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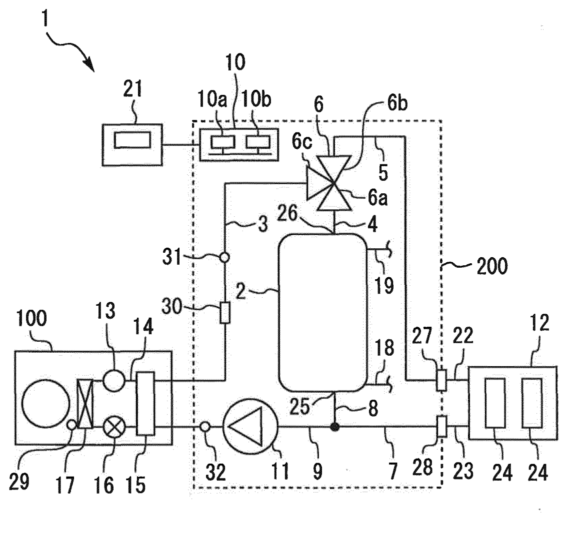
(54) HEATING MEDIUM CIRCULATION SYSTEM

(57) A heating medium circulation system (1) includes: a circulation pump (11) configured to circulate a heating medium through a circulation circuit passing through an indoor-heating terminal (12) and a heat pump device (100); a controller (10) configured to execute indoor-heating operation for supplying the heating medium heated by the heat pump device (100) to the indoor-heating terminal (12) and defrosting operation for causing frost adhering to an air heat exchanger (17) to melt, and a supply temperature sensor (31) configured to detect a supply temperature that is a temperature of the heating medium supplied to the indoor-heating terminal (12) from the heat pump device (100). The controller (10) deactivates the compressor (13) when the supply temperature exceeds a first deactivation temperature in the indoor-heating operation after a predetermined period of time elapses from a switching time point from the defrosting operation to the indoor-heating operation and continues operation of the compressor (13) even when the supply temperature exceeds the first deactivation temperature in the indoor-heating operation in a post-defrosting period that is a period until the predetermined period of time elapses from the switching time point.

FIG. 1



EP 3 608 603 A1

Description

[Technical Field]

[0001] The present invention relates to a heating medium circulation system.

[Background Art]

[0002] An indoor-heating system that circulates a liquid heating medium heated by a heat pump to an indoor-heating terminal has been known. The heat pump includes an air heat exchanger that exchanges heat between a refrigerant and air and a compressor that compresses the refrigerant. When indoor-heating operation is performed when the outside air temperature is low, frost may adhere to the air heat exchanger. In this case, there is a need to temporarily suspend the indoor-heating operation and perform defrosting operation for removing the frost.

[0003] A system disclosed in PTL 1 described below is as follows. When the operation is restarted after the defrosting operation ends, an upper limit of the temperature of warm water supplied to the floor indoor-heating device is set to 55°C, 50°C, 45°C, and the like. The period of time at the upper limit 55°C is set to five minutes and the period of time at the upper limit 50°C is set to five minutes.

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Patent Application Publication No. 2006-046703

[Summary of Invention]

[Technical Problem]

[0005] When the supply temperature of the heating medium to the indoor-heating terminal becomes too high, comfort may possibly be deteriorated. Therefore, it can be conceived to stop the indoor-heating operation when the supply temperature exceeds a predetermined temperature. However, when the frequency of activating and deactivating the compressor is high, there may be harmful effects such as energy loss and a decrease in the life of the compressor.

[0006] The present invention has been made in order to solve the problems as above, and has an object to provide a heating medium circulation system capable of reducing the frequency of activating and deactivating a compressor included in heating means for heating a heating medium.

[Solution to Problem]

[0007] A heating medium circulation system according to the present invention includes: a heating means for heating a liquid heating medium, the heating means including an air heat exchanger configured to exchange heat between a refrigerant and air and a compressor configured to compress the refrigerant; a pump configured to circulate the heating medium through a circulation circuit passing through an indoor-heating terminal and the heating means; a control means electrically connected to the heating means and the pump, the control means being configured to execute indoor-heating operation for suppling the heating medium heated by the heating means to the indoor-heating terminal and defrosting operation for causing frost adhering to the air heat exchanger to melt; and a means for detecting a supply temperature that is a temperature of the heating medium supplied to the indoor-heating terminal from the heating means. The control means is configured to deactivate the compressor when the supply temperature exceeds a first deactivation temperature in the indoor-heating operation after a predetermined period of time elapses from a switching time point from the defrosting operation to the indoor-heating operation. The control means is configured not to deactivate the compressor when the supply temperature exceeds the first deactivation temperature in the indoor-heating operation in a post-defrosting period that is a period until the predetermined period of time elapses from the switching time point.

[Advantageous Effects of Invention]

[0008] According to the present invention, the frequency of activating and deactivating the compressor included in the heating means for heating the heating medium can be reduced.

[Brief Description of Drawings]

[0009]

Fig. 1 is a view illustrating a heating medium circulation system according to Embodiment 1.

Fig. 2 is a view illustrating circulation circuits of a refrigerant and a heating medium at the time of an indoor-heating operation of the heating medium circulation system of Embodiment 1.

Fig. 3 is a view illustrating a circulation circuit of the refrigerant at the time of a defrosting operation of the heating medium circulation system of Embodiment 1.

Fig. 4 is a graph showing an example of a temporal fluctuation of an actual supply temperature when an operation is switched in the order of the indoor-heating operation, the defrosting operation, and the restart of the indoor-heating operation.

[Description of Embodiments]

[0010] Embodiments are described below with reference to the drawings. Common or corresponding elements in the drawings are denoted by the same reference numerals, and duplicate descriptions are simplified or omitted.

Embodiment 1

[0011] Fig. 1 is a view illustrating a heating medium circulation system 1 according to Embodiment 1. As illustrated in Fig. 1, the heating medium circulation system 1 includes a heat pump device 100, a tank unit 200, and a controller 10. The heating medium circulation system 1 corresponds to a heat-pump-type hot-water supply indoor-heating system. The heat pump device 100 and the tank unit 200 are connected to each other via a first passage 3, a second passage 9, and electric wiring (not shown). The heat pump device 100 is installed outdoors. The tank unit 200 may be installed outdoors or may be installed indoors.

[0012] The heating medium circulation system 1 of Embodiment 1 has a configuration in which the heat pump device 100 and the tank unit 200 are separated from each other. The present invention is not limited to the configuration as above, and the heat pump device 100 and the tank unit 200 may be integrated.

