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(54) HEAT PUMP HEAT SOURCE DEVICE AND HEAT PUMP WATER HEATER

(57) A heat pump hot water supply device according to one embodiment includes a compressor, water heat exchanger, tank, water heat radiator, pump, heater, first temperature sensor, second temperature sensor, and controller. The first temperature sensor senses a first temperature of water flowing into a flow path of the water heat exchanger after releasing heat thereof to water retained in the tank. The second temperature sensor senses a second temperature of the water retained in the tank. The controller controls an operation or a stop of the compressor on the basis of the first temperature and second temperature and controls a rotational speed of the compressor on the basis of the first temperature while the compressor is in operation.

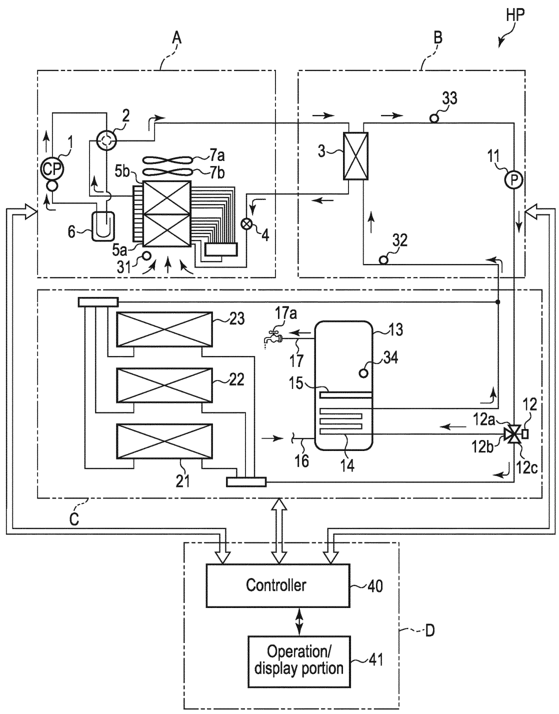

FIG.1

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Description

Technical Field

[0001] Embodiments of the present invention relate to a heat pump heat source device configured to obtain hot water to be used for indoor heating and hot water supply by an operation of a heat pump refrigeration cycle and heat pump hot water supply device configured to produce hot water to be used for hot water supply.

Background Art

[0002] A heat pump heat source device configured to pump up heat from outdoor air by an operation of a heat pump refrigeration cycle and supply hot water heated by the pumped-up heat to a heat radiator for indoor heating, tank for hot water supply or the like is known. The heat pump heat source device includes, as main constituent elements, a compressor, water heat exchanger, pressure reducer, evaporator, and control unit and heats water flowing through the water heat exchanger by a refrigerant discharged from the compressor. Further, there is a heat pump hot water supply device configured to change water stored in a tank for hot water supply into hot water by making the water heated by the refrigerant by using the aforementioned heat pump heat source device release the heat thereof to the inside of the tank for hot water supply.

Citation List

Patent Literature

[0003] Patent Literature 1: JP 2013-155991 A

Summary of Invention

Technical Problem

[0004] The temperature (tank water temperature) of the hot water inside the tank is adjusted to a temperature (supplied hot water temperature) to be set from an operation/display portion or the like of the control unit. In order to hold down the power consumption at this time to the utmost extent possible, in the state where the thermal capability of the heat pump heat source device is sufficient to make the tank water temperature the supplied hot water temperature, it is desirable that, for example, the compressor be prevented from continuing to operate at the maximum rotational speed.

[0005] Further, in the case of a heat pump hot water supply device incorporating a heater in the tank thereof in order to further raise the tank water temperature, the temperature of the water inside the tank is raised to a temperature of a certain degree by the heat pump and, as to further raising of the temperature, the heat pump is stopped and water temperature is raised to the set supplied hot water temperature by the heater. The heater is inferior to the heat pump in efficiency, and hence regarding such a system, it is desirable that the tank water temperature be raised by utilizing the operation of the heat pump to the utmost extent possible.

[0006] Embodiments described herein aim to provide a heat pump heat source device and heat pump hot water supply device capable of realizing energy saving by appropriately controlling the rotational speed of the compressor.

Solution to Problem

[0007] A heat pump hot water supply device according to an embodiment includes a rotary compressor, water heat exchanger, tank, water heat radiator, pump, heater, first temperature sensor, second temperature sensor, and controller. The rotary compressor discharges a compressed gaseous refrigerant therefrom. The water heat exchanger heats water flowing through a flow path included in the water heat exchanger by the gaseous refrigerant. The tank retains water therein. The water heat radiator is provided inside the tank and makes the water heated in the water heat exchanger release the heat thereof to the inside of the tank. The pump circulates water between the water heat radiator and the water heat exchanger. The heater heats the water inside the tank. The first temperature sensor senses a first temperature of the water flowing into the flow path of the water heat exchanger after releasing heat thereof to the water retained in the tank. The second temperature sensor senses a second temperature of the water retained in the tank. The controller controls an operation or a stop of the compressor on the basis of the first temperature and the second temperature and controls a rotational speed of the compressor on the basis of the first temperature while the compressor is in operation.

[0008] A heat pump heat source device according to an embodiment includes a rotary compressor, a water heat exchanger, a pump, a first temperature sensor, a controller. The rotary compressor discharges a compressed gaseous refrigerant. The water heat exchanger heats water flowing through a flow path included in the water heat exchanger by the gaseous refrigerant. The pump circulates water between the water heat exchanger and a heat exchanger on the usage side. The first temperature sensor senses a first temperature of water flowing into the flow path of the water heat exchanger. The controller controls a stop of the compressor on the basis of the first temperature, controls, while the compressor is in operation, when the first temperature is higher than a predetermined set value, a rotational speed of the compressor to a rotational speed at which high efficiency can be obtained, and controls, when the first temperature is lower than a temperature set lower than the set value, the rotational speed of the compressor to a rotational speed lower than the rotational speed at which the high efficiency can be obtained.

Brief Description of Drawings

[0009]

FIG. 1 is a block diagram schematically showing the configuration of a heat pump heat source device and heat pump hot water supply device according to an embodiment.

FIG. 2 is a control flowchart of a controller at the time of a heating operation of the heat pump heat source device and heat pump hot water supply device according to a first embodiment.

FIG. 3 is a view showing a relationship between a temperature difference between the entrance water temperature TWI and tank water temperature TTW and variations in the rotational speed of the compressor at the time of a heating operation of the heat pump heat source device and heat pump hot water supply device according to the first embodiment.

FIG. 4 is a control flowchart of a controller at the time of a heating operation of the heat pump heat source device and heat pump hot water supply device according to a second embodiment.

FIG. 5 is a view showing a relationship between the operating state (frequency and stop) of the compressor and entrance water temperature TWI at the time of a heating operation of the heat pump heat source device and heat pump hot water supply device according to the second embodiment.

FIG. 6 is a view showing the performance characteristics of the refrigeration cycle of the heat pump heat source device and heat pump hot water supply device according to the second embodiment by a relationship between the operation frequency [Hz] of the compressor and coefficient of performance [COP].

Mode for Carrying Out the Invention

[0010] Embodiments of the present invention will be described below with reference to FIGS. 1 to 6.

(First Embodiment)

[0011] FIG. 1 is a block diagram schematically showing the configuration a heat pump hot water supply device HP including a heat pump heat source device according to this embodiment. The heat pump hot water supply device HP is a device configured to obtain hot water by an operation of a heat pump refrigeration cycle. As shown in FIG. 1, the heat pump hot water supply device HP includes an outdoor unit A, water heat exchanging unit B, load unit C, and control unit D. The heat pump heat source device is a device including a configuration formed by excluding the hot water supply tank 13, heat radiating coil (water heat radiator) 14, heater 15, and tank water temperature sensor 34 from the constituent elements of the heat pump hot water supply device HP to be described later. In short, the heat pump heat source device is constituted of the outdoor unit A and water heat exchanging unit B.

[0012] In the heat pump hot water supply device HP, the outdoor unit A and water heat exchanging unit B are piping-connected to each other, whereby a refrigerant is circulated, and water heat exchanging unit B and load unit C are piping-connected to each other, whereby water (hot water) is circulated. Flows of the refrigerant and water (hot water) are controlled by the control unit D.

[0013] To a discharge port of a compressor 1, one end of a refrigerant flow path of a water heat exchanger 3 is piping-connected through a four-way valve 2, and the other end of the refrigerant flow path is piping-connected to one end of air heat exchangers 5a and 5b through an expansion valve 4 serving as a pressure reducer. Further, the other end of the air heat exchangers 5a and 5b is piping-connected to a suction port of the compressor 1 through the four-way valve 2 and accumulator 6. By the aforementioned piping connection, the heat pump refrigeration cycle is configured.

