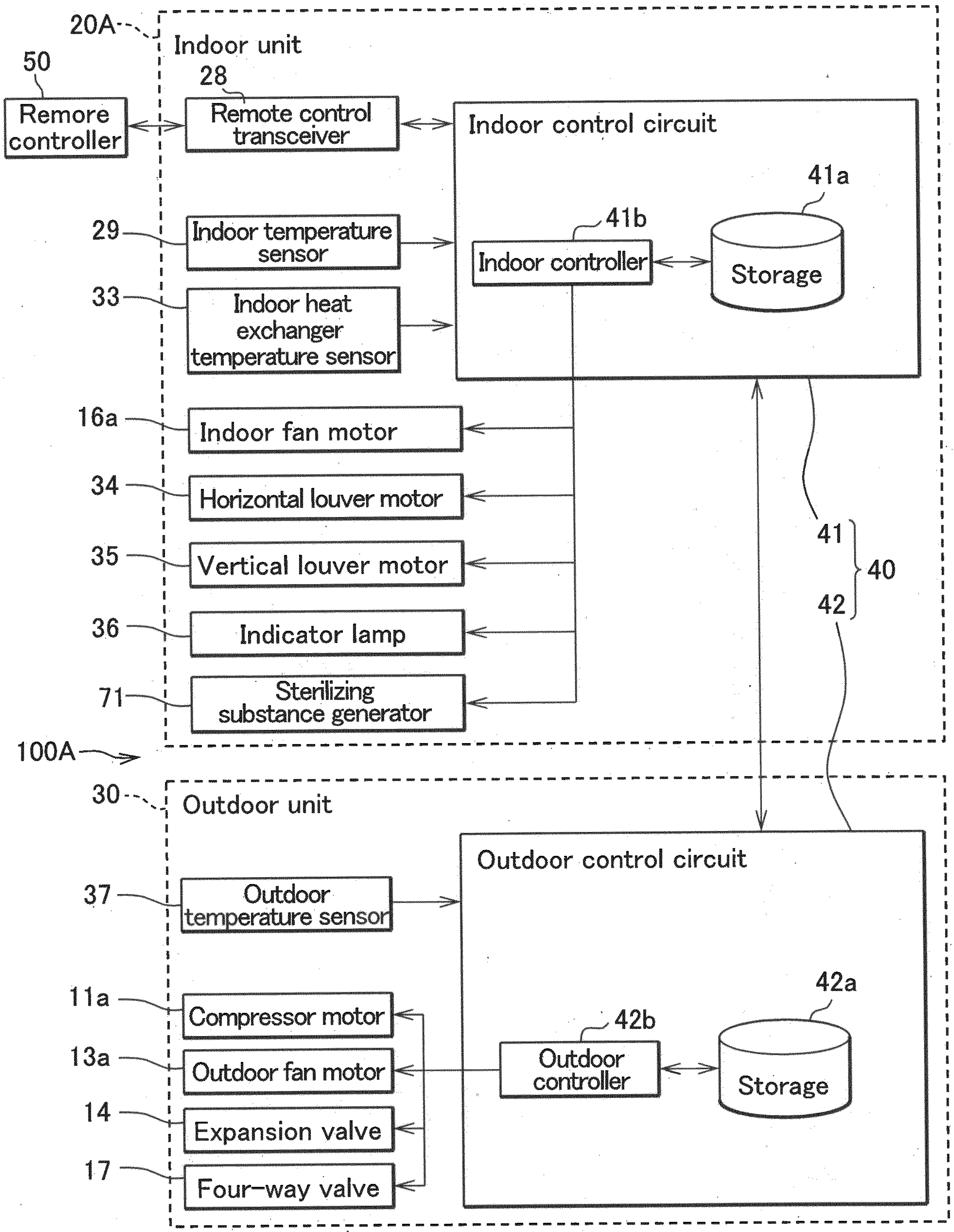

20A
Indoor unit
50
Remore controller
28
Remote control transceiver
Indoor control circuit
41a
41b
Indoor controller
Storage
29
Indoor temperature sensor
33
Indoor heat exchanger temperature sensor
16a
Indoor fan motor
34
Horizontal louver motor
35
Vertical louver motor
36
Indicator lamp
71
Sterilizing substance generator
41
42
40
100A
30
Outdoor unit
Outdoor control circuit
37
Outdoor temperature sensor
42a
42b
11a
Compressor motor
13a
Outdoor fan motor
Outdoor controller
Storage
14
Expansion valve
17
Four-way valve