[0013] The heat pump device 100 of Embodiment 1 is an example of heating means for heating a liquid heating medium. The heating medium may be liquid water or may be a liquid heating medium other than water such as any of a calcium chloride solution, an ethylene glycol solution, a propylene glycol solution, and alcohol, for example. The heat pump device 100 includes a refrigerant circuit including a compressor 13 that compresses the refrigerant, a heat exchanger 15, a decompression device 16 that decompresses the refrigerant, an air heat exchanger 17, and a refrigerant pipe 14 that annularly connects those devices. The heat pump device 100 performs an operation of a heat pump cycle, that is, a refrigerating cycle in the refrigerant circuit. The refrigerant sealed in the refrigerant circuit may be any of carbon dioxide, ammonia, propane, isobutane, fluorocarbons such as HFC, HFO-1123, and HFO-1234yf, for example. The heat exchanger 15 exchanges heat between a high-pressure and high-temperature refrigerant compressed by the compressor 13 and the heating medium. The decompression device 16 decompresses and expands the high-pressure refrigerant that has passed through the heat exchanger 15. The decompression device 16 may be an expansion valve capable of electrically controlling the opening degree. The refrigerant that has passed through the decompression device 16 flows into the air heat exchanger 17. The air heat exchanger 17 exchanges heat between outdoor air and the refrigerant. At the time of indoor-heating operation and heat accumulating operation, the refrigerant evaporates in the air heat exchanger 17 by absorbing the heat of the air. The heat pump device 100 may include a blower (not shown) that transmits outside air to the air heat exchanger 17.

[0014] The tank unit 200 includes a heat storage tank 2, a switching valve 6, and a circulation pump 11. The heating medium is stored in the heat storage tank 2. In the heat storage tank 2, a thermal stratification in which the temperature on the upper side is high and the temperature on the lower side is low is formed due to the difference in specific gravity of the heating medium in accordance with the temperature. A lower portion inlet passage 18 is connected to the lower portion of the heat storage tank 2. The heating medium having a relatively low temperature flows into the heat storage tank 2 through the lower portion inlet passage 18. An upper portion outlet passage 19 is connected to the upper portion of the heat storage tank 2. The heating medium accumulated in the heat storage tank 2 is supplied to a heat demand portion (not shown) through the upper portion outlet passage 19. The heat demand portion may be a heat exchanger for suppling hot water that heats water by exchanging heat between the heating medium and the water. A circulation circuit in which the heating medium that has passed through the heat demand portion returns to the lower portion of the heat storage tank 2 through the lower portion inlet passage 18 may be formed. When hot water is accumulated in the heat storage tank 2 as the heating medium, the hot water may be directly supplied to heat demand portions such as a hot water supply faucet, a bathtub, and a shower from the heat storage tank 2 through the upper portion outlet passage 19.

[0015] The heat storage tank 2 has an outlet 25 and an inlet 26. The heating medium in the heat storage tank 2 flows out from the outlet 25. The heating medium heated by the heat pump device 100 enters the heat storage tank 2 from the inlet 26. The outlet 25 is at the lower portion of the heat storage tank 2. The inlet 26 is at the upper portion of the heat storage tank 2. The switching valve 6 includes a first port 6a, a second port 6b, and a third port 6c. The switching valve 6 can be switched between a state in which the third port 6c and the first port 6a are in communication with each other and the second port 6b is blocked and a state in which the third port 6c and the second port 6b are in communication with each other and the first port 6a is blocked.

[0016] The lower portion outlet passage 8 connects the outlet 25 of the heat storage tank 2 and an upstream end of the second passage 9 to each other. A downstream end of the second passage 9 is connected to a heating medium inlet of the heat exchanger 15 of the heat pump device 100. The circulation pump 11 is connected to a place in the middle of the second passage 9. The operation speed of the circulation pump 11 can be changed. The circulation pump 11 may include a pulse width modulation control DC motor that can change the operation speed in accordance with a speed command voltage from the controller 10. In the illustrated configuration, the circulation pump 11 is installed in the tank unit

200. In place of the configuration, the circulation pump 11 may be installed in the heat pump device 100. The first passage 3 connects the heating medium outlet of the heat exchanger 15 of the heat pump device 100 and the third port 6c of the switching valve 6 to each other. The upper portion inlet passage 4 connects the first port 6a of the switching valve 6 and the inlet 26 of the heat storage tank 2 to each other. In the illustrated configuration, the circulation pump 11 is connected to a place in the middle of the second passage 9. In place of the configuration, the circulation pump 11 may be connected to a place in the middle of the first passage 3.

[0017] An indoor-heating terminal 12 includes at least one indoor-heating unit 24. The indoor-heating unit 24 heats the inside of a room by dissipating the heat of the heating medium. As the indoor-heating unit 24, at least one type out of a floor indoor-heating panel provided under the floor, a radiator or a panel heater provided on an indoor wall surface, and a fan convector, for example, can be used. When the indoor-heating terminal 12 includes a plurality of the indoor-heating units 24, the types of the indoor-heating units 24 may be the same or different. When the indoor-heating terminal 12 includes the plurality of indoor-heating units 24, the way of connecting the plurality of indoor-heating units 24 may be any of connection in series, parallel connection, and a combination of the connection in series and the parallel connection.

[0018] The tank unit 200 and the indoor-heating terminal 12 are connected to each other via an external passage 22 and an external passage 23. The tank unit 200 has an outlet 27 and an inlet 28. The heating medium supplied to the indoor-heating terminal 12 from the tank unit 200 flows out to the outside of the tank unit 200 from the outlet 27. A third passage 5 connects the second port 6b of the switching valve 6 and the outlet 27 to each other in the tank unit 200. An upstream end of the external passage 22 is connected to the outlet 27 from the outside of the tank unit 200. A downstream end of the external passage 22 is connected to an inlet of the indoor-heating terminal 12. An upstream end of the external passage 23 is connected to an outlet of the indoor-heating terminal 12. A downstream end of the external passage 23 is connected to the inlet 28 from the outside of the tank unit 200. A fourth passage 7 connects the inlet 28 and an upstream end of the second passage 9 to each other in the tank unit 200. The heating medium returning to the tank unit 200 from the indoor-heating terminal 12 enters the tank unit 200 from the inlet 28.

[0019] In the illustrated configuration, the controller 10 is installed in the tank unit 200. The controller 10 and a terminal device 21 are connected to each other so as to be able to transmit data to each other in a wired or wireless manner. The terminal device 21 may be installed in a room including the indoor-heating unit 24. The terminal device 21 has a function of receiving an operation motion command, the change of the setting value, and operations by a user relating to other matters. The terminal device 21 is an example of an operation display terminal or a user interface. The terminal device 21 may include a display that displays information on the state of the heating medium circulation system 1 and the like, operation portions such as buttons or keys operated by the user, a speaker, a microphone, and the like. The heating medium circulation system 1 may include a plurality of the terminal devices 21 installed in different places. The above-mentioned display may be any of a liquid crystal display, an organic electro-luminescence (EL) display, and a touchscreen also having a function of an operation portion. The terminal device 21 may output a speech guidance from the speaker. The terminal device 21 functions as notification means for the user by performing at least one of the display by the display and the speech guidance from the speaker.

[0020] A plurality of temperature sensors (not shown) may be attached to the surface of the heat storage tank 2 so as to be separated from each other in the vertical direction. The controller 10 can calculate the heat storage amount in the heat storage tank 2 by detecting the temperature distribution in the heat storage tank 2 in the vertical direction by those temperature sensors.

