



(11)

EP 2 851 635 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

13.06.2018 Bulletin 2018/24

(51) Int Cl.:

F25B 47/02 ^(2006.01) **F24D 3/18** ^(2006.01)
F25B 49/02 ^(2006.01) **F25D 21/00** ^(2006.01)
F24D 19/10 ^(2006.01) **F25B 30/02** ^(2006.01)

(21) Application number: **13790186.4**

(86) International application number:

PCT/JP2013/002520

(22) Date of filing: **12.04.2013**

(87) International publication number:

WO 2013/171971 (21.11.2013 Gazette 2013/47)

(54) **HEATING SYSTEM CONTROL METHOD AND HEATING SYSTEM**

STEUERVERFAHREN FÜR EIN HEIZSYSTEM UND HEIZSYSTEM

PROCÉDÉ DE COMMANDE DE SYSTÈME DE CHAUFFAGE ET SYSTÈME DE CHAUFFAGE

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

- **HAYASHIDA, Gaku**
2-1-61 Shiromi, Chuo-ku,
Osaka 540-6207 (JP)
- **TAKASAKI, Shinichi**
2-1-61 Shiromi, Chuo-ku,
Osaka 540-6207 (JP)

(30) Priority: **16.05.2012 JP 2012112706**

(43) Date of publication of application:

25.03.2015 Bulletin 2015/13

(74) Representative: **Vigand, Philippe et al**

Novagraaf International SA
Chemin de l'Echo 3
1213 Onex - Genève (CH)

(73) Proprietor: **Panasonic Intellectual Property
Management Co., Ltd.**

Osaka-shi, Osaka 540-6207 (JP)

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(72) Inventors:

- **KHAISONGRAM, Wathanyoo**
2-1-61 Shiromi, Chuo-ku,
Osaka 540-6207 (JP)

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Description

[Technical Field]

[0001] The present invention is related to heating system control methods, and in particular to a control method for a heating system including a heat pump heating device.

[Background Art]

[0002] A heat pump hot water supply device heats a refrigerant by absorbing heat from the atmosphere and compressing the refrigerant using electricity. The heat is then transferred to the water via a heat exchanger, creating hot water. Moreover, the heat pump heating device uses hot water heated by the heat pump for heating.

[0003] When the outdoor temperature is low, frost forms on the heat exchanger as the heat pump absorbs heat from the atmosphere. The more frost builds up on the heat exchanger, the more difficult heat is to absorb from the atmosphere. This causes the output and efficiency of the heat pump to decrease. For this reason, heat pump apparatuses include a function for removing frost (defrosting) upon detection of a certain amount of frost on the heat exchanger.

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Unexamined Patent Application Publication No. 2010-249333

[Summary of Invention]

[Technical Problem]

[0005] The percentage of power used as a source of energy for covering thermal demands has increased along with the use of heat pumps in recent years. As such, the power demand peak continues to rise.

[0006] For this reason, in addition to the conventional contract based system in which electricity costs increase during a peak time period, power companies have begun offering consumers the choice of a contract based system with somewhat reduced electricity costs in exchange for electric load modulation during a specified peak time period.

[0007] Under this contract system, when the electric load is modulated during the peak time period, there are times when comfort is sacrificed due to a decrease in room temperature from insufficient power output by the heat pump with respect to the demand from the heater.

[0008] Thus, in order to solve the above-mentioned problem, the present invention aims to provide a heat pump heating system control method which reduces a decrease in the comfort level of the user while reducing

the power demand peak. US 2011/0035075 A1 discloses a customer-dedicated energy management apparatus for controlling the power consumption amount into a target value by adjusting the air-conditioning of the customer.

[Solution to Problem]

[0009] The heating system control method according to an aspect of the present invention is a method of controlling a heating system that operates using power supplied from a power supply source. The heating system includes a heat pump that generates heat using the power supplied from the power supply source and a radiator unit that radiates the heat generated by the heat pump. The heat pump operates in either a heating mode for generating the heat to be radiated by the radiating unit or a defrost mode for removing frost formed on the heat pump. The heating system control method includes: obtaining, from the power supply source, an output modulation instruction specifying an output modulation period during which power consumption by the heat pump is modulated; determining a first defrost condition to be used in a period outside the output modulation period and a second defrost condition to be used in the output modulation period, the first defrost condition and the second defrost condition each including a defrost initiation condition for causing the heat pump to start operating in the defrost mode and a defrost termination condition for causing the heat pump to stop operating in the defrost mode; and controlling operation of the heat pump to cause the heat pump to start operating in the defrost mode based on the defrost initiation condition determined in the determining being met and cause the heat pump to stop operating in the defrost mode based on the defrost termination condition determined in the determining being met, wherein in the determining, a continuous operation time of the heat pump in the defrost mode under the second defrost condition is made to be shorter than under the first defrost condition by making at least one of the defrost initiation condition or the defrost termination condition included in the second defrost condition different from that of the first defrost condition.

[0010] It should be noted that general or specific embodiments may be realized as a system, method, integrated circuit, computer program, storage media, or any elective combination thereof.

[Advantageous Effects of Invention]

[0011] Since the continuous operation time in the defrost mode during the output modulation period is shortened, the present invention allows for the comfort level of the user to be kept from reducing as well as the power demand peak to be reduced.

[Brief Description of Drawings]

[0012]

[FIG. 1] FIG. 1 is a flow chart outlining the processes performed by the heat pump heating system according to Embodiment 1.

[FIG. 2] FIG. 2 is a block diagram showing the configuration of heat pump heating system according to Embodiment 1.

[FIG. 3] FIG. 3 is a block diagram showing the heat pump heating device according to Embodiment 1 in detail.

[FIG. 4A] FIG. 4A shows the refrigerant cycle in the heat pump when operating in the heating mode according to Embodiment 1.

[FIG. 4B] FIG. 4B shows the refrigerant cycle in the heat pump when operating in the defrost mode according to Embodiment 1.

[FIG. 5] FIG. 5 is a block diagram showing the system control unit according to Embodiment 1 in detail.

[FIG. 6] FIG. 6 is a flow chart of the processes of the heat pump heating system as a whole according to Embodiment 1.

[FIG. 7] FIG. 7 is a flow chart of the heat pump (HP) control process according to Embodiment 1.

[FIG. 8] FIG. 8 is a flow chart of the DR period control process according to Embodiment 1.

[FIG. 9A] FIG. 9A is an example of a table showing required defrost times according to Embodiment 1.

[FIG. 9B] FIG. 9B is an example of a table showing permissible defrost times according to Embodiment 1.

[FIG. 9C] FIG. 9C shows a model of transitions in required defrost time, permissible defrost time, and heat exchanger surface temperature according to Embodiment 1.

[FIG. 10] FIG. 10 shows an example of transitions in required defrost time, permissible defrost time, heat exchanger surface temperature, room temperature, and power consumption when controlling according to Embodiment 1 is performed.

[FIG. 11] FIG. 11 is a flow chart of the DR period control process according to Embodiment 2.

[FIG. 12] FIG. 12 shows an example of transitions in heat exchanger surface temperature when the controlling method according to Embodiment 2 is performed.

[FIG. 13] FIG. 13 is a flow chart of the DR period control process according to Embodiment 3.

[FIG. 14] FIG. 14 shows an example of transitions in heat exchanger surface temperature when the controlling methods according to Embodiments 2 and 3 are performed.

[Description of Embodiments]

(Underlying Knowledge Forming Basis of the Present Invention)

[0013] For example, PTL 1 discloses a technique of generating an operation schedule for reducing power consumption using optimization problem solutions, along with a decrease in heat pump efficiency due to frost and a defrost timing chart.

[0014] However, with the method disclosed in PTL 1, when an operation schedule designed with power consumption in mind and the contract system disclosed in the Technical Problem section are used, there are times when the defrost cycle is used during the peak time period (when the cost of electricity is high). In this case, there is a problem that despite being in the peak time period during which room temperature decreases due to an insufficient power output of the heat pump, the room temperature decreases even further and comfort is sacrificed because it is not possible for the heat pump to cater to thermal demands while defrosting.

[0015] Moreover, when defrosting is performed during the peak time period, despite not being able to cater to thermal demands nor contributing to comfort, not only is it uneconomical due to the costly electricity rates, but an unnecessary load is placed on grid power. Furthermore, applying the technique disclosed in PTL 1 to optimize power consumption as well as electricity expenses and comfort is problematic because total cost increases and a solution cannot be obtained in real-time.

[0016] In order to solve the above problem, the heating system control method according to an aspect of the present invention is a method of controlling a heating system that operates using power supplied from a power supply source. The heating system includes a heat pump that generates heat using the power supplied from the power supply source and a radiator unit that radiates the heat generated by the heat pump. The heat pump operates in either a heating mode for generating the heat to be radiated by the radiating unit or a defrost mode for removing frost formed on the heat pump. The heating system control method includes: obtaining, from the power supply source, an output modulation instruction specifying an output modulation period during which power consumption by the heat pump is modulated; determining a first defrost condition to be used in a period outside the output modulation period and a second defrost condition to be used in the output modulation period, the first defrost condition and the second defrost condition each including a defrost initiation condition for causing the heat pump to start operating in the defrost mode and a defrost termination condition for causing the heat pump to stop operating in the defrost mode; and controlling operation of the heat pump to cause the heat pump to start operating in the defrost mode based on the defrost initiation condition determined in the determining being met and cause the heat pump to stop operating in the defrost

mode based on the defrost termination condition determined in the determining being met, wherein in the determining, a continuous operation time of the heat pump in the defrost mode under the second defrost condition is made to be shorter than under the first defrost condition by making at least one of the defrost initiation condition or the defrost termination condition included in the second defrost condition different from that of the first defrost condition.

[0017] With this method, since the continuous operation time in the defrost mode during the output modulation period (the amount of time required per defrost operation) is shortened, room temperature can be kept from decreasing while defrosting and power consumed to run a heater for keeping the room temperature from decreasing can be conserved. As a result, the comfort level of the user can be kept from decreasing while also reducing the power demand peak.

[0018] Moreover, for example, in the determining, at predetermined intervals in the output modulation period, achievement of the defrost initiation condition included in the second defrost condition may be determined to be a required defrost time reaching a permissible defrost time, the required defrost time being an amount of time from when the heat pump switches to the defrost mode until the defrost termination condition is met, and the permissible defrost time being an amount of time from when the heat pump switches to the defrost mode until a room temperature reaches a predetermined lower limit value.

[0019] In one example, the heating system may hold information associating an outdoor temperature and a surface temperature of an outdoor heat exchanger included in the heat pump with the required defrost time, and information associating the outdoor temperature and the room temperature with the permissible defrost time. In the obtaining, the outdoor temperature, the surface temperature of the outdoor heat exchanger, and the room temperature may be obtained. Then, in the controlling, achievement of the defrost initiation condition included in the second defrost condition may be assessed at predetermined intervals in the output modulation period using (i) the required defrost time associated with the outdoor temperature and the surface temperature of the outdoor heat exchanger obtained in the obtaining and (ii) the permissible defrost time associated with the outdoor temperature and the room temperature obtained in the obtaining.

[0020] In another example, the heating system may hold information associating an outdoor temperature and a temperature of a refrigerant in the heat pump with the required defrost time, and information associating the outdoor temperature and the room temperature with the permissible defrost time. In the obtaining, the outdoor temperature, the temperature of the refrigerant, and the room temperature may be obtained. Then, in the controlling, achievement of the defrost initiation condition included in the second defrost condition may be assessed at predetermined intervals in the output modulation period

using (i) the required defrost time associated with the outdoor temperature and the temperature of the refrigerant obtained in the obtaining and (ii) the permissible defrost time associated with the outdoor temperature and the room temperature obtained in the obtaining.

[0021] Moreover, the defrost initiation condition may include a lower limit value for a surface temperature of an outdoor heat exchanger included in the heat pump. Then, in the determining, the lower limit value for the surface temperature of the outdoor heat exchanger included in the second defrost condition may be set higher than the lower limit value for the surface temperature of the outdoor heat exchanger included in the first defrost condition.

[0022] Moreover, the defrost termination condition may include an upper limit value for a surface temperature of an outdoor heat exchanger included in the heat pump. Then, in the determining, the upper limit value for the surface temperature of the outdoor heat exchanger included in the second defrost condition may be set lower than the upper limit value for the surface temperature of the outdoor heat exchanger included in the first defrost condition.

[0023] Moreover, the defrost initiation condition may include a lower limit value for a temperature of a refrigerant in the heat pump. Then, in the determining, the lower limit value for the temperature of the refrigerant included in the second defrost condition may be set higher than the lower limit value for the temperature of the refrigerant included in the first defrost condition.

[0024] Moreover, the defrost termination condition may include an upper limit value for a temperature of a refrigerant in the heat pump. Then, in the determining, the upper limit value for the temperature of the refrigerant included in the second defrost condition may be set lower than the upper limit value for the temperature of the refrigerant included in the first defrost condition.

[0025] Moreover, in the controlling, the heat pump may be caused to start operating in the defrost mode based on the defrost initiation condition being continuously met for a predetermined period of time, and caused to stop operating in the defrost mode based on the defrost termination condition being continuously met for a predetermined period of time.

[0026] Furthermore, in the controlling, the heat pump operating in the heating mode may further be caused to generate a first amount of heat per unit time in a period outside the output modulation period and generate a second amount of heat per unit time in the output modulation period, the second amount of heat being less than the first amount of heat.

[0027] The heating system according to an aspect of the present invention is a heating system that operates using power supplied from a power supply source. The heating system includes a heat pump that generates heat using the power supplied from the power supply source, a radiator unit configured to radiate the heat generated by the heat pump, and a control unit configured to control

operation of the heat pump. The heat pump operates in either a heating mode for generating the heat to be radiated by the radiator unit or a defrost mode for removing frost formed on the heat pump. The control unit includes: an obtaining unit configured to obtain, from the power supply source, an output modulation instruction specifying an output modulation period during which power consumption by the heat pump is modulated; a defrost condition determination unit configured to determine a first defrost condition to be used in a period outside the output modulation period and a second defrost condition to be used in the output modulation period, the first defrost condition and the second defrost condition each including a defrost initiation condition for causing the heat pump to start operating in the defrost mode and a defrost termination condition for causing the heat pump to stop operating in the defrost mode; and an operation control unit configured to cause the heat pump to start operating in the defrost mode based on the defrost initiation condition determined by the defrost condition determination unit being met and cause the heat pump to stop operating in the defrost mode based on the defrost termination condition determined by the defrost condition determination unit being met. Then, the defrost condition determination unit is configured to make a continuous operation time of the heat pump in the defrost mode under the second defrost condition shorter than under the first defrost condition by making at least one of the defrost initiation condition or the defrost termination condition included in the second defrost condition different from that of the first defrost condition.

[0028] These general and specific aspects may be implemented using a system, a method, an integrated circuit, a computer program, or a computer-readable recording medium such as a CD-ROM, or any combination of systems, methods, integrated circuits, computer programs, or computer-readable recording media.

[0029] Hereinafter, embodiments are specifically described with reference to the Drawings.

[0030] Each of the embodiments described below shows a general or specific example. The numerical values, shapes, materials, structural elements, the arrangement and connection of the structural elements, steps, the processing order of the steps etc. shown in the following embodiments are mere examples, and therefore do not limit the scope of the Claims. Therefore, among the structural elements in the following embodiments, structural elements not recited in any one of the independent claims defining the most generating part of the inventive concept are described as arbitrary structural elements.

(Embodiment 1)

(Outline)

[0031] First, an outline of the heat pump heating system control method according to Embodiment 1 of the

present invention will be given. FIG. 1 is a flow chart outlining the control processes performed by heat pump heating system according to Embodiment 1. As FIG. 2 shows, a heat pump heating system 1 includes a heat pump heating device 100 and a system control unit 8.

[0032] As FIG. 1 shows, the heat pump heating system 1 according to Embodiment 1 first receives an output modulation signal (hereinafter referred to as a demand response signal (DR signal)) for the high electricity cost time period from the energy supplier (step S101). The DR signal includes information specifying an output modulation period (hereinafter referred to as a DR period) which is a time period during which power consumption by the heat pump is modulated.

[0033] The output modulation period is a period arbitrarily designated by the energy supplier. The period can be, for example, a peak time of power supply by the energy supplier, such as a two hour period between 18:00 and 20:00. Moreover, the heat pump heating system 1 receives the DR signal before the DR period start time (for example, at 17:30).

[0034] Next, the heat pump heating system 1 switches the defrost condition from the first defrost condition to the second defrost condition at the DR period start time (step S102), and switches the defrost condition from the second defrost condition to the first defrost condition at the DR period end time (step S103). In other words, the heat pump heating system 1 assesses the necessity of performing a defrost operation under the first defrost condition in a time period outside of the DR period (hereinafter referred to as the normal period), and assesses the necessity of performing a defrost operation under the second defrost condition in the DR period.

[0035] Here, a defrost operation refers to an operation for removing frost accumulated on the heat exchanger (to be described later) in the heat pump heating device 100. In other words, the heat pump heating device 100 is capable of operating in a heating mode for generating heat to be used for heating or operating in a defrost mode for removing frost generated on the heat pump heating device 100.

[0036] Moreover, the defrost condition includes a defrost initiation condition for causing the heat pump heating device 100 to start operating in the defrost mode and a defrost termination condition for causing the heat pump heating device 100 to stop operating in the defrost mode. The first defrost condition and the second defrost condition are different with respect to at least one of the defrost initiation condition or the defrost termination condition.

[0037] More specifically, the first and second defrost conditions are determined so that the length of continuous operation time of the heat pump heating device 100 in the defrost mode under the second defrost condition is shorter than the length of continuous operation time of the heat pump heating device 100 in the defrost mode under the first defrost condition (this will be described in further detail later).

[0038] Furthermore, the heat pump heating system 1

causes the heat pump heating device 100 operating in the heating mode to generate a first amount of heat per unit time in the normal period (for example, 5 kW) and generate a second amount of heat per unit time in the DR period that is less than the first amount of heat (for example, 2 kW). In other words, the heating mode includes a normal mode for causing the generation of a first amount of heat per unit time and an output modulation mode for causing the generation of a second amount of heat per unit time.