FIG. 13

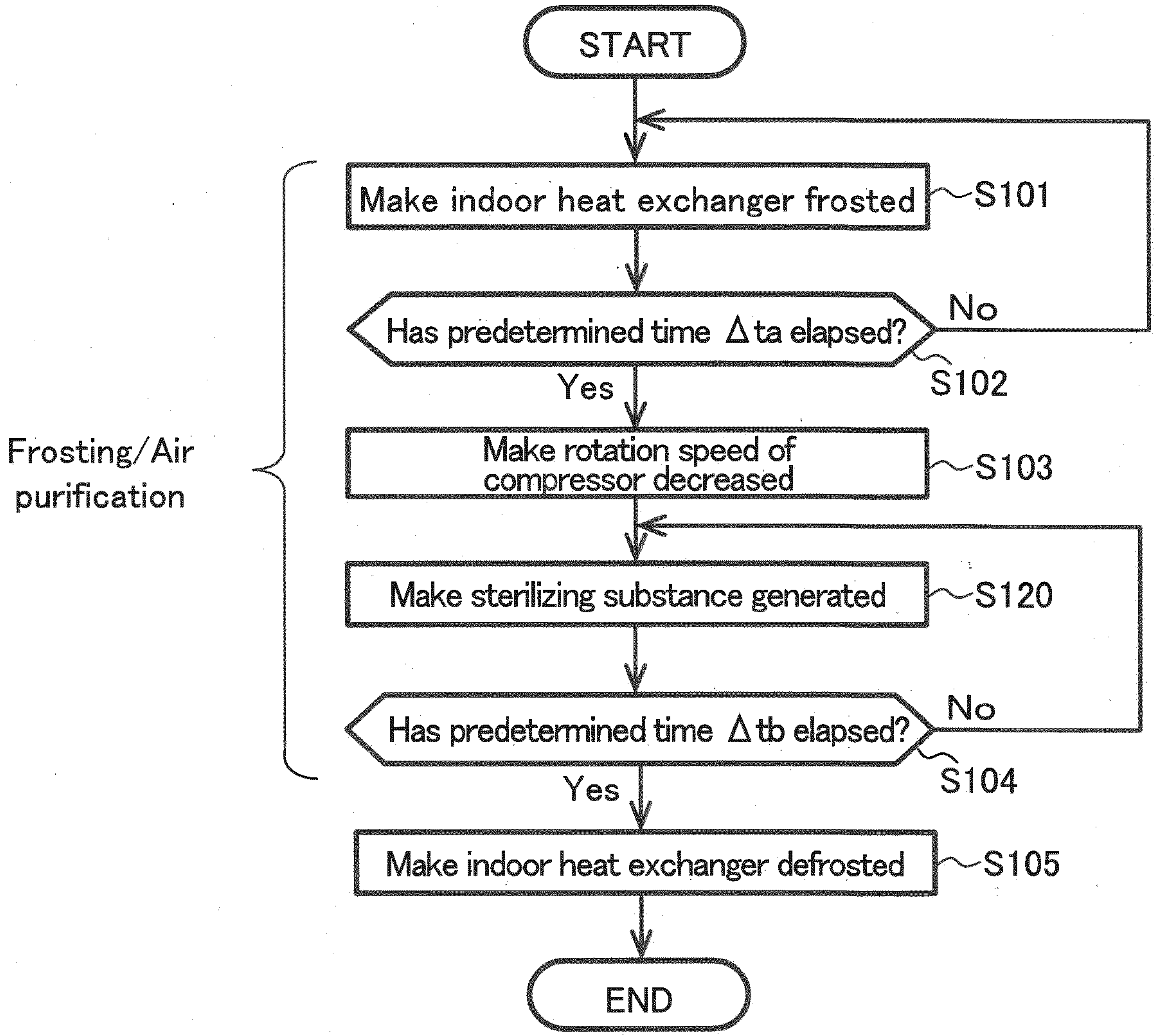