[0014] In the vicinity of the air heat exchangers 5a and 5b, outdoor fans 7a and 7b are arranged. The outdoor fans 7a and 7b suck outdoor air and pass the sucked air through the air heat exchangers 5a and 5b. On the upstream side of a suction air flow path formed by the outdoor fans 7a and 7b, an outdoor air temperature sensor 31 is arranged. The outdoor air temperature sensor 31 senses the temperature of the outdoor air sucked by the outdoor fans 7a and 7b.

[0015] At the time of indoor heating and at the time of heating hot water inside the hot water supply tank 13 to be described later, as indicated by arrows, the compressed gaseous refrigerant discharged from the compressor 1 flows through the refrigerant flow path of the water heat exchanger 3 through the four-way valve 2. When flowing through the refrigerant flow path of the water heat exchanger 3, the gaseous refrigerant is deprived of the heat thereof by the water flowing through a water flow path of the water heat exchanger 3 to thereby be condensed. The liquid refrigerant flowing out of the refrigerant flow path of the water heat exchanger 3 is decompressed by the expansion valve 4 and flows through the air heat exchangers 5a and 5b. The liquid refrigerant flowing through the air heat exchangers 5a and 5b pumps up heat from the outdoor air to thereby be evaporated. The gaseous refrigerant flowing out of the air heat exchangers 5a and 5b is sucked into the compressor 1 through the four-way valve 2 and accumulator 6. As described above, at the time of indoor heating, the water heat exchanger 3 functions as a condenser and air heat exchangers 5a and 5b function as an evaporator.

[0016] When a need for defrosting of the air heat exchangers 5a and 5b arises during indoor heating or during a heating operation of the hot water inside the hot water supply tank 13, the flow path is switched by the four-way valve 2 and high-temperature compressed gaseous refrigerant discharged from the compressor 1 flows from the four-way valve 2 through the refrigerant flow path of the air heat exchangers 5a and 5b. By flowing of this high-temperature gaseous refrigerant, the air heat exchangers 5a and 5b are defrosted. At the time of defrosting, the air heat exchangers 5a and 5b function as a condenser and water heat exchanger 3 functions as an evaporator.

[0017] An exit of the water flow path of the water heat exchanger 3 is piping-connected to a suction port of a circulating pump 11 and discharge port of the circulating pump 11 is piping-connected to a water entrance 12a of a three-way valve 12. Further, a water exit 12b of the three-way valve 12 is piping-connected to a water inlet of a heat radiating coil (water heat radiator) 14 accommodated in a tank for hot water supply (hereinafter referred to as a hot water supply tank) 13 and, water outlet of the heat radiating coil 14 is piping-connected to an entrance of the water flow path of the water heat exchanger 3. Furthermore, a water exit 12c of the three-way valve 12 is connected to each of water entrances of a plurality of heat radiators 21, 22, and 23 for indoor heating, i.e., socalled fan-coil units, and water exit of each of the heat radiators 21, 22, and 23 is piping-connected to the entrance of the water flow path of the water heat exchanger 3.

[0018] The circulating pump 11 sends the hot water flowing out of the water heat exchanger 3 to the hot water supply tank 13 or heat radiators 21, 22, and 23 and makes the water returning from the hot water supply tank 13 or heat radiators 21, 22, and 23 flow into the water heat exchanger 3.

[0019] The three-way valve 12 is an electromagnetic valve including a water entrance 12a and two water exits 12b and 12c and configured to switch the internal flow path to one of a first flow path leading from the water entrance 12a to the water exit 12b and second flow path leading from the water entrance 12a to the water exit 12c.

[0020] By the piping connections between the water heat exchanger 3, hot water supply tank 13, and heat radiators 21, 22, and 23, a hot-water circulation cycle is formed.

[0021] At the time of indoor heating, in the three-way valve 12, the water entrance 12a is connected to the water exit 12c by the control unit D to be described later, and hot water sent forth from the circulating pump 11 is supplied to the heat radiators 21, 22, and 23. On the other hand, at the time of a heating operation of heating hot water inside the hot water supply tank 13, in the three-way valve 12, the water entrance 12a is connected to the water exit 12b by the control unit D, and hot water sent forth from the circulating pump 11 is supplied to the heat radiating coil 14 inside the hot water supply tank 13.

[0022] The piping members leading from each of the hot water supply tank 13 and heat radiators 21, 22, and 23 to the water heat exchanger 3 join together midway, and a temperature sensor (first temperature sensor, hereinafter referred to as an entrance water temperature sensor) 32 is attached to the piping on the downstream side of the confluence. In the example shown in FIG. 1, the entrance water temperature sensor 32 is arranged inside the water heat exchanging unit B. The entrance water temperature sensor 32 senses the temperature (first temperature, hereinafter referred to as an entrance water temperature TWI) of the water flowing out of the hot water supply tank 13 or heat radiators 21, 22, and 23 and flowing into the water flow path of the water heat exchanger 3.

[0023] To the piping leading from the water heat exchanger 3 to the hot water supply tank 13 or heat radiators 21, 22, and 23, a hot-water temperature sensor (hereinafter referred to as an exit water temperature sensor) 33 is attached. In the example shown in FIG. 1, the exit water temperature sensor 33 is arranged on the piping between the water heat exchanger 3 and circulating pump 11. The exit water temperature sensor 33 senses the temperature (hereinafter referred to as an exit water temperature TWO) of the hot water flowing out of the water heat exchanger 3 and sent to the hot water supply tank 13 or heat radiators 21, 22, and 23.

[0024] The hot water supply tank 13 incorporates therein a heat radiating coil 14 and heater (electric heater) 15, heats the water flowing therein from a water-inflow pipe 16 by the heat radiation of the heat radiating coil 14 and heat generation of the heater 15 to thereby retain the heated water as the hot water for hot water supply, and guides the retained hot water to a water-outflow pipe 17. The heat radiating coil 14 makes the hot water flowing out of the water heat exchanger 3 flow from the water inlet to the water outlet, and release, in the course of the flow, the heat thereof to the water (hot water) retained in the hot water supply tank 13. When a faucet 17a provided at the tip end of the water-outflow pipe 17 is opened, the hot water inside the hot water supply tank 13 flows out through the water-outflow pipe 17. Inside the hot water supply tank 13, a temperature sensor (second temperature sensor, hereinafter referred to as a tank water temperature sensor) 34 is arranged. The tank water temperature sensor 34 senses the temperature (second temperature, hereinafter referred to as a tank water temperature TTW) of the water retained in the hot water supply tank 13.

[0025] The compressor 1, four-way valve 2, expansion valve 4, air heat exchangers 5a and 5b, accumulator 6, outdoor fans 7a and 7b, and outdoor air temperature sensor 31 are included in the constituent elements of the outdoor unit A. The water heat exchanger 3, circulating pump 11, entrance water temperature sensor 32, and exit water temperature sensor 33 are included in the constituent elements of the water heat exchanging unit B. The hot water supply tank 13, heat radiating coil 14, heater 15, heat radiators 21, 22, and 23, and three-way valve 12 are included in the constituent elements of the load unit C. However, which of the units A, B, and C includes each of the aforementioned constituent elements is not limited to the above.

[0026] The control unit D controls operations of the outdoor unit A, water heat exchanging unit B, and load unit C, circulates the refrigerant between the outdoor unit A and water heat exchanging unit B, and circulates the hot water between the water heat exchanging unit B and load unit C. The control unit D includes a controller 40 and operation/display portion 41. The control unit D is provided indoors in the same manner as the load unit C.

[0027] The controller 40 is electrically connected to each of the outdoor unit A, water heat exchanging unit B, load unit C, and operation/display portion 41. The controller 40 includes a CPU, memory, storage device (nonvolatile memory), input/output circuit, timer, and the like and executes predetermined arithmetic processing. For example, the controller 40 reads various data items by means of the input/output circuit, carries out arithmetic processing of the data items by means of the CPU by using a program read from the storage device into the memory, and carries out operation control of the outdoor unit A, water heat exchanging unit B, and load unit C on the basis of the processing result. In the heat pump hot water supply device HP, the controller 40 corresponds to a control portion configured to control the rotational speed of the compressor 1.

[0028] The operation/display portion 41 is a remote-control interface portion to be used by the user to carry out setting of an operating condition to the heat pump hot water supply device HP. The operation/display portion 41 includes, for example, an operation button used to specify a start and stop of the operation of the heat pump hot water supply device HP, operation button of the setting temperature (supplied hot water temperature) of hot water supply or indoor setting temperature at the time of indoor heating, operation button used to specify the operation mode of the circulating pump 11, display portion configured to notify the operational state of the heat pump hot water supply device HP, and the like. Although the operation/display portion 41 is provided on the usage side such as each supply destination of hot water or air-conditioned space, the installation site is not limited to these.

