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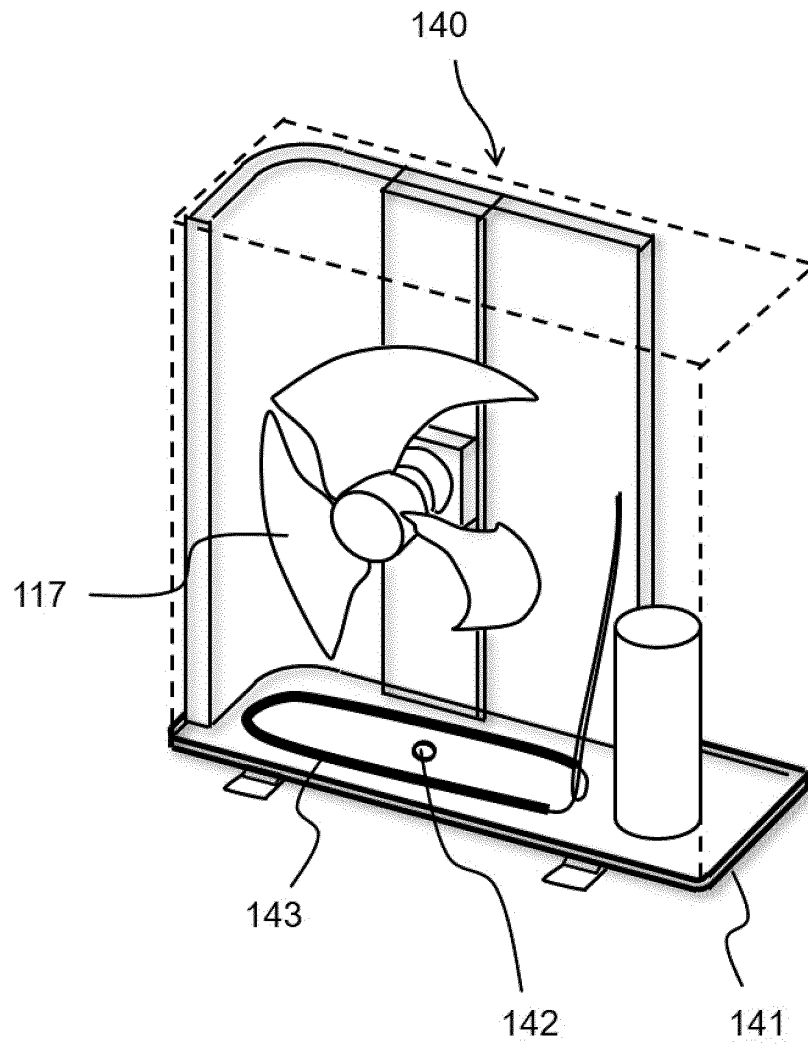
(54) **HEAT MEDIUM CIRCULATION SYSTEM**

(57) A heat medium circulation system 100 comprises: a refrigerant circuit 110 in which a compressor 111, a use-side heat exchanger 112, an expander 113, and a heat source-side heat exchanger 114 are connected annularly and a flammable refrigerant is used; an air blower 117 for flowing air to the heat source-side heat exchanger 114; a casing 140 accommodating at least the refrigerant circuit 110 and the air blower 117; an electric heating device 143 provided on the bottom plate 141 of the casing 140; and a control device 130. The control device 130

simultaneously starts operation of the air blower 117 and energization of the electric heating device 143, and controls power consumption of the electric heating device 143 to be lower than power consumption in a stable state for a predetermined time from the start of energization of the electric heating device 143, thereby safely operating the electric heating device 143 which suppresses freezing of drain water and providing the heat medium circulation system 100 with further improved safety.

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[Fig. 3]



Description**[BRIEF DESCRIPTION OF THE DRAWINGS]****[TECHNICAL FIELD]****[0007]**

[0001] The present disclosure relates to a heat medium circulation system.

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Fig. 1 is a block diagram of a heat medium circulation system in an embodiment of the present invention;

[BACKGROUND TECHNIQUE]

[0002] Patent Document 1 discloses an outdoor unit using a flammable refrigerant. In this outdoor unit, an electric heating device is provided on an upper surface of a bottom plate. The electric heating device is energized when an outdoor blower is rotating.

