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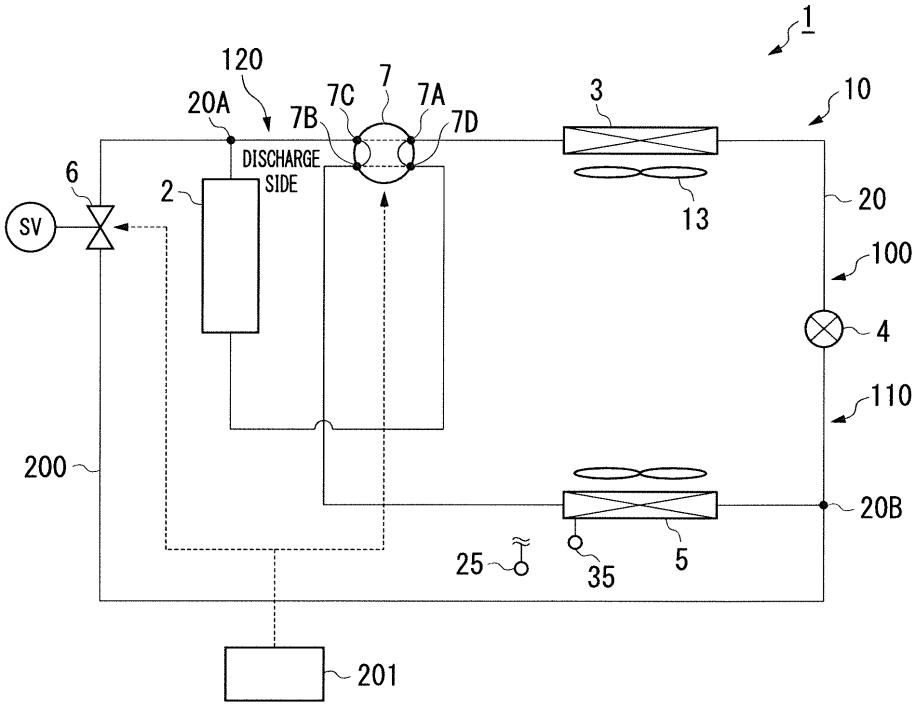
(54) CONTROL DEVICE, AIR CONDITIONER, CONTROL METHOD, AND PROGRAM

(57) The present invention provides a control device that performs a defrosting operation of an air conditioner and has a function of preventing unintended non-execution. The control device performs a defrosting operation after a prohibition period of the defrosting operation ends on the basis of an establishment state of a start condition of the defrosting operation during the prohibition period regardless of whether the start condition is established at the end time point of the prohibition period.

FIG. 1



EP 3 546 853 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a control device, an air conditioner, a control method, and a program.

[0002] Priority is claimed on Japanese Patent Application No. 2018-61733, filed March 28, 2018, the content of which is incorporated herein by reference.

Description of Related Art

[0003] When a heating operation of an air conditioner is performed in an environment in which outdoor air temperature is low, an outdoor unit may be frosted. In order to prevent the reduction of heating capacity due to frosting, a defrosting operation is performed to remove the frost of the outdoor unit. In general, conditions of an elapsed time from the end of a previous defrosting operation or outdoor air temperature and the temperature of an outdoor unit heat exchanger are set, and when the conditions are established, a defrosting operation is started in many cases.

[0004] In contrast, Patent Document 1 discloses a technology for deciding the start of a de-icing operation (a defrosting operation) with two conditional expressions including a linear equation employing the temperature of an outdoor unit heat exchanger and outdoor air temperature as variables. In the technology disclosed in Patent Document 1, values of parameters of the two conditional expressions are adjusted on the basis of an operation time of a previous de-icing operation. In this way, it is possible to start the de-icing operation at an appropriate timing according to a frosted state of the outdoor unit heat exchanger.

[Patent Documents]

[0005] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2008-14593

SUMMARY OF THE INVENTION

[0006] However, even though a start condition of the defrosting operation is established during a prohibition period of the defrosting operation, the start condition may not be established at the end of the prohibition period due to a sudden decrease and the like in the outdoor air temperature due to a change and the like in weather. In such a case, the defrosting operation may not be performed or the start of the defrosting operation may be delayed. Therefore, since the outdoor unit heat exchanger is frosted, there is a possibility that the performance of a heating operation is reduced or it is not possible to remove frost in a next defrosting operation.

[0007] Therefore, an object of the present invention is to provide a control device, an air conditioner, a control method, and a program, by which it is possible to solve the above problems.

[Solution to Problem]

[0008] According to an aspect of the present invention, the control device includes an operation executing unit that performs a defrosting operation after a prohibition period of the defrosting operation ends on the basis of an establishment state of a start condition of the defrosting operation during the prohibition period regardless of whether the start condition is established at an end time point of the prohibition period.

[0009] According to an aspect of the present invention, when a total time, for which the start condition is established during the prohibition period, is equal to or more than a predetermined threshold value, the operation executing unit is configured to start the defrosting operation even though the start condition is not established at the end time point of the prohibition period.

[0010] According to an aspect of the present invention, when the start condition is established with a predetermined time before the prohibition period ends, the operation executing unit is configured to start the defrosting operation even though the start condition is not established at the end time point of the prohibition period.

[0011] According to an aspect of the present invention, the control device further includes a parameter setting unit that is configured to set a parameter related to an operational maintenance of the defrosting operation on the basis of a trend of operation times of defrosting operations performed in the past.

[0012] According to an aspect of the present invention, when the operation times become shorter than an operation time of an immediately previous defrosting operation more than a predetermined number of consecutive times, the parameter setting unit is configured to increase the length of the prohibition period.

[0013] According to an aspect of the present invention, when the operation times become longer than an operation time of an immediately previous defrosting operation more than a predetermined number of consecutive times, the parameter setting unit is configured to decrease the length of the prohibition period.

[0014] According to an aspect of the present invention, when the operation times reach a predetermined upper limit value, which has been set for the defrosting operation, more than a predetermined number of consecutive times, the parameter setting unit is configured to increase the upper limit value.

[0015] According to an aspect of the present invention, an air conditioner includes the control device according to any one of the above.

[0016] According to an aspect of the present invention, a control method includes a step of calculating an establishment state of a start condition of a defrosting operation during a prohibition period of the defrosting operation,

and a step of determining whether to perform the defrosting operation after the prohibition period ends on the basis of the establishment state regardless of whether the start condition is established at an end time point of the prohibition period.

[0017] According to an aspect of the present invention, a program causes a computer to serve as a means that is configured to calculate an establishment state of a start condition of a defrosting operation during a prohibition period of the defrosting operation, and a means that is configured to determine whether to perform the defrosting operation after the prohibition period ends on the basis of the establishment state regardless of whether the start condition is established at an end time point of the prohibition period.

[0018] According to the aforementioned control device, air conditioner, control method, and program, it is possible to prevent non-execution of a defrosting operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is an overall view showing an example of an air conditioner in an embodiment of the present invention.

FIG. 2 is a diagram showing a start condition of a defrosting operation in an embodiment of the present invention.

FIG. 3 is a functional block diagram showing an example of a control device of an air conditioner in an embodiment of the present invention.

FIG. 4 is a diagram showing a control method of a defrosting operation in an embodiment of the present invention.

FIG. 5 is a diagram showing an adjustment method of parameters related to operational maintenance of a defrosting operation in an embodiment of the present invention.

FIG. 6 is a flowchart showing an example of a control method in an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

<Embodiment>

[0020] Hereinafter, defrost control in an air conditioner according to an embodiment of the present invention will be described with reference to FIG. 1 to FIG. 6.

[0021] FIG. 1 is an overall view showing an example of an air conditioner in an embodiment of the present invention.

[0022] An air conditioner 1 according to a first embodiment includes a refrigerant circuit 10. The refrigerant circuit 10 includes a compressor 2, an indoor heat exchanger 3, an expansion valve 4, an outdoor heat exchanger 5, a two way valve 6, and a four way valve 7. The compressor 2, the indoor heat exchanger 3, the expansion valve 4, the outdoor heat exchanger 5, the two way valve 6, and the four way valve 7 are connected to a refrigerant pipe 20 capable of circulating a refrigerant.

[0023] The refrigerant circuit 10 includes a main circuit 100 used in a heating operation, a positive cycle defrosting operation, and a reverse cycle defrosting operation, and a bypass pipe 200 used only in the positive cycle defrosting operation.

[0024] The main circuit 100 includes a heat exchanger-side main circuit 110 connected to a first terminal 7A and a second terminal 7B of terminals of the four way valve 7, and a compressor-side main circuit 120 connected to a third terminal 7C and a fourth terminal 7D of the terminals of the four way valve 7 when starting from the four way valve 7. In other words, the heat exchanger-side main circuit 110 and the compressor-side main circuit 120 are connected to each other via the four way valve 7.