[0029] The operation/display portion 41 and controller 40 may be accommodated in one housing or may each be accommodated in housings separate from each other and may each be provided at positions different from each other. Providing the operation/display portion 41 and controller 40 in the vicinity of the hot water supply tank 13 is a common example.

[0030] Here, the operation and function of the heat pump hot water supply device HP at the time of a heating operation will be described according to the flow of control of the outdoor unit A, water heat exchanging unit B, and load unit C to be carried out by the controller. In FIG. 2, the control flow of the controller 40 at the time of a heating operation is shown. It should be noted that although the indoor heating operation control of the heat pump hot water supply device HP at the time of indoor heating is also executed by the controller 40, the above-mentioned operation control is not the main subject of this embodiment and hence a description thereof is omitted.

[0031] In the heat pump hot water supply device HP, the heating operation (operation of boiling up the water (hot water) retained in the hot water supply tank 13) is started by operating the operation button of the operation/display portion 41 by, for example, the user. Normally, the user operates the operation button to start the operation at the time of installation and thereafter never stops the operation except for the case where the user is absent for a long time.

[0032] When a start instruction of a heating operation is issued from the operation/display portion 41, the controller 40 determines a thermo-on condition (S101). The thermo-on condition is a condition for determining whether or not there is a need for boiling up the water (hot water) retained in the hot water supply tank 13. According to success/failure of the thermo-on condition, it is determined whether or not the circulating pump 11 and compressor 1 be started. More specifically, whether or not the tank water temperature TTW of the hot water supply tank 13 is lower than or equal to the thermo-on water temperature is determined as the thermo-on condition. The thermo-on water temperature is a temperature requiring boiling up of the hot water retained in the hot water supply tank 13 and is a value obtained by subtracting a predetermined value (as an example, 20°C) from the supplied hot water temperature (thermo-off temperature to be described later) which is the tank water temperature set by, for example, the user by operating the operation button of the operation/display portion 41. The value of the thermo-on water temperature is retained in, for example, the storage device of the controller 40 and is read into the memory to be used as a parameter at the time of determination of the thermo-on condition.

[0033] When determining the thermo-on condition, the controller 40 acquires the tank water temperature TTW from the tank water temperature sensor 34 and compares the acquired tank water temperature TTW with the thermo-on water temperature. In this embodiment, as an example, when the tank water temperature is lower than or equal to the thermo-on water temperature, the controller 40 determines the thermo-on condition to be established while considering that there is a need for boiling up the hot water retained in the hot water supply tank 13. On the other hand, when the tank water temperature TTW exceeds the thermo-on water temperature, the controller 40 determines that the thermo-on condition is not established while considering that there is no need for boiling up the hot water retained in the hot water supply tank 13.

[0034] The controller 40 repeats the determination of the thermo-on condition until the thermo-on condition is established. At this time, the controller 40 may execute predetermined non-establishment processing. The non-establishment processing is, for example, waiting processing of waiting for determination of the thermo-on condition for a predetermined time, time-out processing or retry processing of terminating the heating operation in the case where the thermo-on condition is not established even when the determination is repeated for a predetermined time or is repeated a predetermined number of times, and processing formed by combining these, and the like.

[0035] On the other hand, when the thermo-on condition is established in S101, the controller 40 starts the circulating pump 11 (S102). Thereby, hot water starts circulation between the water heat exchanging unit B and hot water supply tank 13 (more specifically, heat radiating coil 14). Hereinafter, the hot water circulating between the water heat exchanging unit B and hot water supply tank 13 as described above is referred to as circulating water. At that time, the controller 40 switches the internal flow path of the three-way valve 12 in such a manner that the first flow path leading from the water entrance 12a to the water exit 12b is obtained.

[0036] Subsequently, the controller 40 starts the compressor 1 (S103). At this time, the controller 40 controls the four-way valve 2 to make the refrigerant discharged from the compressor 1 circulate by way of the water heat exchanger 3, expansion valve 4, air heat exchangers 5a and 5b, four-way valve 2, and accumulator 6 in sequence in the order mentioned and return to the compressor 1 while carrying out gas-liquid phase change. Thereby, the hot water (circulating water) circulating between the water heat exchanging unit B and hot water supply tank 13 is heated by the gaseous refrigerant discharged from the compressor 1 while the hot water flows through the water heat exchanger 3 and the temperature thereof (water temperature) is raised. Then, the aforementioned hot water radiates heat inside the hot water supply tank 13 while the hot water flows through the heat radiating coil 14. Thereby, the tank water temperature (TTW) of the hot water supply tank 13 is raised.

[0037] Subsequently, the controller 40 determines a thermo-off condition (S104). The thermo-off condition is a condition for determining whether or not there is no longer any need for boiling up the hot water retained in the hot water supply tank 13. More specifically, it is determined as the thermo-off condition whether or not it is needed to continue to boil up the hot water while keeping the compressor 1 operating. According to success/failure of the thermo-off condition, it is determined whether or not the circulating pump 11 and compressor 1 should be stopped. In this embodiment, when one of a first thermo-off condition and second thermo-off condition is established, the thermo-off condition is established and compressor 1 is stopped and, when neither of the first thermo-off condition and second thermo-off condition is established, the thermo-off condition is not established and hence the operation of the circulating pump 11 and compressor 1 is continued.

[0038] More specifically, it is determined as the first thermo-off condition whether or not the tank water temperature TTW of the hot water supply tank 13 is higher than or equal to the thermo-off water temperature. The thermo-off water temperature is a temperature requiring no further heating (boiling up) of the hot water retained in the hot water supply tank 13 and is the supplied hot water temperature set by, for example, the user by operating the operation button of the operation/display portion 41. The value of the thermo-off water temperature is retained in, for example, the memory of the controller 40 and is used as a parameter at the time of determination of the first thermo-off condition.

[0039] When determining the first thermo-off condition, the controller 40 acquires the tank water temperature TTW from the tank water temperature sensor 34 and compares the acquired tank water temperature TTW with the thermo-off water temperature. In this embodiment, as an example, when the tank water temperature TTW is higher than or equal to the thermo-off water temperature, the controller 40 determines the first thermo-off condition to be established while considering that there is no longer any need for boiling up the hot water retained in the hot water supply tank 13. On the other hand, when the tank water temperature TTW is lower than the thermo-off water temperature, the controller 40 determines that the first thermo-off condition is not established while considering that there is a need for further boiling up the hot water retained in the hot water supply tank 13.

[0040] Further, it is determined as the second thermo-off condition whether or not the entrance water temperature TWI is higher than or equal to a protecting temperature (hereinafter referred to also as a first set value). The protecting temperature is set for the purpose of protecting the compressor 1 by avoiding the temperature of the gaseous refrigerant to be sucked into the compressor 1 from rising to an excessively high temperature, and is a temperature of the upper limit of the hot water (circulating water) permitted to flow into the water heat exchanger 3. In other words, the protecting temperature is a temperature of the upper limit of the circulating water carrying out heat exchange with the high-temperature gaseous refrigerant and is set in advance according to, for example, the performance or the like of the compressor 1. The value of the protecting temperature is retained in, for example, the storage device of the controller 40 and is read into the memory to be used as a parameter at the time of determination of the second thermo-off condition.

[0041] When determining the second thermo-off condition, the controller 40 acquires the entrance water temperature TWI from the entrance water temperature sensor 32 and compares the acquired entrance water temperature TWI with the protecting temperature (for example, 54°C). In this embodiment, as an example, when the entrance water temperature TWI is higher than or equal to the protecting temperature, the controller 40 determines the second thermo-off condition to be established. In this case, the second thermo-off condition is determined to be established in consideration of the situation where stopping of the compressor 1 is required so that the permissible operating range of the compressor 1 may not be exceeded. Thereby, protection of the compressor 1 is achieved. On the other hand, when the entrance water temperature TWI is lower than the protecting temperature, the controller 40 determines that the second thermo-off condition is not established. In this case, it is determined that the second thermo-off condition is not established in consideration of the situation where even when the hot water retained in the hot water supply tank 13 is further boiled up, the compressor 1 is within the permissible operating range and operation of the compressor 1 can be continued.

[0042] When the thermo-off condition is established on the basis of the first thermo-off condition and second thermo-off condition, the controller 40 stops the compressor 1 (S105) and, at the same time, stops the circulating pump 11 (S106). Thereby, the heating operation of the heat pump hot water supply device HP is terminated.