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Fig. 2 is a pressure-enthalpy diagram (P-h diagram) of the heat medium circulation system in the embodiment;

Fig. 3 is a schematic diagram of an installation configuration of an electric heating device in the embodiment;

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[PRIOR ART DOCUMENT]

Fig. 4 is a block diagram of a control system of the heat medium circulation system in the embodiment;

[PATENT DOCUMENT]

[0003] [Patent Document 1] Japanese Patent Application Laid-open No.2015-055455

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Fig. 5 is a correlation diagram of a power density and heater surface temperature of the electric heating device of the heat medium circulation system in the embodiment; and

[SUMMARY OF THE INVENTION]**[PROBLEM TO BE SOLVED BY THE INVENTION]**

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Fig. 6 is a flowchart for explaining a control operation of a blower and the electric heating device of the heat medium circulation system in the embodiment.

[0004] The present disclosure provides a heat medium circulation system in which safety is further improved by controlling power consumption while ventilating an atmospheric gas of an electric heating device.

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[MODE FOR CARRYING OUT THE INVENTION]

(Perception which becomes a basis of present disclosure)

[MEANS FOR SOLVING THE PROBLEM]

[0005] A heat medium circulation system in this disclosure comprises a refrigerant circuit in which a compressor, use-side heat exchanger, an expander, and a heat source-side heat exchanger are connected annularly using a flammable refrigerant; a blower for flowing air to the heat source-side heat exchanger; at least a casing for accommodating the refrigerant circuit and the blower; an electric heating device provided on the surface of the bottom plate of the casing; a control device, wherein the control device simultaneously starts operation of the blower and energization of the electric heating device, and controls such that power consumption of the electric heating device is lower than power consumption in a stable state for a predetermined time from start of energization of the electric heating device.

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[0008] When an electric heating device is not energized until flammable refrigerant is ventilated by an outdoor blower, temperature of a bottom plate may drop and moisture on a surface of the bottom plate freezes. As a result, damage to a drainpipe may occur.

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[0009] Therefore, in the present disclosure, the operation of the blower device and the energization of the electric heating device are simultaneously started, and power consumption of the electric heating device is controlled to be lower than power consumption in a stable state for a predetermined time from start of energization of the electric heating device. As a result, even if the flammable refrigerant leaks, an amount of heat that does not ignite the flammable refrigerant is suppressed. By doing so, the electric heating device can be ventilated to exhaust the leaked refrigerant while suppressing the temperature drop of the bottom plate. This provides a heat medium circulation system that further improves reliability and safety of device.

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[EFFECT OF THE INVENTION]

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[0006] In the heat medium circulation system in the present disclosure, surface temperature of the electric heating device is kept low until the atmospheric gas of the electric heating device is ventilated, so that safety is further improved. In addition, freezing of the bottom plate is prevented.

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[0010] The embodiment will be described below in detail with reference to the drawings. Excessively detailed description will be omitted in some cases. For example, detailed description of already well-known matters, or redundant description of substantially the same configuration will be omitted in some cases. This is for preventing the following description becoming redundant more than

necessary, and for making it easy for a person skilled in the art to understand.

[0011] The accompanying drawing and the following description are provided so that the person skilled in the art can sufficiently understand the present disclosure, and it is not intended that they limit the subject matter described in claims.

[0012] An embodiment of the present invention will be described below using Figs. 1 to 5.

[1-1. Configuration]

[1-1-1. Configuration of heat medium circulation system]

[0013] In Fig. 1, a heat medium circulation system 100 includes a refrigerant circuit 110, a heat medium circuit 120 and a control device 130.

[0014] The refrigerant circuit 110 is a vapor compression type refrigeration cycle. The refrigerant circuit 110 is configured by sequentially connecting a compressor 111, a use-side heat exchanger 112, an expander 113 and a heat source-side heat exchanger 114 to one another through a pipe 116. As refrigerant, propane which is flammable refrigerant is used.

[0015] The refrigerant circuit 110 is provided with a four-way valve 115. The four-way valve 115 switches between a heating operation to produce warm water and a cooling operation to produce cold water.

[0016] The refrigerant circuit 110 is housed in an outdoor casing 140. The casing 140 includes an air blower 117 that flows outdoor air to the heat source-side heat exchanger 114.