[0025] The heat exchanger-side main circuit 110 is provided with the indoor heat exchanger 3, the expansion valve 4, the outdoor heat exchanger 5. The compressor-side main circuit 120 is provided with the compressor 2.

[0026] In the four way valve 7, four pipelines connected to the terminals can be connected by two pairs or these pairs can be switched. Specifically, the four way valve 7 can connect a pair of the first terminal 7A and the fourth terminal 7D and a pair of the second terminal 7B and the third terminal 7C. Furthermore, the four way valve 7 can connect a pair of the first terminal 7A and the third terminal 7C and a pair of the second terminal 7B and the fourth terminal 7D.

[0027] In this way, it is possible to switch a connection relation between the heat exchanger-side main circuit 110 and the compressor-side main circuit 120. When the second terminal 7B and the third terminal 7C of the four way valve 7 are connected to each other, a high temperature and high pressure refrigerant discharged from the compressor 2 flows through a path (a cooling path) from the second terminal 7B to the outdoor heat exchanger 5. When the first terminal 7A and the third terminal 7C of the four way valve 7 are connected to each other, the high temperature and high pressure refrigerant discharged from the compressor 2 flows through a path (a heating path) from the first terminal 7A to the indoor heat exchanger 3.

[0028] The refrigerant circuit 10 of the air conditioner 1 is provided with the bypass pipe 200 as described above. The bypass pipe 200 is a refrigerant pipe that connects between the compressor 2 and the four way valve 7 (between a bypass start point 20A and a bypass end point 20B provided between the expansion valve 4 and the outdoor heat exchanger 5 of the heat exchanger-side main circuit 110) at a discharge side of the compressor 2 of the compressor-side main circuit 120. The bypass pipe 200 is provided with the two way valve 6, so that it is possible to open and close the bypass pipe 200. In the normal heating operation, the cooling operation, and the reverse cycle defrosting operation, the two way valve 6

is closed.

[0029] Circulation of a refrigerant in a heating operation will be described. In the heating operation, the four way valve 7 is in the connection relation of the heating path. The refrigerant is compressed by the compressor 2 to reach high temperature and high pressure, enters the third terminal 7C of the four way valve 7, and then flows from the first terminal 7A to the indoor heat exchanger 3. In the indoor heat exchanger 3, the refrigerant is cooled and condensed by heat exchange, and instead, heat is given to indoor air outside the indoor heat exchanger 3. The indoor air is blown by an indoor-side blower 13. The condensed refrigerant flows into the expansion valve 4 and reaches low temperature and low pressure. The refrigerant exiting the expansion valve 4 flows into the outdoor heat exchanger 5, is heated by outdoor air, and is evaporated and vaporized in the outdoor heat exchanger 5. The vaporized refrigerant returns to the compressor 2 through the second terminal 7B and the fourth terminal 7D of the four way valve 7. By continuously repeating the above cycle, the air conditioner 1 performs the heating operation.

[0030] During the heating operation, since the temperature of the air outside the outdoor heat exchanger 5 is deprived of heat by the refrigerant and becomes lower as described above, the temperature of the surface of the outdoor heat exchanger 5 is lowered to a subzero temperature range, and therefore frost may occur and may form layers. Therefore, heat conduction of the heat exchanger may be disturbed and thus heat exchange efficiency may be reduced.

[0031] In order to remove the frost, two types of defrosting operations are known. That is, there are a positive cycle defrosting operation (a bypass cycle defrosting operation, hereinafter, referred to as DfP) and a reverse cycle defrosting operation (hereinafter, referred to as DfR).

[0032] The DfP indicates a defrosting operation for defrosting the outdoor heat exchanger 5 by circulating the refrigerant via the bypass pipe 200 that sends some of refrigerant gas discharged from the compressor 2 to the outdoor heat exchanger 5 during the heating operation. By opening the two way valve 6, the DfP is performed.

[0033] The circulation of the refrigerant during the DfP will be described. During the DfP, the connection relation of the heating path is maintained in the four way valve 7, so that the refrigerant circulation during the aforementioned heating operation is maintained. In addition, the two way valve 6 is opened and the refrigerant also flows through the bypass pipe 200, so that some of the high temperature and high pressure refrigerant discharged from the compressor 2 is sent to the outdoor heat exchanger 5 without passing through the indoor heat exchanger 3. In this way, heat is applied to the outdoor heat exchanger 5 to perform defrosting.

[0034] In addition, in the DfP, since some of the high temperature and high pressure refrigerant to be originally sent to the indoor heat exchanger 3 is sent to the outdoor heat exchanger 5, it is possible to continue the heating operation while performing the defrosting, but the heating capability is reduced to about 1/3 as compared with the normal heating operation. Furthermore, since the amount of the refrigerant sent to the outdoor heat exchanger 5 is a part of the total refrigerant, the defrosting capability becomes lower as compared with the DfR to be described later.

[0035] On the other hand, the DfR indicates a defrosting operation in which defrosting is performed by circulating the refrigerant in the heat exchanger-side main circuit 1 10 in a direction opposite to that of the heating operation. The refrigerant is circulated in the direction opposite to that of the heating operation, so that all of the refrigerant gas discharged from the compressor 2 is sent to the outdoor heat exchanger 5. In this way, in the DfR, it is possible to strongly melt frost as compared with the DfP. However, since the DfR is performed by switching the four way valve 7 to the connection relation of the cooling path, substantially the same refrigerant circulation as that in the cooling operation is performed except that air is not blown to the indoor heat exchanger 3. Therefore, during the DfR, since the heating operation is stopped and indoor heat deprived, the room temperature drops.

[0036] The circulation of the refrigerant during the DfR will be described. The refrigerant is compressed by the compressor 2 to reach high temperature and high pressure, enters the third terminal 7C of the four way valve 7, and then flows from the second terminal 7B to the outdoor heat exchanger 5. In the outdoor heat exchanger 5, the refrigerant is cooled and condensed by heat exchange, and instead, heat is given to outdoor air outside the outdoor heat exchanger 5. Therefore, the condensed refrigerant flows into the expansion valve 4 and reaches low temperature and low pressure. The refrigerant exiting the expansion valve 4 flows into the indoor heat exchanger 3, is heated by indoor air, and is evaporated and vaporized in the indoor heat exchanger 3. At this time, heat is taken away from indoor air outside the indoor heat exchanger 3. In the cooling operation, the indoor air that has reached low temperature is blown by the indoor-side blower 13 and is used for indoor cooling, but in the DfR, no air is blown. The vaporized refrigerant enters the first terminal 7A of the four way valve 7, and returns to the compressor 2 through the fourth terminal 7D.

[0037] The aforementioned cycle is continuously repeated.

[0038] In the present embodiment, the air conditioner 1 is further provided with an outside air temperature sensor 25 and a heat exchanger temperature sensor 35, and further includes a control device 201 for switching the three operation modes of the aforementioned heating operation, DfP and DfR. A start condition M of the defrosting operation (DfP or DfR) will be described using FIG. 2.

[0039] FIG. 2 is a diagram showing the start condition of the defrosting operation in an embodiment of the present invention. A line L1 shown in FIG. 2 denotes the

start condition M of the defrosting operation when an outdoor heat exchanger temperature ThoR is set as a vertical axis and an outside air temperature ThoA is set as a horizontal axis. This relation, for example, can be expressed by α (=outside air temperature ThoA-outdoor heat exchanger temperature ThoR) (α is a predetermined constant). The outdoor heat exchanger temperature ThoR is a temperature measured by the heat exchanger temperature sensor 35. The outside air temperature ThoA is a temperature measured by the outside air temperature sensor 25.

[0040] When the relation between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA is in a region below the line L1 (outside air temperature ThoA-outdoor heat exchanger temperature ThoR$\geq\alpha$), for example, when the outside air temperature ThoA and the outdoor heat exchanger temperature ThoR are in a relation indicated by a point P1, the start condition M of the defrosting operation is established.

[0041] When the relation between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA is in a region above the line L1 (outside air temperature ThoA-outdoor heat exchanger temperature ThoR$<\alpha$), for example, when they are in a relation indicated by a point P2, the start condition M of the defrosting operation is not established.