[0021] A flow rate sensor 30 and a supply temperature sensor 31 are installed in the middle of the first passage 3. The flow rate sensor 30 detects the volumetric flow rate of the heating medium passing through the first passage 3. In the description below, the temperature of the heating medium flowing out from the heat pump device 100 is referred to as a "supply temperature". The "supply temperature" at the time of the indoor-heating operation corresponds to the temperature of the heating medium supplied to the indoor-heating terminal 12 from the heat pump device 100. The supply temperature can be detected by the supply temperature sensor 31. In Embodiment 1, the flow rate sensor 30 and the supply temperature sensor 31 are installed in the tank unit 200. In place of the configuration, the flow rate sensor 30 and the supply temperature sensor 31 may be installed in the heat pump device 100.

[0022] A return temperature sensor 32 is provided in the second passage 9. The return temperature sensor 32 detects the temperature of the heating medium flowing into the heat pump device 100. The temperature of the heating medium flowing into the heat pump device 100 is hereinafter also referred to as a "return temperature". In the illustrated configuration, the return temperature sensor 32 is installed in the tank unit 200. In place of the configuration, the return temperature sensor 32 may be installed in the heat pump device 100.

[0023] The heating power of the heat pump device 100 may be variable. The heating power means a heat quantity given to the heating medium from the heat pump device 100 per unit time. The unit of the heating power is "watt", for example. The controller 10 may control the heating power by changing the capacity of the compressor 13, for example. The controller 10 may control the capacity of the compressor 13 by changing the rotational speed of the compressor 13, for example. The controller 10 may change the rotational speed of the compressor 13 by inverter control, for example.

[0024] Next, the heat accumulating operation of the heating medium circulation system 1 is described. The heat accumulating operation is performed as follows. The switching valve 6 is placed in a state in which the third port 6c communicates with the first port 6a and the second port 6b is blocked. The heat pump device 100 and the circulation pump 11 are operated. A low-temperature heating medium in the lower portion of the heat storage tank 2 is transmitted to the heat exchanger 15 through the outlet 25, the lower portion outlet passage 8, and the second passage 9. The high-temperature heating medium heated by the heat exchanger 15 flows into the upper portion of the heat storage tank 2 through the first passage 3, the third port 6c and the first port 6a of the switching valve 6, the upper portion inlet passage 4, and the inlet 26. In the heat accumulating operation, the high-temperature heating medium is accumulated from the top to the bottom in the heat storage tank 2 by the circulation of the heating medium as described above. As a result, the heat storage amount of the heat storage tank 2 increases. The circulation circuit of the heating medium at the time of the heat accumulating operation described above is referred to as a "heat accumulating circuit".

[0025] The controller 10 may start the heat accumulating operation when the heat storage amount in the heat storage tank 2 becomes equal to or less than a preset low level. When the heat storage amount in the heat storage tank 2 increases by the heat accumulating operation and reaches a preset high level, the controller 10 may end the heat accumulating operation. Note that the present invention can be applied to a system that does not include the heat storage tank 2 as described above, that is, a system that does not perform the heat accumulating operation.

[0026] Next, the indoor-heating operation of the heating medium circulation system 1 is described with reference to Fig. 2. Fig. 2 is a view illustrating circulation circuits of the refrigerant and the heating medium at the time of the indoor-heating operation of the heating medium circulation system 1 of Embodiment 1. The arrows in Fig. 2 indicate the directions in which the refrigerant and the heating medium flow. The indoor-heating operation is as follows. The switching valve 6 is placed in a state in which the third port 6c communicates with the second port 6b and the first port 6a is blocked. The heat pump device 100 and the circulation pump 11 are operated. The heating medium heated by the heat exchanger 15 of the heat pump device 100 is delivered to the indoor-heating terminal 12 through the first passage 3, the third port 6c and the second port 6b of the switching valve 6, the third passage 5, the outlet 27, and the external passage 22. The temperature of the heating medium decreases when heat is removed from the heating medium by the indoor air or the floor as the heating medium passes through the indoor-heating unit 24 of the indoor-heating terminal 12. The heating medium of which temperature has decreased returns to the heat exchanger 15 of the heat pump device 100 through the external passage 23, the inlet 28, the fourth passage 7, and the second passage 9. The heating medium that has returned to the heat exchanger 15 is reheated and recirculated. The circulation circuit of the heating medium at the time of the indoor-heating operation described above is referred to as an "indoor-heating circuit". In Embodiment 1, the heat accumulating circuit and the indoor-heating circuit can be switched by the switching valve 6.

[0027] In the room including the indoor-heating unit 24, an indoor terminal (not shown) including a room temperature sensor may be installed. The indoor terminal and the controller 10 are connected to each other so as to be able to transmit data to each other in a wired or wireless manner. The indoor terminal can transmit information on the room temperature detected by the room temperature sensor to the controller 10. When the terminal device 21 is installed in the room including the indoor-heating unit 24, the terminal device 21 may include the room temperature sensor and the terminal device 21 may transmit the room temperature information to the controller 10. The room temperature detected by the room temperature sensor is hereinafter referred to as an "actual room temperature". The user can set a value of a desired "target room temperature" with use of the terminal device 21 or the indoor terminal. The controller 10 may end the indoor-heating operation when the actual room temperature reaches the target room temperature on the basis of information received from the indoor terminal or the terminal device 21.

[0028] The supply temperature detected by the supply temperature sensor 31 is hereinafter referred to as an "actual supply temperature". At the time of the indoor-heating operation and the heat accumulating operation, the controller 10 can execute a feedback control as below so that the actual supply temperature becomes equal to a target supply temperature. The controller 10 can control the actual supply temperature by increasing and reducing the operation speed of the circulation pump 11, that is, increasing and reducing the circulation flow rate of the heating medium. When the actual supply temperature is higher than the target supply temperature, the controller 10 can cause the actual supply temperature to approach the target supply temperature by increasing the circulation flow rate of the heating medium so as to lower the actual supply temperature. When the actual supply temperature is lower than the target supply temperature, the controller 10 can cause the actual supply temperature to approach the target supply temperature by reducing the circulation flow rate of the heating medium so as to raise the actual supply temperature. The controller 10 may control the actual supply temperature by adjusting the heating power of the heat pump device 100 instead of the operation speed of the circulation pump 11. The value of the target supply temperature at the time of the indoor-heating operation may be a value within the range of from

25°C to 60°C, for example. The value of the target supply temperature at the time of the heat accumulating operation may be a value within the range of from 60°C to 80°C, for example.

[0029] The controller 10 may determine the target supply temperature in the indoor-heating operation in accordance with any of the following methods.

(1) The user can set the value of the target supply temperature with use of the terminal device 21 or the indoor terminal. The controller 10 may determine the value set by the user as the target supply temperature.

(2) The user can preset a relationship between the outside air temperature and the target supply temperature with use of the terminal device 21 or the indoor terminal. The controller 10 may determine the target supply temperature on the basis of the relationship and the outside air temperature detected by the outside air temperature sensor (not shown).