[0043] Here, as to the second thermo-off condition, the entrance water temperature TWI is about 54°C, this being a common example. On the other hand, the set temperature of the tank water temperature TTW is normally settable in units of 1°C within the range from 45°C to 70°C. When the set value of the tank water temperature TTW is higher than or equal to a high temperature, for example, 55°C, a case where although the second thermo-off condition is satisfied, first thermo-off condition is not satisfied occurs. In this case, there is a need to raise the water temperature even after the compressor 1 and circulating pump 11 are stopped, and hence the heater 15 is started. The operation of the heater 15 is continued until the first thermo-off condition is satisfied, and the tank water temperature TTW reaches the target supplied hot water temperature by this operation.

[0044] On the other hand, when the thermo-off condition is not established in S104, the controller 40 controls the rotational speed of the compressor 1 in such a manner that the compressor 1 is placed in the optimum operating state. For this purpose, the controller 40 determines a temperature-difference condition. The temperature-difference condition is a condition for determining which of "increasing", "keeping", and "decreasing" is the step to which the rotational speed of the compressor 1 should be caused to make a transition. According to success/failure of the temperature-difference condition, it is determined which of "increasing", "keeping", and "decreasing" is the step to which the rotational speed of the compressor 1 should be caused to make a transition. In this embodiment, as the temperature-difference condition, each of a first temperature-difference condition and second temperature-difference condition is determined. When the first temperature-difference condition is established, the rotational speed of the compressor 1 is increased and, when the second temperature-difference condition is established, the rotational speed of the compressor 1 is decreased. When neither of these temperature-difference conditions is established, the rotational speed of the compressor 1 is kept as it is.

[0045] FIG. 3 is a view showing a relationship between a temperature difference (hereinafter referred to as a water temperature difference) between the entrance water temperature TWI and tank water temperature TTW and "increasing", "keeping", and "decreasing" of the rotational speed of the compressor 1. As shown in FIG. 3, the controller 40 causes the rotational speed of the compressor 1 to make a transition from/to HzUP_Zone to/from HzDOWN_Zone between which HzKEEP_Zone is interposed according to the water temperature difference. Here, HzUP_Zone is a range of the water temperature difference within which the rotational speed is increased, HzDOWN_Zone is a range of the water temperature difference within which the rotational speed is decreased, and HzKEEP_Zone is a range of the water temperature difference within which the rotational speed is kept as it is.

[0046] When determining the temperature-difference condition, the controller 40 first determines, as an example, the first temperature-difference condition (S107). The first temperature-difference condition is a condition for determining whether or not the water temperature difference is less than or equal to a first threshold (a). According to success/failure of the first temperature-difference condition, it is determined whether or not the rotational speed of the compressor 1 should be increased. The first threshold is a value of the water temperature difference requiring an increase in the rotational speed of the compressor 1 in order to further boil up the hot water retained in the hot water supply tank 13 and is set in advance according to, for example, the performance or the like of the compressor 1. The first threshold is retained in, for example, the storage device of the controller 40 and is read into the memory to be used as a parameter at the time of determination of the first temperature-difference condition.

[0047] When determining the first temperature-difference condition, the controller 40 acquires the entrance water temperature TWI from the entrance water temperature sensor 32, at the same time, acquires the tank water temperature TTW from the tank water temperature sensor 34, calculates the water temperature difference, and compares the calculated value with the first threshold. When the water temperature difference is less than or equal to the first threshold, the controller 40 determines the first temperature-difference condition to be established. On the other hand, when the water temperature difference exceeds the first threshold, the controller 40 determines that the first temperature-difference condition is not established.

[0048] When the first temperature-difference condition is established, the controller 40 increases the rotational speed of the compressor 1 in order to further boil up the hot water retained in the hot water supply tank 13 (S108). In this case, the situation is made such that the water temperature difference is within HzUP_Zone as shown in FIG. 3, and an increase in the rotational speed of the compressor 1 is needed. When the rotational speed of the compressor 1 is increased, temperature of the circulating water is raised, and heat radiation amount inside the hot water supply tank 13 is increased. Thereby, the hot water retained in the hot water supply tank 13 is boiled up, and tank water temperature TTW is raised. The increase amount of the rotational speed is not particularly limited and is arbitrarily settable.

[0049] On the other hand, when the first temperature-difference condition is not established in S107, the controller 40 determines the second temperature-difference condition (S109). The second temperature-difference condition is a condition for determining whether or not the water temperature difference exceeds a second threshold (β). According to success/failure of the second temperature-difference condition, it is determined whether or not the rotational speed of the compressor 1 should be decreased. The second threshold is a value of the water temperature difference requiring a decrease in the rotational speed of the compressor 1 in order to suppress boiling up of the hot water retained in the hot water supply tank 13 and is set in advance according to, for example, the performance or the like of the compressor 1. The second threshold is a value greater than the first threshold. The second threshold is retained in, for example, the storage device of the controller 40 and is read into the memory to be used as a parameter at the time of determination of the second temperature-difference condition.

[0050] When determining the second temperature-difference condition, the controller 40 compares the calculated value of the water temperature difference with the second threshold. When the water temperature difference exceeds the second threshold, the controller 40 determines the second temperature-difference condition to be established. On the other hand, when the water temperature difference is less than or equal to the second threshold, the controller 40 determines that the second temperature-difference condition is not established.

[0051] When the second temperature-difference condition is established, the controller 40 decreases the rotational speed of the compressor 1 in order to suppress boiling up of the hot water retained in the hot water supply tank 13 (S110). In this case, the situation is made such that the water temperature difference is within HzDOWN_Zone as shown in FIG. 3, and a decrease in the rotational speed of the compressor 1 is needed. When the rotational speed of the compressor 1 is decreased, a rise in the temperature of the circulating water is suppressed, and the heat radiation amount inside the hot water supply tank 13 is decreased. Thereby, boiling up of the hot water retained in the hot water supply tank 13 is suppressed, and tank water temperature TTW is lowered. The decrease amount of the rotational speed is not particularly limited and is arbitrarily settable. For example, the increase amount of the rotational speed and decrease amount thereof may be coincident with each other or may be different from each other. Further, these values may be fixed amounts (fixed values) irrespective of, for example, the water temperature difference or may be variable amounts (variable values) corresponding to the water temperature difference.

[0052] On the other hand, when the second temperature-difference condition is not established in S109, the controller 40 keeps the rotational speed of the compressor 1 as it is in order to maintain the tank water temperature TTW (S111). In this case, the situation is made such that the water temperature is within HzKEEP_Zone as shown in FIG. 3, and it is necessary to keep the rotational speed of the compressor 1 as it is. When the rotational speed of the compressor 1 is kept as it is, the temperature (in other words, heat radiation amount inside the hot water supply tank 13) of the circulating water is maintained in such a manner that the water temperature difference is greater than the first threshold and is less than or equal to the second threshold. Thereby, boiling up of the hot water retained in the hot water supply tank 13 is continued in order that the tank water temperature TTW may get closer to the thermo-off water temperature.

[0053] After causing the rotational speed of the compressor 1 to make a transition to one of increasing, decreasing, and keeping in S108, S110 or S111, the controller 40 determines the thermo-off condition again (S104). That is, the controller 40 appropriately repeats the determination of the first temperature-difference condition and second temperature-difference condition until the thermo-off condition is established. Therefore, according to success/failure of determination of the first and second temperature-difference conditions, increasing, decreasing or keeping of the rotational speed of the compressor 1 is appropriately repeated. Such variations of the rotational speed of the compressor 1 are appropriately repeated, whereby, for example, the tank water temperature TTW gradually becomes closer to the thermo-off water temperature. As a result, when the tank water temperature TTW becomes higher than or equal to the thermo-off water temperature, the thermo-off condition (first thermo-off condition) is established, compressor 1 and circulating pump 11 are stopped, and heating operation of the heat pump hot water supply device HP is terminated.

[0054] As described above, according to the heat pump hot water supply device HP and heat pump heat source device of this embodiment, it is possible to appropriately increase, decrease or keep the rotational speed of the compressor 1 on the basis of the water temperature difference (temperature difference between the entrance water temperature TWI and tank water temperature TTW). Thereby, it is possible to operate the compressor 1 while keeping the water temperature difference within a certain fixed temperature range. For example, the state where the water temperature difference is not fixed and becomes gradually greater is the state where the amount of heating of the circulating water by the refrigerant is greater than the heat radiation amount of the circulating water inside hot water supply tank 13, and supplied amount of heat is excessive.