[0042] During the heating operation, when the relation between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA satisfies the start condition M of the defrosting operation, the control device 201 stops the heating operation and starts the defrosting operation of the DfP or the DfR. When the defrosting operation is started and a predetermined stop condition of the defrosting operation is established, the control device 201 stops the defrosting operation and resumes the heating operation. The stop condition of the defrosting operation, for example, is that the temperature difference (ThoA-ThoR) is within a predetermined threshold value. Furthermore, an upper limit value is set for the operation time of the defrosting operation. When the upper limit value passes from the start of the defrosting operation, the control device 201 ends the defrosting operation. Furthermore, as described above, since the defrosting operation reduces the capability of the original heating operation, when the defrosting operation is performed once, execution is prohibited for a while (a predetermined prohibition period). That is, even though the start condition M of the defrosting operation is established during this prohibition period, the control device 201 performs no defrosting operation during the prohibition period.

[0043] For example, it is assumed that the relation between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA is the relation indicated by the point P1 during the prohibition period of the defrosting operation. When the same relation is maintained after the prohibition period passes, the control device 201 starts the defrosting operation after the end of the prohibition period. However, it is assumed that when the outside air temperature suddenly decreases before the end of the prohibition period, the relation between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA is changed to a relation indicated by a point P3 and is maintained. Then, even though the prohibition period passes, since the start condition M of the defrosting operation is not established, the control device 201 performs no defrosting operation. In such a case, while the start condition M of the defrosting operation is established during the prohibition period, there is a possibility that the outdoor heat exchanger 5 is frosted. However, in the related control, until the outdoor heat exchanger temperature ThoR decreases due to the outside air temperature ThoA, for example, they are in a relation as indicated by a point P4, since the control device 201 performs no defrosting operation, the heating operation is in an operation state with low efficiency during that time period. In contrast, the control device 201 of the present embodiment has a function of starting the defrosting operation according to the establishment state of a frost formation condition during the prohibition period after the end of the prohibition period of the defrosting operation.

[0044] Next, the function of the control device 201 will be described using FIG. 3.

[0045] FIG. 3 is a functional block diagram showing an example of the control device of the air conditioner in an embodiment of the present invention.

[0046] As shown in FIG. 3, an outdoor unit 1A includes the control device 201. The control device 201, for example, is a computer including a central processing unit (CPU) and the like. The control device 201 includes an outside air temperature acquiring unit 41, an outdoor heat exchanger temperature acquiring unit 42, an operation executing unit 43, a parameter setting unit 44, a storage unit 45, and a timer 46.

[0047] The outside air temperature acquiring unit 41 acquires the outside air temperature (outside air temperature ThoA) of the outdoor unit 1A through the outside air temperature sensor 25.

[0048] The outdoor heat exchanger temperature acquiring unit 42 acquires the temperature (outdoor heat exchanger temperature ThoR) of the outdoor heat exchanger 5 of the outdoor unit 1A through the heat exchanger temperature sensor 35.

[0049] The operation executing unit 43 performs the heating operation and the defrosting operation. The operation executing unit 43 switches the heating operation and the defrosting operation by mainly controlling the two way valve 6 and the four way valve 7. For example, when the start condition M of the defrosting operation is established, the operation executing unit 43 switches the heating operation to the defrosting operation. Furthermore, for example, when the end condition of the defrosting operation is established, the operation executing unit 43 switches the defrosting operation to the heating operation. As described above, the operation executing unit 43 can perform the defrosting operation of the DfP or the

DfR. The operation executing unit 43, for example, may select the DfP or the DfR in accordance with the temperature difference between the outdoor heat exchanger temperature ThoR and the outside air temperature ThoA, and perform the selected type of defrosting operation. In addition, since a control method for preventing the non-execution of the defrosting operation according to the present embodiment can be applied without distinction between the DfP and the DfR, the defrosting operation will be described without particular distinction in the following description. On the basis of the establishment state of the start condition M of the defrosting operation during the prohibition period of the defrosting operation, the operation executing unit 43 performs the defrosting operation regardless of whether the start condition M is established at the end time point of the prohibition period.

[0050] The parameter setting unit 44 sets parameters related to the operational maintenance of the defrosting operation. The parameters related to the operational maintenance, for example, include a length of the prohibition period, the upper limit value of the operation time of the defrosting operation, and the like. On the basis of the trend of operation times of defrosting operations performed in the past, the parameter setting unit 44 appropriately adjusts the parameters related to the operational maintenance of the defrosting operation.

[0051] The storage unit 45 stores various types of information of the outside air temperature ThoA, the outdoor heat exchanger temperature ThoR, the parameters such as the length of the prohibition period and the upper limit value of the operation time of the defrosting operation, and the like.

[0052] The timer 46 measures time.

[0053] Next, start control of the defrosting operation based on the establishment state of the defrosting operation start condition during the prohibition period according to the present embodiment will be described.

[0054] FIG. 4 is a diagram showing the control method of the defrosting operation in an embodiment of the present invention. FIG. 4 (a) shows related defrost control. The time T1 to the time T2 is the prohibition period of the defrosting operation. It is assumed that at the time T4 to the time T4' of the prohibition period, the start condition M is established and then the prohibition period ends due to the non-establishment of the start condition M. At the end of the prohibition period, the start condition M is not established. In such a case, in the related control, the defrosting operation is not performed immediately after the end of the prohibition period. Thereafter, when the start condition M is established at the time T3, the defrosting operation is started. In the case of such control, frost formation may occur from the time T1 to the time T2, and in the heating operation from the time T2 to the time T3, heating capacity may be reduced.

[0055] FIG. 4 (b) to FIG. 4 (d) show the defrost control of the present embodiment. FIG. 4 (b) shows a control method of the defrosting operation when the control device 201 of the present embodiment has operated the air conditioner 1 in the same operation state as that of FIG. 4 (a). That is, at the time T4 to the time T4' of the prohibition period, the start condition M of the defrosting operation is established, and then the prohibition period ends due to the non-establishment of the start condition M. The operation executing unit 43 calculates the period of time between the time T4 and the time T4', in which the start condition M of the defrosting operation is established, by using the timer 46. When the calculated period of time is equal to or more than a predetermined period of time "h1", the operation executing unit 43 starts the defrosting operation after the end of the prohibition period of the defrosting operation (the time T2). In such a case, it is irrelevant whether the start condition M is established at the time T2.

[0056] FIG. 4 (c) shows a case where the start condition M of the defrosting operation has been established at each of the times T5 to T5', the times T6 to T6', and the times T7 to T7' of the prohibition period and the prohibition period has ended with the start condition M not being established. In such a case, the operation executing unit 43 calculates each period of time between the times T5 to T5', the times T6 to T6', and the times T7 to T7', in which the start condition M of the defrosting operation has been established, by using the timer 46, and calculates the sum of the three time zones in which the start condition M has been established. When the calculated total time is equal to or more than the predetermined period of time "h1", the operation executing unit 43 starts the defrosting operation at the time T2 even though the start condition M has not been established at the time T2 at which the prohibition period ends.

[0057] FIG. 4 (d) shows a case where the start condition M of the defrosting operation has been established once within a predetermined period of time "h2" immediately before the prohibition period ends and the prohibition period has ended with the start condition M not being established. In such a case, by using the timer 46, the operation executing unit 43 confirms whether the start condition M has been established after the time T8 before "h2" with reference to the time T2 at which the prohibition period ends. When the start condition M has been established even once in this time zone, the operation executing unit 43 starts the defrosting operation even though the start condition M is not established at the time T2.

[0058] According to the control method of the defrosting operation shown in FIG. 4 (b) to FIG. 4 (d), (A) when the total time in which the start condition M is established during the prohibition period is equal to or more than the predetermined period of time "h1" or (B) when the start condition M is established even once within the predetermined period of time "h2" before the end of the prohibition, the defrosting operation is started immediately after the prohibition period ends regardless of whether the start condition M is established at the end time point of the prohibition period. In this way, even in a state in which frost formation is proceeding during the prohibition period, it is possible to quickly perform defrosting after the

end of the prohibition period and to prevent the reduction of heating capability. In addition, the length of the prohibition period, for example, is 35 minutes, the predetermined period of time "h1", for example, is 20 minutes, and the predetermined period of time "h2", for example, is 3 minutes.

[0059] Next, a method for adjusting the parameters related to the operational maintenance of the defrosting operation according to the present embodiment will be described.

[0060] FIG. 5 is a diagram showing an adjustment method of the parameters related to the operational maintenance of the defrosting operation in an embodiment of the present invention.