(3) The controller 10 may determine the target supply temperature that is appropriate at the time point on the basis of a predetermined calculation, a table value prepared in advance, or the like with use of two or more parameters out of the actual room temperature, the target room temperature, the actual supply temperature, the outside air temperature, and the return temperature detected by the return temperature sensor 32.

[0030] When the temperature of the heating medium flowing through the indoor-heating unit 24 at the time of the indoor-heating operation is too high, comfort may be deteriorated or the temperature of the indoor-heating unit 24 may exceeded the heat resistant temperature thereof, thereby causing a failure. In the indoor-heating operation, the controller 10 deactivates the compressor 13 and the circulation pump 11 when the actual supply temperature exceeds a "first deactivation temperature". As a result, a heating medium of which temperature is too high can be reliably prevented from flowing into the indoor-heating unit 24. The controller 10 may determine the first deactivation temperature on the basis of the target supply temperature. For example, the controller 10 may set a temperature that is higher than the target supply temperature by a predetermined value as the first deactivation temperature. For example, the controller 10 may set a temperature that is higher than the target supply temperature by 2°C as the first deactivation temperature.

[0031] When the indoor-heating operation is performed under the condition of low outside air temperature, frost may adhere to the air heat exchanger 17. When frost adheres to the air heat exchanger 17, the heat exchange efficiency of the air heat exchanger 17 decreases, and the heating power of the heat pump device 100 decreases. When frost adheres to the air heat exchanger 17, the controller 10 temporarily suspends the indoor-heating operation and performs the defrosting operation for causing the frost adhering to the air heat exchanger 17 to melt.

[0032] The controller 10 determines whether the defrosting operation is necessary during the execution of the indoor-heating operation. In this embodiment, whether the defrosting operation is necessary can be determined on the basis of the temperature detected by a defrosting temperature sensor 29. The defrosting temperature sensor 29 detects the temperature of the air heat exchanger 17. The controller 10 determines that the defrosting operation is necessary when the defrosting temperature sensor 29 continuously detects a temperature that is equal to or less than a predetermined threshold value for a predetermined period of time or more. The threshold value may be -3°C, for example. The predetermined period of time may be three minutes, for example.

[0033] Fig. 3 is a view illustrating a circulation circuit of the refrigerant at the time of the defrosting operation of the heating medium circulation system 1 of Embodiment 1. The arrows in Fig. 3 indicate the directions in which the refrigerant flows. The defrosting operation is as follows. The controller 10 controls hot gas that is high-temperature refrigerant gas compressed by the compressor 13 to flow into the air heat exchanger 17. The opening degree of the decompression device 16 is fully open. As a result, the temperature of the hot gas can be prevented from decreasing while the hot gas passes through the heat exchanger 15 and the decompression device 16. The frost melts by the heat of the hot gas flowing into the air heat exchanger 17. According to this embodiment, the defrosting operation can be performed without switching the flow path of the refrigerant, and hence the defrosting operation can be performed by a simple configuration.

[0034] The controller 10 deactivates the circulation pump 11 during the defrosting operation. As a result, the heating medium does not flow in the heat exchanger 15, and hence a case where the heat of the hot gas discharged from the compressor 13 is removed by the heating medium can be prevented in a more reliable manner. As a result, the heat quantity of the hot gas that flows into the air heat exchanger 17 can be caused to be higher, and hence the defrosting capacity can be caused to be higher.

[0035] The controller 10 determines whether the frost adhering to the air heat exchanger 17 has been able to be removed during the defrosting operation. In this embodiment, it can be determined whether the frost has been able to be removed on the basis of the temperature detected by the defrosting temperature sensor 29. For example, when the defrosting temperature sensor 29 continuously detects a temperature that is equal to or more than a predetermined threshold value for a predetermined period of time or more, the controller 10 determines that the frost has been able to be removed. When it is determined that the frost has been able to be removed, the controller 10 ends the defrosting operation and restarts the indoor-heating operation.

[0036] Fig. 4 is a graph showing an example of a temporal fluctuation of the actual supply temperature when the operation is switched in the order of the indoor-heating operation, the defrosting operation, and the restart of the indoor-heating operation. The features of Embodiment 1 are described below with reference to Fig. 4.

[0037] The example of Fig. 4 is as follows. The target supply temperature is 45°C. The first deactivation temperature is 47°C. In the indoor-heating operation until time t1 in Fig. 4, the actual supply temperature is stable at a temperature that is approximately equal to the target supply temperature. Frost adheres to the air heat exchanger 17 while the indoor-heating operation continues. When the controller 10 determines that the defrosting operation is necessary, the operation switches from the indoor-heating operation to the defrosting operation. The time t1 corresponds to a switching time point from the indoor-heating operation to the defrosting operation. During the defrosting operation, the circulation pump 11 deactivates and the heating medium is not supplied to the supply temperature sensor 31 and the indoor-heating terminal 12. Therefore, the actual supply temperature detected by the supply temperature sensor 31 decreases from the time t1.

[0038] When the controller 10 determines that the frost is removed by the defrosting operation, the operation switches from the defrosting operation to the indoor-heating operation. That is, the indoor-heating operation is restarted, the operation of the circulation pump 11 is restarted, and the heating medium is supplied to the supply temperature sensor 31 and the indoor-heating terminal 12. Time t2 in Fig. 4 corresponds to a switching time point from the defrosting operation to the indoor-heating operation. During the defrosting operation, the hot gas from the compressor 13 is supplied to the air heat exchanger 17 through the heat exchanger 15. As a result, the temperature of the heat exchanger 15 during the defrosting operation is higher than the temperature of the heat exchanger 15 before the indoor-heating operation starts. Therefore, the actual supply temperature immediately after the switching from the defrosting operation to the indoor-heating operation rises more rapidly as compared to the actual supply temperature immediately after the indoor-heating operation starts. As a result, in the feedback control for causing the actual supply temperature to match with the target supply temperature, the actual supply temperature easily overshoots the target supply temperature because the adjustment of the operation speed of the circulation pump 11 or the adjustment of the heating power of the heat pump device 100 is falling behind. In the example of Fig. 4, the actual supply temperature changes so as to be stable at 45°C after exceeding 45°C that is the target supply temperature and rising to 49°C.

[0039] At time t3 in Fig. 4, the actual supply temperature reaches 47°C that is the first deactivation temperature. Supposing that the controller 10 deactivates the compressor 13 and the circulation pump 11 at the time point at which the actual supply temperature exceeds the first deactivation temperature, the compressor 13 and the circulation pump 11 are deactivated at the time t3. In the example in Fig. 4, the time t3 is about nine minutes after the time t2 that is the switching time point from the defrosting operation to the indoor-heating operation. At the time point of the time t3, it is conceived that the actual room temperature has not reached the target room temperature, and hence the compressor 13 and the circulation pump 11 are not preferred to be deactivated.