[0039] With this configuration, it is possible to reduce the power demand peak by making the amount of heat generated per unit time in the DR period less than the amount of heat generated per unit time in the normal period. Moreover, it is possible to keep the comfort level of a user from decreasing by making the second defrost condition used in the DR period a condition that causes the length of a single defrost operation to be shorter compared to the first defrost condition used in the normal period.

(System Block Diagram)

[0040] FIG. 2 is a block diagram of the heat pump heating system 1 including the heat pump heating device 100 according to Embodiment 1. In the example shown in FIG. 2, power is delivered to a home (building) from an energy supplier (power supply source) 4 via first and second power grids. The first power grid is a network that provides a stable supply of power. Moreover, the first power grid is a power grid having a relatively high electrical utility rate, and the amount of power consumed from the first power grid is measured by a first power meter 6. On the other hand, the second power grid is a power grid through which the energy supplier 4 can reduce the supply of power for a given time period. Moreover, the second power grid is a power grid having an electrical utility rate that is lower than that of the first power grid, and the amount of power consumed from the second power grid is measured by a second power meter 7.

[0041] Moreover, an electric load 5, a system control unit 8, and a heat pump heating device 100 are installed inside the home shown in FIG. 2. The heat pump heating device 100 includes at least a heat pump (heat generation unit) 101, a heat exchanger 102, and a heating device (radiator unit) 104.

[0042] The heat pump heating device 100 is a device which, by radiating the heat generated by the heat pump 101 from the heating device 104 via the heat exchanger 102, maintains the temperature of a room equipped with the heating device 104 to within a predetermined temperature range including a predetermined set temperature.

[0043] The first power meter 6 measures the power consumption of electronic devices other than the heat pump heating device 100 (that is, an electric load 5 and a system control unit 8). In other words, the system control unit 8 and the electric load 5 operate off power sup-

plied from the energy supplier 4 via the first power grid.

[0044] On the other hand, the second power meter 7 measures the power consumption of components of the heat pump heating device 100, such as the compressor, pump, and fan (not shown in the Drawings). In other words, the components of the heat pump heating device 100 operate off power supplied from the energy supplier 4 via the second power grid.

[0045] It should be noted that two power meters are shown in the example in FIG. 2, but the present invention is not limited to this example. In other words, a single power meter which (i) includes a first interface which outputs power from the first power grid and a second interface which outputs power from the second power grid and (ii) individually measures power output through each interface may be provided.

[0046] The system control unit 8 is functionally capable of communicating with the energy supplier 4 and administering control commands to the heat pump heating device 100. For example, the system control unit 8 controls operation of the heat pump heating device 100 to modulate power consumption by the heat pump 101 during the DR period.

[0047] The energy supplier 4 is a company which delivers electricity or gas to individual homes and, when the energy supplier 4 wishes to modulate the use of power by a given home, sends a DR signal to the system control unit 8. After the DR signal is received, the system control unit 8 modulates the consumption of power supplied to each home (to the heat pump heating device 100) via the second power grid.

[0048] FIG. 3 is a block diagram showing configuration of the heat pump heating device 100 according to Embodiment 1 in detail. FIG. 4A and FIG. 4B show the configuration of the heat pump 101.

[0049] The heat pump heating device 100 shown in FIG. 3 includes the heat pump 101, the heat exchanger 102, the heating device 104, the HP control unit 103, an outdoor temperature detecting unit 105, a room temperature detecting unit 106, a heat exchanger surface temperature detecting unit 107, a heater 108, an outlet temperature detecting unit 109, a flow rate detecting unit 110, and an inlet temperature detecting unit 111. Moreover, the combination of the heat pump 101 and the heat exchanger 102 is called the heat pump unit.

[0050] The heat pump 101 is an air-source heat pump which compresses a refrigerant into a high temperature, high pressure state. More specifically, as is shown in FIG. 4A, the heat pump 101 includes an outdoor heat exchanger 101a which facilitates heat exchange between outdoor air and low temperature, low pressure liquid refrigerant to generate a low temperature, low pressure vaporized refrigerant, a motor-driven compressor 101b which compresses the low temperature, low pressure vaporized refrigerant into a high temperature, high pressure vaporized refrigerant, an expansion valve 101c which reduces the pressure of the low temperature, high pressure vaporized refrigerant to generate a low temperature, low

pressure liquid refrigerant, and a fan (not shown in the Drawings) to accelerate the heat conversion between the refrigerant in the evaporator and the outdoor air, for example.

[0051] The high temperature, high pressure vaporized refrigerant output from the compressor 101b transfers heat in the heat exchanger 102 between water (thermal storage medium) and enters the expansion valve 101c as a low temperature, high pressure liquid refrigerant. In other words, the refrigerant in the heat pump 101 circulates through the heat pump cycle shown in FIG. 4A in a clock-wise direction. The refrigerant in the heat pump 101 is, for example, R-410A. As a result of a property of this refrigerant, the temperature at the exit of the water cycle of the heat exchanger 102 peaks at 55 degrees Celsius, so the upper temperature limit of the heating temperature setting is set to 55 degrees Celsius. However, this upper temperature limit changes depending on the properties of the refrigerant, and as such, the above example is not limiting.

[0052] The heat exchanger (water heat exchanger) 102 facilitates heat exchange between the high temperature, high pressure refrigerant exiting the heat pump 101 and the secondary side of the water cycle filled with water (that is, the water cycling between the heat exchanger 102 and the heating device 104). Moreover, as FIG. 3 shows, a water pump is provided along the channel in which water flows from the heating device 104 to the heat exchanger 102. The water pump adjusts the amount of water flowing into the heat exchanger 102.

[0053] The heating device 104 is a device for heating the inside of a home, such as a radiator or floor heater which radiates heat energy in a room via a radiator panel, or an air conditioner which blows hot air heated by the heat exchanger 102. It should be noted that a specific example of the heating device 104 is not limited to these examples, but corresponds to any device having a radiator unit which radiates heat generated by the heat pump 101 to a target.

[0054] The outdoor temperature detecting unit 105 detects the outdoor temperature, and more specifically, detects the outdoor temperature in the vicinity in which the heat pump heating device 100 is installed. The room temperature detecting unit 106 detects the room temperature, and more specifically, detects the temperature of the room in which the heat pump heating device 100 is installed. The heat exchanger surface temperature detecting unit 107 detects the surface temperature of the outdoor heat exchanger 101a. Moreover, the heat pump heating device 100 may include a refrigerant temperature detecting unit (not shown in the Drawings) for detecting the temperature of the refrigerant circulating in the heat pump 101.

[0055] It should be noted that the outdoor temperature detecting unit 105, the room temperature detecting unit 106, the heat exchanger surface temperature detecting unit 107, and the refrigerant temperature detecting unit are not intended to be limited to a specific configuration.

For example, a general configuration which can measure temperature may be chosen to suit the target to be measured. Examples include a thermocouple, a resistance thermometer, a thermistor, and a bimetallic thermometer.

[0056] The HP control unit 103 controls the generation of heat by controlling the compressor 101b and the expansion valve 101c in the heat pump 101. The HP control unit 103 can operate the heat pump 101 in a heating mode (the normal mode or the output modulation mode) or a defrost mode.

[0057] The heating mode is a mode of operation for generating heat to be radiated by the heating device 104, and is ran by circulating the refrigerant in the heat pump 101 as is shown in FIG. 4A. More specifically, during the normal period, the HP control unit 103 set to the heating mode controls operation of the heat pump 101 according to operation conditions set by the user, for example (normal mode). On the other hand, during the DR period, instructions from the system control unit 8 have priority, and the HP control unit 103 controls operation of the heat pump 101 in accordance with these instructions (output modulation mode).

[0058] The defrost mode is a mode of operation for removing frost build-up on the surface of the outdoor heat exchanger 101a, and is ran by circulating the refrigerant in the heat pump 101 as is shown in FIG. 4B (in a direction opposite that of FIG. 4A). In other words, frost can be melted from the surface of the outdoor heat exchanger 101a by supplying the high temperature, high pressure vaporized refrigerant generated by the compressor 101b to the outdoor heat exchanger 101a.

[0059] It should be noted that the method of operating the heat pump 101 in the defrost mode is not limited to the example shown in FIG. 4B. For example, even when the direction of circulation of the refrigerant is made to be the same as shown in FIG. 4A, by decreasing the expansion rate in the expansion valve 101c to a value lower than in the heating mode, it is possible to supply high pressure refrigerant to the outdoor heat exchanger 101a. This makes it possible to melt off frost in this case as well.

[0060] Moreover, the HP control unit 103 determines the switching between the heating mode and the defrost mode using the outdoor temperature measured by the outdoor temperature detecting unit 105 and the heat exchanger surface temperature measured by the heat exchanger surface temperature detecting unit 107. The HP control unit 103 according to the Embodiment 1 switches the heat pump 101 mode of operation from the heating mode to the defrost mode when the outdoor temperature is 5 degrees Celsius or less and the surface temperature of the heat exchanger is -10 degrees Celsius or less (first defrost initiation condition). On the other hand, the HP control unit 103 switches the heat pump 101 mode of operation from the defrost mode to the heating mode when the surface temperature of the heat exchanger is 10 degrees Celsius or more (first defrost termination condition).

[0061] Moreover, when the HP control unit 103 receives a defrost initiation notice from an operation control unit 83 (to be described later) in the system control unit 8, regardless of whether the above first defrost initiation condition has been met or not, the HP control unit 103 switches the heat pump 101 mode of operation from the heating mode to the defrost mode.

[0062] Similarly, when the HP control unit 103 receives a defrost termination notice from an operation control unit 83 (to be described later) in the system control unit 8, regardless of whether the above first defrost termination condition has been met or not, the HP control unit 103 switches the heat pump 101 mode of operation from the defrost mode to the heating mode.

[0063] Moreover, the HP control unit 103 notifies a data collection unit 81 in the system control unit 8 of the current mode of operation. The timing of the notification is not particularly limited, and may be performed, for example, at a point in time at which the mode of operation is switched, at a point in time at which the notification is requested from the system control unit 8, or at a predetermined point in time (for example, every day at 00:00).

[0064] Moreover, the HP control unit 103 calculates the output value of the heat pump 101 by multiplying (i) a difference between the temperature of the hot water output from the heat exchanger 102 measured by the outlet temperature detecting unit 109 shown in FIG. 3 (outlet temperature) and the temperature of the water input into the heat exchanger 102 measured by the inlet temperature detecting unit 111 (inlet temperature) by (ii) a flow rate measured by the flow rate detecting unit 110 in the channel between the heat exchanger 102 and the heating device 104. Moreover, the HP control unit 103 transmits the calculated output value to the system control unit 8.

[0065] The heater 108 is capable of further heating the hot water exiting the heat exchanger 102, and as FIG. 3 shows, is installed along the channel in which water flows from the heat exchanger 102 to the heating device 104. The heater 108 is not intended to be limited to a specific configuration. For example, the heater 109 may be an electrically-heated wire.

[0066] With the heat pump heating device 100 having the above configuration, the outlet temperature, which is the temperature of the hot water exiting the heat exchanger 102, is set by the user, and operation conditions for the heat pump 101 are determined in order to achieve this set outlet temperature. However, the heat pump 101 requires some time to reach a stable amount of generated heat after being turned on, and has trouble keeping up with the large settings changes in real time.

[0067] For this reason, when the outlet temperature detected by the outlet temperature detecting unit 109 (the measured outlet temperature) is less than the temperature set by the user (the set outlet temperature), the heater 108 adds heats to approximate the measured outlet temperature of hot water exiting the heat exchanger 102 to the set outlet temperature.

[0068] Moreover, when the heat pump 101 mode is operating in the defrost mode, the outlet temperature as well as the room temperature decrease since the heat pump 101 circuit is switched to defrosting. As such, the heater 108 can heat the hot water output from the heat exchanger 102 while the heat pump 101 is operating in the defrost mode to prevent a loss of user comfort.

(System Control Unit 8 Block Diagram)

[0069] FIG. 5 is a block diagram showing the configuration of the system control unit (system control device) 8 according to Embodiment 1. The system control unit 8 shown in FIG. 5 includes the data collection unit 81, a communication unit 82, the operation control unit 83, and a defrost condition determination unit 84.

[0070] It should be noted that the system control unit 8 shown in FIG. 2 and FIG. 5 is configured to be structurally separate from the heat pump heating device 100. However, the present invention is not limited to this configuration. In other words, the system control unit 8 may be configured to be integrated in the heat pump heating device 100. For example, the heat pump heating device 100 may be internally equipped with a function that is equivalent to the system control unit 8.

[0071] The data collection unit 81 collects various data, such as the various temperatures and the like detected by the outdoor temperature detecting unit 105, the room temperature detecting unit 106, and the heat exchanger surface temperature detecting unit 107, as well as the various power consumption amounts measured by the first and second power meters 6 and 7. Moreover, the data collection unit 81 receives a notice of the current heat pump 101 mode of operation from the HP control unit 103.

[0072] The communication unit 82 receives the DR signal from the energy supplier 4. Moreover, the communication unit 82 notifies the energy supplier 4 of the modulation and restarting of the supply of power to the heat pump heating device 100 via the second power grid. It should be noted that the communication unit 82 may communicate with the energy supplier 4 via power line communication (PLC), or may communicate with the energy supplier 4 via a different method, such as the internet.

[0073] The DR signal is transmitted from the energy supplier 4 prior to the start of the DR period for modulating power use by each home (from 0.5 to 12 hours in advance, for example). In this case, information specifying the DR period start time and end time is included in the DR signal. In Embodiment 1, the information is "DR period start time: 18:00; DR period end time: 20:00".

[0074] Here, "informations specifying the DR period start time and end time" is not limited to a specific example, and may be information specifying actual start and end times (such as "(DR period start time: 18:00; DR period end time: 20:00)") or information indicating the start time and length of the DR period (such as "(DR period start time: 18:00; DR period length: 2 hours)").

[0075] The operation control unit 83 switches the operation of the HP control unit 103 based on the normal period and the DR period. In other words, in the normal period, the operation control unit 83 causes the HP control unit 103 to control operation of the heat pump 101 to achieve the outlet temperature set by the user (typically, the heat pump 101 is caused to operate in the normal mode).

[0076] On the other hand, when the communication unit 82 receives the DR signal, the operation control unit 83 determines the operation conditions for the heat pump 101 for the DR period. In the DR period, the operation control unit 83 causes the HP control unit 103 to control operation of the heat pump 101 based on operation conditions determined internally (typically, the heat pump 101 is caused to operate in the output modulation mode). In this case, the instructions from the system control unit 8 (the operation control unit 83) have priority over the HP control unit 103.

[0077] These operation conditions include, for example, the temperature (outlet temperature) setting of the hot water output from the heat exchanger 102 and the operating state of the heater 108. The operation control unit 83 determines the DR period outlet temperature for the heat pump 101 that, for example, makes the heat pump 101 generate an amount of heat (the second amount of heat) that is less than the amount of heat generated per unit time by the heat pump 101 in a period other than the DR period (the first amount of heat).

[0078] More specifically, the operation control unit 83, for example, changes the outlet temperature of the heat exchanger 102 from the first temperature setting (55 degrees Celsius, for example) to the second temperature setting that is lower than the first temperature (30 degrees Celsius, for example) to decrease the amount of heat generated per unit time by the heat pump 101 from the first amount of heat to the second amount of heat. Moreover, in order to reduce power consumption, the operation control unit 83 modulates (or prohibits) operation of the heater 108. Here, the hot water exiting the heat exchanger 102 (hot water output) is assumed to be a constant amount. Processes for determining these operation conditions are performed, for example, when the DR signal is received by the communication unit 82 from the energy supplier 4, but the timing is not limited to this.

[0079] The defrost condition determination unit 84 determines the defrost condition to be used for each of the normal period and the DR period. The defrost condition determination unit 84 according to Embodiment 1 determines the defrost condition for the normal period (the first defrost condition) to be the first defrost initiation condition and the first defrost termination condition set by the HP control unit 103. In other words, defrost determination during the normal period according to Embodiment 1 is performed by the HP control unit 103.

[0080] On the other hand, the defrost condition determination unit 84 according to Embodiment 1 determines, among the defrost conditions (second defrost conditions)

used in the DR period, the second defrost initiation condition to be the required defrost time reaching the permissible defrost time (the required defrost time going from being under the permissible defrost time to being equal to the permissible defrost time), and the second defrost termination condition to be the same as the first defrost termination condition. Moreover, the defrost condition determination unit 84 notifies the operation control unit 83 of the starting of the defrost determination based on the second defrost condition at the DR period start time and of the ending of the defrost determination based on the second defrost condition at the DR period end time. In other words, defrost determination during the DR period according to Embodiment 1 is performed by the operation control unit 83.

[0081] It should be noted that the required defrost time refers to the amount of time required for the second defrost termination condition to be met, starting when the heat pump 101 is switched to the defrost mode. Moreover, the permissible defrost time refers to the amount of time it takes for the room temperature to reach a predetermined lower limit value, starting when the heat pump 101 is switched to the defrost mode.

[0082] In the DR period, the operation control unit 83 obtains the required defrost time and the permissible defrost time at predetermined intervals (for example, every minute) and determines whether the second defrost initiation condition is met or not. Then, when the second defrost initiation condition is met, the operation control unit 83 transmits a defrost initiation notice to the HP control unit 103. Moreover, in the DR period, at predetermined intervals (for example, every minute), the operation control unit 83 obtains, via the data collection unit 81, the outdoor temperature detected by the outdoor temperature detecting unit 105 and determines whether the second defrost termination condition is met or not. Then, when the second defrost termination condition is met, the operation control unit 83 transmits a defrost termination notice to the HP control unit 103.

[0083] Next, the control method of the heat pump heating system according to Embodiment 1 will be explained with reference to FIG. 6 through FIG. 9C.