[0055] In this state, it becomes possible to decrease the rotational speed of the compressor 1 and suppress the supplied amount of heat. That is, by varying the rotational speed of the compressor 1 according to the water temperature difference, it is possible to optimize the rotational speed, and it becomes possible to reduce the power consumption. It should be noted that formerly the rotational speed of the compressor 1 was raised, according to the exit water temperature TWO, to the maximum rotational speed set in such a manner that, for example, the exit water temperature TWO becomes the predetermined target temperature. The exit water temperature TWO does not directly reflect the heat radiation amount of the circulating water inside the hot water supply tank 13 and, when rotational speed of the compressor 1 is raised to the maximum rotational speed, the control is liable to become unnecessary rotational speed control. Conversely, the water temperature difference is a value directly reflecting the heat radiation amount of the circulating water. Accordingly, in comparison with the case where the rotational speed of the compressor 1 is controlled according to the exit water temperature TWO, in the case where the control is carried out according to the water temperature difference, it is possible to further enhance the accuracy of variation of the rotational speed of the compressor 1 for controlling of the tank water temperature TTW. That is, by controlling the rotational speed of the compressor 1 in such a manner that the water temperature difference becomes approximately constant, it is possible to suppress an unnecessary rise in the rotational speed. Thereby, it is possible to operate the compressor 1 while keeping the variation of the rotational speed to a minimum, and it becomes possible to reduce the power consumption.

[0056] Further, for example, in the state where the supplied amount of heat is excessive as described above, the temperature of the circulating water is raised, and refrigerant pressure is also raised. For this reason, formerly the compressor 1 was stopped for the purpose of protecting the compressor 1 and, instead, the heater 15 was started to generate heat. In this embodiment, it is possible not to carry out starting of the heater 15 or to delay the starting, and to continue the operation of the compressor 1. Accordingly, it is possible to shorten the operating time of the heater 15 and, from such a point of view, it becomes possible to reduce the power consumption.

[0057] Here, in the case where the tank water temperature TTW is low, the state is such that the temperature of the circulating water is low, and pressure of the gaseous refrigerant flowing through the refrigerant flow path of the water heat exchanger 3 is also low. Accordingly, even when the rotational speed of the compressor 1 is increased, the heater 15 is not immediately started. In this state, limiting the rotational speed of the compressor 1 is liable to cause, due to the performance/characteristics thereof, an inefficient operation. Further, in the case where the tank water temperature TTW is low and compressor 1 is operated at a low rotational speed as described above, the operation is carried out with a low compression ratio, whereby deterioration in the reliability, sound noise, and the like of the compressor 1 is liable to occur.

(Second Embodiment)

[0058] Subsequently, as another embodiment in which the heat pump operation is carried out as much as possible and use of the heater 15 is made as little as possible, a second embodiment will be described below. The configuration itself of the heat pump heat source device of the second embodiment is equivalent to the configuration of the heat pump hot water supply device HP of the first embodiment shown in FIG. 1.

[0059] In FIG. 4, a control flow of a controller 40 at the time of a heating operation in this embodiment is shown. Hereinafter, control of the controller 40 at the time of the heating operation in this embodiment will be described according to the control flow shown in FIG. 4. It should be noted that the control flow of the heating operation of this embodiment is formed in such a manner that a part of the control flow (FIG. 2) of the first embodiment is added to the control peculiar to the second embodiment for alteration. Accordingly, control items equivalent to the first embodiment described above are denoted by step numbers identical to the first embodiment and descriptions of these control items are omitted and control peculiar to the second embodiment will be described below in detail.

[0060] As shown in FIG. 4, at the time of the heating operation, the controller 40 determines a thermo-on condition (S101), then, when the thermo-on condition is established, starts the circulating pump 11 (S102) and, at the same time, starts the compressor 1 (S103). At this time, the controller 40 repeats the determination of the thermo-on condition until the thermo-on condition is established.

[0061] Upon starting of the compressor 1, the controller 40 determines an entrance water temperature condition. In this embodiment, two entrance water temperature conditions having thresholds different from each other are determined.

[0062] A first entrance water temperature condition is a condition for determining whether or not the entrance water temperature TWI is lower than a first set value. According to success/failure of the first entrance water temperature condition, it is determined whether or not the compressor 1 should be stopped and heater 15 should be started.

[0063] A second entrance water temperature condition is a condition for determining whether or not the entrance water temperature TWI is lower than or equal to a second set value. According to success/failure of the second entrance water temperature condition, it is determined at which of a rotational speed corresponding to a high-efficiency frequency (hereinafter referred to as a high-efficiency frequency Fl) and rotational speed corresponding to a low-capability frequency (hereinafter referred to as a low-capability frequency Fm) the compressor 1 should be operated.

[0064] FIG. 5 is a view showing a relationship between the entrance water temperature TWI and operation control (frequency and stop) of the compressor 1. In FIG. 5, the area higher than the first set value is a range of the entrance water temperature TWI within which the compressor is stopped for protection of the compressor 1, and area lower than the second set value set to a value lower than the first set value is a range of the entrance water temperature TWI within which the compressor 1 is operated at a high-efficiency frequency Fl. Further, the area interposed between these two values is the range of the entrance water temperature TWI within which the compressor 1 is operated at a low-capability frequency Fm. The value of the high-efficiency frequency Fl and value of the low-capability frequency Fm are set according to, for example, the performance or the like of the compressor 1.

[0065] In FIG. 6, an example of the performance characteristics of the refrigeration cycle is shown by a relationship between the frequency [Hz], i.e., compressor rotational speed and coefficient of performance [COP]. On the basis of the performance characteristics shown in FIG. 6, in this embodiment, as an example, the value of the high-efficiency frequency Fl is made about 45 Hz, and value of the low-capability frequency Fm is made about 30 Hz. As the value of the high-efficiency frequency Fl, a value of a frequency the coefficient of performance of which is the highest is selected and, as the value of the low-capability frequency Fm, a value less than the value of the high-efficiency frequency Fl and of such a degree that the coefficient of performance thereof is not extremely lowered is selected.

[0066] When determining the entrance water temperature condition, the controller 40 first determines a first water temperature condition (S201). In this case, the controller 40 acquires the entrance water temperature TWI from the entrance water temperature sensor 32, and compares the acquired entrance water temperature TWI with the first set value. In this embodiment, the first set value is the protecting temperature and is set to, for example, 54°C. When the entrance water temperature TWI is lower than the first set value, the controller 40 determines the first entrance water temperature condition to be established. On the other hand, when the entrance water temperature TWI is higher than or equal to the first set value, the controller 40 determines that the first entrance water temperature condition is not established.

[0067] When the first entrance water temperature condition is not established, the controller 40 stops the compressor 1 (S105). Thereby, the heating operation based on the heat pump is terminated.

[0068] Then, upon stopping of the compressor 1, the controller 40 starts the heater 15 (S202). Thereby, the heating operation based on the heater 15 is started. That is, the operation of the heat pump hot water supply device HP is switched from the heating operation based on the heat pump to the heating operation based on the heater 15.

[0069] On the other hand, when the first entrance water temperature condition is established in S201, the controller 40 determines the second entrance water temperature condition (S203). In this case, the heat pump hot water supply device HP continues the heating operation based on the heat pump without switching to the heating operation based on the heater 15. When determining the second entrance water temperature condition, the controller 40 compares the entrance water temperature TWI with the second set value. The second set value is a value less than the first set value and, in this embodiment, as an example, is set to about 52°C lower than the first set value which is the protecting temperature of, for example, 54°C. When the entrance water temperature TWI is lower than or equal to the second set value, the controller 40 determines the second entrance water temperature condition to be established. On the other hand, when the entrance water temperature TWI exceeds the second set value, the controller 40 determines that the second entrance water temperature condition is not established.

[0070] When the second entrance water temperature condition is established, the controller 40 operates the compressor 1 at a rotational speed corresponding to the high-efficiency frequency Fl (S204). Accordingly, the controller 40 increases/decreases the rotational speed of the compressor 1 according to the rotational speed thereof at this time in such a manner that the frequency of the compressor 1 becomes the high-efficiency frequency Fl.

[0071] On the other hand, when the second entrance water temperature condition is not established in S203, the controller 40 operates the compressor 1 at a frequency corresponding to the low-capability frequency Fm (S205). Accordingly, the controller 40 increases/decreases the rotational speed of the compressor 1 according to the rotational speed thereof at this time in such a manner that the frequency of the compressor 1 becomes the low-capability frequency Fm.

[0072] When the heating operation based on the heater 15 is started or when the heating operation based on the heat pump is continued at the high-efficiency frequency Fl or low-capability frequency Fm, the controller 40 determines the thermo-off condition (S104).

[0073] When the thermo-off condition is not established, the controller 40 determines the first entrance water temperature condition again (S201). That is, the controller 40 appropriately repeats the subsequent processing steps according to success/failure of the first entrance water temperature condition until the thermo-off condition is established.

[0074] On the other hand, when the thermo-off condition is established in S104, the controller 40 executes predetermined thermo-off processing (S206). As the thermo-off processing, the controller 40 stops the equipment members in the following manner. When the compressor 1 is already started, the controller 40 stops the compressor 1 and, when the heater 15 is already started, stops the heater 15. Further, the controller 40 stops the circulating pump 11. Thereby, the heating operation of the heat pump hot water supply device HP is terminated.