[0017] The heat medium circuit 120 is configured by sequentially connecting the use-side heat exchanger 112, a use-side terminal 122, switching valves 124a, 124b, and a conveyance pump 121 with a heat medium pipe 126. The switching valves 124a, 124b selectively switch the circuit of heat medium. The conveyance pump 121 is a conveyance device for the heat medium. Water or antifreeze is used as the heat medium.

[0018] Further, the heat medium circuit 120 includes a hot water storage tank 123 in parallel with the use-side terminal 122. The hot water storage tank 123 is connected through the heat medium pipe 126 that branches from the switching valve 124b and joins the switching valve 124a.

[0019] In the heat medium circuit 120, a water heating device 127 having a heater element is provided on the downstream side of the use-side heat exchanger 112. At the highest position of the water heating device 127, a deaerating device 128 which is capable of discharging gases flowing in the heat medium circuit 120 to the outside is provided. A discharge port of the deaerating device 128 is open to the outdoor atmosphere.

[0020] Further, in the heat medium circuit 120, a shut-off valve 129a for stopping a flow of the heat medium is provided between the conveying device 121 and the use-side heat exchanger 112. In addition, a shut-off valve

129b is provided between the use-side heat exchanger 112 and the water heating device 127.

[0021] In Fig. 1, a flow direction of the refrigerant during the heating operation is indicated by a solid arrow, and a flow direction of the refrigerant during the cooling operation is indicated by a broken arrow.

[0022] A state change of refrigerant in the heating operation and the cooling operation will be described using Fig. 2.

[0023] At the time of the heating operation, high pressure refrigerant (point a) discharged from the compressor 111 flows into the use-side heat exchanger 112 through the four-way valve 115, and radiates heat to heat medium which flows through the use-side heat exchanger 112. The high pressure refrigerant (point b) after it radiates heat in the use-side heat exchanger 112 is decompressed and expanded by the expander 113 and then, the refrigerant flows into the heat source-side heat exchanger 114. The low pressure refrigerant (point c) which flows into the heat source-side heat exchanger 114 absorbs heat from outside air and evaporates, and again returns to a suction side (point d) of the compressor 111 through the four-way valve 115.

[0024] On the other hand, at the time of the cooling operation, high pressure refrigerant (point a) discharged from the compressor 111 flows into the heat source-side heat exchanger 114 through the four-way valve 115, and radiates heat to the outside air in the heat source-side heat exchanger 114. The high pressure refrigerant (point b) after it radiates heat in the heat source-side heat exchanger 114 is decompressed and expanded by the expander 113 and then, the refrigerant flows into the use-side heat exchanger 112. The low pressure refrigerant (point c) which flows into the use-side heat exchanger 112 absorbs heat from the heat medium which flows through the use-side heat exchanger 112 and evaporates, and again returns to the suction side (point d) of the compressor 111 through the four-way valve 115.

[0025] Next, change of a state of heat medium in the heat medium circuit 120 will be described.

[0026] First, at the time of the heating operation, heat medium is heated by high temperature refrigerant in the use-side heat exchanger 112, and the heat medium is circulated by the conveying device 121. The heat medium radiates heat, in the use-side terminal 122, for example, to the air in the living space. The heat medium is utilized for heating a use-side load. The heat medium which radiates heat in the use-side terminal 122 and whose temperature is lowered is again heated by the use-side heat exchanger 112.

[0027] Here, if an amount of heating in the use-side heat exchanger 112 is less than an amount of heat that can sufficiently heat the use-side load, the heater element of the water heating device 127 is energized, and the heat medium flowing into the water heating device 127 is directly heated.

[0028] High temperature heat medium heated by the use-side heat exchanger 112 circulates through the hot

water tank 123 by switching operations of the switching valve 124a and the switching valve 124b. The high temperature heat medium is introduced from an upper portion of the hot water tank 123 into the hot water tank 123, and lower temperature heat medium is derived from a lower portion of the hot water tank 123, and is heated by the use-side heat exchanger 112.

[0029] On the other hand, at the time of the cooling operation, heat medium is cooled by the use-side heat exchanger 112, and the heat medium is circulated by the conveying device 121. According to this, the heat medium absorbs heat in the use-side terminal 122, and is utilized for cooling a use-side load. The heat medium which absorbs heat in the use-side terminal 122 and whose temperature rises is again cooled by the use-side heat exchanger 112.