[0040] In view of the above-mentioned features, in this embodiment, the controller 10 is configured so as not to deactivate the compressor 13 and the circulation pump 11 even when the actual supply temperature exceeds the first deactivation temperature in the indoor-heating operation in a post-defrosting period. The "post-defrosting period" is a period until a predetermined period of time elapses from the switching time point from the defrosting operation to the indoor-heating operation. In the example illustrated in Fig. 4, the period from the time t2 to time t4 corresponds to the "post-defrosting period". In the example illustrated in Fig. 4, the above-mentioned predetermined period of time, that is, the length of the post-defrosting period is 15 minutes. The length of the post-defrosting period is not limited thereto and may be a period of time within the range of from 10 minutes to one hour, for example. According to this embodiment, the following effects can be obtained, for example. The indoor-heating operation is continued without deactivating the compressor 13 and the circulation pump 11 at the time t3 in Fig. 4. As described above, the compressor 13 and the circulation pump 11 can be prevented from being deactivated when the actual supply temperature suddenly rises after the defrosting operation, and hence the frequency of activating and deactivating the compressor 13 and the circulation pump 11 can be reduced. Therefore, in the operation of the heating medium circulation system 1, energy loss due to the activation and the deactivation of the compressor 13 can be reduced and the life of the compressor 13 can be prevented from decreasing.

[0041] When a sufficient period of time elapses from the switching time point from the defrosting operation to the indoor-heating operation, the actual supply temperature is conceived to be stable around the target supply temperature. That is, in the example of Fig. 4, in the indoor-heating operation after the time t4, the actual supply temperature is conceived to be stable around the target supply temperature. Therefore, in the indoor-heating operation after the post-defrosting period, the condition of the deactivation temperature at which the compressor 13 and the circulation pump 11 are deactivated does not need to be alleviated. Therefore, in the indoor-heating operation after the post-defrosting period, the controller 10 deactivates the compressor 13 and the circulation pump 11 when the actual supply temperature exceeds the first deactivation temperature. As a result, in the indoor-heating operation after the post-defrosting period, the heating medium of which temperature is higher than the temperature expected by the user can be reliably prevented from flowing into the indoor-heating terminal 12.

[0042] In this embodiment, the controller 10 deactivates the compressor 13 and the circulation pump 11 when the actual supply temperature exceeds a "second deactivation temperature" in the indoor-heating operation in the post-defrosting period. The "second deactivation temperature" is a temperature that is higher than the "first deactivation temperature". The controller 10 may determine the second deactivation temperature on the basis of the target supply temperature. For example, the controller 10 may set a temperature that is higher than the target supply temperature by a predetermined value as the second deactivation temperature. For example, the controller 10 may set a temperature that is higher than the target supply temperature by 5°C as the second deactivation temperature. In the example of Fig. 4, the second deactivation temperature is 50°C. According to this embodiment, the following effects are obtained. In the indoor-heating operation in the post-defrosting period, the heating medium of which temperature is higher than the second deactivation temperature can be reliably prevented from flowing into the indoor-heating terminal 12.

[0043] The heating medium circulation system 1 may include means for enabling the user to set a value of a parameter for determining the second deactivation temperature. For example, the following is possible. The controller 10 determines a value obtained by adding a parameter Y to the target supply temperature as the second deactivation temperature. The value of the parameter Y may be settable by a user with use of the terminal device 21. By the configuration, in accordance with conditions such as the pipe length of the external passages 22 and 23 and the like, the number of the indoor-heating units 24, and the installation environment, the second deactivation temperature can be determined in a more appropriate manner, and hence convenience is enhanced.

Embodiment 2

[0044] Next, Embodiment 2 is described, but the differences from Embodiment 1 described above are mainly described, and the description of the same parts or corresponding parts is simplified or omitted. The hardware configuration of the heating medium circulation system 1 of Embodiment 2 is the same as that of Embodiment 1, and hence the illustration thereof is omitted.

[0045] Embodiment 2 is as follows. The "second deactivation temperature" as in Embodiment 1 is not set. The controller 10 continues, regardless of the actual supply temperature, operation of the compressor 13 and the circulation pump 11 in the indoor-heating operation in the post-defrosting period. As a result, the following effects can be obtained. In the indoor-heating operation in the post-defrosting period, the compressor 13 and the circulation pump 11 can be prevented from being deactivated in a more reliable manner. Therefore, the frequency of activating and deactivating the compressor 13 and the circulation pump 11 can be further reduced as compared to Embodiment 1.

[0046] In at least one of Embodiments 1 and 2, the heating medium circulation system 1 may include means for enabling the length of the post-defrosting period, that is, the value of the above-mentioned predetermined period of time to be set by the user. For example, the length of the post-defrosting period may be able to be set by the user with use of the terminal device 21. By the configuration as above, the length of the post-defrosting period can be determined in a more appropriate manner in accordance with the conditions such as the pipe length of the external passages 22 and 23 and the like, the number of the indoor-heating units 24, and the installation environment, and hence the convenience is enhanced.

[0047] In at least one of Embodiments 1 and 2, the controller 10 may deactivate, regardless of the actual supply temperature, the compressor 13 when the actual room temperature reaches the target room temperature. That is, the controller 10 deactivates the compressor 13 when the actual room temperature reaches the target room temperature even when the actual supply temperature is not exceeding the first deactivation temperature. As a result, the room temperature can be reliably prevented from increasing too much, and comfort can be maintained.

[0048] The controller 10 may limit the first deactivation temperature and the second deactivation temperature so as not to exceed a predetermined upper limit temperature. The upper limit temperature is a temperature in accordance with the heat resistant temperature of the external passage 22 or the heat resistant temperature of the indoor-heating terminal 12, for example. As a result, the external passage 22 and the indoor-heating terminal 12 can be protected in a more reliable manner.

[0049] In at least one of Embodiments 1 and 2, the heating medium circulation system 1 may include means for notifying a user of the possibility of the supply temperature becoming higher than normal in the post-defrosting period. For example, the following may be performed. At the time of the indoor-heating operation in the post-defrosting period, a phrase of "caution high temperature" is displayed on the display of the terminal device 21. As a result, the user pays attention so as not to touch the indoor-heating unit 24, and hence actively avoids discomfort in an easier manner.

[0050] In at least one of Embodiments 1 and 2, the controller 10 may operate the circulation pump 11 so that the circulation flow rate of the heating medium immediately after the defrosting operation becomes higher than the circulation flow rate of the heating medium immediately before the defrosting operation. As a result, the following effects can be obtained. When the circulation flow rate of the heating medium immediately after the defrosting operation becomes high, the amount of the heating medium that removes heat from the heat exchanger 15 increases, and hence it becomes difficult for the actual supply temperature to rise. Therefore, the rise of the actual supply temperature in the indoor-heating operation in the post-defrosting period can be delayed, and the compressor 13 can be reliably prevented from being deactivated.