[0075] As described above, according to the heat pump hot water supply device HP of this embodiment, when the entrance water temperature TWI is lower than or equal to the second set value (for example, 52°C), the heating operation based on the heat pump is carried out at the high-efficiency frequency Fl, and thus it is possible to efficiently raise the tank water temperature TTW. At this time, when the entrance water temperature TWI rises to become close to the protecting temperature (for example, 54°C), it is possible to switch the operation to the heating operation based on the heat pump at the low-capability frequency Fm. Thereby, it is possible to carry out the operation at the low-capability frequency Fm within the area from the second set value to the first set value without the operation being continued at the high-efficiency frequency Fl until the entrance water temperature TWI reaches the protecting temperature (first set value).

[0076] Here, when the operation at the high-efficiency frequency Fl is continued until the entrance water temperature TWI reaches the protecting temperature, the rise in the entrance water temperature TWI is great due to the high heating capability, and hence the entrance water temperature TWI becomes higher than or equal to the protecting temperature in a short time. In this case, the operation is switched to the heating operation based on the heater the efficiency of which is poorer as compared with the heat pump.

[0077] However, in this embodiment, the operation of the compressor 1 is switched to the heating operation at the low-capability frequency Fm before the entrance water temperature TWI reaches the protecting temperature, and hence it is possible to appropriately lower the heating capability when the entrance water temperature TWI gets close to the protecting temperature. Accordingly, it is possible to moderate the rate of rise in the entrance water temperature TWI, prolong the time taken by the entrance water temperature TWI to reach the protecting temperature, and gradually raise the tank water temperature TTW. When the compressor 1 is made to carry out the heating operation at the low-capability frequency Fm as described above, it becomes possible to make the average temperature of the tank water temperature TTW higher during the time until the tank water temperature TTW reaches the protecting temperature in comparison with the case where the compressor 1 is made to carry out the heating operation at the high-efficiency frequency Fl.

[0078] Further, when the entrance water temperature TWI rises to a temperature close to the protecting temperature, it is possible to suppress the operation frequency (repetition) and accumulated operating time of the heater 15 by making the compressor 1 carry out the heating operation at the low-capability frequency Fm and continue the heating operation based on the heat pump as much as possible. Thereby, it is possible to improve the operating efficiency of the heat pump hot water supply device HP and realize saving of energy.

[0079] The value of the first set value which is the protecting temperature described above is separately set according to the type of the refrigerant and configuration of the compressor 1 to be used for the refrigeration cycle of the heat pump hot water supply device HP. As to setting of the second set value, although when the temperature difference between the second set value and first set value is made as small as possible, the percentage of the time during which the compressor 1 can be operated at the high-efficiency frequency Fl increases, if the aforementioned temperature difference is made excessively small, the possibility of the operation being switched from the heating operation based on the operation of the compressor 1 to the heating operation based on the heater 15 at an earlier stage becomes stronger. For this reason, in consideration of an overshoot of the entrance water temperature TWI at the time of heating based on the operation of the compressor 1, it is desirable that as the second set value, a value lower than the first set value by 1 to 2°C be set.

[0080] Although in the embodiment described above, the heater 15 configured to heat the water in the hot water supply tank 13 is provided inside the hot water supply tank 13, the heater 15 may be provided in the circulation pathway through which the water flows between the heat radiating coil (water heat radiator) 14 and water heat exchanger 3. However, when the heater 15 is provided in the circulation pathway of the water, it is necessary to make the circulating pump 11 in operation all the time while the compressor 1 is in operation or the heater 15 is energized.

[0081] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Reference Signs List

[0082] 1 ... compressor, 2 ... four-way valve, 3 ... water heat exchanger, 4 ... expansion valve, 5 ... air heat exchanger, 6 ... accumulator, 7a, 7b ... outdoor fan, 11 ... circulating pump, 12 ... three-way valve, 12a ... water entrance, 12b ... water exit, 12c ... water exit, 13 ... hot water supply tank, 14 ... heat radiating coil (water heat radiator), 15 ... heater, 16 ... water-inflow pipe, 17 ... water-outflow pipe, 17a ... faucet, 21, 22, 23 ... heat radiator, 31 ... outdoor air temperature sensor, 32 ... hot-water temperature sensor (entrance water temperature sensor), 33 ... hot-water temperature sensor (exit water temperature sensor), 34 ... hot-water temperature sensor (tank water temperature sensor), 40 ... controller, 41 ... operation/display portion, A ... outdoor unit, B ... water heat exchanging unit, C ... load unit, D ... control unit, HP ... heat pump hot water supply device

Claims

1. A heat pump hot water supply device **characterized by** comprising:

   a rotary compressor which discharges a compressed gaseous refrigerant therefrom;
   a water heat exchanger which heats water flowing through a flow path included in the water heat exchanger by the gaseous refrigerant;
   a tank which retains water therein;
   a water heat radiator which is provided inside the tank and makes the water heated in the water heat exchanger release the heat thereof to the inside of the tank;
   a pump which circulates water between the water heat radiator and the water heat exchanger;
   a heater which heats the water inside the tank;
   a first temperature sensor which senses a first temperature of the water flowing into the flow path of the water heat exchanger after releasing heat thereof to the water retained in the tank;
   a second temperature sensor which senses a second temperature of the water retained in the tank; and
   a controller which controls an operation or a stop of the compressor on the basis of the first temperature and the second temperature and controls a rotational speed of the compressor on the basis of the first temperature while the compressor is in operation.

2. The heat pump hot water supply device of claim 1, **characterized in that**

   the controller
   controls, when the first temperature is higher than a predetermined set value, the rotational speed of the compressor to a rotational speed at which high efficiency can be obtained, and
   controls, when the first temperature is lower than a temperature set lower than the set value, the rotational speed of the compressor to a rotational speed lower than the rotational speed at which the high efficiency can be obtained.

3. The heat pump hot water supply device of claim 2, **characterized in that**
   the controller stops, when the first temperature reaches a protecting temperature of the compressor higher than the set value, the compressor.

4. The heat pump hot water supply device of claim 1, **characterized in that**
   the controller controls the rotational speed of the compressor on the basis of a difference between the first temperature and the second temperature while the compressor is in operation.

5. The heat pump hot water supply device of claim 4, **characterized in that**

   the controller
   increases, when the difference between the first temperature and the second temperature is less than or equal to a first threshold, the rotational speed of the compressor,
   decreases, when the difference between the first temperature and the second temperature exceeds a second threshold greater than the first threshold, the rotational speed of the compressor, and
   keeps, when the difference between the first temperature and the second temperature exceeds the first threshold and is less than or equal to the second threshold, the rotational speed of the compressor as it is.

6. The heat pump hot water supply device of claim 5, **characterized in that**

   the controller determines a condition for determining whether or not the operation of the compressor should be continued to heat the water retained in the tank,
   when the condition is established, repeats the control of the rotational speed of the compressor to thereby continue to heat the water retained in the tank, and
   when the condition is not established, stops the compressor.

7. The heat pump hot water supply device of claim 6, **characterized in that**
   the controller determines, when the first temperature is higher than or equal to a temperature of the upper limit of the water flowing into the water heat exchanger set for the purpose of protecting the compressor or when the second temperature is higher than or equal to a preset temperature, the condition to be established and determines, when neither of the foregoing situations is obtained, that the condition is not established.