[0061] FIG. 5 (a) shows a case where an execution time Dx (x: 1 to n) of the defrosting operation has been continuously shortened n times. That is, D1>D2>···>Dn. Such a case is considered to be an operational environment (the outside air temperature ThoA, the outdoor heat exchanger temperature ThoR and the like) in which frost hardly occurs. Accordingly, since the necessity to perform the defrosting operation is relatively low, it is preferable that a long time is allocated to the heating operation as much as possible. Accordingly, the parameter setting unit 44 sets the length of the prohibition period longer by a predetermined period of time "h3". In this way, it is possible to decrease the number of opportunities of performing the defrosting operation and to prevent the heating operation from being disturbed more than necessary. In addition, after the prohibition period is adjusted, when the execution time of the defrosting operation is continuously shortened n times, the predetermined period of time "h3" may be further added with a predetermined period of time "h4" for an initial value (for example, 35 minutes) of the prohibition period as an upper limit value of an increment. In addition, the value "h3" to be added at a time, for example, is 5 minutes and the upper limit value "h4", for example, is 10 minutes.

[0062] FIG. 5 (b) shows a case where the execution time Dx (x: 1 to n) of the defrosting operation has been continuously increased n times. That is, D1<D2<···<Dn. Such a case is considered to be an operational environment in which frost easily occurs or a state in which defrosting is not possible in a one-time defrosting operation and unmelted frost easily occurs. Accordingly, it is preferable to increase the number of executions of the defrosting operation and to operate the defrosting operation such that defrosting can be reliably performed. Accordingly, the parameter setting unit 44 sets the length of the prohibition period shorter by a predetermined period of time "h5". In this way, it is possible to increase the number of opportunities of performing the defrosting operation and to prevent frost formation and unmelted frost. In addition, after the prohibition period is adjusted, when the execution time of the defrosting operation is continuously increased n times, the predetermined period of time "h5" may be further subtracted with a predetermined period of time "h6" for the initial value (for example, 35 minutes) of the prohibition period as an upper limit value of a decrement. In addition, the value "h5" to be subtracted at a time, for example, is 5 minutes, and the upper limit value "h6", for example, is 10 minutes.

[0063] FIG. 5 (c) shows a case where the execution time Dx (x: 1 to n) of the defrosting operation has continuously expired n times. That is, D1=D2=···=Dn=upper limit value (for example, is 15 minutes) of the execution time of the defrosting operation. Such a case is considered to be an operational environment in which frost easily occurs or a state in which defrosting is not possible in a one-time defrosting operation and unmelted frost easily occurs. Accordingly, it is preferable to increase the execution time of the defrosting operation and to operate the defrosting operation such that defrosting can be performed without unmelted frost. Accordingly, the parameter setting unit 44 sets the upper limit value of the operation time longer by a predetermined period of time "h7". In this way, it is possible to increase the execution time of the defrosting operation and to prevent frost formation and unmelted frost. In addition, after the operation time is adjusted, when the defrosting operation has continuously expired n times, the predetermined period of time "h7" may be further added with a predetermined period of time "h8" for the initial value (for example, 15 minutes) of the operation time as an upper limit value. In addition, the value "h7" to be added at a time, for example, is 5 minutes and the upper limit value "h8", for example, is 10 minutes.

[0064] In addition, even though the execution time of the defrosting operation has continuously expired n times, the length of the prohibition period may be set shorter by "h5" in the same manner as the adjustment described in FIG. 5 (b).

[0065] According to the adjustment method of the operational parameters shown in FIG. 5 (a) to FIG. 5 (c), on the basis of the trend of the operation times of the defrosting operation, (a) when the operation time of the defrosting operation of each time has been shorter than an operation time at the time of immediately previous execution more than a predetermined number of consecutive times up to a defrosting operation performed previous time, the length of the prohibition period is increased. Furthermore, (b) when the operation time of the defrosting operation of each time has been longer than an operation time at the time of immediately previous execution more than a predetermined number of consecutive times up to a defrosting operation performed previous time, the length of the prohibition period is decreased. Furthermore, (c) when the operation time of each time has reached an upper limit value of the operation time more than a predetermined number of consecutive times up to a defrosting operation performed previous time, the upper limit value of the operation time is increased. In this way, it is possible to appropriately adjust the operational maintenance of the defrosting operation in accordance with a frosting state, and it is possible to prevent the reduction of heating capacity by pre-

venting the progression of frost formation and unmelted frost.

[0066] Next, the process flow of the execution control of the defrosting operation will be described using FIG. 6.

[0067] FIG. 6 is a flowchart showing an example of the control method in an embodiment of the present invention. In addition, in the following description, a case where the operation executing unit 43 performs the defrosting operation of the DfR will be described as an example; however, the same control can also be applied to a case of performing the defrosting operation of the DfP.

[0068] Firstly, when a user starts to use heating. Then, the control device 201 starts the heating operation (step S11). Specifically, the operation executing unit 43 controls the four way valve 7 such that refrigerant gas discharged from the compressor 2 circulates the heating path (the path connecting the first terminal 7A to the third terminal 7C, connecting the second terminal 7B to the fourth terminal 7D, and allowing the refrigerant gas to flow from the compressor 2 to the indoor heat exchanger 3), and closes the two way valve 6. Next, the operation executing unit 43 determines whether the outside air temperature ThoA and the outdoor heat exchanger temperature ThoR satisfy the defrosting start condition M (for example, outside air temperature ThoA-outdoor heat exchanger temperature ThoR>α) (step S12). In addition, at the start of the heating operation, the operation executing unit 43 may continue the heating operation without performing this determination during a predetermined prohibition period (for example, 35 minutes).

[0069] When the temperature difference (ThoA-ThoR) does not exceed the predetermined constant α (step S12: No), the operation executing unit 43 continues the process of step S11 and continuously performs the heating operation.

[0070] When the temperature difference (ThoA-ThoR) exceeds α (step S12: Yes), the operation executing unit 43 determines that the outdoor heat exchanger 5 is frosted. Next, the operation executing unit 43 determines whether the present time is the prohibition period of the defrosting operation (step S13). When the present time is not the prohibition period of the defrosting operation (step S13: No), the operation executing unit 43 performs the defrosting operation (step S14). Specifically, the operation executing unit 43 switches the four way valve 7 to the connection relation of the cooling path while keeping the two way valve 6 closed, and performs an operation. In this way, the discharged refrigerant gas is sent to the outdoor heat exchanger 5, so that defrosting is performed. The timer 46 measures an elapsed time after the start of the defrosting operation. The operation executing unit 43 records the start time of the defrosting operation in the storage unit 45 by using the timer 46. Next, the operation executing unit 43 determines whether defrosting of the outdoor heat exchanger 5 has been achieved, and stops the defrosting operation when it is determined that the defrosting has been achieved. In relation to the determination regarding whether the defrosting has been achieved, for example, it may be determined that the defrosting has been achieved when the temperature difference (ThoA-ThoR) is within a predetermined threshold value. When a predetermined upper limit value has passed from the start of the defrosting operation, the operation executing unit 43 stops the defrosting operation. In addition, when the upper limit value of the operation time of the defrosting operation is updated in step S16 to be described later, the operation executing unit 43 performs determination of time-up with the updated value. When the defrosting operation ends, the operation executing unit 43 switches the four way valve 7 to the connection relation of the heating path and resumes the heating operation. Furthermore, the operation executing unit 43 records the end time of the defrosting operation in the storage unit 45 by using the timer 46. When the defrosting operation ends, the prohibition period of the defrosting operation is reached. The timer 46 measures an elapsed time since entering the prohibition period.

[0071] Next, the operation executing unit 43 calculates the operation time of the defrosting operation by subtracting the start time of the defrosting operation from the end time of the defrosting operation, and records the calculated operation time in the storage unit 45 in correlation with the start time or the end time of a defrosting operation of this time (step S15).

[0072] Next, the parameter setting unit 44 adjusts the parameters related to the operational maintenance of the defrosting operation (step S16). For example, when the operation time of the defrosting operation recorded in the storage unit 45 has become short a predetermined number of consecutive times, the parameter setting unit 44 adds h3 (for example, 5 minutes) to a current prohibition period (for example, 35 minutes) and updates the prohibition period with the added value (for example, 40 minutes). Furthermore, when the operation time of the defrosting operation has become long a predetermined number of consecutive times, the parameter setting unit 44 subtracts h5 (for example, 5 minutes) from the current prohibition period (for example, 35 minutes) and updates the prohibition period with the subtracted value (for example, 30 minutes). Furthermore, when the operation time of the defrosting operation has expired a predetermined number of consecutive times, the parameter setting unit 44 adds h7 (for example, 5 minutes) to an upper limit value (for example, 15 minutes) of a current operation time and updates the upper limit value of the operation time with the added value (for example, 20 minutes).