[0084] FIG. 6 is a flow chart outlining the control processes performed by heat pump heating system according to Embodiment 1. FIG. 7 is a flow chart of the HP control process shown in FIG. 6 (S603 in FIG. 6). FIG. 8 is a flow chart of the DR period control process shown in FIG. 6 (S604 in FIG. 6). FIG. 9A through FIG. 9C are for illustrating the second defrost initiation condition determining method according to Embodiment 1.

[0085] First, the communication unit 82 in the system control unit 8 receives the DR signal from the energy supplier 4 (step S601). The system control unit 8 then waits for the arrival of the DR period start time specified in the DR signal (step S602).

[0086] The HP control unit 103 performs the HP control process (step S603). The HP control process shown in FIG. 6 (step S603) is shown in FIG. 7 in detail. The HP

control unit 103 first confirms whether the heat pump 101 current mode of operation is the defrost mode or not (step S701).

[0087] When the current mode of operation is not the defrost mode (No in step S701), this means that the heat pump 101 is already operating in the heating mode (heating operation). Next, the HP control unit 103 confirms whether it has received the defrost initiation notice from the operation control unit 83 in the system control unit 8 or not (step S702).

[0088] When the HP control unit 103 has not received the defrost initiation notice (No in step S702), the HP control unit 103 refers to the outdoor temperature measured by the outdoor temperature detecting unit 105 and the surface temperature of the heat exchanger measured by the heat exchanger surface temperature detecting unit 107, and determines whether the current state satisfies the first defrost initiation condition or not (step S703). It should be noted that the first defrost initiation condition according to Embodiment 1 is, for example, that the outdoor temperature is 5 degrees Celsius or less and the heat exchanger surface temperature is -10 degrees Celsius or less.

[0089] When the current state satisfies the first defrost initiation condition (Yes in step S703), the HP control unit 103 sets the heat pump 101 mode of operation to the defrost mode (step S705) and operates the heat pump 101 in the defrost mode (step S706). On the other hand, when the current state does not satisfy the first defrost initiation condition (No in step S703), the HP control unit 103 continues operating the heat pump 101 in the heating mode (step S704).

[0090] Moreover, when the defrost initiation notice is received (Yes in step S702), the HP control unit 103 sets the heat pump 101 mode of operation to the defrost mode (step S705) and operates the heat pump 101 in the defrost mode (step S706) without determining whether the first defrost initiation condition is met or not.

[0091] However, when the current mode of operation is the defrost mode (Yes in S701), this means that the heat pump 101 is already operating in the defrost mode (is performing a defrost operation). Next, the HP control unit 103 confirms whether it has received the defrost termination notice from the operation control unit 83 in the system control unit 8 or not (step S707).

[0092] When the HP control unit 103 has not received the defrost termination notice (No in step S707), the HP control unit 103 refers to the heat exchanger surface temperature measured by the heat exchanger surface temperature detecting unit 107 and determines whether or not the first defrost termination condition is satisfied or not (step S708). The defrost termination condition according to Embodiment 1 is, for example, that the heat exchanger surface temperature is 10 degrees Celsius or higher.

[0093] When the first defrost termination condition is met (Yes in step S708), the HP control unit 103 sets the heat pump 101 mode of operation to the heating mode

(step S710) and starts operating the heat pump 101 in the heating mode (step S711). On the other hand, when the first defrost termination condition is not met (No in step S708), the HP control unit 103 continues operating the heat pump 101 in the defrost mode (step S709).

[0094] Moreover, when the defrost termination notice is received (Yes in step S707), the HP control unit 103 sets the heat pump 101 mode of operation to the heating mode (step S710) and starts operating the heat pump 101 in the heating mode (step S711) without determining whether the first defrost termination condition is met or not.

[0095] The HP control unit 103 then repeats the above set of processes (steps S701 through S711) at predetermined intervals (for example, every minute) (step S712). Here, since the defrost initiation notice and the defrost termination notice are not generated in the normal period, the HP control unit 103 internally determines whether the first defrost initiation condition and the first defrost termination condition are met or not and switches the mode of operation of the heat pump 101, as FIG. 6 shows.

[0096] Next, returning to FIG. 6, when the DR period start time is reached (Yes in step S02), the system control unit 8 performs the DR period control process (step S604). The DR period control process shown in FIG. 6 (step S604) is shown in FIG. 8 in detail.

[0097] The operation control unit 83 in the system control unit 8 transmits an output modulation instruction to the HP control unit 103 (step S801). The output modulation instruction transmitted at this time, for example, as FIG. 6 shows, instructs for the outlet temperature of the heat exchanger 102 to be 30 degrees Celsius. The HP control unit 103 having received the output modulation instruction then switches the heat pump 101 mode of operation to the output modulation mode.

[0098] Next, the operation control unit 83 in the system control unit 8 obtains, via the data collection unit 81, the current outdoor temperature detected by the outdoor temperature detecting unit 105, the current room temperature detected by the room temperature detecting unit 106, and the current heat exchanger surface temperature detected by the heat exchanger surface temperature detecting unit 107 (step S802).

[0099] Next, the operation control unit 83 calculates the required defrost time and the permissible defrost time based on the temperatures obtained in step S802 (step S803). The operation control unit 83 according to Embodiment 1 calculates the required defrost time based on the required defrost time table shown in FIG. 9A, and calculates the permissible defrost time based on the permissible defrost time shown in FIG. 9B, for example. Next, the process in steps S803 will be described in detail with reference to FIG. 9A through FIG. 9B.

[0100] First, the required defrost time table shown in FIG. 9A is a table in which required defrost times are held in association with corresponding outdoor temperatures and heat exchanger surface temperatures. For example, the first column in the required defrost time table shows

that when the outdoor temperature is 0 degrees Celsius and the heat exchanger surface temperature is -5 degrees Celsius, the required defrost time is 7 minutes.

[0101] Moreover, the permissible defrost time table shown in FIG. 9B is a table in which permissible defrost times are held in association with corresponding outdoor temperatures and room temperatures. For example, the first column in the permissible defrost time table shows that when the outdoor temperature is 0 degrees Celsius and the room temperature is 19 degrees Celsius, it takes 4 minutes for room temperature to decrease by 0.5 degrees Celsius and it takes 7 minutes for the room temperature to decrease by 1.0 degree Celsius. In other words, the permissible defrost time refers to the amount of time required for the room temperature to decrease by a given amount (for example, one degree Celsius), relative to the current outdoor temperature and the current room temperature.

[0102] The permissible defrost times held in this permissible defrost time table increase in length with increasing outdoor temperature, increase in length with increasing room temperature, and increase in length with increasing permissible amount of decrease in room temperature. It should be noted that in the example shown in FIG. 9B, the permissible defrost time when the room temperature decreases by 0.5 degrees Celsius and the permissible defrost time when the room temperature decreases by 1.0 degree Celsius are shown, but the table may hold permissible defrost times corresponding to even greater amounts of decrease (for example, 1.5 degrees Celsius, 2.0 degrees Celsius, etc.)

[0103] Next, the operation control unit 83 determines whether the second defrost initiation condition is met or not using the required defrost time and the permissible defrost time calculated in step S803 (step S804). More specifically, the operation control unit 83 determines that the second defrost initiation condition is met when the required defrost time reaches the permissible defrost time (Yes in step S804) and determines that the second defrost initiation condition is not met when the required defrost time is less than the permissible defrost time (No in step S804).

[0104] Next, the relationships between the required defrost time, the permissible defrost time, and the heat exchanger surface temperature will be described with reference to FIG. 9C. First, the required defrost time gradually increases in length as time passes. On the other hand, the permissible defrost time hardly changes with the passing of time. As such, the permissible defrost time exceeds the required defrost time, but as time passes, the difference between the permissible defrost time and the required defrost time shrinks. Next, at the point in time at which the required defrost time reaches the permissible defrost time, the operation control unit 83 determines that the second defrost initiation condition is met, as FIG. 9C shows.

[0105] On the other hand, the heat exchanger surface temperature gradually decreases with the passing of

time, and the first defrost initiation condition (-10 degrees Celsius) is met. However, in a home with an average thermal insulation efficiency, the second defrost initiation condition is met before the first defrost initiation condition is met, as FIG. 9C shows. In other words, by using the second defrost initiation condition, the defrost start time arrives sooner than when the first defrost initiation condition is used.

[0106] When the second defrost initiation condition is met (Yes in step S804), the operation control unit 83 transmits the defrost initiation notice to the HP control unit 103 (step S805). It should be noted that the HP control unit 103 having received the defrost initiation notice (Yes in step S702 in FIG. 7), the operation mode of the heat pump 101 is switched to the defrost mode.

[0107] However, when the second defrost initiation condition is not met (No in step S804), the operation control unit 83 determines whether the second defrost termination condition is met or not (step S806). It should be noted that since the second defrost termination condition according to Embodiment 1 is the same as the first defrost termination condition (in other words, that the heat exchanger surface temperature is 10 degrees Celsius or higher), step S806 in FIG. 8 is written as "(first defrost termination condition met?".

[0108] When the second defrost termination condition is met (Yes in step S806), the operation control unit 83 transmits the defrost termination notice to the HP control unit 103 (step S807). It should be noted that the HP control unit 103, having received the defrost termination notice (Yes in step S707 in FIG. 7), switches the operation mode of the heat pump 101 to the heating mode.

[0109] Next, the system control unit 8 determines whether the DR period end time has arrived or not (step S808). When the DR period end time has not been yet reached (no in step S808), the system control unit 8 repeats the above set of processes (steps S802 through S807) after a predetermined amount of time has elapsed (for example, one minute) (Yes in step S809). In other words, the system control unit 8 repeats the processes in steps S802 through S807 until the DR period end time is reached (Yes in step S808), at predetermined intervals (for example, every minute) (step S809).

[0110] Then, when the DR period end time is reached (Yes in step S808), the operation control unit 83 transmits an output modulation cancel instruction to the HP control unit 103 (step S810) and ends the DR period control process. Here, the transmitted output modulation cancel instruction, for example, as FIG. 6 shows, instructs for the outlet temperature of the heat exchanger 102 to be 55 degrees Celsius. The HP control unit 103 having received the output modulation cancel instruction then switches the heat pump 101 mode of operation to the normal mode.

[0111] The advantageous effect gained by the above processes will be described with reference to FIG. 10. (a) in FIG. 10 shows an example of transitions in required defrost time (dashed line) and permissible defrost time

(dot and dashed line). (b) in FIG. 10 shows an example of transitions in heat exchanger surface temperature. (c) in FIG. 10 shows an example of transitions in room temperature. (d) in FIG. 10 shows an example of transitions in power consumption by the heat pump 101.

[0112] It should be noted that in (b) through (d) in FIG. 10, the short dashed lines indicate transitions when defrost determination is performed based on the first defrost condition and use of the heater 108 during defrost operation is prohibited (normal defrost control (1)), the long dashed lines indicate transitions when defrost determination is performed based on the first defrost condition and use of the heater 108 during defrost operation is permissible (normal defrost control (2)), and the solid lines indicate transitions when defrost determination is performed based on the second defrost condition and use of the heater 108 during defrost operation is prohibited (DR period defrost control).

[0113] Moreover, in the examples in FIG. 10, operation of the heat pump 101 is controlled so that the room temperature in the normal period is maintained at 20 degrees Celsius and the room temperature in the DR period is maintained at 19 degrees Celsius. In other words, in this example, the normal mode is a mode of operation which maintains the room temperature at 20 degrees Celsius, and the output modulation mode is a mode of operation which maintains the room temperature at 19 degrees Celsius.

[0114] Moreover, in the example shown in FIG. 10, the DR period start time is 18:00, the DR period end time is 20:00, and the DR period is two hours long. In the DR period defrost control, the amount of decrease in room temperature when the defrost operation is being performed in the DR period is allowed to be up to one degree Celsius (in other words, the lower limit value of the room temperature is set to 18 degrees Celsius).

[0115] First, since the heat pump 101 mode of operation switches from normal mode to output modulation mode at 18:00, in all control methods, the power consumption by the heat pump 101 is reduced from 5 kW (normal mode) to 2 kW (output modulation mode), as (d) in FIG. 10 shows. Moreover, as (c) in FIG. 10 shows, in all control methods, the room temperature gradually decreases from 20 degrees Celsius to 19 degrees Celsius.

[0116] First, in the DR period defrost control, as (a) in FIG. 10 shows, the second defrost initiation condition is met at 18:40 and the heat pump 101 mode of operation switches to the defrost mode at this time (DR period defrost). As a result, as (b) in FIG. 10 shows, since the heat exchanger surface temperature gradually increases and reaches 10 degrees Celsius at 18:45 (in other words, the second defrost termination condition is met), the heat pump 101 mode of operation switches to the heating mode at this time (output modulation mode).

[0117] Moreover, as (c) in FIG. 10 shows, since radiation of heat from the heating device 104 stops when the heat pump 101 switches to the defrost mode at 18:40, the room temperature gradually decreases and reaches

the lower limit value, 18 degrees Celsius, at 10:45 (the same time the second defrost termination condition is met). Moreover, since radiation of heat from the heating device 104 restarts when the heat pump switches to the output modulation mode at 18:45, the room temperature gradually increase at returns to 19 degrees Celsius at 10:50.

[0118] Furthermore, as (d) in FIG. 10 shows, the power consumption by the heat pump 101 increases from 2 kW (output modulation mode) to 4 kW (defrost mode) since the heat pump 101 switches to the defrost mode at 18:40. Furthermore, between 18:45 and 18:50, the heat pump 101 operating in the output modulation mode consumes 4 kW of electricity to increase the room temperature from 18 degrees Celsius to 19 degrees Celsius.

[0119] It should be noted that the transitions in the heat exchanger surface temperature, room temperature, and power consumption from 19:25 to 19:35 when the DR period defrost control is performed are the same as the transitions from 18:40 to 18:50, description thereof is omitted.

[0120] Next, in the normal defrost control (1), as (a) in FIG. 10 shows, the first defrost initiation condition is met at 19:20 and the heat pump 101 mode of operation switches to the defrost mode at this time (normal defrost). As a result, as (b) in FIG. 10 shows, since the heat exchanger surface temperature gradually increases and reaches 10 degrees Celsius at 19:30 (in other words, the first defrost termination condition is met), the heat pump 101 mode of operation switches to the heating mode at this time (output modulation mode).

[0121] Moreover, as (c) in FIG. 10 shows, since radiation of heat from the heating device 104 stops when the heat pump 101 switches to the defrost mode at 19:20, the room temperature gradually decreases and reaches the lower limit value. Here, in the normal defrost control (1), the room temperature at 19:30 decreases to 17 degrees Celsius since use of the heater 108 during the DR period is prohibited.

[0122] Furthermore, as (d) in FIG. 10 shows, in the normal defrost control (1), the power consumption by the heat pump 101 increases from 2 kW (output modulation mode) to 4 kW (defrost mode) since the heat pump 101 switches to the defrost mode at 18:40. Furthermore, between 19:30 and 19:40, the heat pump 101 operating in the output modulation mode consumes 4 kW of electricity to increase the room temperature from 17 degrees Celsius to 19 degrees Celsius.

[0123] Here, looking at the DR period defrost control and the normal defrost control (1), the peak power consumption is the same in both cases during the DR period (4 kW). However, the room temperature after normal defrost has completed (17 degrees Celsius) is lower than the room temperature after DR period defrost has completed (18 degrees Celsius). In other words, the DR period defrost control is more capable of keeping the comfort level from decreasing than the normal defrost control (1).

[0124] Next, in the normal defrost control (2), as (a) in FIG. 10 shows, the first defrost initiation condition is met at 19:20 and the heat pump 101 mode of operation switches to the defrost mode at this time (normal defrost). As a result, as (b) in FIG. 10 shows, since the heat exchanger surface temperature gradually increases and reaches 10 degrees Celsius at 19:30 (in other words, the first defrost termination condition is met), the heat pump 101 mode of operation switches to the heating mode at this time (output modulation mode).

[0125] Moreover, as (c) in FIG. 10 shows, since radiation of heat from the heating device 104 stops when the heat pump 101 switches to the defrost mode at 19:20, the room temperature gradually decreases and reaches the lower limit value. Here, in the normal defrost control (2), the room temperature at 19:30 only decreases to 18 degrees Celsius since use of the heater 108 during the DR period is permissible.

[0126] Furthermore, as (d) in FIG. 10 shows, in the normal defrost control (2), the power consumption by the heat pump 101 increases from 2 kW (output modulation mode) since the heat pump 101 switches to the defrost mode at 19:40. Here, in the normal defrost control (2), since use of the heater 108 is permissible, the heat pump 101 consumes 6 kW of electricity during defrost operation (4 kW for operating in the defrost mode and 2 kW for consumption by the heater 108). Furthermore, between 19:30 and 19:35, the heat pump 101 operating in the output modulation mode consumes 4 kW of electricity to increase the room temperature from 18 degrees Celsius to 19 degrees Celsius.

[0127] Here, looking at the DR period defrost control and the normal defrost control (2), the lower limit value of the room temperature during the defrost operation is the same for both (18 degrees Celsius). However, in the normal defrost control (2), since the heater 108 is used to keep the room temperature from decreasing during the defrost operation, the power consumption peak (6 kW) is higher than in the DR period defrost control (4 kW). In other words, the DR period defrost control is more capable of reducing peak power consumption during the DR period than the normal defrost control (2).

[0128] As described above, the amount of time required per DR period defrost (5 minutes) is shorter than the amount of time required per normal defrost (10 minutes). As such, with the DR period defrost control according to Embodiment 1, it is possible to reduce the amount of decrease in room temperature during the defrost operation more so than in the case of the normal defrost control (1) in which use of the heater 108 is prohibited in order to keep peak power consumption in the DR period to a minimum. Moreover, with the DR period defrost control according to Embodiment 1, it is possible to keep the peak power consumption low in the DR period more so than in the case of the normal defrost control (2) in which use of the heater 108 is permissible in order to keep the room temperature from reducing during the defrost operation.