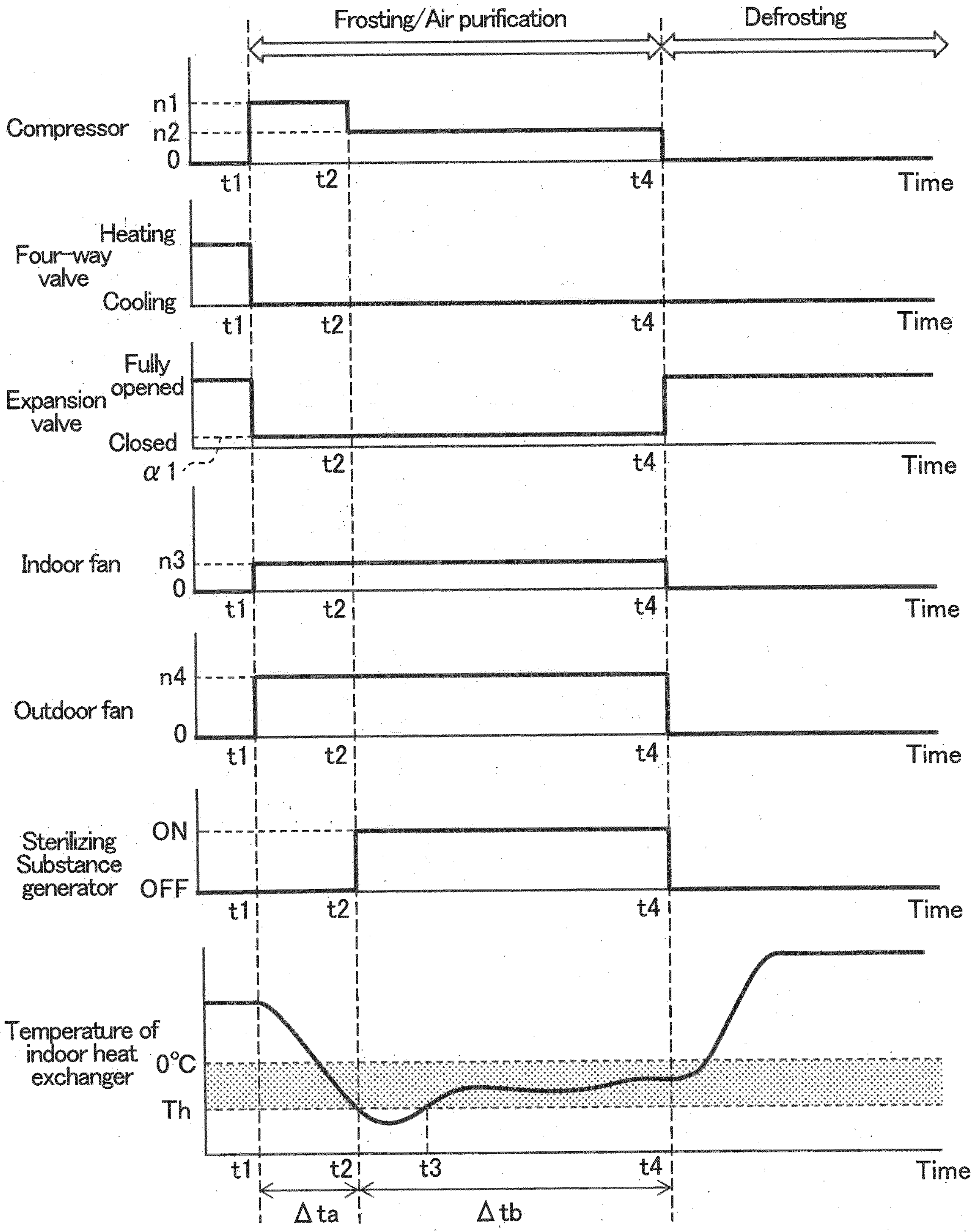
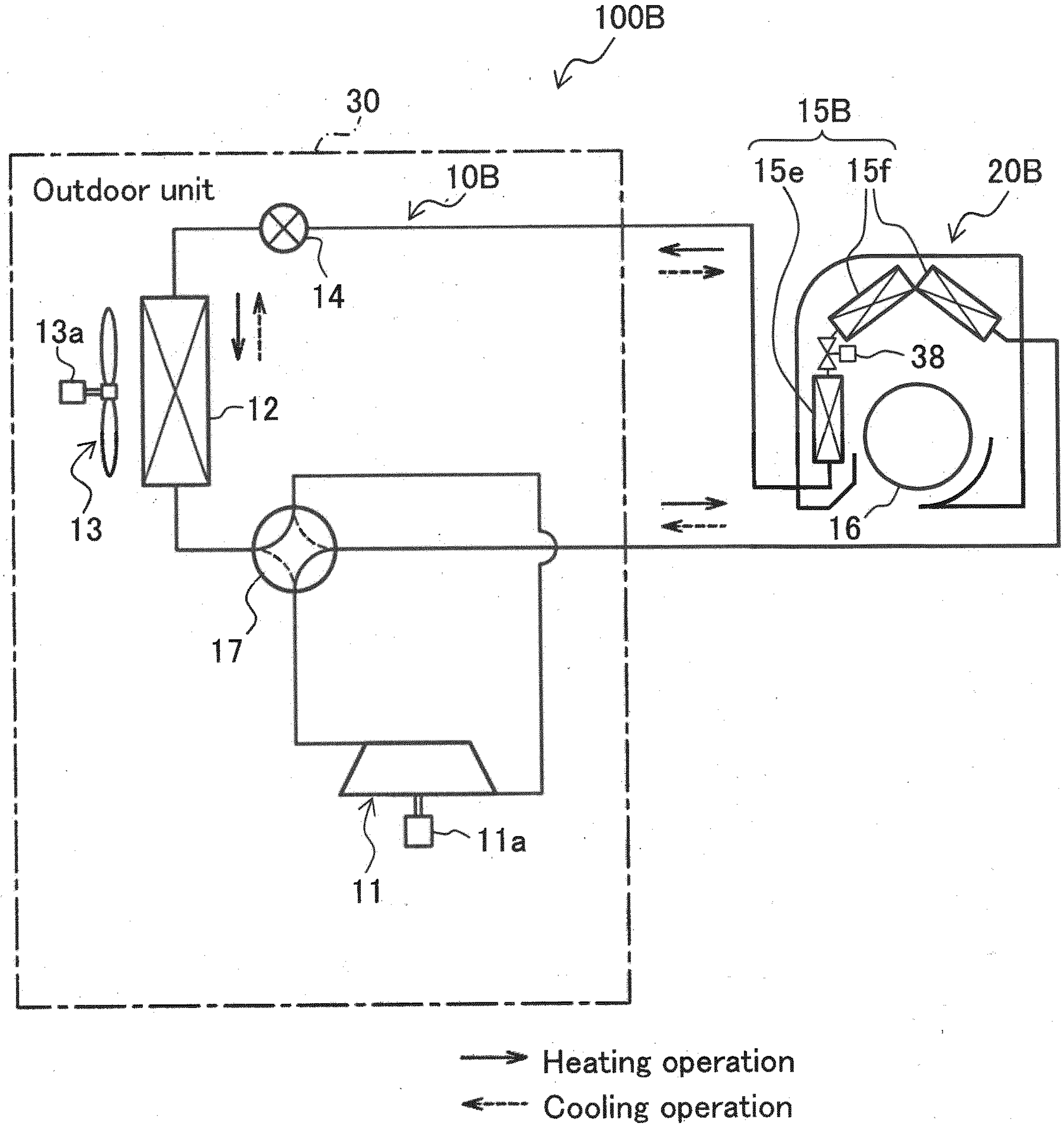