[0051] At least one of Embodiments 1 and 2 may be as follows. The controller 10 stores therein an indoor-heating abnormal temperature. The indoor-heating abnormal temperature may be 75°C, for example. The indoor-heating abnormal temperature is a value for determining abnormality such as a failure of the heat pump device 100 or a failure of the circulation pump 11 in the indoor-heating operation. The controller 10 deactivates the compressor 13 and causes the terminal device 21 to notify abnormality to a user of when the actual supply temperature exceeds the indoor-heating abnormal temperature in the indoor-heating operation after the post-defrosting period. Meanwhile, the controller 10 continues operation of the compressor 13 and does not execute the notification of the abnormality to the user even when the actual supply temperature exceeds the indoor-heating abnormal temperature in the indoor-heating operation in the post-defrosting period. By the configuration as above, the compressor 13 can be prevented from being unnecessarily deactivated in a more reliable manner in the indoor-heating operation in the post-defrosting period. The controller 10 may switch the switching valve 6 so that the heating medium from the heat pump device 100 flows into the heat storage tank 2 and not into the indoor-heating terminal 12 when the actual supply temperature exceeds the indoor-heating abnormal temperature in the indoor-heating operation in the post-defrosting period. There is no problem even when the temperature of the heating medium flowing into the heat storage tank 2 exceeds the indoor-heating abnormal temperature. Therefore, when the operation is temporarily switched to the heat accumulating operation when the actual supply temperature exceeds the indoor-heating abnormal temperature in the indoor-heating operation, the heat of the high-temperature heating medium can be stored in the heat storage tank 2 without waste and without deteriorating comfort.

[0052] Each function of the controller 10 included in the heating medium circulation system 1 of Embodiments 1 and 2 may be implemented by a processing circuit. In the illustrated example, the processing circuit of the controller 10 includes at least one processor 10a and at least one memory 10b. When the processing circuit includes at least one processor 10a and at least one memory 10b, each function of the controller 10 may be implemented by software, firmware, or the combination of the software and the firmware. At least one of the software and the firmware may be described as a program. At least one of the software and the firmware may be stored in at least one memory 10b. At least one processor 10a may implement each function of the controller 10 by reading out and executing the program stored in at least one memory 10b. At least one memory 10b may include a nonvolatile or volatile semiconductor memory, a magnetic disc, and the like.

[0053] The processing circuit of the controller 10 may include at least one dedicated hardware. When the processing circuit includes at least one dedicated hardware, the processing circuit may be a single circuit, a composite circuit, a programmed processor, a parallel-programmed processor, an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA), or a combination thereof, for example. The functions of the units of the controller 10 may be respectively implemented by the processing circuit. The functions of the units of the controller 10 may be implemented by the processing circuit altogether. For the functions of the controller 10, a part may be implemented by a dedicated hardware, and another part may be implemented by software or firmware. The processing circuit may implement each function of the controller 10 by hardware, software, firmware, or a combination thereof.

[0054] It is not limited to a configuration in which the operation of the heating medium circulation system 1 is controlled by a single controller. A configuration in which the operation of the heating medium circulation system 1 is controlled by a plurality of controllers cooperating can be used.

[Reference Signs List]

[0055]

1	heating medium circulation system
2	heat storage tank 2
6	switching valve
10	controller
11	circulation pump
12	indoor-heating terminal
13	compressor
14	refrigerant pipe
15	heat exchanger
16	decompression device
17	air heat exchanger
21	terminal device
24	indoor-heating unit
29	defrosting temperature sensor
30	flow rate sensor 30
31	supply temperature sensor
100	heat pump device
200	tank unit

Claims

1. A heating medium circulation system, comprising:

a heating means for heating a liquid heating medium, the heating means comprising:

an air heat exchanger configured to exchange heat between a refrigerant and air; and

a compressor configured to compress the refrigerant;

a pump configured to circulate the heating medium through a circulation circuit passing through an indoor-heating terminal and the heating means;

a control means electrically connected to the heating means and the pump, the control means being configured to execute indoor-heating operation for suppling the heating medium heated by the heating means to the indoor-heating terminal and defrosting operation for causing frost adhering to the air heat exchanger to melt; and

a means for detecting a supply temperature that is a temperature of the heating medium supplied to the indoor-heating terminal from the heating means, wherein

the control means is configured to deactivate the compressor when the supply temperature exceeds a first deactivation temperature in the indoor-heating operation after a predetermined period of time elapses from a switching time point from the defrosting operation to the indoor-heating operation,

and wherein the control means is configured not to deactivate the compressor when the supply temperature exceeds the first deactivation temperature in the indoor-heating operation in a post-defrosting period that is a period until the predetermined period of time elapses from the switching time point.

2. The heating medium circulation system according to claim 1, wherein:

a second deactivation temperature is a temperature that is higher than the first deactivation temperature; and

the control means is configured to deactivate the compressor when the supply temperature exceeds the second deactivation temperature in the indoor-heating operation in the post-defrosting period.

3. The heating medium circulation system according to claim 1, wherein the control means is configured, regardless of the supply temperature, not to deactivate the compressor in the indoor-heating operation in the post-defrosting period.

4. The heating medium circulation system according to any one of claims 1 to 3, further comprising means for enabling a value of the predetermined period of time to be set by a user.

5. The heating medium circulation system according to claim 2, further comprising means for enabling a value of a parameter for determining the second deactivation temperature to be set by a user.

6. The heating medium circulation system according to any one of claims 1 to 5, further comprising means for detecting an actual room temperature that is a temperature of a space in which the indoor-heating terminal is installed, wherein the control means is configured, regardless of the supply temperature, to deactivate the compressor when the actual room temperature reaches a target room temperature.

7. The heating medium circulation system according to any one of claims 1 to 6, further comprising means for notifying a user of a possibility of the supply temperature becoming higher than normal in the post-defrosting period.

8. The heating medium circulation system according to any one of claims 1 to 7, wherein the control means is configured to control the operation of the pump so that a circulation flow rate of the heating medium immediately after the defrosting operation is higher than a circulation flow rate of the heating medium immediately before the defrosting operation.

9. The heating medium circulation system according to any one of claims 1 to 8, further comprising notification means for notifying a user of information,

wherein, in the indoor-heating operation after the post-defrosting period, the control means is configured, if the supply temperature exceeds an indoor-heating abnormal temperature, to execute deactivation of the compressor and cause the notification means to make a notification of abnormality,

and wherein, in the indoor-heating operation in the post-defrosting period, the control means is configured not to execute deactivation of the compressor and not to cause the notification means to make a notification of abnormality even if the supply temperature exceeds the indoor-heating abnormal temperature.