[0129] It should be noted that in Embodiment 1, an example is given in which the defrost termination condition is the same and only the defrost initiation condition is made to be different between the first and second defrost conditions. More specifically, when the heat pump heating device 100 is operated under identical conditions, the defrost condition determination unit 84 according to Embodiment 1 determines the second defrost initiation condition such that the second defrost initiation condition is met ahead of the first defrost initiation condition.

[0130] In other words, compared to the first defrost condition, when defrost determination is performed according to the second defrost condition, the heat exchanger surface temperature at the defrost operation start time is higher. As such, assuming the defrost termination conditions are the same, the time required per defrost operation is shorter with the second defrost condition than with the first defrost condition.

[0131] As a result, when the heat pump heating device 100 is operated under identical conditions, it is possible to reduce the amount of decrease in room temperature when the heat pump heating device 100 is operated in the defrost mode according to the second defrost condition, more so than when the heat pump heating device 100 is operated in the defrost mode according to the first defrost condition.

[0132] It should be noted that in Embodiment 1, an instantaneous value of the outdoor temperature and the heat exchanger surface temperature are used as the first defrost initiation condition, but the present invention is not limited to this example. For example, the condition may be a condition using a consecutive value or an average time of movement such as "then heat exchanger surface temperature remained at or below -10 degrees Celsius for a given period of time (for example 3 minutes)". This also applies to the first defrost termination condition, the second defrost initiation condition, and the second defrost termination condition.

[0133] Moreover, in Embodiment 1, an example is given in which the heat exchanger surface temperature is included in the first defrost initiation condition, the first defrost termination condition, and the second defrost termination condition, but the temperature of the refrigerant flowing through the ducts may be used instead. Furthermore, the amount of frost build-up may be estimated using a combination of, for example, the heat exchanger surface temperature and the refrigerant temperature. Furthermore, the amount of frost build-up may be measured directly using an imaging apparatus (camera) or the like.

[0134] Furthermore, in Embodiment 1, an example is given in which the required defrost time is calculated using the outdoor temperature and the heat exchanger surface temperature and the permissible defrost time is calculated using the outdoor temperature and the room temperature, but the present invention is not limited to this example. The required defrost time and the permissible

defrost time may be calculated using other parameters. Moreover, parameters other than the required defrost time and the permissible defrost time may be included in the second defrost initiation condition.

(Embodiment 2)

[0135] Next, the control method of the heat pump heating system according to Embodiment 2 will be explained with reference to FIG. 11 and FIG. 12. FIG. 11 is a flow chart of the DR period control process according to Embodiment 2. FIG. 12 shows an example of transitions in heat exchanger surface temperature when the controlling method according to Embodiment 2 is performed. The explanation will therefore focus on the points of difference with Embodiment 1, and details regarding common points with Embodiment 1 will be omitted.

[0136] The basic configuration of the heat pump heating system according to Embodiment 2 is the same as that shown in FIG. 2 through FIG. 5. Moreover, the basic operations of the heat pump heating system are the same as that shown in FIG. 6 through FIG. 8. However, the DR period control process according to Embodiment 2 shown in FIG. 11 is different from Embodiment 1 in that it includes steps S1102 and S1103 instead of steps S802 and S803 in the DR period control process shown in FIG. 8.

[0137] First, the defrost condition determination unit 84 according to Embodiment determines the second defrost initiation condition and the second defrost termination condition in step S1102 shown in FIG. 11. The defrost condition determination unit 84 according to Embodiment 2 makes the threshold (upper limit value / lower limit value) for the heat exchanger surface temperature included in the defrost initiation condition and the defrost termination condition different for the first defrost condition and the second defrost condition.

[0138] More specifically, the defrost condition determination unit 84 makes the upper limit value for the heat exchanger surface temperature included in the second defrost initiation condition higher than the lower limit value for the heat exchanger surface temperature included in the first defrost initiation condition. In the following example, the first defrost initiation condition is that the outdoor temperature is 5 degrees Celsius or below and the heat exchanger surface temperature is -10 degrees Celsius or below, and the second defrost initiation condition is that the outdoor temperature is 5 degrees Celsius or below and the heat exchanger surface temperature is 0 degrees Celsius or below.

[0139] Moreover, the defrost condition determination unit 84 makes the upper limit value for the heat exchanger surface temperature included in the second defrost termination condition lower than the upper limit value for the heat exchanger surface temperature included in the first defrost termination condition. In the following example, the first defrost termination condition is that the heat exchanger surface temperature is 10 degrees Celsius or

above and the second defrost termination condition is that the heat exchanger surface temperature is 5 degrees Celsius or above.

[0140] Next, in step S1103 shown in FIG. 11, the operation control unit 83 according to Embodiment 2 obtains, via the data collection unit 81, the outdoor temperature detected by the outdoor temperature detecting unit 105 and the heat exchanger surface temperature detected by the heat exchanger surface temperature detecting unit 107. The operation control unit 83 then compares the second defrost condition determined in step S1103 with the information obtained in step S1103, and determines whether to start defrosting (step S804) and whether to stop defrosting (step S806).

[0141] The advantageous effect gained by the above processes will be described with reference to FIG. 12. FIG. 12 shows an example of transitions in heat exchanger surface temperature. In the example shown in FIG. 12, by performing the defrosting determination under the second defrost condition in the DR period (from 18:00 to 20:00), DR period defrosting is performed in the five minutes between 18:35 and 18:40, and the five minutes between 19:30 and 19:35. On the other hand, by performing the defrosting determining under the first defrost condition in the normal period, normal defrosting is performed in the 30 minutes between 22:00 and 22:30.

[0142] In Embodiment 2, both the second defrost initiation condition and the second defrost termination condition are changed so that the second defrost initiation condition is met before the first defrost initiation condition is met, and so that the second defrost termination condition is met before the first defrost termination condition is met. In other words, when the heat pump 101 is operated under identical conditions, DR period defrosting starts and ends earlier than when normal defrosting is performed. As a result, it is possible to make the amount of time required per DR period defrosting operation even shorter than the amount of time required per normal defrosting operation.

[0143] It should be noted that in the DR period control process shown in FIG. 11, the system control unit 8 internally determines whether to start the defrosting operation using the second defrost initiation condition determined in step S1102 (step S804), and internally determines whether to stop the defrosting operation using the second defrost termination condition determined in step S1102 (step S806).

[0144] However, the present invention is not limited to this example. For example, the system control unit 8 may transmit to the HP control unit 103 the second defrost condition determined in step S1102 (the second defrost initiation condition and the second defrost termination condition) and cause the HP control unit 103 to determine the starting and stopping of defrosting. In other words, the HP control unit 103 may determine the starting and stopping of defrosting in the normal period (step S703, S708 in FIG. 7) using the first defrost condition, and may determine the starting and stopping of defrosting in the

DR period using the second defrost condition obtained from the system control unit 8.

[0145] In this case, the system control unit 8 may perform the process of transmitting the second defrost condition to the HP control unit 103 after step S1102 instead of omitting steps S1103 through S807, and S809, in FIG. 11. This also applies for the following Embodiment 3.

(Embodiment 3)

[0146] Next, the control method of the heat pump heating system according to Embodiment 4 will be explained with reference to FIG. 13 and FIG. 14. FIG. 13 is a flow chart of the DR period control process according to Embodiment 3. FIG. 14 shows an example of transitions in heat exchanger surface temperature when the controlling methods according to Embodiments 2 and 3 are performed. The explanation will therefore focus on the points of difference with Embodiments 1 and 2, and details regarding common points with Embodiments 1 and 2 will be omitted.

[0147] The basic configuration of the heat pump heating system according to Embodiment 3 is the same as that shown in FIG. 2 through FIG. 5. Moreover, the basic operations of the heat pump heating system are the same as that shown in FIG. 6, FIG. 7, and FIG. 11. However, the DR period control process according to Embodiment 2 shown in FIG. 14 is different from Embodiment 2 in that it includes step S1302 instead of step S1102 in the DR period control process shown in FIG. 11. More specifically, the defrost condition determination unit 84 according to Embodiment 3 makes the defrost initiation condition the same for the first defrost condition and the defrost condition (the first defrost initiation condition = the second defrost initiation condition), and only changes the defrost termination condition (the first defrost termination condition $\neq$ the second defrost termination condition).

[0148] The advantageous effect gained by the above processes will be described with reference to FIG. 14. FIG. 14 shows an example of transitions in heat exchanger surface temperature when the controlling methods according to Embodiments 2 and 3 are performed. Since the lower limit value for the heat exchanger surface temperature in the second defrost initiation condition is higher than in the first defrost initiation condition in Embodiment 2, in the example shown in FIG. 14, DR period defrosting is performed twice in the DR period by performing the DR period defrost control according to Embodiment 2.

[0149] On the other hand, since the second defrost initiation condition is the same as the first defrost initiation condition in Embodiment 3 (that is to say, the lower limit value for the heat exchanger surface temperature is lower than in the second defrost initiation condition according to Embodiment 2), in the example shown in FIG. 14, DR period defrosting is not performed in the DR period by performing the DR period defrost control according to Embodiment 3.

[0150] In this way, by raising the lower limit value for

the heat exchanger surface temperature in the second defrost initiation condition in order to reduce the amount of time required per DR defrost operation (Embodiment 2), there is a possibility DR defrosting will be performed in the DR period even when a defrost operation is not actually necessary (Embodiment 3). As such, by lowering only the upper limit value for the heat exchanger surface temperature in the second defrost termination condition, as is the case in Embodiment 3, it is possible to reduce the amount of time required per DR period defrost operation as well as effectively prevent an unnecessary DR period defrost operation from being performed when the DR period is short.

[0151] It should be noted that both Embodiments 1 and 2 are written in regard to a heat pump hot water heating system, but the present invention is not limited to this, and may be a heat pump air conditioning unit.

[0152] It should be noted that although the present invention is described based on the previous embodiments, the present invention is not limited to these embodiments. The following examples are also intended to be included within the scope of the present invention.

(1) The preceding devices are, specifically, realized as a computer system configured from a microprocessor, ROM, RAM, a hard disk unit, a display unit, a keyboard, and a mouse, for example. A computer program is stored in the RAM or the hard disk unit. Each of the devices achieves its function as a result of the microprocessor operating according to the computer program. Here, the computer program is configured of a plurality of pieced together instruction codes indicating commands to be made to the computer in order to achieve a given function.

(2) A portion or all of the components of each of the preceding devices may be configured from one system LSI (Large Scale Integration). A system LSI is a super-multifunction LSI manufactured with a plurality of components integrated on a single chip, and specifically is a computer system configured of a microprocessor, ROM, and RAM, for example. A computer program is stored in the ROM. The system LSI achieves its function as a result of the microprocessor loading the computer program from the ROM into the RAM and performing operations such as calculations according to the computer program.

(3) A portion or all of the components of each of the preceding devices may each be configured from a detachable IC card or a stand-alone module. The IC card and the module are computer systems configured from a microprocessor, ROM, and RAM, for example. The IC card and the module may include the super-multifunction LSI described above. The IC card and the module achieve their function as a result of the microprocessor operating according to a computer program. The IC card and the module may be tamperproof.

(4) The present invention may be realized as a meth-

od shown above. Moreover, the present invention may also be realized as a computer program realizing these methods with a computer, or a digital signal of the computer program.

[0153] Moreover, the present invention may also be realized as the computer program or the digital signal stored on storage media readable by a computer, such as a flexible disk, hard disk, CD-ROM, MO, DVD, DVD-ROM, DVD-RAM, BD (Blu-ray Disc), or a semiconductor memory. The present invention may also be realized as a digital signal stored on the above mentioned storage media.

[0154] Moreover, the present invention may also be realized by transmitting the computer program or the digital signal, for example, via an electric communication line, a wireless or wired line, a network such as the Internet, or data broadcasting.

[0155] Moreover, the present invention may be a computer system including memory storing a computer program and a microprocessor operating according to the computer program.

[0156] Moreover, the computer program or the digital signal may be implemented by an independent computer system by being stored on the storage media and transmitted, or sent via the network.

[0157]

(5) The preceding embodiments and the preceding transformation examples may be individually combined.

[0158] The herein disclosed description of the heating system control method according to one or more aspect was made based on the above embodiments, but the present invention is not limited to these embodiments.

[Industrial Applicability]

[0159] The heat pump heating system control method according to the present invention is useful as an operation method which contributes to the stabilization of grid power due to the peak cut and a decrease in user electricity expenses since defrosting is not required during the peak time period, during which power consumption increases.

[Reference Signs List]

[0160]

1 heat pump heating system
4 energy supplier
5 electric load
6 first power meter
7 second power meter
8 system control unit
81 data collection unit

82 communication unit
83 operation control unit
84 defrost condition determination unit
100 heat pump heating device
5 101 heat pump
101a outdoor heat exchanger
101b compressor
101c expansion valve
102 heat exchanger
10 103 HP control unit
104 heating device
105 outdoor temperature detecting unit
106 room temperature detecting unit
107 heat exchanger surface temperature detecting unit
15 108 heater
109 outlet temperature detecting unit
110 flow rate detecting unit
111 inlet temperature detecting unit
20

Claims

1. A method of controlling a heating system that operates using power supplied from a power supply source, the heating system including:

a heat pump that generates heat using the power supplied from the power supply source; and
a radiator unit that radiates the heat generated by the heat pump,
the heat pump operating in either a heating mode for generating the heat to be radiated by the radiating unit or a defrost mode for removing frost formed on the heat pump,
the method comprising:

obtaining, from the power supply source, an output modulation instruction specifying an output modulation period during which power consumption by the heat pump is modulated;
determining a first defrost condition to be used in a period outside the output modulation period and a second defrost condition to be used in the output modulation period, the first defrost condition and the second defrost condition each including a defrost initiation condition for causing the heat pump to start operating in the defrost mode and a defrost termination condition for causing the heat pump to stop operating in the defrost mode; and
controlling operation of the heat pump to cause the heat pump to start operating in the defrost mode based on the defrost initiation condition determined in the determining being met and cause the heat pump to

- stop operating in the defrost mode based on the defrost termination condition determined in the determining being met, wherein in the determining, a continuous operation time of the heat pump in the defrost mode in the output modulation period under the second defrost condition is made to be shorter than in a period outside of the output modulation period under the first defrost condition by making at least one of the defrost initiation condition or the defrost termination condition included in the second defrost condition different from that of the first defrost condition.
2. The method according to Claim 1, wherein in the determining, at predetermined intervals in the output modulation period, achievement of the defrost initiation condition included in the second defrost condition is determined to be a required defrost time reaching a permissible defrost time, the required defrost time being an amount of time from when the heat pump switches to the defrost mode until the defrost termination condition is met, and the permissible defrost time being an amount of time from when the heat pump switches to the defrost mode until a room temperature reaches a predetermined lower limit value.
 3. The method according to Claim 2, wherein the heating system holds information associating an outdoor temperature and a surface temperature of an outdoor heat exchanger included in the heat pump with the required defrost time, and information associating the outdoor temperature and the room temperature with the permissible defrost time, in the obtaining, the outdoor temperature, the surface temperature of the outdoor heat exchanger, and the room temperature are obtained, and in the controlling, achievement of the defrost initiation condition included in the second defrost condition is assessed at predetermined intervals in the output modulation period using (i) the required defrost time associated with the outdoor temperature and the surface temperature of the outdoor heat exchanger obtained in the obtaining and (ii) the permissible defrost time associated with the outdoor temperature and the room temperature obtained in the obtaining.
 4. The method according to Claim 2, wherein the heating system holds information associating an outdoor temperature and a temperature of a refrigerant in the heat pump with the required defrost time, and information associating the outdoor temperature and the room temperature with the permissible defrost time,
- in the obtaining, the outdoor temperature, the temperature of the refrigerant, and the room temperature are obtained, and in the controlling, achievement of the defrost initiation condition included in the second defrost condition is assessed at predetermined intervals in the output modulation period using (i) the required defrost time associated with the outdoor temperature and the temperature of the refrigerant obtained in the obtaining and (ii) the permissible defrost time associated with the outdoor temperature and the room temperature obtained in the obtaining.
5. The method according to Claim 1, wherein the defrost initiation condition includes a lower limit value for a surface temperature of an outdoor heat exchanger included in the heat pump, and in the determining, the lower limit value for the surface temperature of the outdoor heat exchanger included in the second defrost condition is set higher than the lower limit value for the surface temperature of the outdoor heat exchanger included in the first defrost condition.
 6. The method according to any one of Claims 1 or 5, wherein the defrost termination condition includes an upper limit value for a surface temperature of an outdoor heat exchanger included in the heat pump, and in the determining, the upper limit value for the surface temperature of the outdoor heat exchanger included in the second defrost condition is set lower than the upper limit value for the surface temperature of the outdoor heat exchanger included in the first defrost condition.
 7. The method according to Claim 1, wherein the defrost initiation condition includes a lower limit value for a temperature of a refrigerant in the heat pump, and in the determining, the lower limit value for the temperature of the refrigerant included in the second defrost condition is set higher than the lower limit value for the temperature of the refrigerant included in the first defrost condition.
 8. The method according to any one of Claims 1 or 7, wherein the defrost termination condition includes an upper limit value for a temperature of a refrigerant in the heat pump, and in the determining, the upper limit value for the temperature of the refrigerant included in the second defrost condition is set lower than the upper limit value for the temperature of the refrigerant included in the first defrost condition.
 9. The method according to any one of Claims 1 to 8, wherein in the controlling, the heat pump is caused

to start operating in the defrost mode based on the defrost initiation condition being continuously met for a predetermined period of time, and caused to stop operating in the defrost mode based on the defrost termination condition being continuously met for a predetermined period of time.

10. The method according to any one of Claims 1 to 9, wherein in the controlling, the heat pump operating in the heating mode is further caused to generate a first amount of heat per unit time in a period outside the output modulation period and generate a second amount of heat per unit time in the output modulation period, the second amount of heat being less than the first amount of heat.