START
Make indoor heat exchanger frosted
S101
Has predetermined time Δta elapsed?
No
S102
Yes
Make rotation speed of compressor decreased
S103
Make sterilizing substance generated
S120
Has predetermined time Δtb elapsed?
No
S104
Yes
Make indoor heat exchanger defrosted
S105
END
Frosting/Air purification

FIG. 14



Frosting/Air purification
Defrosting
Compressor
n1
n2
0
t1
t2
t4
Time
Heating
Four-way valve
Cooling
Fully opened
Expansion valve
Closed
α1
Indoor fan
n3
Outdoor fan
n4
Sterilizing Substance generator
ON
OFF
Temperature of indoor heat exchanger
0°C
Th
t3
Δta
Δtb

FIG. 15


100B
30
15B
Outdoor unit
10B
15e
15f
20B
14
13a
38
12
13
16
17
11a
11
Heating operation
Cooling operation

INTERNATIONAL SEARCH REPORT	International application No. PCT/JP2021/004203

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F24F11/48(2018.01)i, F24F110/10(2018.01)n
FI: F24F11/48, F24F110:10

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)
Int.Cl. F24F11/48, F24F110/10

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	WO 2020/148846 A1 (HITACHI-JOHNSON CONTROLS AIR CONDITIONING INC.) 23 July 2020 (2020-07-23), paragraphs [0010]-[0088]	1-6, 11 8 7, 9-10
Y	JP 2019-39637 A (HITACHI-JOHNSON CONTROLS AIR CONDITIONING INC.) 14 March 2019 (2019-03-14), paragraphs [0009]-[0060]	8

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2021	06 April 2021

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)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/004203

WO 2020/148846 A1	23 July 2020	(Family: none)
JP 2019-39637 A	14 March 2019	WO 2019/043968 A1 TW 201913007 A

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018189270 A **[0003]**