FIG. 1

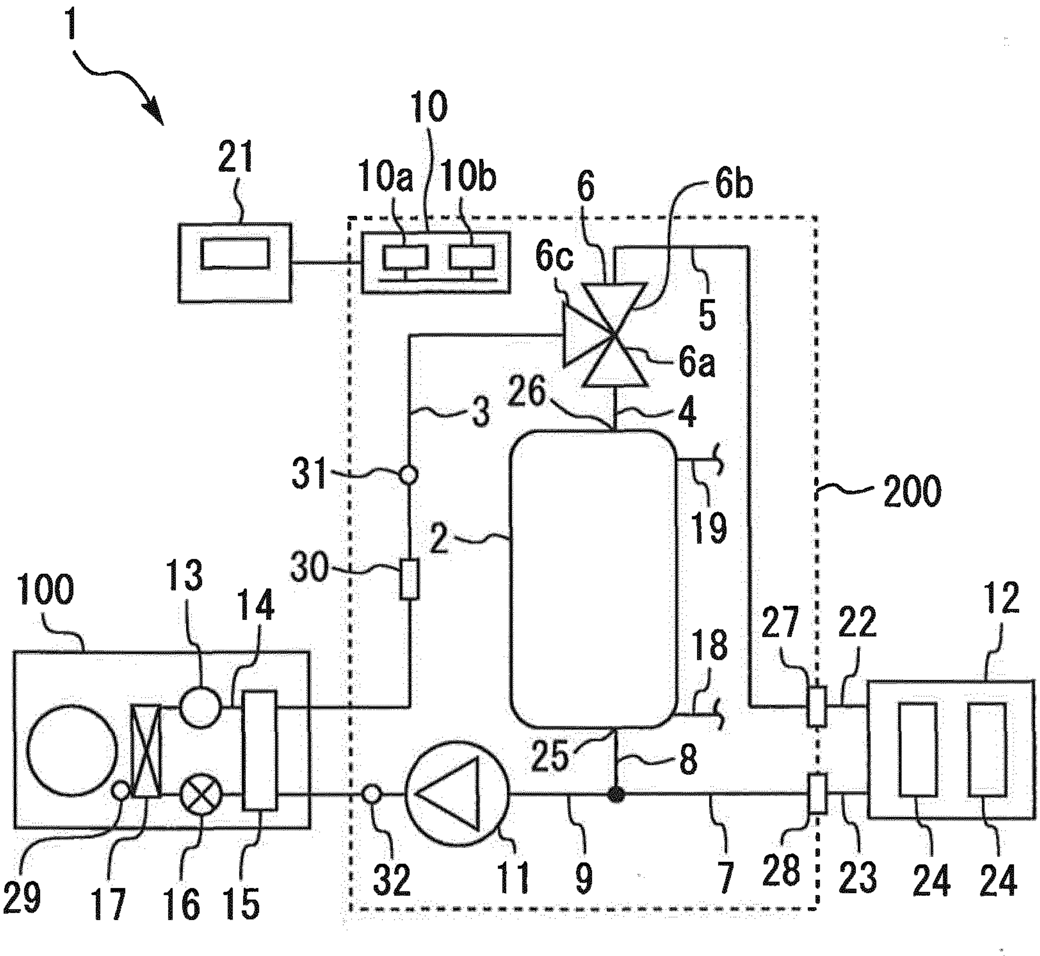

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FIG. 2

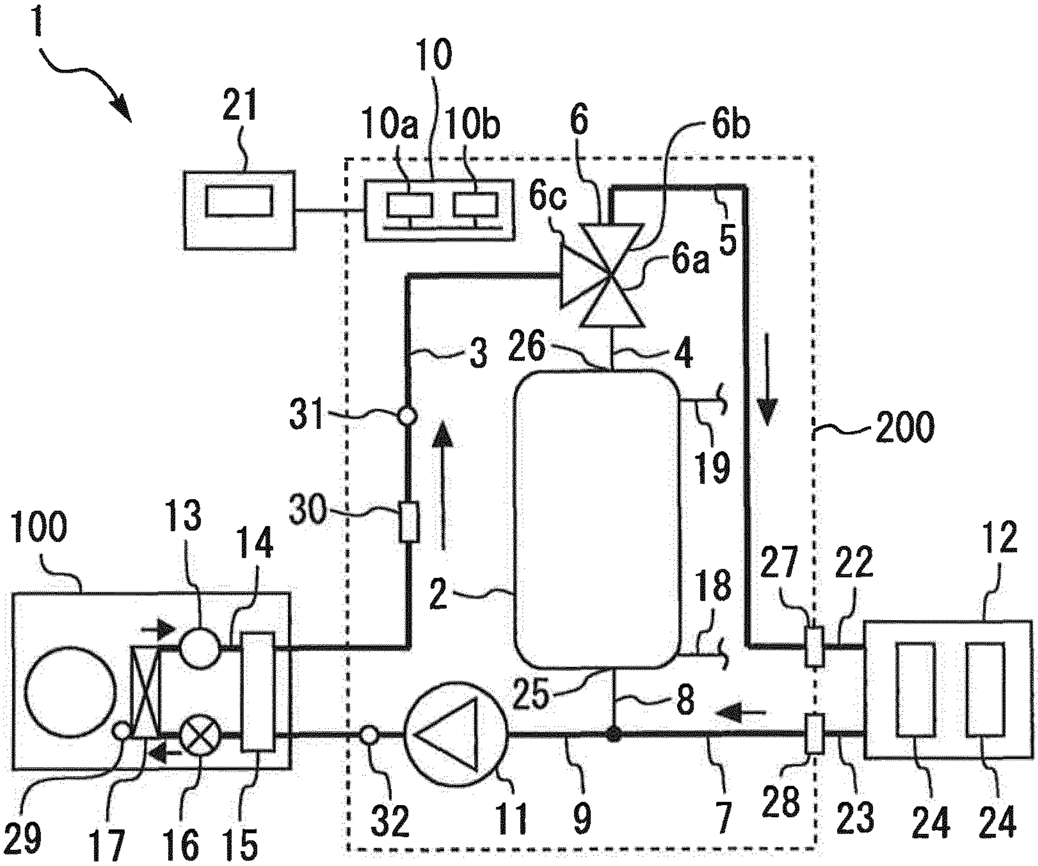
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FIG. 3