11. A heating system that operates using power supplied from a power supply source, the heating system comprising:

a heat pump that generates heat using the power supplied from the power supply source;
a radiator unit configured to radiate the heat generated by the heat pump; and
a control unit configured to control operation of the heat pump,
the heat pump operating in either a heating mode for generating the heat to be radiated by the radiator unit or a defrost mode for removing frost formed on the heat pump, and
the control unit including:

an obtaining unit configured to obtain, from the power supply source, an output modulation instruction specifying an output modulation period during which power consumption by the heat pump is modulated;
a defrost condition determination unit configured to determine a first defrost condition to be used in a period outside the output modulation period and a second defrost condition to be used in the output modulation period, the first defrost condition and the second defrost condition each including a defrost initiation condition for causing the heat pump to start operating in the defrost mode and a defrost termination condition for causing the heat pump to stop operating in the defrost mode; and
an operation control unit configured to cause the heat pump to start operating in the defrost mode based on the defrost initiation condition determined by the defrost condition determination unit being met and cause the heat pump to stop operating in the defrost mode based on the defrost termination condition determined by the defrost condition determination unit being met,

wherein the defrost condition determination unit is configured to make a continuous operation time of the heat pump in the defrost mode in the output modulation period under the second defrost condition shorter than in the defrost mode in a period outside of the output modulation period under the first defrost condition by making at least one of the defrost initiation condition or the defrost termination condition included in the second defrost condition different from that of the first defrost condition.

15 Patentansprüche

1. Verfahren zum Steuern eines Heizsystems, das unter Verwendung von Energie arbeitet, die von einer Energieversorgungsquelle zugeführt wird, wobei das Heizsystem Folgendes aufweist:

eine Wärmepumpe, die Wärme unter Verwendung der von der Energieversorgungsquelle zugeführten Energie erzeugt; und
eine Radiatoreinheit, die die von der Wärmepumpe erzeugte Wärme abstrahlt,
wobei die Wärmepumpe entweder in einem Heizmodus zum Erzeugen der von der Radiatoreinheit abstrahlenden Wärme oder in einem Abtaumodus zum Entfernen von auf der Wärmepumpe gebildetem Frost arbeitet,
wobei das Verfahren umfasst:

Erlangen einer Ausgangsmodulationsanweisung von der Energieversorgungsquelle, die eine Ausgangsmodulationsperiode spezifiziert, während der der Energieverbrauch durch die Wärmepumpe moduliert wird;
Bestimmen einer ersten Abtaubedingung, die in einer Periode außerhalb der Ausgangsmodulationsperiode zu verwenden ist, und einer zweiten Abtaubedingung, die in der Ausgangsmodulationsperiode zu verwenden ist, wobei die erste Abtaubedingung und die zweite Abtaubedingung jeweils eine Abtaueinleitungsbedingung umfassen, die die Wärmepumpe zum Starten des Betriebs im Abtaumodus veranlasst, und eine Abtaubeendungsbedingung, die die Wärmepumpe zum Beenden des Betriebs im Abtaumodus veranlasst, umfasst; und
Steuern des Betriebs der Wärmepumpe, um die Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen bestimmten Abtaueinleitungsbedingung, zum Starten des Betriebs im Abtaumodus zu veranlassen,

- und um die Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen bestimmten Abtauendeungsbedingung, zum Beenden des Betriebs im Abtaumodus zu veranlassen, wobei beim Bestimmen bestimmt wird, dass eine kontinuierliche Betriebszeit der Wärmepumpe im Abtaumodus in der Ausgangsmodulationsperiode unter der zweiten Abtaubedingung kürzer sein soll als eine Periode außerhalb der Ausgangsmodulationsperiode unter der ersten Abtaubedingung, indem sich mindestens eine der in der zweiten Abtaubedingung enthaltenen Abtaueinleitungsbedingung oder der Abtauendeungsbedingung unterschiedlich von der ersten Abtaubedingung unterscheidet.
2. Verfahren nach Anspruch 1, wobei beim Bestimmen, in im Voraus bestimmten Intervallen in der Ausgangsmodulationsperiode, das Erreichen der in der zweiten Abtaubedingung enthaltenen Abtaueinleitungsbedingung als eine erforderliche Abtauzeit bestimmt wird, die eine zulässige Abtauzeit erreicht, wobei die erforderliche Abtauzeit eine Zeitdauer ist, ab der die Wärmepumpe in den Abtaumodus wechselt, bis die Abtauendeungsbedingung erfüllt ist, und die zulässige Abtauzeit eine Zeitdauer ist, ab der die Wärmepumpe in den Abtaumodus wechselt, bis eine Raumtemperatur einen im Voraus bestimmten unteren Grenzwert erreicht.
 3. Verfahren nach Anspruch 2, wobei das Heizsystem Information speichert, die eine Außentemperatur und eine Oberflächentemperatur eines in der Wärmepumpe enthaltenen Außenwärmetauschers mit der erforderlichen Abtauzeit verknüpfen, und Information, die die Außentemperatur und die Raumtemperatur mit der zulässigen Abtauzeit verknüpfen, beim Erlangen die Außentemperatur, die Oberflächentemperatur des Außenwärmetauschers und die Raumtemperatur erlangt werden, und beim Steuern das in der zweiten Abtaubedingung enthaltene Erreichen der Abtaueinleitungsbedingung in im Voraus bestimmten Intervallen in der Ausgangsmodulationsperiode unter Verwendung von (i) der erforderlichen Abtauzeit in Verbindung mit der Außentemperatur und der Oberflächentemperatur des Außenwärmetauschers, die beim Erlangen erlangt werden, und (ii) der zulässigen Abtauzeit in Verbindung mit der Außentemperatur und der Raumtemperatur, die beim Erlangen erlangt werden, bewertet wird.
 4. Verfahren nach Anspruch 2, wobei das Heizsystem Information speichert, die eine Außentemperatur und eine Temperatur des Kältemittels in der Wärmepumpe mit der erforderlichen Abtauzeit verknüpfen, und Information, die die Außentemperatur und die Raumtemperatur mit der zulässigen Abtauzeit verknüpfen, beim Erlangen die Außentemperatur, die Oberflächentemperatur des Außenwärmetauschers und die Raumtemperatur erlangt werden, und beim Steuern das in der zweiten Abtaubedingung enthaltene Erreichen der Abtaueinleitungsbedingung in im Voraus bestimmten Intervallen in der Ausgangsmodulationsperiode unter Verwendung von (i) der erforderlichen Abtauzeit in Verbindung mit der Außentemperatur und der Temperatur des Kältemittels, die beim Erlangen erlangt werden, und (ii) der zulässigen Abtauzeit in Verbindung mit der Außentemperatur und der Raumtemperatur, die beim Erlangen erlangt werden, bewertet wird.
 5. Verfahren nach Anspruch 1, wobei die Abtaueinleitungsbedingung einen unteren Grenzwert für eine Oberflächentemperatur eines in der Wärmepumpe enthaltenen Außenwärmetauschers enthält, und beim Bestimmen der untere Grenzwert für die Oberflächentemperatur des in der zweiten Abtaubedingung enthaltenen Außenwärmetauschers höher eingestellt wird als der untere Grenzwert für die in der ersten Abtaubedingung enthaltene Oberflächentemperatur des Außenwärmetauschers.
 6. Verfahren nach einem der Ansprüche 1 oder 5, wobei die Abtauendeungsbedingung einen oberen Grenzwert für eine Oberflächentemperatur eines in der Wärmepumpe enthaltenen Außenwärmetauschers enthält, und beim Bestimmen der obere Grenzwert für die Oberflächentemperatur des in der zweiten Abtaubedingung enthaltenen Außenwärmetauschers niedriger eingestellt wird als der obere Grenzwert für die in der ersten Abtaubedingung enthaltene Oberflächentemperatur des Außenwärmetauschers.
 7. Verfahren nach Anspruch 1, wobei die Abtaueinleitungsbedingung einen unteren Grenzwert für eine Temperatur eines Kältemittels in der Wärmepumpe enthält, und beim Bestimmen der untere Grenzwert für die Temperatur des in der zweiten Abtaubedingung enthaltenen Kältemittels höher eingestellt wird als der untere Grenzwert für die Temperatur des in der ersten Abtaubedingung enthaltenen Kältemittels.
 8. Verfahren nach einem der Ansprüche 1 oder 7, wobei die Abtauendeungsbedingung einen oberen Grenzwert für eine Temperatur eines Kältemittels in der Wärmepumpe umfasst, und beim Bestimmen der obere Grenzwert für die Temperatur des in der zweiten Abtaubedingung enthal-

tenen Kältemittels niedriger eingestellt wird als der obere Grenzwert für die Temperatur des in der ersten Abtaubedingung enthaltenen Kältemittels.

9. Verfahren nach einem der Ansprüche 1 bis 8, wobei beim Steuern die Wärmepumpe zum Starten des Betriebs im Abtaumodus, auf Basis des kontinuierlichen Erfüllens der Abtaueinleitungsbedingung während einer im Voraus bestimmten Zeitdauer, veranlasst wird, und zum Beenden des Betriebs im Abtaumodus, auf Basis des kontinuierlichen Erfüllens der Abtaubeendungsbedingung während einer im Voraus bestimmten Zeitdauer, veranlasst wird. 5
10. Verfahren nach einem der Ansprüche 1 bis 9, wobei beim Steuern die im Heizmodus arbeitende Wärmepumpe ferner zum Erzeugen einer ersten Wärmemenge pro Zeiteinheit in einer Periode außerhalb der Ausgangsmodulationsperiode und zum Erzeugen einer zweiten Wärmemenge pro Zeiteinheit innerhalb der Ausgangsmodulationsperiode veranlasst wird, wobei die zweite Wärmemenge geringer ist als die erste Wärmemenge. 10
11. Heizsystem, das unter Verwendung von Energie arbeitet, die von einer Energieversorgungsquelle zugeführt wird, wobei das Heizsystem Folgendes aufweist: 15
 - eine Wärmepumpe, die Wärme unter Verwendung der von der Energieversorgungsquelle zugeführten Energie erzeugt; 20
 - eine Radiatoreinheit, die konfiguriert ist zum Abstrahlen der von der Wärmepumpe erzeugten Wärme; und 25
 - eine Steuereinheit, die konfiguriert ist zum Steuern des Betriebs der Wärmepumpe, wobei die Wärmepumpe entweder in einem Heizmodus, zum Erzeugen der von der Radiatoreinheit abstrahlenden Wärme, oder in einem Abtaumodus zum Entfernen von auf der Wärmepumpe gebildetem Frost arbeitet, und die Steuereinheit Folgendes aufweist: 30
 - eine Erlangungseinheit, die konfiguriert ist zum Erlangen, von der Stromversorgungsquelle, einer Ausgangsmodulationsanweisung, die eine Ausgangsmodulationsperiode spezifiziert, während der der Energieverbrauch durch die Wärmepumpe moduliert wird; 35
 - eine Abtaubedingungsbestimmungseinheit, die konfiguriert ist zum Bestimmen einer ersten Abtaubedingung, die in einer Periode außerhalb der Ausgangsmodulationsperiode zu verwenden ist, und einer zweiten Abtaubedingung, die in der Ausgangsmodulationsperiode zu verwenden ist, wobei die erste Abtaubedingung und die zweite Abtaubedingung jeweils eine Abtaueinleitungsbedingung, die die Wärmepumpe zum Starten des Betriebs im Abtaumodus veranlasst, und eine Abtaubeendungsbedingung, die die Wärmepumpe zum Beenden des Betriebs im Abtaumodus veranlasst; und 40
 - eine Betriebssteuereinheit, die konfiguriert ist zum Veranlassen der Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen durch die Abtaubedingungsbestimmungseinheit bestimmten Abtaueinleitungsbedingung, zum Starten des Betriebs im Abtaumodus und zum Veranlassen der Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen bestimmten Abtaubeendungsbedingung, zum Beenden des Betriebs im Abtaumodus, wobei die Abtaubedingungsbestimmungseinheit konfiguriert ist zum Bewirken, dass eine kontinuierliche Betriebszeit der Wärmepumpe im Abtaumodus in der Ausgangsmodulationsperiode unter der zweiten Abtaubedingung kürzer ist als im Abtaumodus in einer Periode außerhalb der Ausgangsmodulationsperiode unter der ersten Abtaubedingung, indem sich mindestens eine der in der zweiten Abtaubedingung enthaltenen Abtaueinleitungsbedingung oder der Abtaubeendungsbedingung von der ersten Abtaubedingung unterscheidet. 45

dulationsperiode zu verwenden ist, wobei die erste Abtaubedingung und die zweite Abtaubedingung jeweils eine Abtaueinleitungsbedingung, die die Wärmepumpe zum Starten des Betriebs im Abtaumodus veranlasst, und eine Abtaubeendungsbedingung, die die Wärmepumpe zum Beenden des Betriebs im Abtaumodus veranlasst; und 5

eine Betriebssteuereinheit, die konfiguriert ist zum Veranlassen der Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen durch die Abtaubedingungsbestimmungseinheit bestimmten Abtaueinleitungsbedingung, zum Starten des Betriebs im Abtaumodus und zum Veranlassen der Wärmepumpe, auf Basis des Erfüllens der beim Bestimmen bestimmten Abtaubeendungsbedingung, zum Beenden des Betriebs im Abtaumodus, 10

wobei die Abtaubedingungsbestimmungseinheit konfiguriert ist zum Bewirken, dass eine kontinuierliche Betriebszeit der Wärmepumpe im Abtaumodus in der Ausgangsmodulationsperiode unter der zweiten Abtaubedingung kürzer ist als im Abtaumodus in einer Periode außerhalb der Ausgangsmodulationsperiode unter der ersten Abtaubedingung, indem sich mindestens eine der in der zweiten Abtaubedingung enthaltenen Abtaueinleitungsbedingung oder der Abtaubeendungsbedingung von der ersten Abtaubedingung unterscheidet. 15

Revendications

1. Procédé de commande d'un système de chauffage qui fonctionne au moyen d'un courant amené d'une source d'alimentation en courant, le système de chauffage comportant : 40
 - une pompe à chaleur qui génère de la chaleur au moyen du courant amené de la source d'alimentation en courant ; et 45
 - une unité de rayonnement qui fait rayonner la chaleur générée par la pompe à chaleur, la pompe à chaleur fonctionnant soit en mode chauffage destiné pour la génération de la chaleur destinée à être rayonnée par l'unité de rayonnement soit en mode dégivrage pour l'élimination du givre formé sur la pompe à chaleur, le procédé comprenant : 50
 - l'obtention, de la source d'alimentation en courant, d'une instruction de modulation de sortie indiquant une période de modulation 55

- de sortie pendant laquelle la consommation de courant par la pompe à chaleur est modulée ;
- la détermination d'un premier état de dégivrage à utiliser pendant une période située en dehors de la période de modulation de sortie et d'un deuxième état de dégivrage à utiliser pendant la période de modulation de sortie, le premier état de dégivrage et le deuxième état de dégivrage incluant chacun un état de démarrage de dégivrage destiné à amener la pompe à chaleur à commencer à fonctionner en mode dégivrage et un état d'arrêt de dégivrage destiné à amener la pompe à chaleur à arrêter de fonctionner en mode dégivrage ; et la commande du fonctionnement de la pompe à chaleur pour amener la pompe à chaleur à commencer à fonctionner en mode dégivrage sur la base de la satisfaction de l'état de démarrage de dégivrage déterminé lors de la détermination et pour amener la pompe à chaleur à s'arrêter de fonctionner en mode dégivrage sur la base de la satisfaction de l'état d'arrêt de dégivrage déterminé lors de la détermination, dans lequel, lors de la détermination, un temps de fonctionnement continu de la pompe à chaleur en mode dégivrage pendant la période de modulation de sortie dans le deuxième état de dégivrage est rendu plus court que pendant une période en dehors de la période de modulation de sortie dans le premier état de dégivrage en rendant au moins un parmi l'état de démarrage de dégivrage ou l'état d'arrêt de dégivrage inclus dans le deuxième état de dégivrage différent de celui du premier état de dégivrage.
2. Procédé selon la revendication 1, dans lequel, lors de la détermination, à intervalles prédéterminés pendant la période de modulation de sortie, l'atteinte de l'état de démarrage de dégivrage inclus dans le deuxième état de dégivrage est déterminée pour être un temps de dégivrage requis atteignant un temps de dégivrage permmissible, le temps de dégivrage requis étant un laps de temps allant du moment où la pompe à chaleur passe en mode dégivrage au moment où l'état d'arrêt de dégivrage est satisfait, et le temps de dégivrage permmissible étant un laps de temps allant du moment où la pompe à chaleur passe en mode dégivrage au moment où une température de la pièce atteint une valeur limite inférieure prédéterminée.
 3. Procédé selon la revendication 2, dans lequel le système de chauffage détient des in-

formations associant une température extérieure et une température de surface d'un échangeur de chaleur extérieur inclus dans la pompe à chaleur au temps de dégivrage requis, et des informations associant la température extérieure et la température de la pièce au temps de dégivrage permmissible, lors de l'obtention, la température extérieure, la température de surface de l'échangeur de chaleur extérieur, et la température de la pièce sont obtenues, et lors de la commande, l'atteinte de l'état de démarrage de dégivrage inclus dans le deuxième état de dégivrage est évaluée à intervalles prédéterminés pendant la période de modulation de sortie au moyen (i) du temps de dégivrage requis associé à la température extérieure et à la température de surface de l'échangeur de chaleur extérieur obtenues lors de l'obtention et (iii) du temps de dégivrage permmissible associé à la température extérieure et à la température de la pièce obtenues lors de l'obtention.