[0030] The control device 130 is provided in the casing 140 of the heat medium circulation system 100. The control device 130 controls a rotation speed of the compressor 111, a rotation speed of the conveying device 121, a throttle amount of the expander 113, and applied voltage of the water heating device 127. The control device 130 also switches the four-way valve 115 and the switching valves 124a and 124b. By doing this, the efficiency of the vapor compression refrigeration cycle is increased.

[0031] In addition, when heating operation is performed, moisture in the air, etc., freezes and forms frost on the heat source-side heat exchanger 114. As a result, the heating capacity and coefficient of performance decrease due to the deterioration of the heat transfer performance of the heat source-side heat exchanger 114. In such cases, the degree of frosting is determined from external temperature, operating time, or the temperature of the heat source-side heat exchanger 114, and the frost is melted and removed by the heat of the refrigerant. This is called defrosting operation.

[0032] Typical defrosting methods include reverse cycle defrosting and hot gas defrosting. Reverse cycle defrosting is a method of reversing the direction of refrigerant circulation by switching the four-way valve 115, introducing the high-temperature and high-pressure gas refrigerant discharged from the compressor 111 into the heat source-side heat exchanger 114, and melting the frost with the condensation heat of the gas refrigerant. Hot gas defrosting is a method of increasing the opening of the expander 113 without switching the four-way valve 115, introducing the high-temperature and high-pressure gas refrigerant discharged from the compressor 111 into the heat source-side heat exchanger 114 without reducing the pressure, and melting the frost with the heat of the gas refrigerant.

[0033] Next, the flow of drain water during defrosting operation will be described, using Fig. 3.

[0034] First, frost adheres to the surface of the heat transfer tubes and fins of the heat source-side heat exchanger 114 during heating operation. In defrosting operation, the frost on the heat source-side heat exchanger 114 is heated and melted. The melted drain water flows

down the fin surface of the heat source-side heat exchanger 114 from the lower side of the heat source-side heat exchanger 114 to a bottom plate 141 of the outdoor casing 140. The drain water flows out of the casing 140 to the outside through a drain hole 142 provided in the bottom plate 141.

[0035] During defrosting operation, certain amount of the drain water that falls onto the bottom plate 141 flows out through the drain hole 142, but due to installation variations of the casing 140 and structural constraints of the bottom plate 141, some of the drain water may stagnate in areas with a small slope to the drain hole 142. Therefore, there is a possibility that the stagnant drain water will freeze during heating operation under environmental conditions below freezing.

[0036] If defrosting operation and heating operation are repeated in this state, ice will accumulate on the bottom plate 141. In the worst case, the accumulated ice may come into contact with the fan blade of the air blower 117, causing the air blower 117 to malfunction. In addition, it may be occurred a problem such that ice may come into contact with a refrigerant pipe and cause damage to the refrigerant pipe. Therefore, there is a risk that reliability and safety will not be ensured.

[0037] Therefore, it is generally common practice to install an electric heating device 143 on the surface of the bottom plate 141 to heat the bottom plate 141 and prevent the drain water from freezing.

[0038] The electric heating device 143 can be composed of, for example, a sheathed heater, a silicone rubber heater, or a PTC heater. It is desirable to position the electric heating device 143 in a suitable location with a heater length corresponding to the area of the bottom plate 141 so that the temperature of the bottom plate 141 can rise sufficiently.

[0039] In this embodiment, a heater with a power density of 2 W/cm² is used for the electric heating device 143 when the rated voltage is applied.

[1-1-2. Configuration of control device]

[0040] Next, configuration of the control device 130 will be described using Fig. 4.