[0073] On the other hand, when the present time is the prohibition period of the defrosting operation (step S13: Yes) or when the defrosting operation ends and the prohibition period is reached, the operation executing unit 43 continuously performs the same determination as that of step S12. Then, when the start condition M is established, the operation executing unit 43 records the established time in the storage unit 45, and when the start condition M is not established, the operation executing unit 43 records the unestablished time in the storage unit

45 (step S17). Furthermore, the operation executing unit 43 determines whether the prohibition period has ended (step S18). For example, when the elapsed time from the start of the prohibition period measured by the timer 46 reaches a predetermined setting value (for example, 35 minutes), the operation executing unit 43 determines that the prohibition period has ended. When the length of the prohibition period has been updated in the process of step S16, the operation executing unit 43 performs determination with the updated value.

[0074] When the prohibition period has not ended (step S18; No), the operation executing unit 43 continuously performs the process of step S17.

[0075] When the prohibition period has ended (step S18; Yes), the operation executing unit 43 determines whether to perform the defrosting operation on the basis of the establishment state of the start condition M during the prohibition period (step S19). For example, on the basis of the established time and the unestablished time of the start condition M recorded in the storage unit 45, the operation executing unit 43 calculates the sum of the times during which the start condition M is established during the prohibition period. When the total time exceeds h1 (for example, 20 minutes), the operation executing unit 43 determines to perform the defrosting operation. Furthermore, when the start condition M has been established even once between the time before h2 after the end of the prohibition period and the end time, the operation executing unit 43 determines to perform the defrosting operation. When it is determined to perform the defrosting operation (step S19; Yes), the operation executing unit 43 starts the defrosting operation immediately after the end of the prohibition period. That is, after the end of the prohibition period, the operation executing unit 43 performs the process of step S14 within a predetermined time (for example, within 30 seconds). When it is determined to perform no defrosting operation (step S19; No), the operation executing unit 43 continues the heating operation.

[0076] According to the present embodiment, even though the start condition M of the defrosting operation is established during the prohibition period of the defrosting operation, even when the start condition M is not established at the end of the prohibition period due to a subsequent sudden change in outside air temperature, it is possible to avoid non-execution of the defrosting operation, to perform the defrosting operation after the end of the prohibition period, and to perform defrosting. Furthermore, on the basis of the trend of the operation times of the past defrosting operations, when defrosting is not sufficient, it is possible to promote defrosting by shortening the prohibition period or extending the upper limit value of the defrosting operation time. When defrosting is performed more than necessary, it is possible to limit an opportunity of performing the defrosting operation by extending the prohibition period. By these functions, it is possible to realize the operational maintenance of the defrosting operation according to the design intention of the air conditioner 1.

[0077] All functions or some functions of the control device 201, for example, may be realized by hardware composed of a large scale integration (LSI), an application specific integrated circuit (ASIC), a programmable logic device (PLD), a field-programmable gate array (FPGA), an integrated circuit and the like. Furthermore, all functions or some functions of the control device 201, for example, may be configured by a computer including a processor such as a CPU. In such a case, the process of each processing in the control device 201, for example, can be realized when the CPU and the like of the control device 201 execute a program. The program executed by the control device 201 may be recorded on a computer-readable recording medium, and the process of each processing may be realized when the program recorded on the recording medium is read and executed. In addition, the control device 201 is assumed to include an OS and hardware such as a peripheral device. Furthermore, the computer-readable recording medium, for example, is a portable medium such as a flexible disk, a magneto-optical disc, a ROM, and a CD-ROM, and a storage device such as a hard disk embedded in the control device 201. Furthermore, the computer-readable recording medium may also include a medium for dynamically holding a program for a short time period such as a communication line in the case where the program is transmitted via a network such as the Internet or a communication line such as a telephone line, and a medium for holding the program for a constant time period such as a volatile memory in a computer system serving as a server or a client in that case. Furthermore, the aforementioned program may also be a program for realizing some of the aforementioned functions, or a program capable of realizing the aforementioned functions in combination with a program in which the aforementioned functions have been previously recorded in the computer system.

[0078] Besides, the elements in the aforementioned embodiment can be appropriately replaced with well-known elements without departing from the scope of the present invention. Furthermore, the technical range of the present invention is not limited to the aforementioned embodiment and various modifications can be made within the scope of the present invention.

[Reference Signs List]

[0079]

1 Air conditioner
1A Outdoor unit
201 Control device
2 Compressor
3 Indoor heat exchanger
4 Expansion valve
5 Outdoor heat exchanger
6 Two way valve
7 Four way valve

7A First terminal
7B Second terminal
7C Third terminal
7D Fourth terminal
10 Refrigerant circuit
20 Refrigerant pipe
20A Bypass start point
20B Bypass end point
200 Bypass pipe
100 Main circuit
110 Heat exchanger-side main circuit
120 Compressor-side main circuit
201 Control device
41 Outside air temperature acquiring unit
42 Outdoor heat exchanger temperature acquiring unit
43 Operation executing unit
44 Parameter setting unit
45 Storage unit
46 Timer

Claims

1. A control device comprising:
an operation executing unit configured to perform a defrosting operation after a prohibition period of the defrosting operation ends on the basis of an establishment state of a start condition of the defrosting operation during the prohibition period regardless of whether the start condition is established at an end time point of the prohibition period.

2. The control device according to claim 1, wherein, when a total time, for which the start condition is established during the prohibition period, is equal to or more than a predetermined threshold value, the operation executing unit is configured to start the defrosting operation even though the start condition is not established at the end time point of the prohibition period.

3. The control device according to claim 1 or 2, wherein, when the start condition is established with a predetermined time before the prohibition period ends, the operation executing unit is configured to start the defrosting operation even though the start condition is not established at the end time point of the prohibition period.

4. The control device according to any one of claims 1 to 3, further comprising:
a parameter setting unit configured to set a parameter related to an operational maintenance of the defrosting operation on the basis of a trend of operation times of defrosting operations performed in the past.

5. The control device according to claim 4, wherein, when the operation times become shorter than an operation time of an immediately previous defrosting operation more than a predetermined number of consecutive times, the parameter setting unit is configured to increase a length of the prohibition period.

6. The control device according to claim 4 or 5, wherein, when the operation times become longer than an operation time of an immediately previous defrosting operation more than a predetermined number of consecutive times, the parameter setting unit is configured to decrease the length of the prohibition period.

7. The control device according to any one of claims 4 to 6, wherein, when the operation times reach a predetermined upper limit value, which has been set for the defrosting operation, more than a predetermined number of consecutive times, the parameter setting unit is configured to increase the upper limit value.

8. An air conditioner comprising the control device according to any one of claims 1 to 7.

9. A control method comprising:

a step of calculating an establishment state of a start condition of a defrosting operation during a prohibition period of the defrosting operation; and
a step of determining whether to perform the defrosting operation after the prohibition period ends on the basis of the establishment state regardless of whether the start condition is established at an end time point of the prohibition period.

10. A program causing a computer to serve as:

a means that is configured to calculate an establishment state of a start condition of a defrosting operation during a prohibition period of the defrosting operation; and
a means that is configured to determine whether to perform the defrosting operation after the prohibition period ends on the basis of the establishment state regardless of whether the start condition is established at an end time point of the prohibition period.