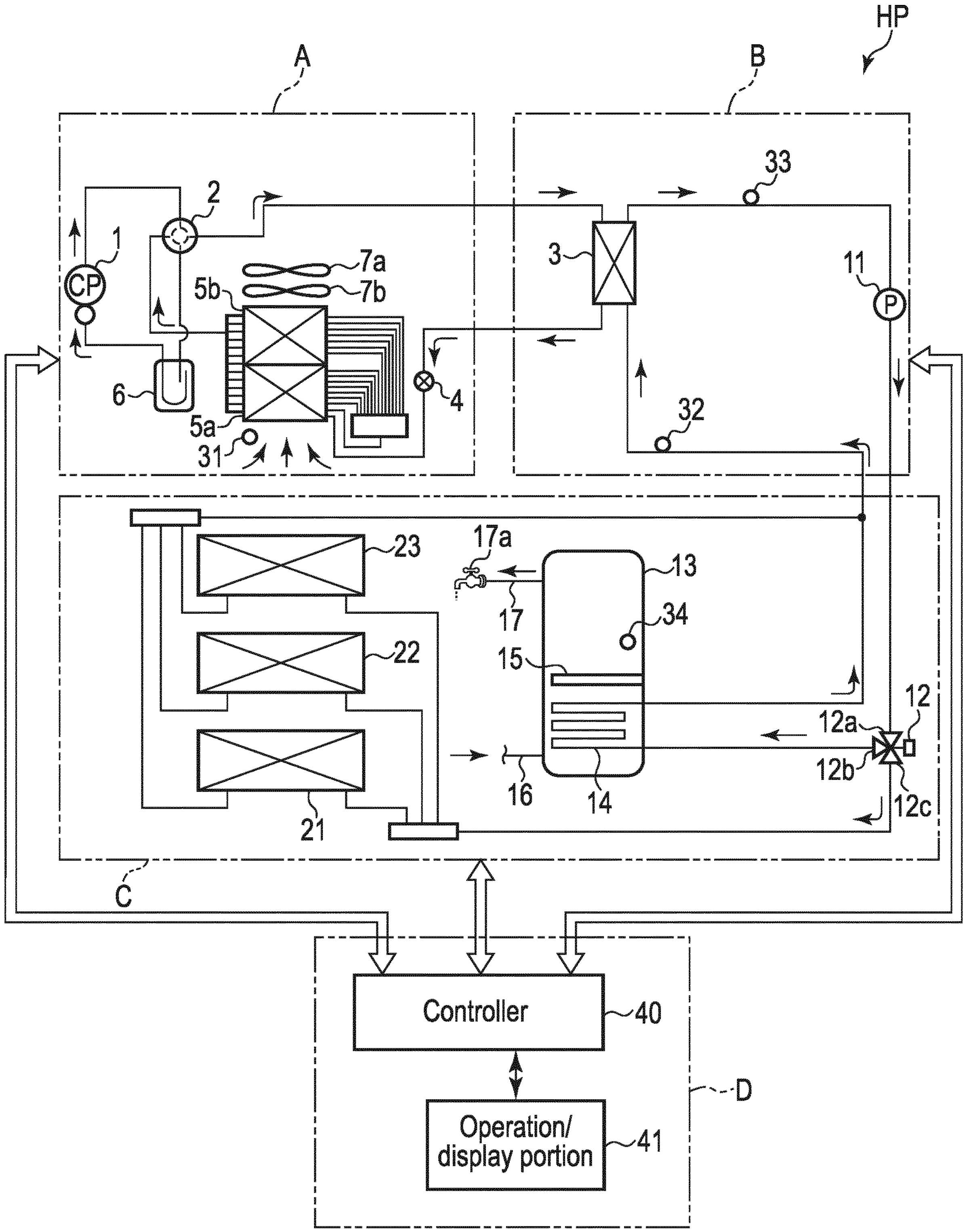
8. The heat pump hot water supply device of any one of claims 1 to 7, **characterized in that**
   the controller stops, when the second temperature reaches the set temperature, the operations of the compressor and the heater.

9. A heat pump heat source device **characterized by**

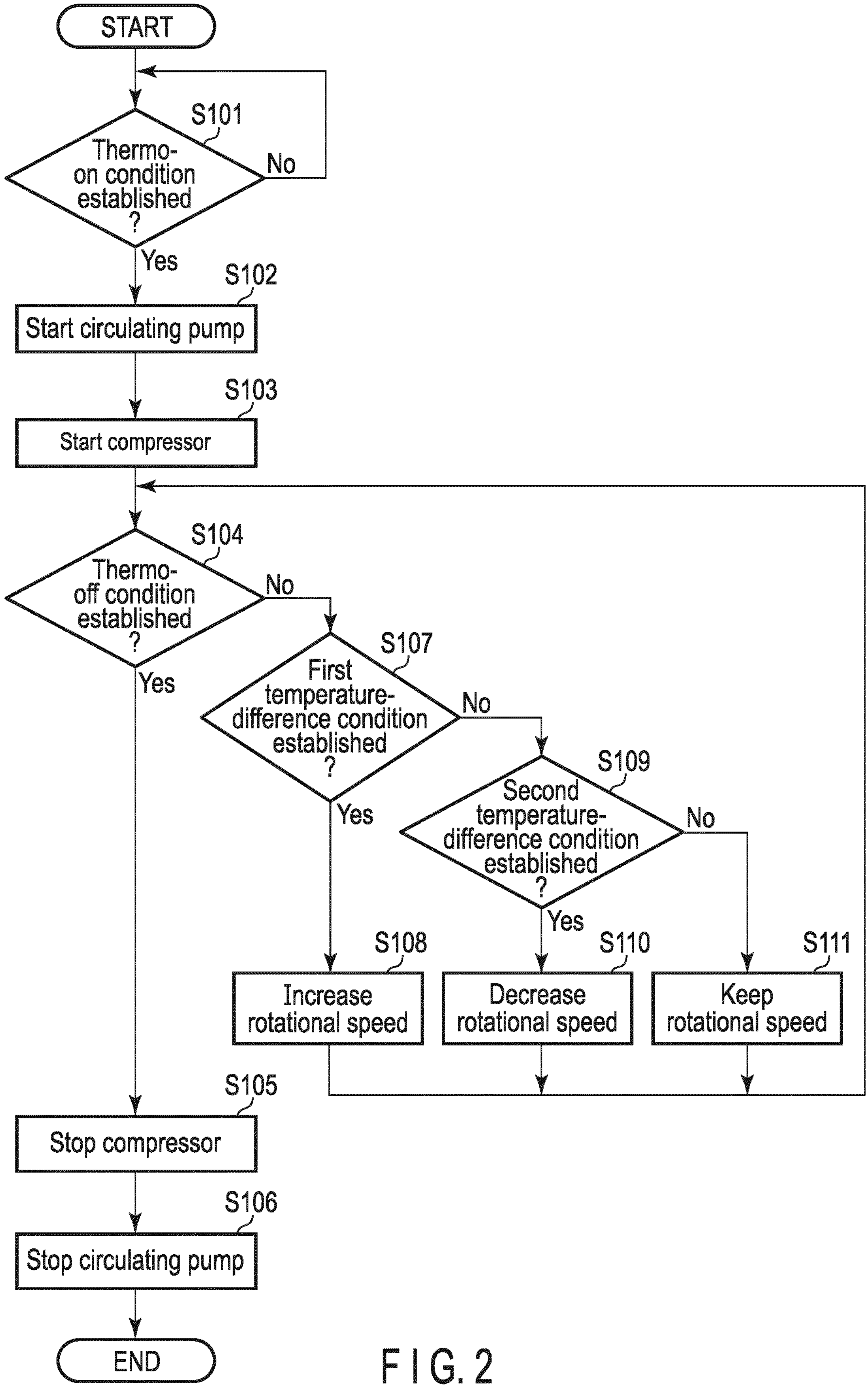
comprising:

a rotary compressor which discharges a compressed gaseous refrigerant;
a water heat exchanger which heats water flowing through a flow path included in the water heat exchanger by the gaseous refrigerant;
a pump which circulates water between the water heat exchanger and a heat exchanger on the usage side;
a first temperature sensor which senses a first temperature of water flowing into the flow path of the water heat exchanger; and
a controller which controls a stop of the compressor on the basis of the first temperature, controls, while the compressor is in operation, when the first temperature is higher than a predetermined set value, a rotational speed of the compressor to a rotational speed at which high efficiency can be obtained, and controls, when the first temperature is lower than a temperature set lower than the set value, the rotational speed of the compressor to a rotational speed lower than the rotational speed at which the high efficiency can be obtained.

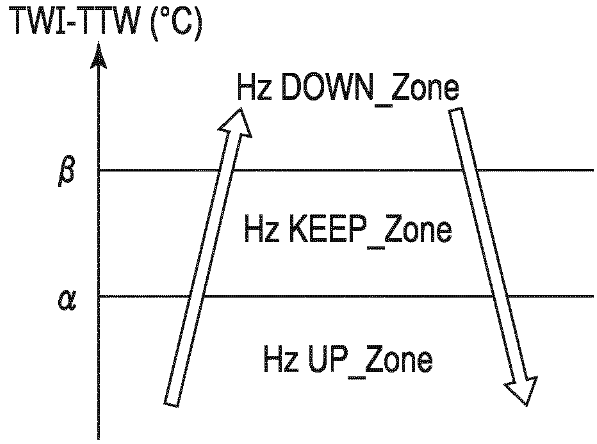
10. The heat pump heat source device of claim 9, **characterized in that**
the heat exchanger on the usage side is a water heat radiator provided inside the hot water supply tank.