[0041] The control device 130 is composed of a controller 131, a user interface 132, a high pressure-side pressure sensor 133, a discharge temperature sensor 134, a heat source-side heat exchange temperature sensor 135, an outside air temperature sensor 136, a water-entering temperature sensor 137, a water-going temperature sensor 138 and a gas sensor 139. The controller 131 is provided with a microcomputer and a memory. The user interface 132 allows users to input information such as starting or stopping the operation of the device and setting the temperature of the heat medium to be generated. The high pressure-side pressure sensor 133 is provided in a discharge-side pipe of the compressor 111, and detects discharge-side pressure. The discharge temperature sensor 134 detects discharged refrigerant

temperature. The heat source-side heat exchange temperature sensor 135 is provided in a refrigerant pipe of the heat source-side heat exchanger 114, and detects saturation temperature of refrigerant which flows through the heat source-side heat exchanger 114. The outside air temperature sensor 136 is provided on an outer surface of the casing 140 of the heat medium circulation system 100, and detects outside air temperature. The water-entering temperature sensor 137 detects temperature of heat medium which flows into the use-side heat exchanger 112 provided in the heat medium circuit 120. The water-going temperature sensor 138 detects temperature of heat medium which flows out from the use-side heat exchanger 112. The gas sensor 139 is provided at the bottom of the casing 140, and detects the concentration of flammable gas.

[1-2. Action]

[0042] Action of the heat medium circulation system 100 configured as described above will be described below.

[1-2-1. Cooling and heating operation actions]

[0043] The controller 131 carries out the heating operation or the cooling operation based on input information from the user interface 132. During operation, the controller 131 controls the compressor 111 based on the detection value of the outside air temperature sensor 136, the detection value of the water-going temperature sensor 138, and the rotation speed of the compressor 11 based on the water-going temperature setting value of the user interface 132. Further, the controller 131 controls the throttling amount of the expander 113 while comparing it with the detection value of the discharge temperature sensor 134 so that the discharge refrigerant temperature becomes the discharge temperature target value. The discharge temperature target value is determined based on the detection value of the high pressure-side pressure sensor 133 and the detection value of the heat source-side heat exchange temperature sensor 135.

[0044] In addition, during operation, the controller 131 controls the rotation speed of the conveyance pump 121 so that the difference between the detection value of the water-going temperature sensor 138 and the detection value of the water-entering temperature sensor 137 becomes a predetermined temperature difference.

[0045] Furthermore, during the heating operation, the controller 131 controls the applied voltage of the heater element of the water heating device 127 so that the detection value of the water-going temperature sensor 138 becomes the water-going temperature setting value.

[1-2-2. Operation of the electric heating device]

[0046] Operation of the electric heating device 143 in heating and defrosting operations will be described.

[0047] When the heating operation is input to the user interface 132, the opening of the expander 113 is set to an initial value, the conveyance pump 121 is operated, and the heat medium in the heat medium circuit 120 is circulated. Thereafter, the air blower 117 is operated, and the air that has passed through the heat source-side heat exchanger 114 passes through the casing 140 and is discharged to the outside. Further, at the same time as the operation of the air blower 117, energization of the electric heating device 143 is started, and the bottom plate 141 is heated. However, the applied voltage is controlled lower than the rated voltage so that the power density is 1 W/cm², and the surface temperature of the electric heating device 143 is kept lower than normal, and the electric heating device 143 is operated.

[0048] Then, when the rotation speed of the air blower 117 becomes a rotation speed that becomes a preset air volume, the applied voltage is raised to the rated voltage to further raise the temperature of the bottom plate 141.

[0049] Further, when frosting is deposited on the heat source-side heat exchanger 114 by heating operation, defrosting operation is started, but when reverse cycle defrosting is executed, the air blower 117 is stopped.

[0050] At this time, the applied voltage of the electric heating device 143 is lowered so that the power density is 2 W/cm² to 1 W/cm², and the surface temperature is kept low. Then, the defrosting operation is completed and the heating operation is started. When the rotation speed of the air blower 117 becomes a rotation speed that becomes a preset air volume, the applied voltage is raised to the rated voltage to keep the surface temperature of the electric heating device 143 high.

[0051] Furthermore, when the detection concentration of the gas sensor 139 becomes higher than a predetermined concentration during heating operation, the energization of the electric heating device 143 is stopped and the surface temperature of the electric heating device 143 is lowered.

[0052] Here, Fig. 5 is a graph showing the relationship between the power density and the surface temperature of the heater (electric heating device). Until the air volume passing through the electric heating device 143 is sufficiently secured, the heater applied voltage is 1 W/cm² at a heater surface temperature well below the propane flash point of 432 °C. Then, after the air volume is sufficiently secured, the heater applied voltage is lower than the flash point of propane and the electric heating device 143 is operated at a surface temperature of 2 W/cm², which is sufficient to heat the bottom plate 141. In this way, the voltage applied to the heater is controlled.