FIG. 1

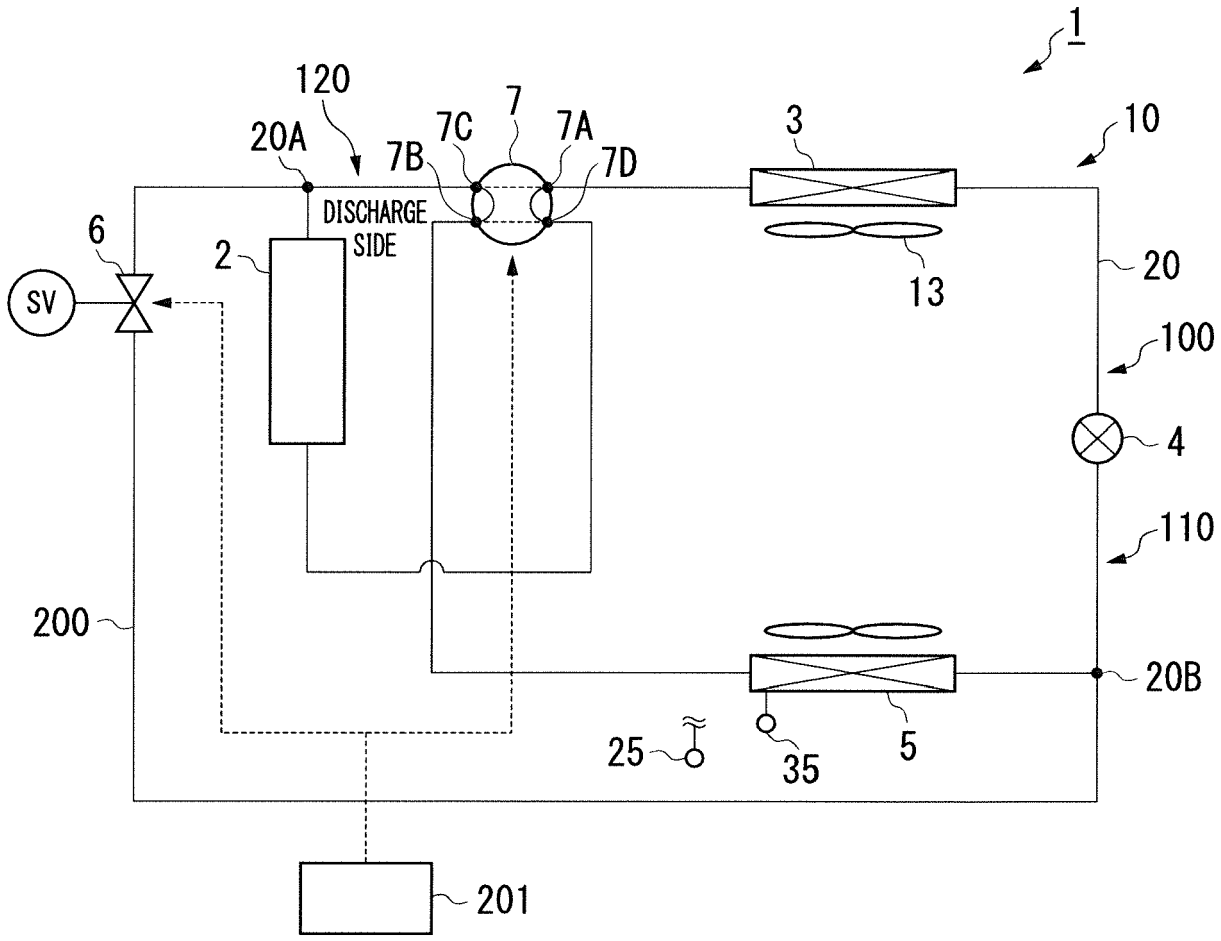

1
120
20A
7
7C
7A
7B
7D
3
10
DISCHARGE SIDE
6
2
SV
13
20
100
4
110
200
20B
25
35
5
201

FIG. 2

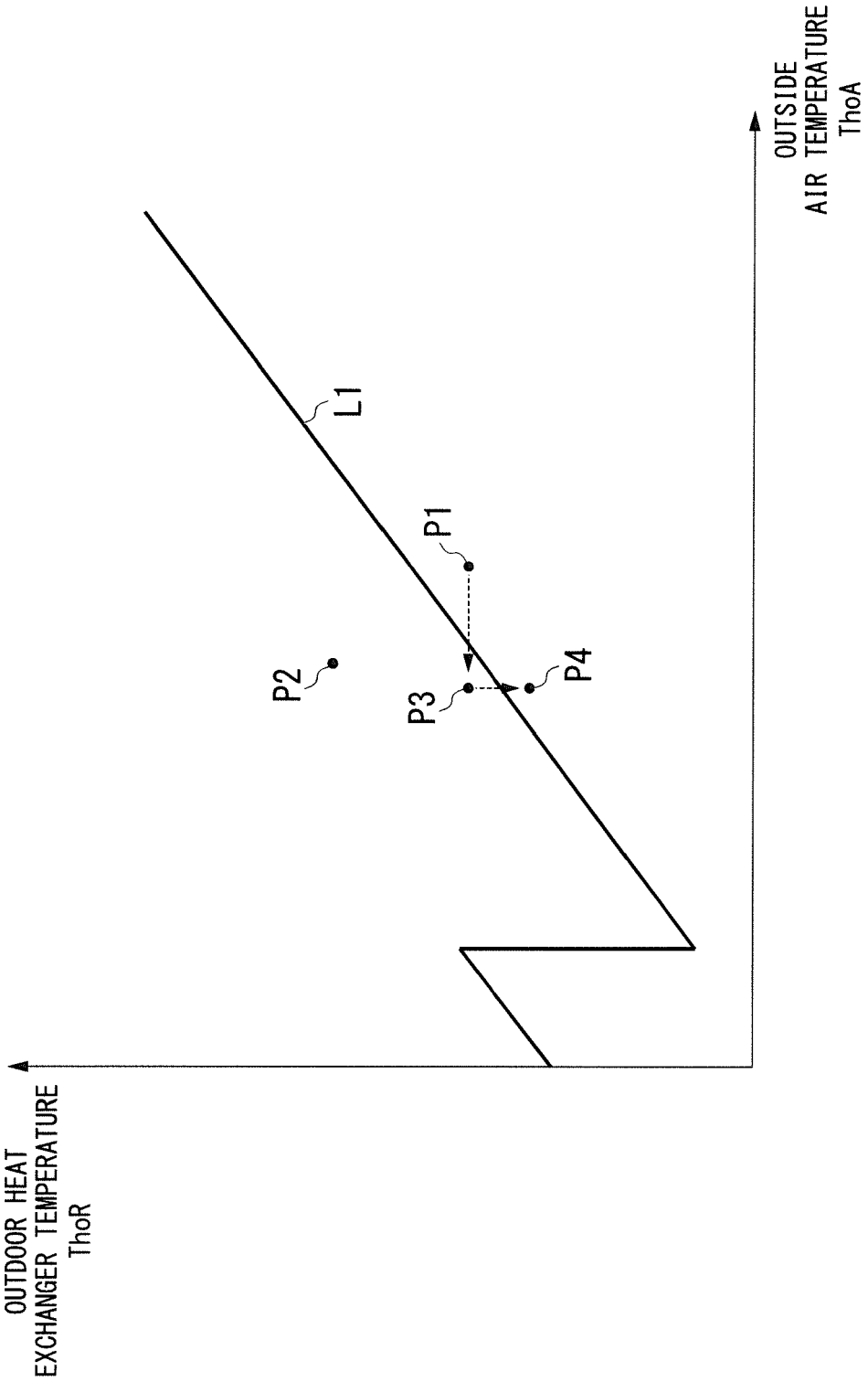

OUTDOOR HEAT EXCHANGER TEMPERATURE ThoR
OUTSIDE AIR TEMPERATURE ThoA
L1
P1
P2
P3
P4

FIG. 3

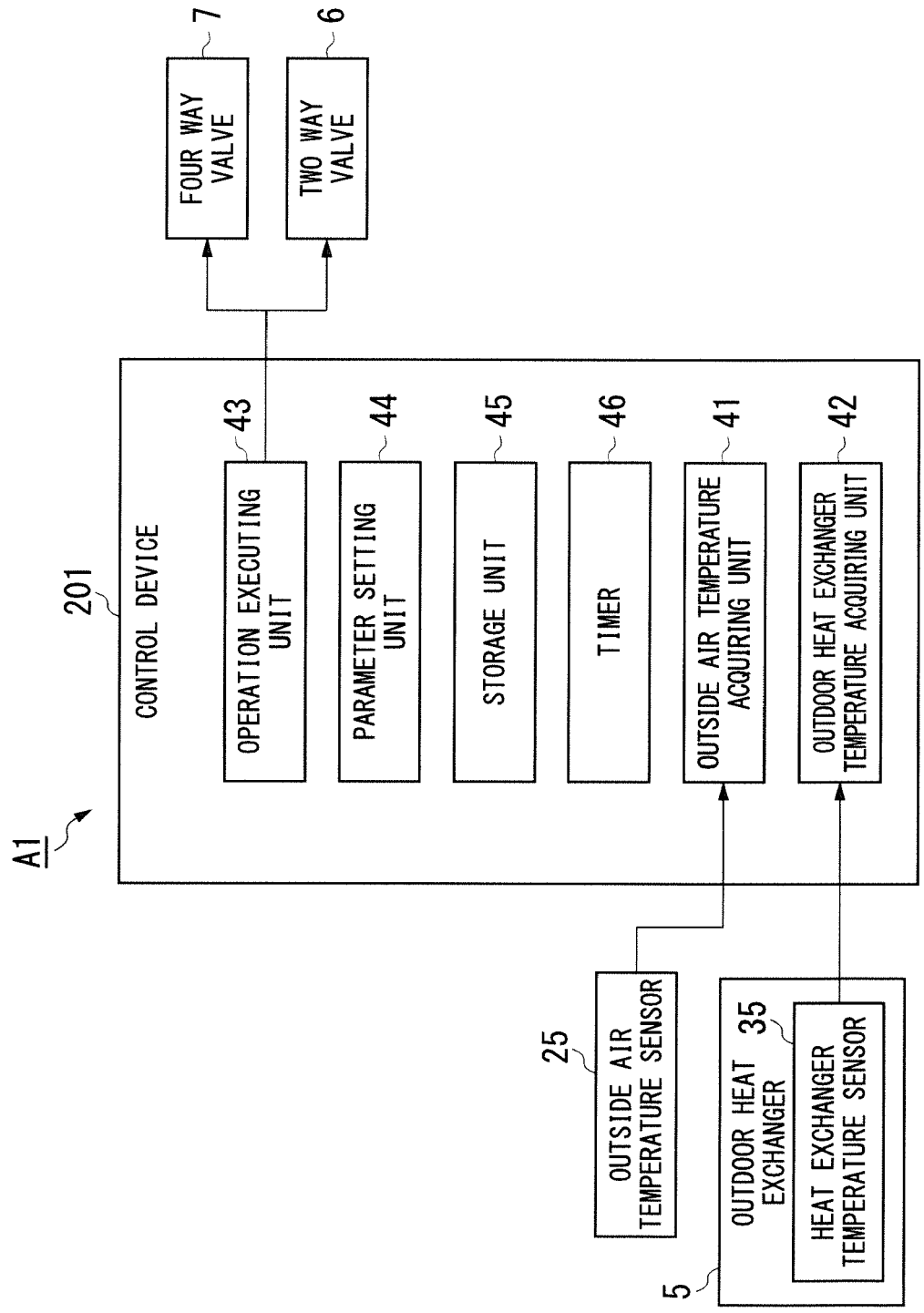

A1
201
CONTROL DEVICE
43
OPERATION EXECUTING UNIT
44
PARAMETER SETTING UNIT
45
STORAGE UNIT
46
TIMER
41
OUTSIDE AIR TEMPERATURE ACQUIRING UNIT
42
OUTDOOR HEAT EXCHANGER TEMPERATURE ACQUIRING UNIT
7
FOUR WAY VALVE
6
TWO WAY VALVE
25
OUTSIDE AIR TEMPERATURE SENSOR