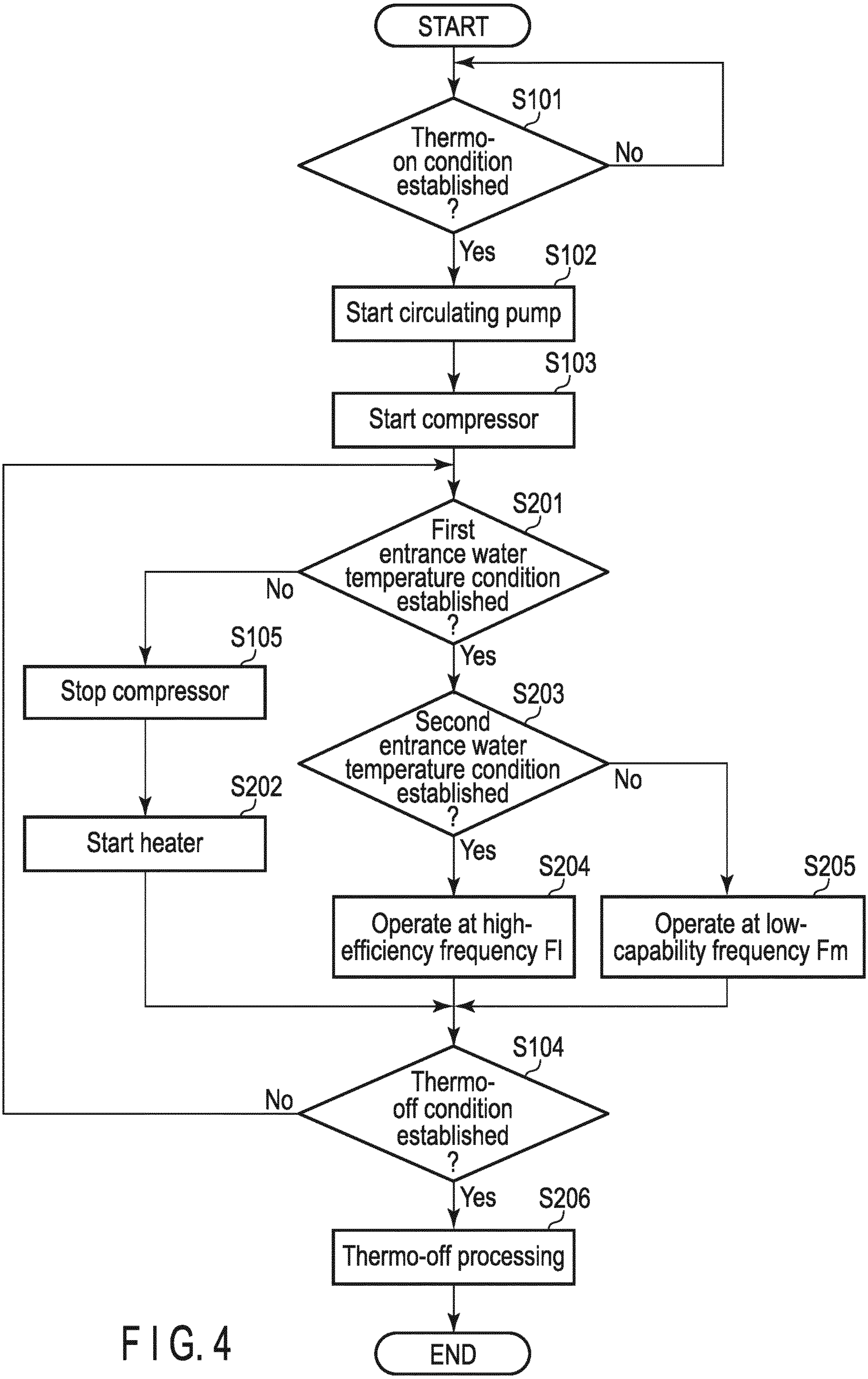
F I G. 1


START
S101
Thermo-on condition established?
No
Yes
S102
Start circulating pump
S103
Start compressor
S104
Thermo-off condition established?
No
Yes
S107
First temperature-difference condition established?
No
Yes
S109
Second temperature-difference condition established?
No
Yes
S108
Increase rotational speed
S110
Decrease rotational speed
S111
Keep rotational speed
S105
Stop compressor
S106
Stop circulating pump
END

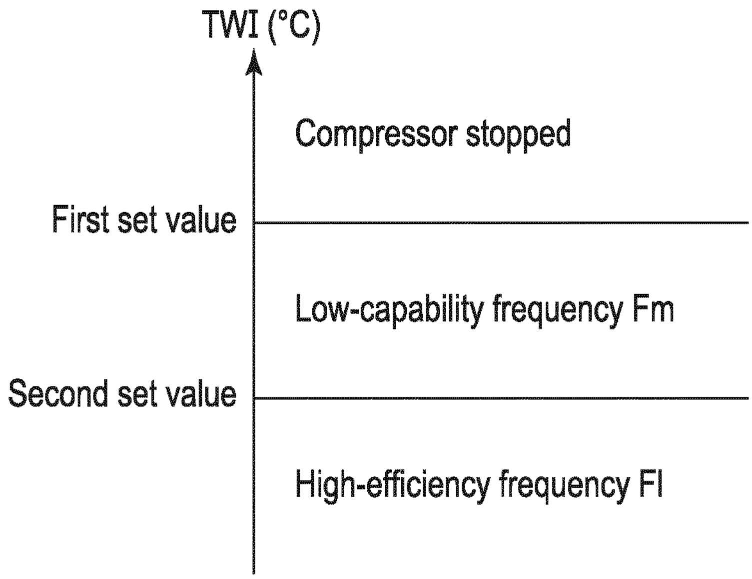
F I G. 2



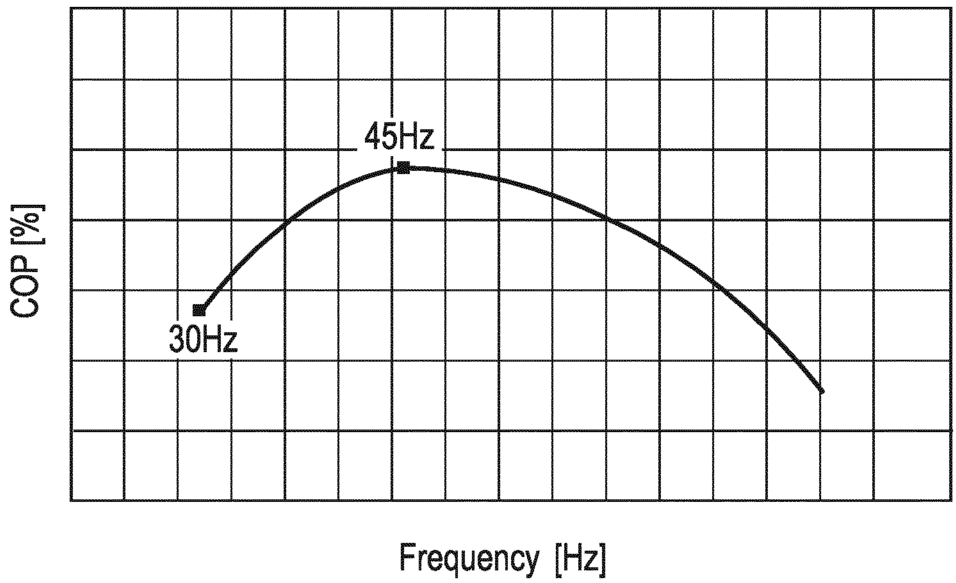
F I G. 3


START
S101
Thermo-
on condition
established
?
No
Yes
S102
Start circulating pump
S103
Start compressor
S201
First
entrance water
temperature condition
established
?
No
S105
Stop compressor
Yes
S203
Second
entrance water
temperature condition
established
?
No
S202
Start heater
Yes
S204
S205
Operate at high-
efficiency frequency Fl
Operate at low-
capability frequency Fm
S104
Thermo-
off condition
established
?
No
Yes
S206
Thermo-off processing
END

F I G. 4


TWI (°C)
Compressor stopped
First set value
Low-capability frequency Fm
Second set value
High-efficiency frequency Fl

F I G. 5


COP [%]
45Hz
30Hz
Frequency [Hz]

F I G. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/012644

A. CLASSIFICATION OF SUBJECT MATTER
F24H 4/02(2006.01)i
FI: F24H4/02 L
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

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2016-75455 A (TOSHIBA CARRIER CORPORATION) 12 May 2016 (2016-05-12) in particular, see paragraphs [0010]-[0016], [0032]-[0033], [0037]-[0038], fig. 1, 3	1, 8
A	entire text, all drawings	2-7, 9-10
Y	JP 2014-43963 A (MITSUBISHI ELECTRIC CORP.) 13 March 2014 (2014-03-13) in particular, see paragraph [0017], fig. 1	1, 8
A	JP 2006-17377 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 19 January 2006 (2006-01-19) in particular, see paragraph [0027]	2, 9
A	JP 2006-132875 A (DENSO CORP.) 25 May 2006 (2006-05-25) in particular, see paragraph [0023]	2, 9

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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