[0053] The operation at this time will be described in more detail using the flowchart shown in Fig. 6. First, the user instructs to start the heating operation by the operation of the user interface 132 (step S1). Then, according to the instruction, the control device 130 operates the air blower 117 and at the same time applies a voltage having a power density of 1 W/cm² to the electric heating device 143 (step S2). Then, the compressor 111 and the con-

veyance pump 121 are operated, their rotation speed is controlled, and the opening degree of the expander 113 is adjusted (step S3). Next, the control device 130 detects the refrigerant concentration Cr in the casing 140 by the gas sensor 139 (step S4). Then, preset refrigerant concentration Ca and the refrigerant concentration Cr are compared in advance, and it is determined whether or not the refrigerant concentration Cr is equal to or higher than the refrigerant concentration Ca (step S5).

[0054] If the refrigerant concentration Cr is equal to or higher than the refrigerant concentration Ca (YES in step S5), it is determined that a refrigerant leak has occurred in the refrigerant circuit 110. Then, the power supply to the electric heating device 143 is interrupted while the air blower 117 continues to operate (step S6). At the same time, the compressor 111 and the conveyance pump 121 are stopped (step S7). Next, the shut-off valves 129a and 129b are energized to actuate them in the closing direction, thereby stopping the flow of the heat medium (step S8).

[0055] If the refrigerant concentration Cr is less than the refrigerant concentration Ca (NO in step S5), it is determined that the flammable refrigerant has not leaked from the refrigerant circuit 110, and the operation is continued. Then, it is determined whether the air blower 117 has operated for a predetermined time (step S9). If it is determined that the blower has operated for a predetermined time and a sufficient air flow has been secured (YES in step S9), the voltage is increased so that the power density of the electric heating device 143 becomes 2 W/cm^2 (step S10).

[0056] Then, preset defrost start temperature Tds and detection temperature Te of the heat source-side heat exchange temperature sensor 135 are compared, and it is determined whether the detection temperature Te, which is the heat exchange temperature, is lower than the defrost start temperature Tds (step S11).

[0057] If the heat exchange temperature Te is equal to or higher than the defrost start temperature Tds (NO in step S11), it is determined that the frost amount on the heat source side heat exchanger 114 is small and defrosting operation is not necessary, and the heating operation is continued.

[0058] On the other hand, if the heat exchange temperature Te is lower than the defrost start temperature Tds (YES in step S11), it is determined that the amount of frost on the heat source-side heat exchanger 114 is large due to the heating operation and defrosting operation is necessary. Then, the four-way valve 115 is switched to the cooling position and the air blower 117 is stopped to start the defrost operation (step S12).

[0059] At this time, the applied voltage is lowered so that the power density of the electric heating device 143 is lowered to 1 W/cm^2 , at the same time as the air blower 117 is stopped (step S13).

[0060] Then, the preset defrost end temperature Tde and the detected temperature Te of the heat source-side heat exchange temperature sensor 135 are compared,

and it is determined whether the heat exchange temperature Te is equal to or higher than the defrost end temperature Tde (step S14). If the heat exchange temperature Te is lower than the defrost end temperature Tde (NO in step S14), it is judged that frost remains on the heat source side heat exchanger 114, and the defrosting operation is continued.

[0061] On the other hand, if the heat exchange temperature Te is equal to or higher than the defrost end temperature Tde (YES in step S14), it is determined that the frost on the heat source-side heat exchanger 114 has completely melted and defrosting is complete. Then, the four-way valve 115 is switched to the heating position and the air blower 117 is operated to start the heating operation (step S15).

[1-3. Effect and the like]

[0062] As described above, in the embodiment of the present invention, the heat medium circulation system 100 comprises a refrigerant circuit 110, a heat medium circuit 120, a control device 130, an air blower 117, a bottom plate 141, and an electric heating device 143. The refrigerant circuit 110 is a vapor compression refrigeration cycle using a flammable refrigerant. The refrigerant circuit 110 formed by annularly connecting a compressor 111, a use-side heat exchanger 112, an expander 113, and a heat source-side heat exchanger 114. The heat medium circuit 120 flows a liquid heat medium that heats and cools the use-side load. The air blower 117 circulates outdoor air to the heat source-side heat exchanger 114. The electric heating device 143 is provided on the surface of the bottom plate 141 and electrically heats the bottom plate 141.