5
OUTDOOR HEAT EXCHANGER
35
HEAT EXCHANGER TEMPERATURE SENSOR

FIG. 4

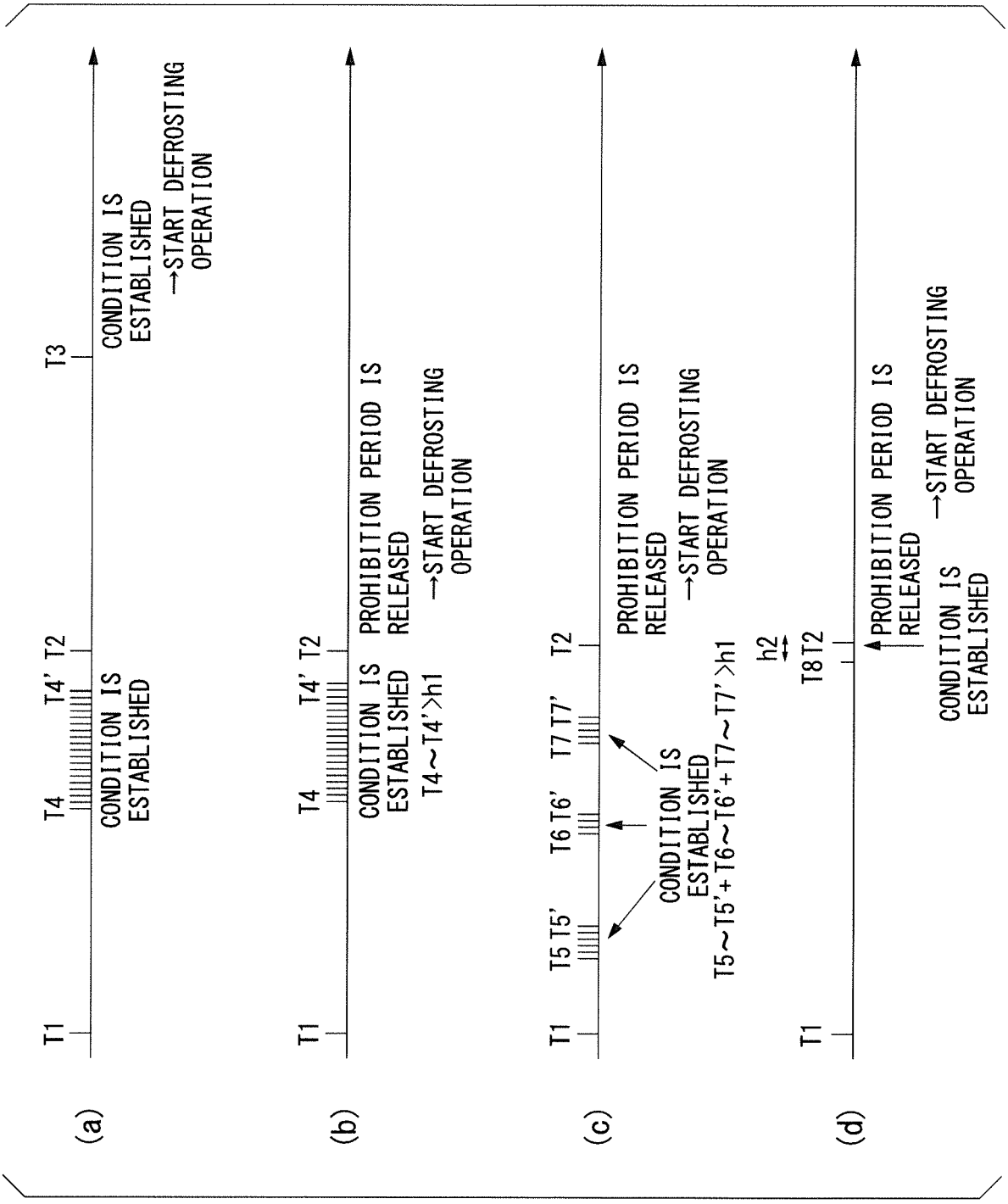

(a)
T1
T4
T4' T2
T3
CONDITION IS ESTABLISHED
CONDITION IS ESTABLISHED
→START DEFROSTING OPERATION
(b)
T1
T4
T4' T2
CONDITION IS ESTABLISHED
T4~T4'>h1
PROHIBITION PERIOD IS RELEASED
→START DEFROSTING OPERATION
(c)
T1
T5 T5'
T6 T6'
T7 T7'
T2
CONDITION IS ESTABLISHED
T5~T5'+T6~T6'+T7~T7'>h1
PROHIBITION PERIOD IS RELEASED
→START DEFROSTING OPERATION
(d)
T1
h2
T8 T2
PROHIBITION PERIOD IS RELEASED
CONDITION IS ESTABLISHED
→START DEFROSTING OPERATION