4. Procédé selon la revendication 2, dans lequel le système de chauffage détient des informations associant la température extérieure et une température d'un réfrigérant dans la pompe à chaleur au temps de dégivrage requis, et des informations associant la température extérieure et la température de la pièce au temps de dégivrage permmissible, lors de l'obtention, la température extérieure, la température du réfrigérant, et la température de la pièce sont obtenues, et lors de la commande, l'atteinte de l'état de démarrage de dégivrage inclus dans le deuxième état de dégivrage est évaluée à intervalles prédéterminés pendant la période de modulation de sortie au moyen (i) du temps de dégivrage requis associé à la température extérieure et à la température du réfrigérant obtenues lors de l'obtention et (ii) du temps de dégivrage permmissible associé à la température extérieure et à la température de la pièce obtenues lors de l'obtention.
5. Procédé selon la revendication 1, dans lequel l'état de démarrage de dégivrage inclut une valeur limite inférieure pour une température de surface d'un échangeur de chaleur extérieur inclus dans la pompe à chaleur, et lors de la détermination, la valeur limite inférieure pour la température de surface de l'échangeur de chaleur extérieur incluse dans le deuxième état de dégivrage est paramétrée pour être supérieure à la valeur limite inférieure pour la température de surface de l'échangeur de chaleur extérieur incluse dans le premier état de dégivrage.
6. Procédé selon l'une quelconque des revendications 1 à 5, dans lequel l'état d'arrêt de dégivrage inclut une va-

- leur limite supérieure pour une température de surface d'un échangeur de chaleur extérieur inclus dans la pompe à chaleur, et
lors de la détermination, la valeur limite supérieure pour la température de surface de l'échangeur de chaleur extérieur incluse dans le deuxième état de dégivrage est paramétrée pour être inférieure à la valeur limite supérieure pour la température de surface de l'échangeur de chaleur extérieur incluse dans le premier état de dégivrage. 5 10
7. Procédé selon la revendication 1, dans lequel l'état de démarrage de dégivrage inclut une valeur limite inférieure pour une température d'un réfrigérant dans la pompe à chaleur, et 15
lors de la détermination, la valeur limite inférieure pour la température du réfrigérant incluse dans le deuxième état de dégivrage est paramétrée pour être supérieure à la valeur limite inférieure pour la température du réfrigérant incluse dans le premier état de dégivrage. 20
8. Procédé selon l'une quelconque des revendications 1 ou 7, dans lequel l'état d'arrêt de dégivrage inclut une valeur limite supérieure pour une température d'un réfrigérant dans la pompe à chaleur, et 25
lors de la détermination, la valeur limite supérieure pour la température du réfrigérant incluse dans le deuxième état de dégivrage est paramétrée pour être inférieure à la valeur limite supérieure pour la température du réfrigérant incluse dans le premier état de dégivrage. 30
9. Procédé selon l'une quelconque des revendications 1 à 8, dans lequel lors de la commande, la pompe à chaleur est amenée à commencer à fonctionner en mode dégivrage sur la base de la satisfaction continue de l'état de démarrage de dégivrage pendant une période de temps prédéterminée, et amenée à interrompre le fonctionnement en mode dégivrage sur la base de la satisfaction continue de l'état d'arrêt de dégivrage pendant une période de temps prédéterminée. 35 40 45
10. Procédé selon l'une quelconque des revendications 1 à 9, dans lequel, lors de la commande, la pompe à chaleur fonctionnant en mode chauffage est amenée en outre à générer une première quantité de chaleur par unité de temps pendant une période située en dehors de la période de modulation de sortie et à générer une deuxième quantité de chaleur par unité de temps pendant la période de modulation de sortie, la deuxième quantité de chaleur étant inférieure à la première quantité de chaleur. 50 55
11. Système de chaleur qui fonctionne au moyen d'un courant amené d'une source d'alimentation en courant, le système de chauffage comprenant :
- une pompe à chaleur qui génère de la chaleur au moyen du courant amené de la source d'alimentation en courant ;
une unité de rayonnement configurée pour faire rayonner la chaleur générée par la pompe à chaleur ; et
une unité de commande configurée pour commander le fonctionnement de la pompe à chaleur, la pompe à chaleur fonctionnant soit en mode chauffage pour la génération de la chaleur destinée à être rayonnée par l'unité de rayonnement soit en mode dégivrage pour l'élimination du givre formé sur la pompe à chaleur, et l'unité de commande comprenant :
- une unité d'obtention configurée pour obtenir, de la source d'alimentation en courant, une instruction de modulation de sortie indiquant une période de modulation de sortie pendant laquelle la consommation de courant par la pompe à chaleur est modulée ;
une unité de détermination d'état de dégivrage configurée pour déterminer un premier état de dégivrage à utiliser pendant une période située en dehors de la période de modulation de sortie et un deuxième état de dégivrage à utiliser pendant la période de modulation de sortie, le premier état de dégivrage et le deuxième état de dégivrage incluant chacun un état de démarrage de dégivrage destiné à amener la pompe à chaleur à commencer à fonctionner en mode dégivrage et un état d'arrêt de dégivrage destiné à amener la pompe à chaleur à arrêter de fonctionner en mode dégivrage ; et
une unité de commande de fonctionnement configurée pour amener la pompe à chaleur à commencer à fonctionner en mode dégivrage sur la base de la satisfaction de l'état de démarrage de dégivrage déterminé par la détermination de l'état de dégivrage et pour amener la pompe à chaleur à s'arrêter de fonctionner en mode dégivrage sur la base de la satisfaction de l'état d'arrêt de dégivrage déterminé par la détermination de l'état de dégivrage, dans lequel l'unité de détermination d'état de dégivrage est configurée pour rendre un temps de fonctionnement continu de la pompe à chaleur en mode dégivrage pendant la période de modulation de sortie dans le deuxième état de dégivrage plus court qu'en mode dégivrage pendant une période

en dehors de la période de modulation de sortie dans le premier état de dégivrage en rendant au moins un parmi l'état de démarrage de dégivrage ou l'état d'arrêt de dégivrage inclus dans le deuxième état de dégivrage différent de celui du premier état de dégivrage.