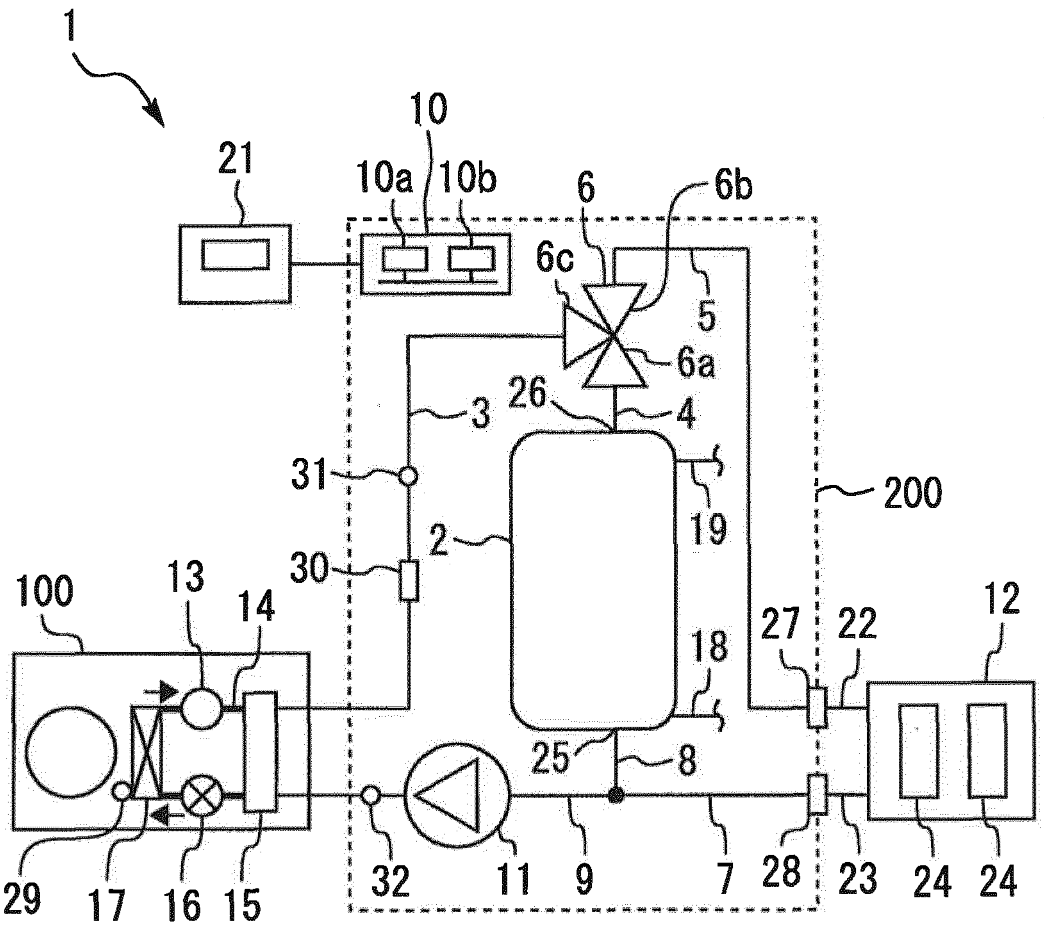
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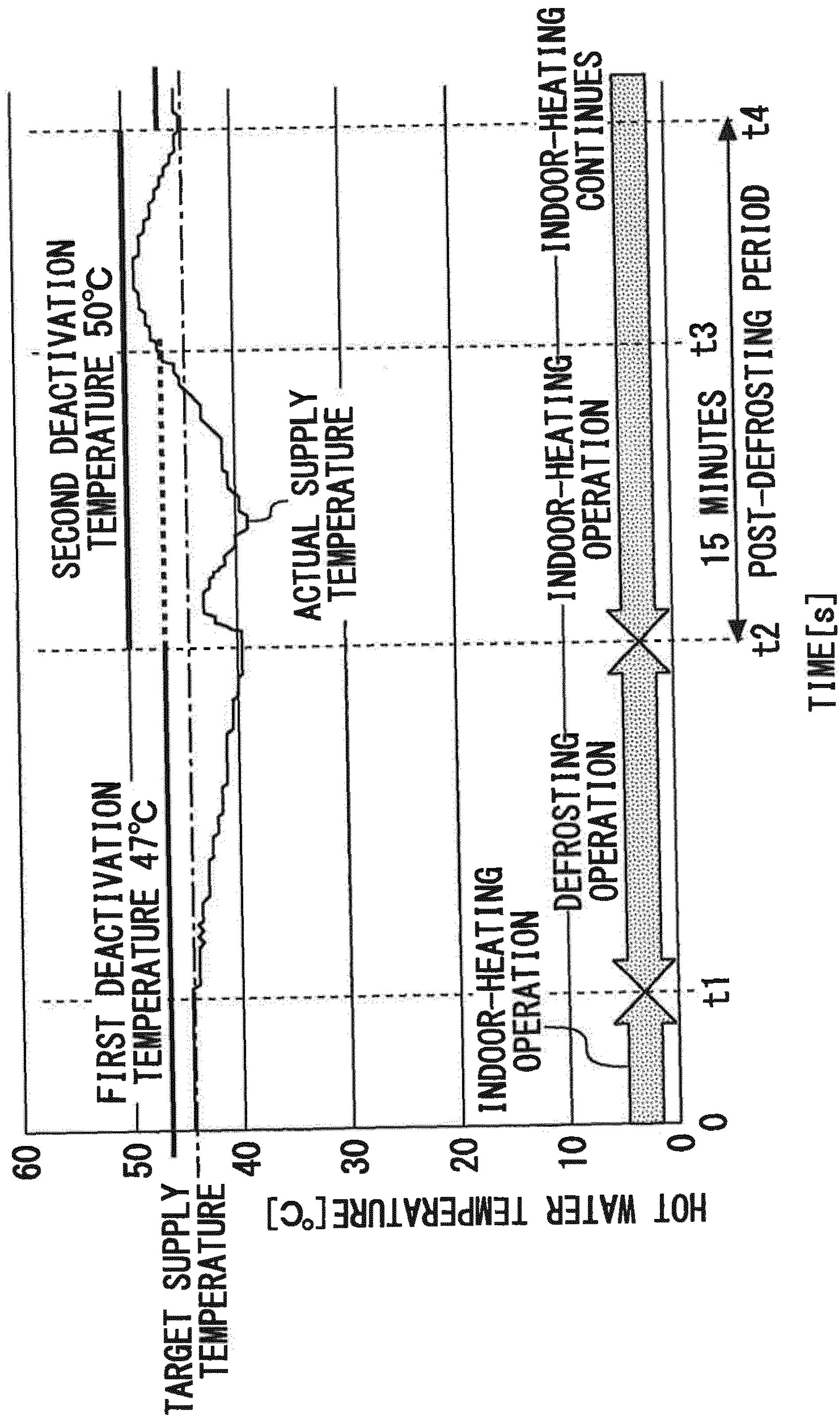
FIG. 4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FIRST DEACTIVATION TEMPERATURE 47°C
TARGET SUPPLY TEMPERATURE
ACTUAL SUPPLY TEMPERATURE
HOT WATER TEMPERATURE[°C]
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50
40
30
20
10
0
0
t1
t2
t3
t4
INDOOR-HEATING OPERATION
DEFROSTING OPERATION
INDOOR-HEATING OPERATION
INDOOR-HEATING CONTINUES
15 MINUTES
POST-DEFROSTING PERIOD
TIME[s]

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/014553

A. CLASSIFICATION OF SUBJECT MATTER
F24H4/02(2006.01)i, *F24D3/18*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24H4/02, F24D3/18

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-46703 A (Daikin Industries, Ltd.), 16 February 2006 (16.02.2006), paragraphs [0038], [0045]; fig. 4 (Family: none)	1-9
A	JP 2008-39306 A (Daikin Industries, Ltd.), 21 February 2008 (21.02.2008), entire text; all drawings & EP 2056025 A1 entire text; all drawings & WO 2008/018397 A1	1-9
A	JP 2011-64398 A (Panasonic Corp.), 31 March 2011 (31.03.2011), entire text; all drawings (Family: none)	1-9

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2017 (23.05.17)	06 June 2017 (06.06.17)

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

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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