FIG. 5

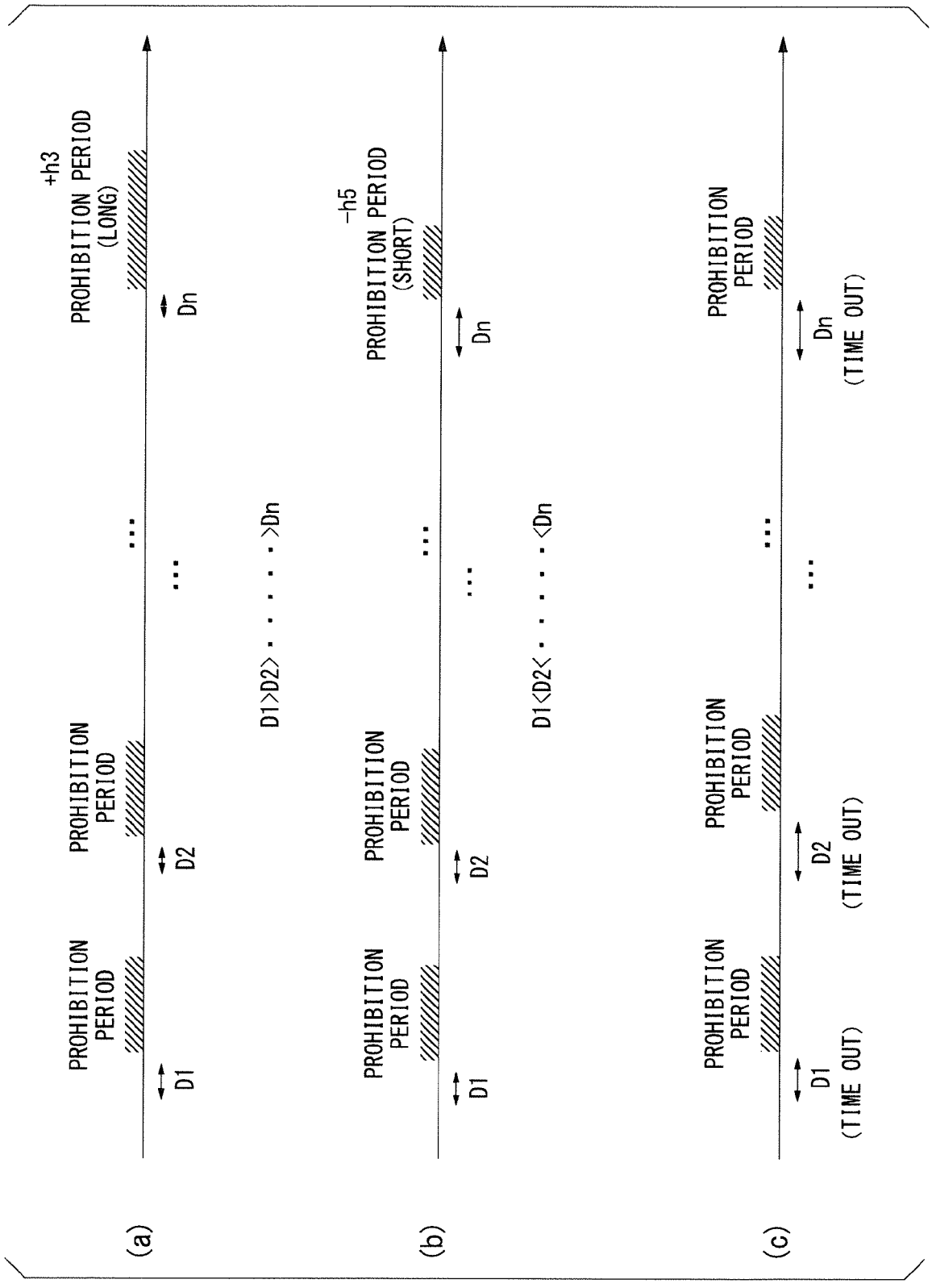
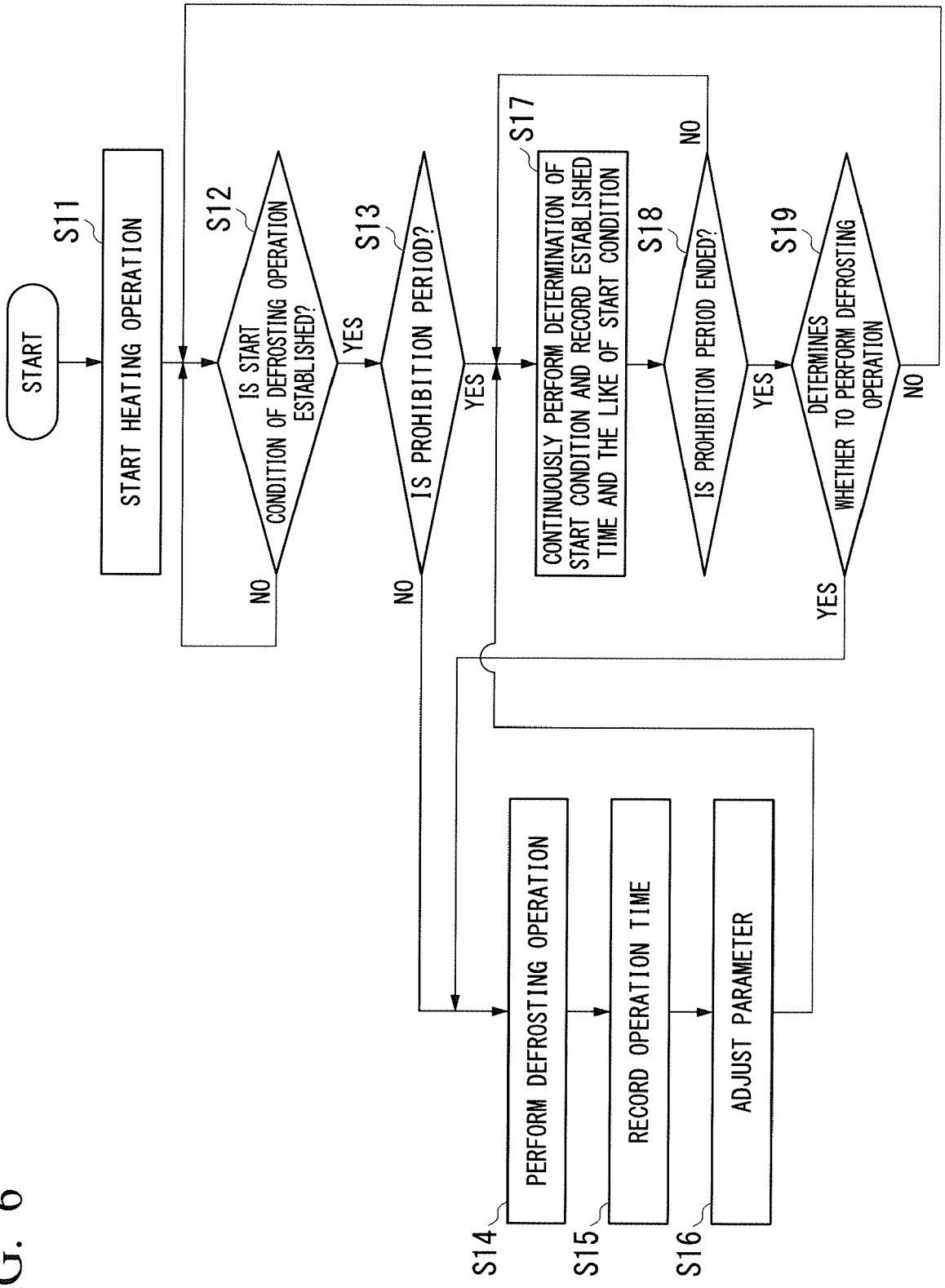

(a)
PROHIBITION PERIOD
PROHIBITION PERIOD
+h3
PROHIBITION PERIOD (LONG)
D1
D2
Dn
D1>D2>.....>Dn
(b)
PROHIBITION PERIOD
PROHIBITION PERIOD
-h5
PROHIBITION PERIOD (SHORT)
D1
D2
Dn
D1<D2<.....<Dn
(c)
PROHIBITION PERIOD
PROHIBITION PERIOD
PROHIBITION PERIOD
D1
(TIME OUT)
D2
(TIME OUT)
Dn
(TIME OUT)

FIG. 6


START
S11
START HEATING OPERATION
S12
IS START CONDITION OF DEFROSTING OPERATION ESTABLISHED?
YES
NO
S13
IS PROHIBITION PERIOD?
YES
NO
S17
CONTINUOUSLY PERFORM DETERMINATION OF START CONDITION AND RECORD ESTABLISHED TIME AND THE LIKE OF START CONDITION
S18
IS PROHIBITION PERIOD ENDED?
YES
NO
S19
DETERMINES WHETHER TO PERFORM DEFROSTING OPERATION
YES
NO
S14
PERFORM DEFROSTING OPERATION
S15
RECORD OPERATION TIME
S16
ADJUST PARAMETER

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 4543

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2009/266093 A1 (AOKI MASANORI [JP]) 29 October 2009 (2009-10-29) * the whole document *	1-10	INV. F25B13/00 F25B49/02 F25B47/02
A	US 9 897 349 B2 (MITSUBISHI ELECTRIC CORP [JP]) 20 February 2018 (2018-02-20) * the whole document *	1-10	
A	DE 11 2013 002239 T5 (DENSO CORP [JP]) 15 January 2015 (2015-01-15) * the whole document *	1-10	

TECHNICAL FIELDS SEARCHED (IPC)

F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 July 2019	Gasper, Ralf

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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18-07-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009266093 A1	29-10-2009	CN 101052848 A	10-10-2007
		EP 1826513 A1	29-08-2007
		JP 5063347 B2	31-10-2012
		JP WO2007013382 A1	05-02-2009
		US 2009266093 A1	29-10-2009
		WO 2007013382 A1	01-02-2007
US 9897349 B2	20-02-2018	CN 203771791 U	13-08-2014
		GB 2528212 A	13-01-2016
		JP 6141425 B2	07-06-2017
		JP WO2014188575 A1	23-02-2017
		US 2016116191 A1	28-04-2016
		WO 2014188575 A1	27-11-2014
DE 112013002239 T5	15-01-2015	CN 104246396 A	24-12-2014
		DE 112013002239 T5	15-01-2015
		JP 2013231522 A	14-11-2013
		WO 2013161256 A1	31-10-2013

EPO FORM P0459

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Patent documents cited in the description

- JP 2018061733 A **[0002]**
- JP 2008014593 A **[0005]**