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FIG. 1

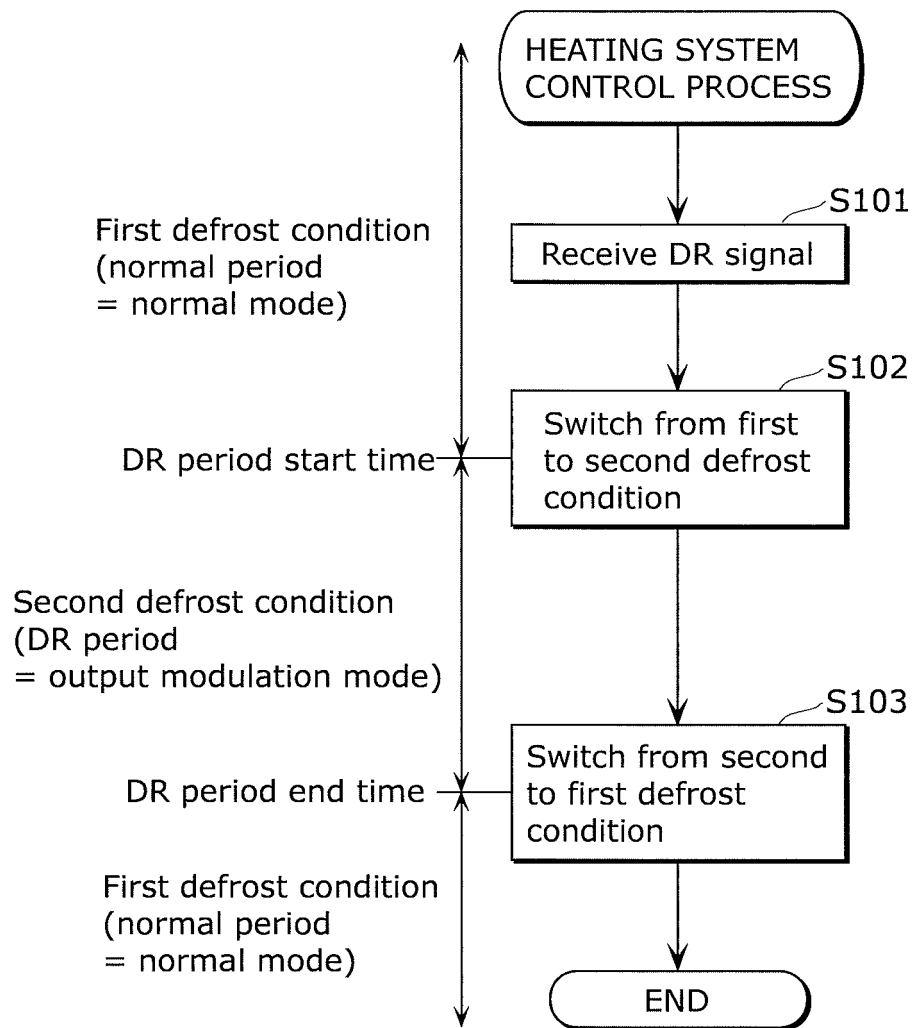


FIG. 2

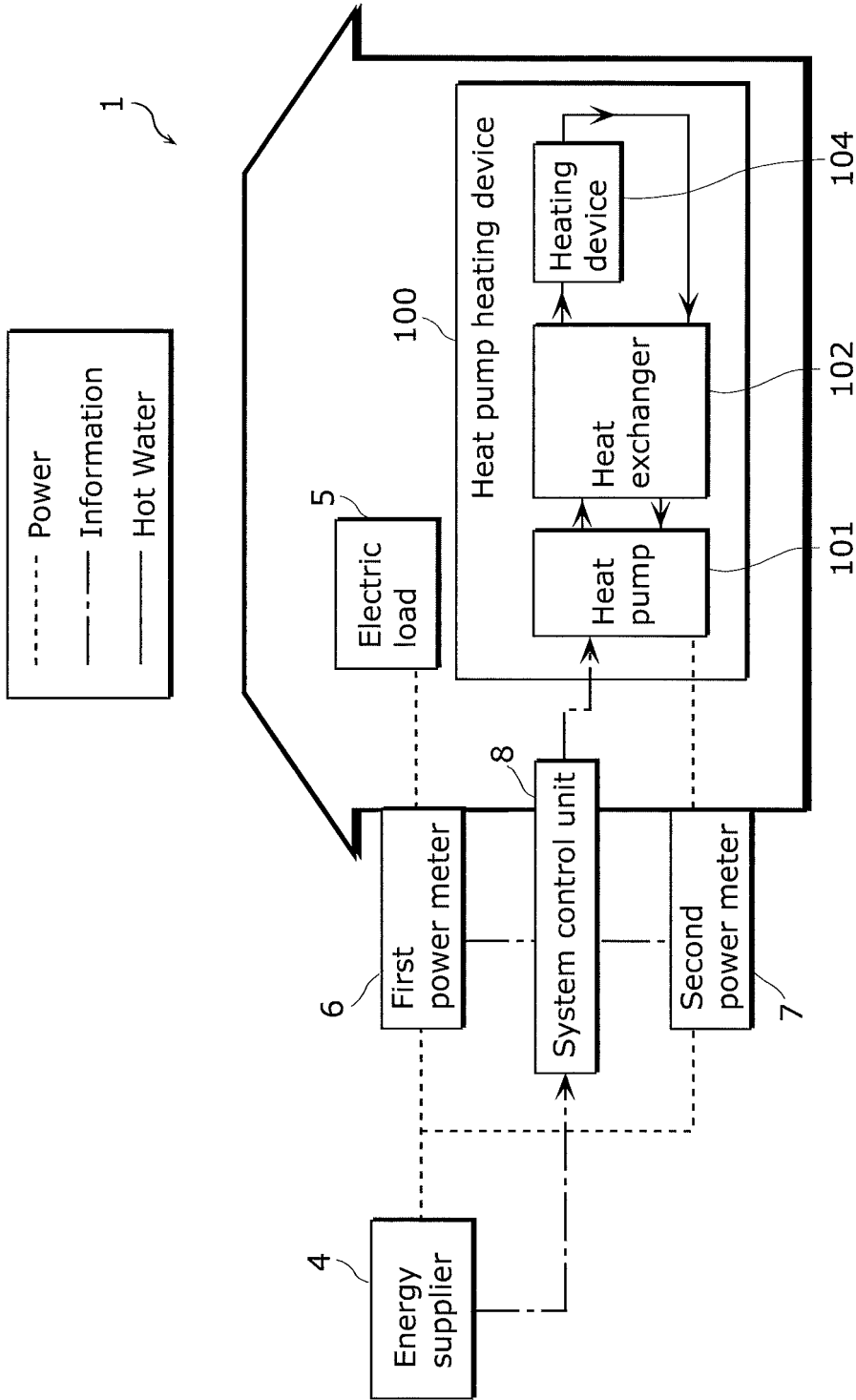


FIG. 3

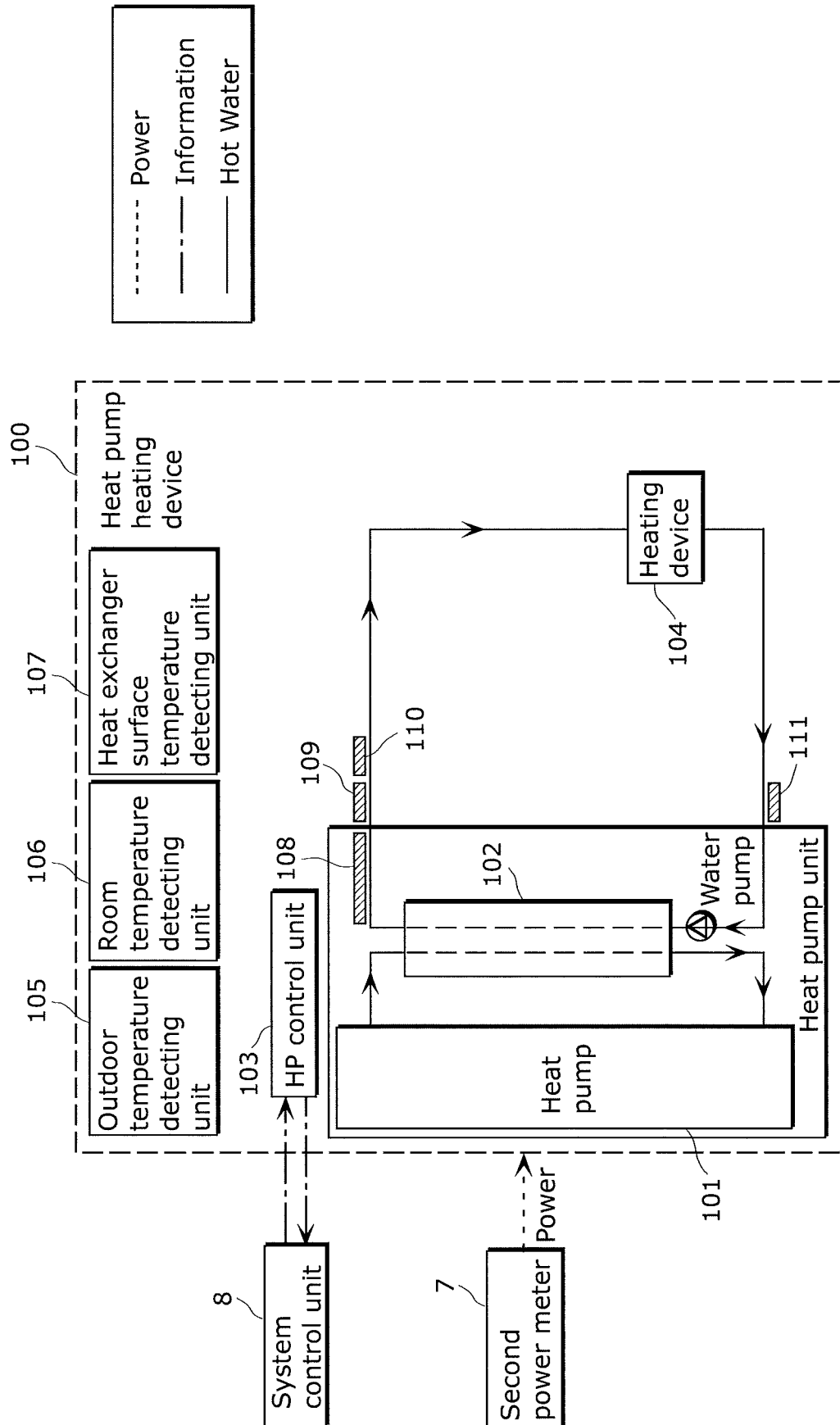


FIG. 4A

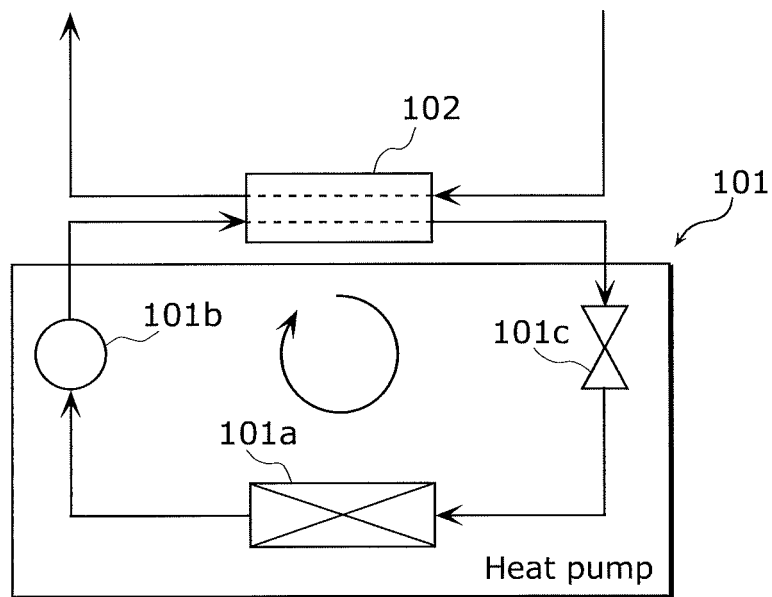


FIG. 4B

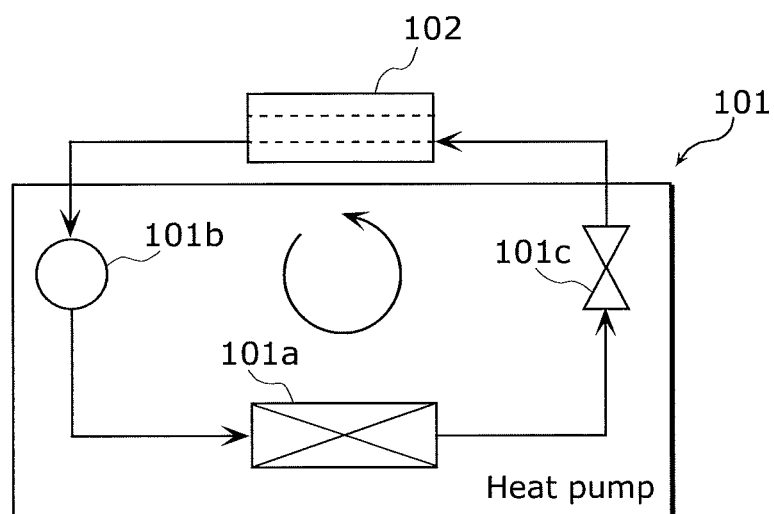


FIG. 5

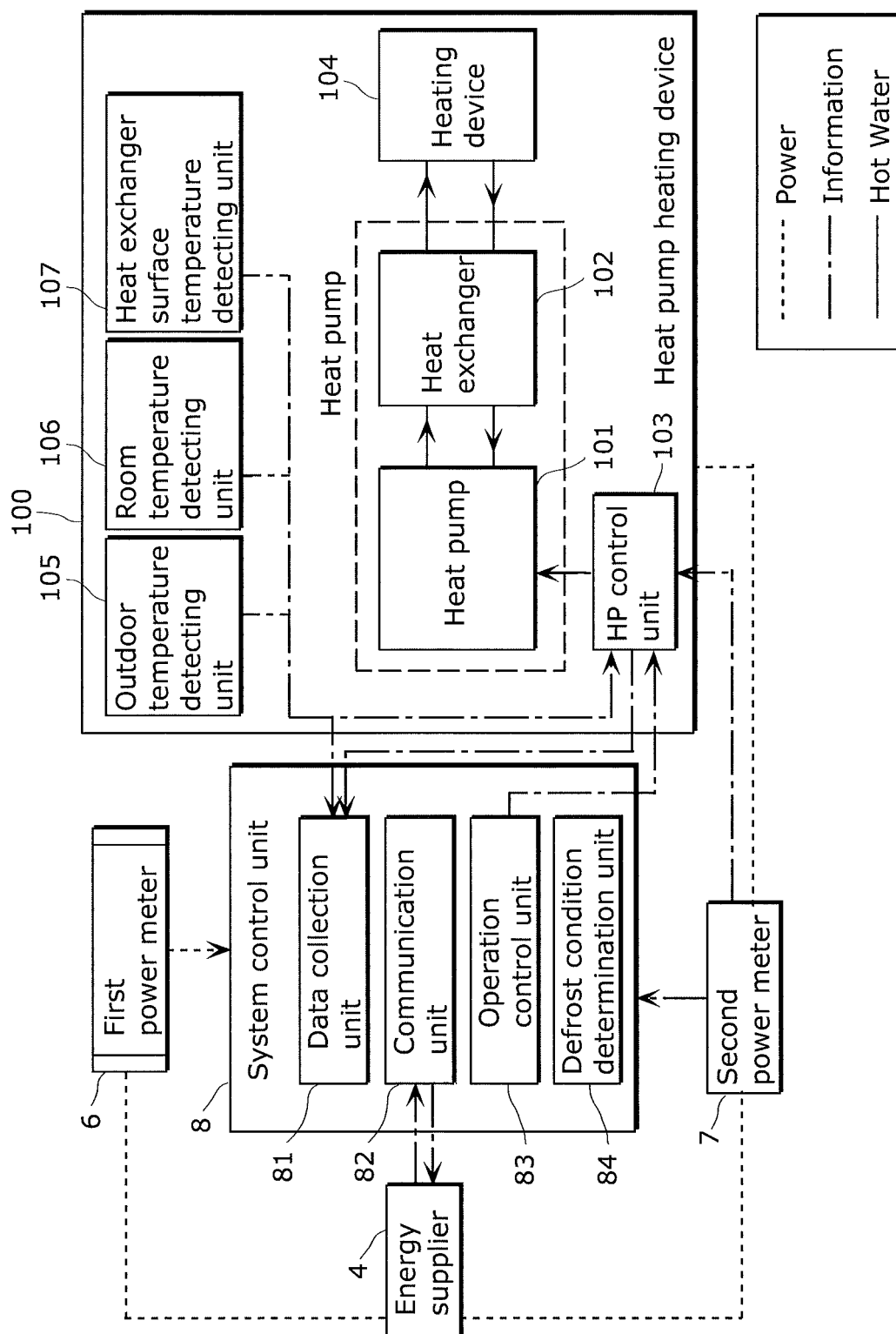


FIG. 6

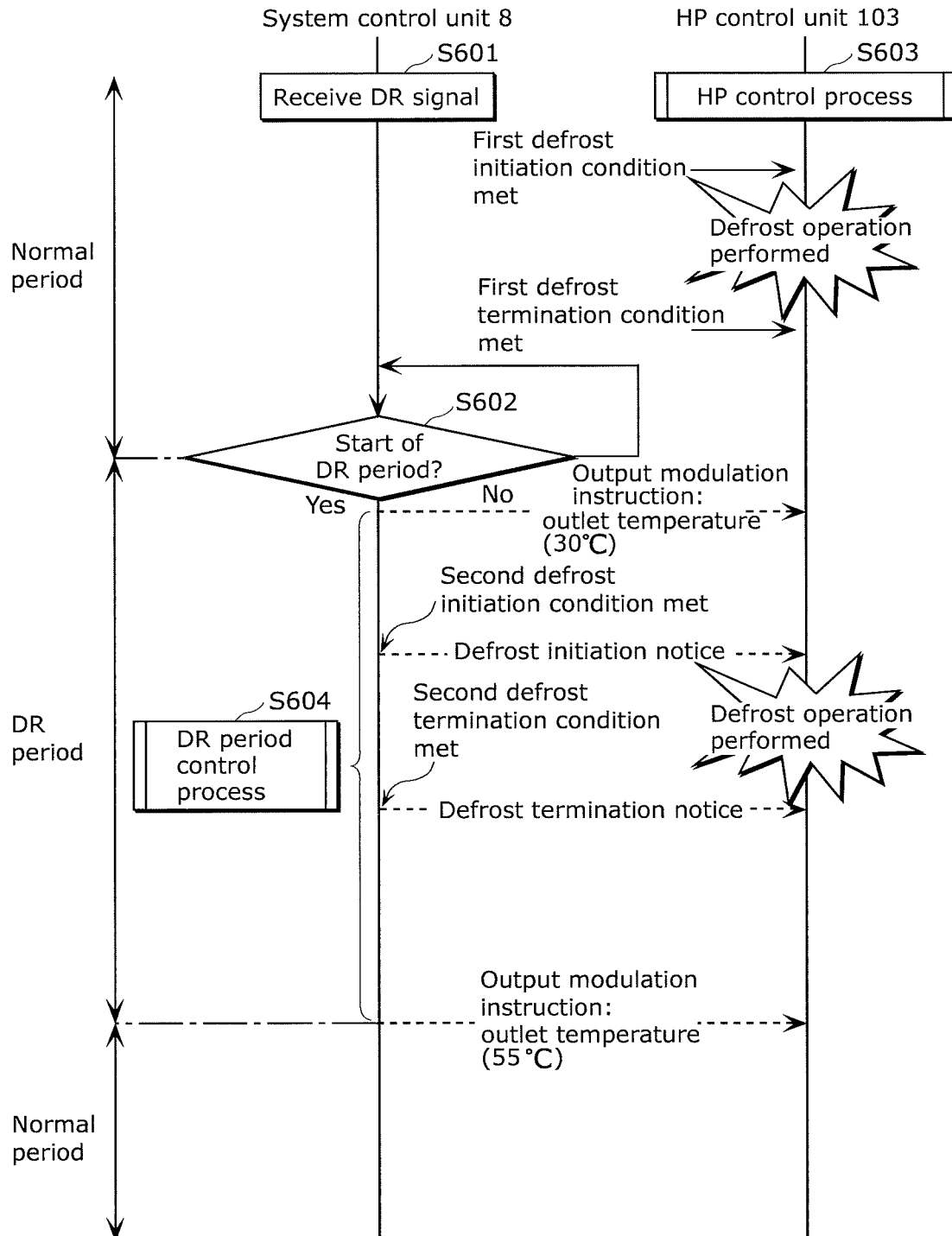


FIG. 7

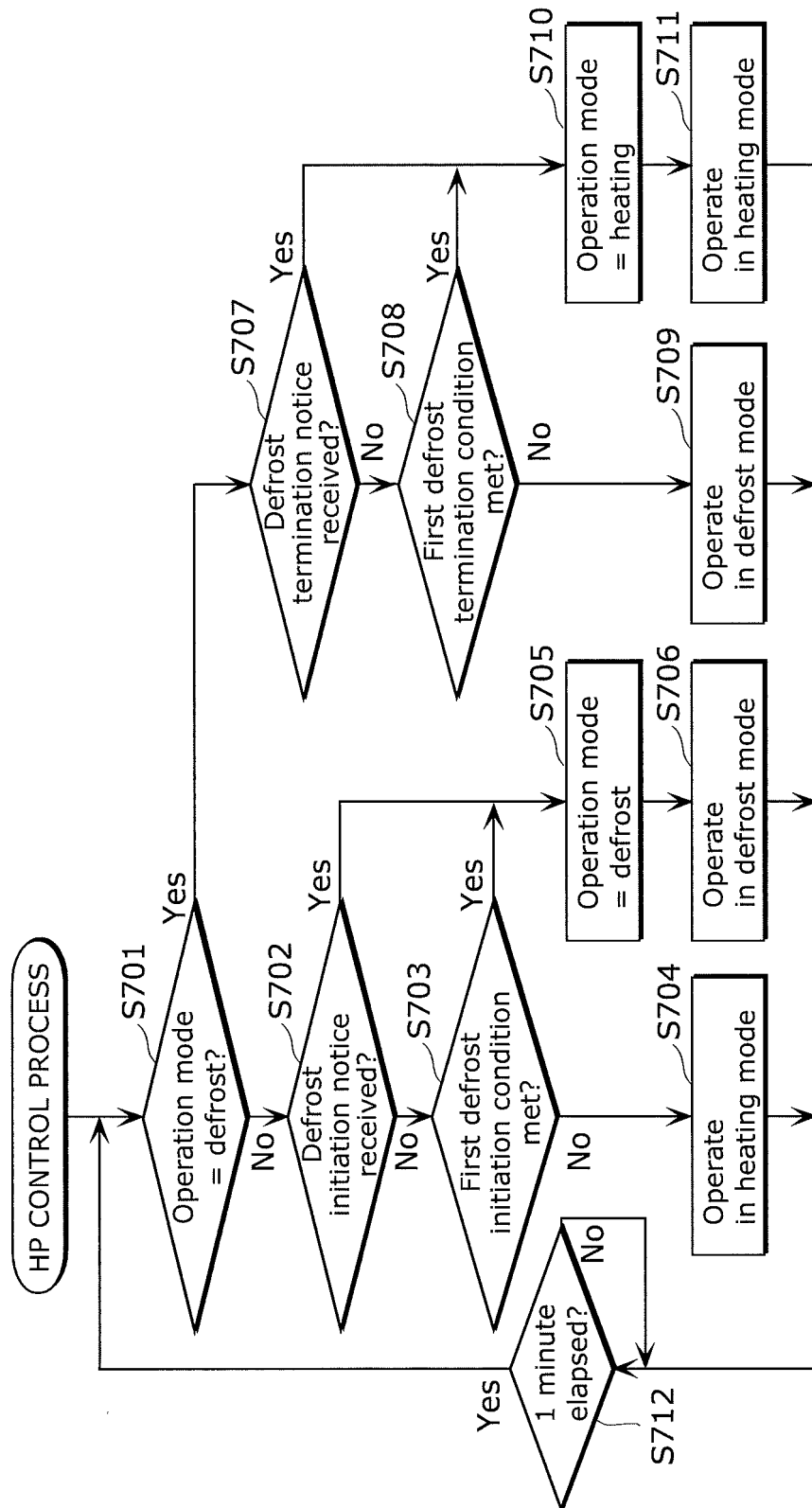


FIG. 8

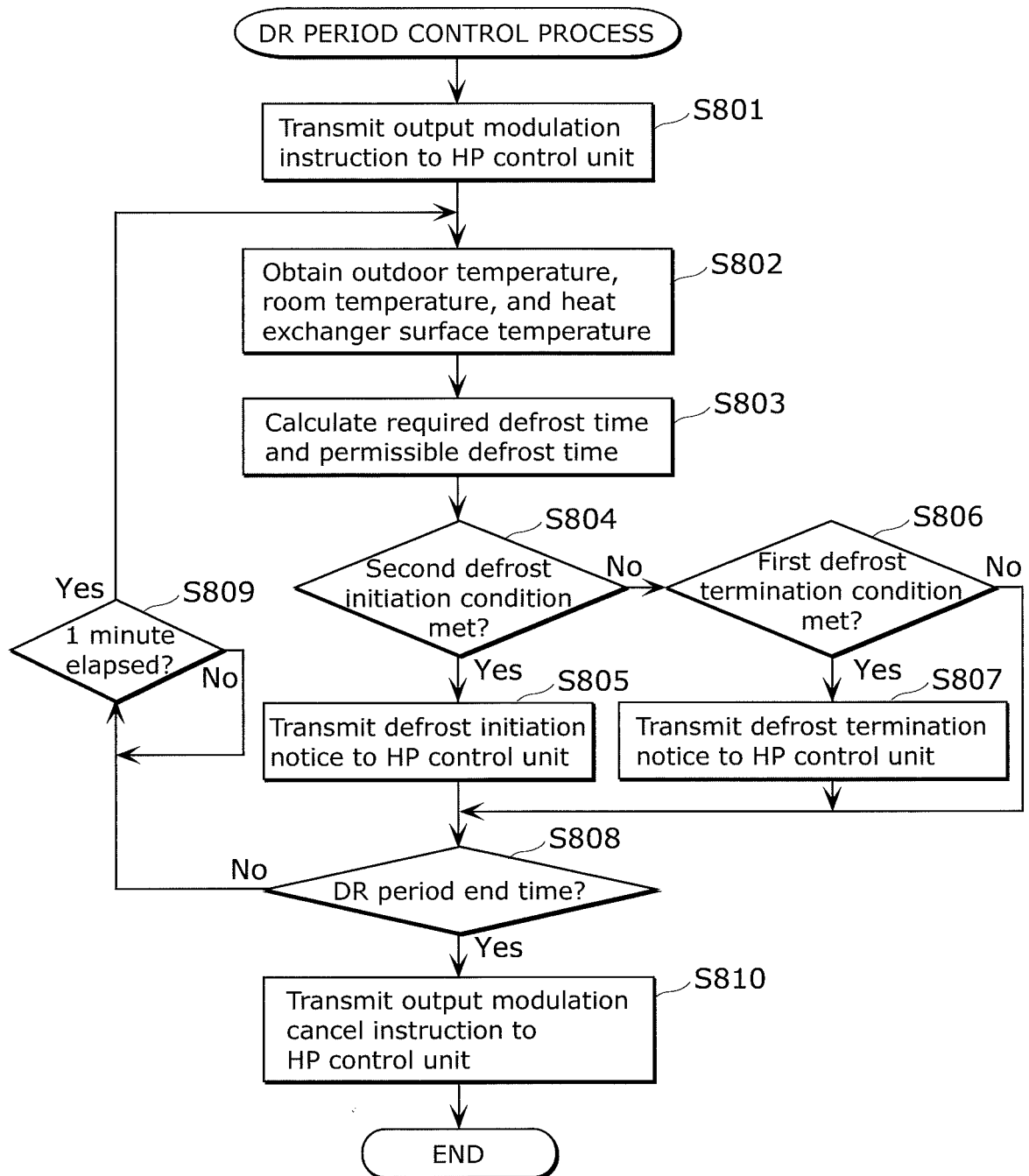


FIG. 9A

Outdoor temperature (°C)	...	0	0	0	0	-1	-1	-1	...
Heat exchanger surface temperature (°C)	...	-5	-6	-7	-8	-5	-6	-7	...
Required defrost time (min)	...	7	7.5	8	8.5	9	9.5	10	...

FIG. 9B

Permissible defrost time	Outdoor temperature (°C)	...	0	0	0	+1	+1	+1	...
	Room temperature (°C)	...	19	20	21	19	20	21	...
	0.5°C decrease in room temperature (min)	...	4	5	6	5	6	7	...
	1.0°C decrease in room temperature (min)	...	7	8	9	8	9	10	...
	...	...							...

FIG. 9C

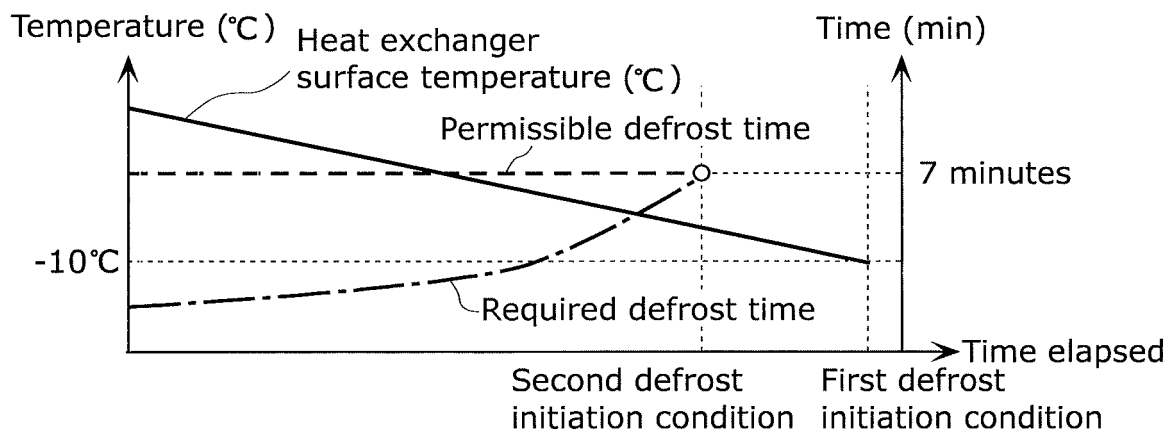


FIG. 10

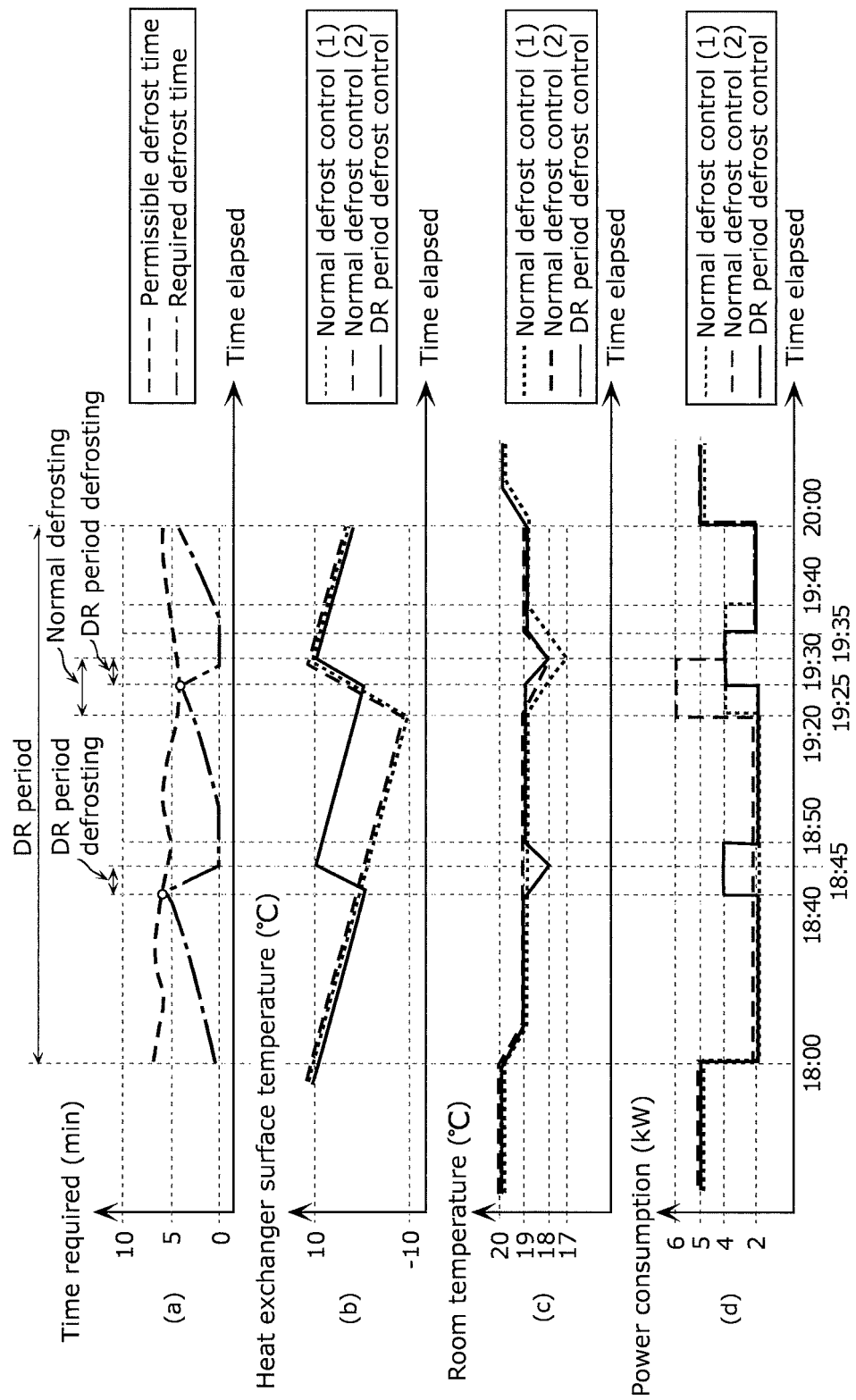


FIG. 11

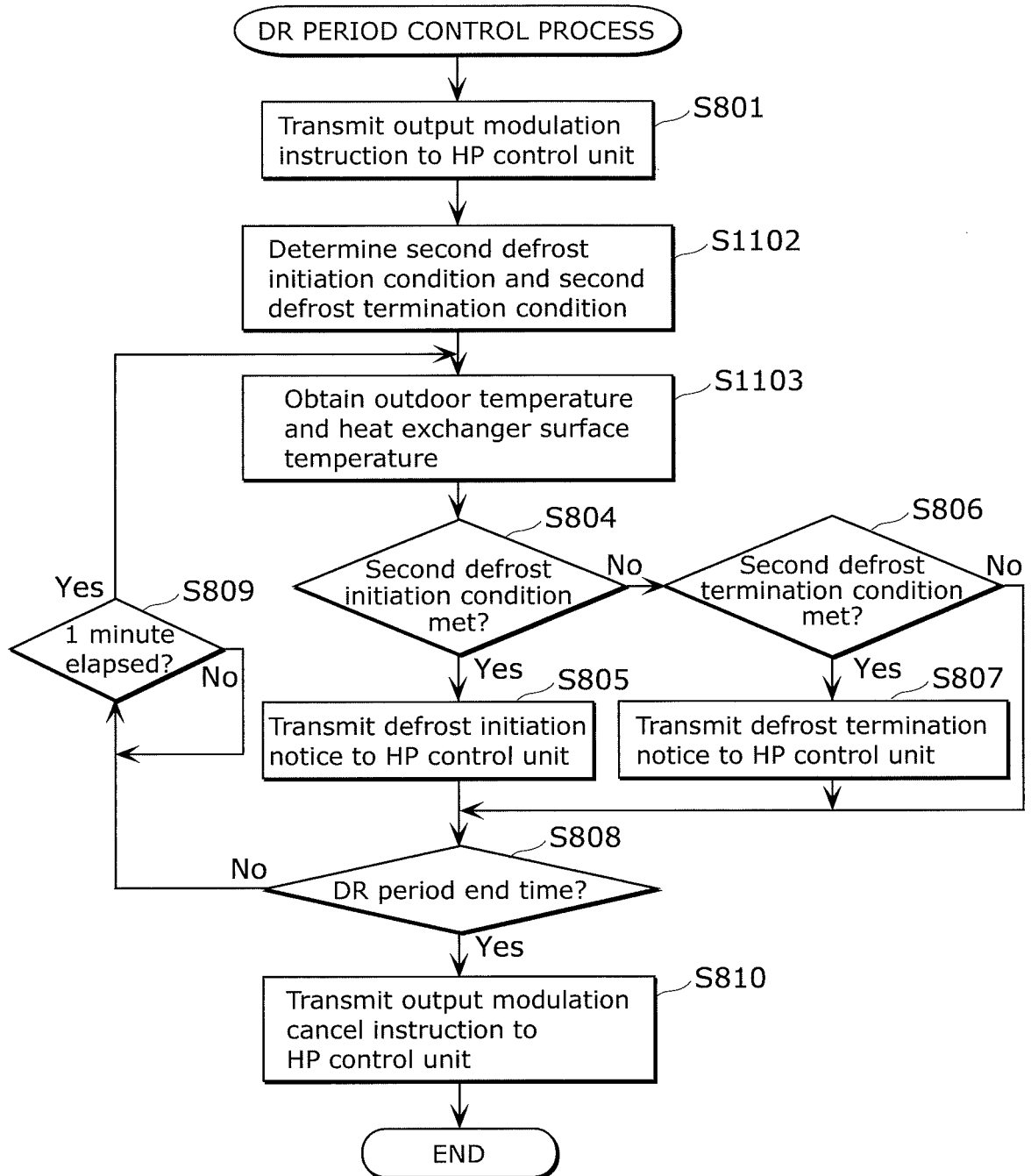


FIG. 12

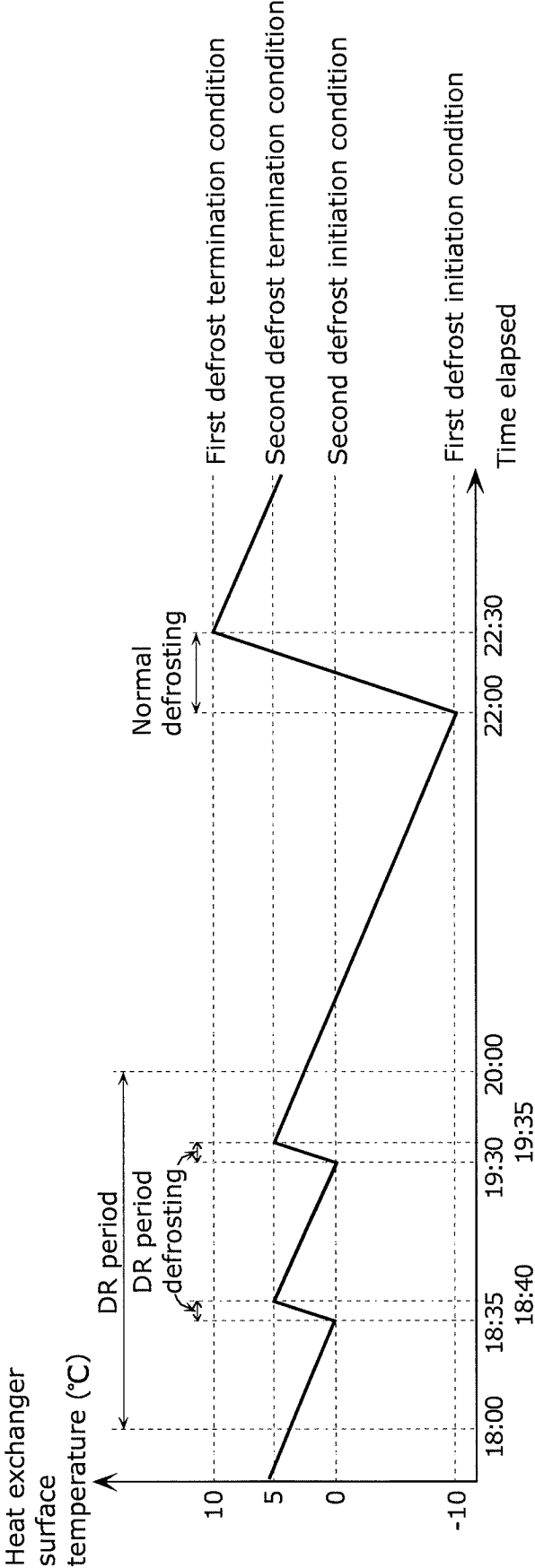


FIG. 13

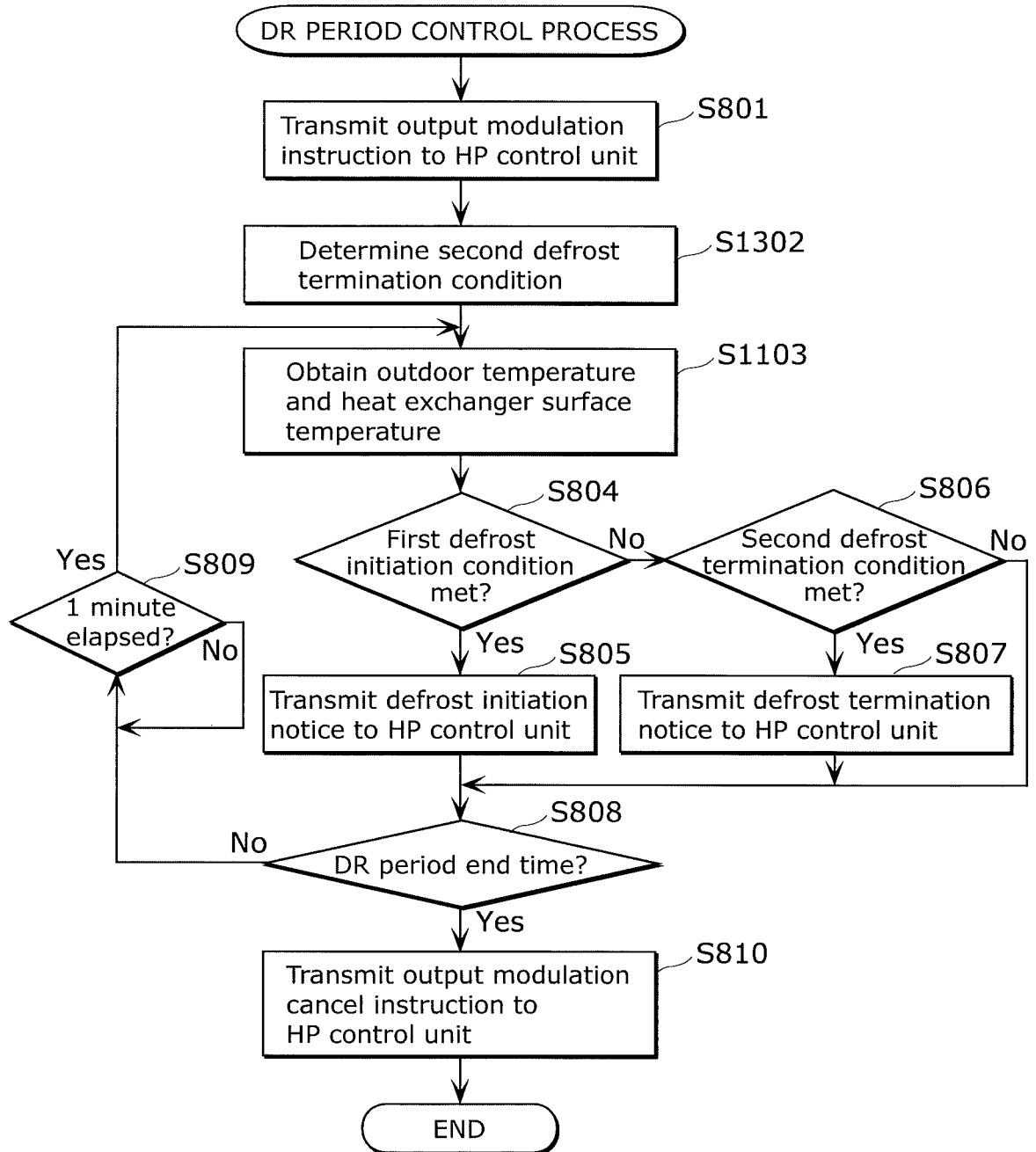
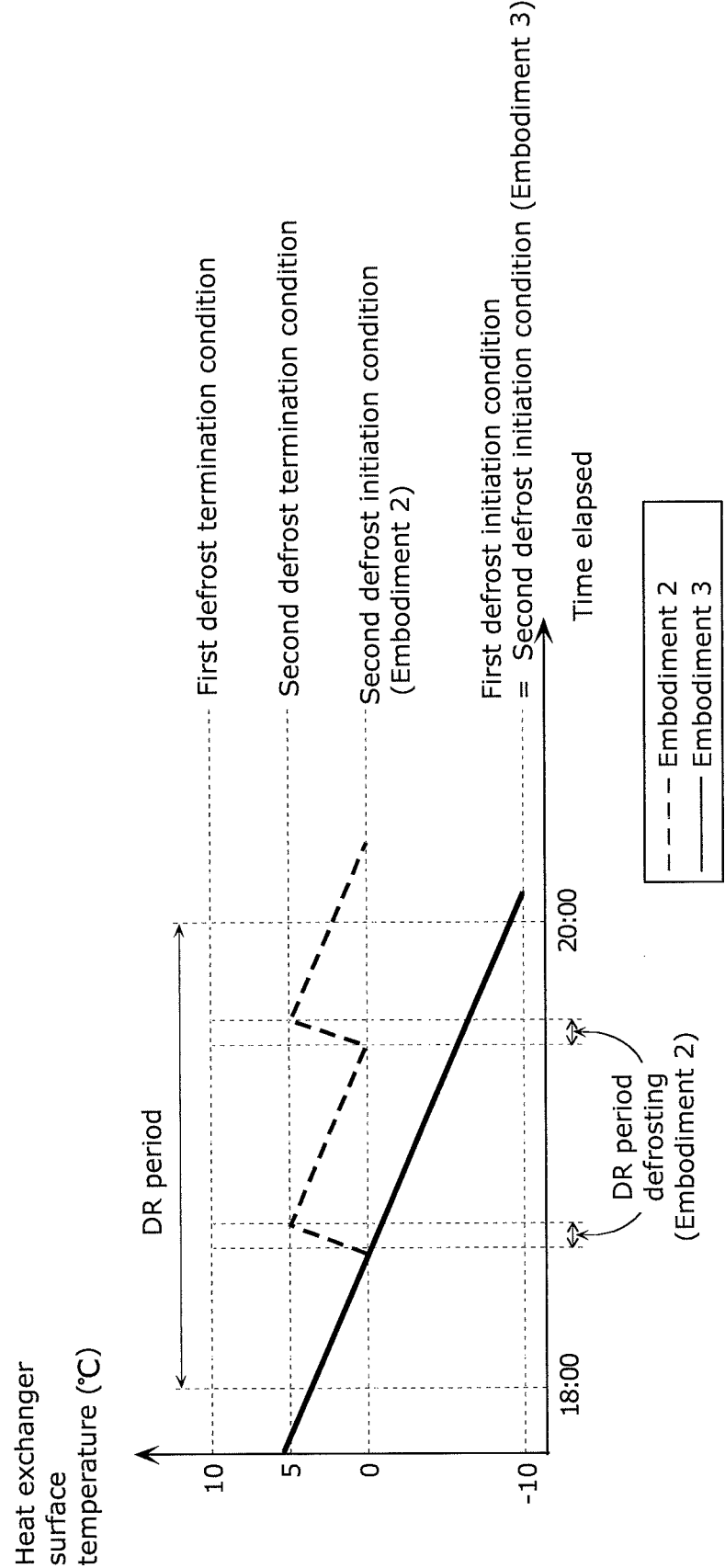


FIG. 14



REFERENCES CITED IN THE DESCRIPTION

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