[0063] The electric heating device 143 is energized at the same time as the air blower 117 is started, and is controlled to be lower than the power consumption in the stable state for a predetermined time after the start of energization.

[0064] As a result, the electric heating device 143 is energized at the same time as the air blower 117 is started. Therefore, the temperature drop of the bottom plate 141 due to air blow is prevented, and the temperature of the base plate 141 rises rapidly.

[0065] In addition, in the event that gas leaks and stagnates on the bottom plate 141 while the operation is stopped, the wind speed is low immediately after the air blower 117 starts, and the stagnant gas is difficult to diffuse. However, the power consumption of the electric heating device 143 is controlled to be lower than the power consumption in the stable state. Therefore, the power density of the electric heating device 143 is low for a predetermined time after the air blower 117 starts, and the surface temperature of the electric heating device 143 is kept low until the atmosphere gas of the electric heating device 143 is ventilated.

[0066] Therefore, it is possible to simultaneously prevent ignition of the leaked refrigerant by the heat of the

electric heating device 143 and prevent freezing of the bottom plate 141. As a result, the safety against leakage of flammable refrigerant is further improved.

[0067] As in the embodiment of the present invention, the power density of the electric heating device 143 is 2 W/cm² or less, and the power density may be controlled to be less than 1 W/cm² for a predetermined time after energization.

[0068] As a result, the power density of the electric heating device 143 is low during the period when the wind speed is low after the air blower 117 starts, and the surface temperature is kept at a temperature sufficiently lower than the ignition temperature of propane. Therefore, even if flammable gas is stagnant, it will not ignite.

[0069] Therefore, it is possible to simultaneously prevent ignition of the leaked refrigerant by the heat of the electric heating device 143 and prevent freezing of the bottom plate 141. As a result, the safety against leakage of flammable refrigerant is further improved.

[0070] In the embodiment of the present invention, the predetermined time period for controlling the power consumption of the electric heating device 143 to be low may be set to the time until the wind speed of the air blower 117 reaches a predetermined wind speed that can sufficiently exhaust the stagnant gas.

[0071] As a result, the flammable gas that has leaked from the refrigerant circuit 110 and is stagnant near the electric heating device 143 is diffused by the wind generated by the air blower 117. Until the flammable gas is exhausted outside the casing 140, the surface temperature of the electric heating device 143 is kept at a temperature sufficiently lower than the ignition temperature of propane, so that the flammable gas will not ignite even if it stagnates.

[0072] In the embodiment of the present invention, if the gas concentration detected by the gas sensor 139 exceeds a predetermined gas concentration, the air blower 117 may be kept operating and the power supply to the electric heating device 143 may be shut off.

[0073] This allows for a reliable determination that a flammable refrigerant has leaked. In the event of a gas leak, the air blower 117 will exhaust the flammable gas and the surface temperature will drop rapidly due to the interruption of the power supply to the electric heating device 143. This further enhances safety.

[0074] In the embodiment of the present invention, the flammable refrigerant may be propane or a mixed refrigerant containing propane. This can lower the global warming potential (GWP) and suppress the adverse effects on the environment in the event of a refrigerant leak. Therefore, the environmental impact is improved.

(Other Embodiments)

[0075] The foregoing embodiments have been described by way of example of the technology disclosed in the present application. However, the technology disclosed herein is not limited thereto, and can be applied

to embodiments with modifications, replacements, additions, and omissions. It is also possible to combine the various components described in the above embodiments to create new embodiments.

[0076] Therefore, other embodiments are exemplified below.

[0077] In this embodiment, a cooling and heating water heater is described as an example of the heat medium circulation system 100. The heat medium circulation system 100 may be any system that can cool or heat a liquid. Therefore, the heat medium circulation system 100 is not limited to cooling and heating water heaters. However, if a cooling and heating water heater is used as the heat medium circulation system 100, it can meet the annual heat demand of a house. A chiller may also be used as the heat medium circulation system 100. If a chiller is used as the heat medium circulation system 100, it can meet the heating and cooling load used in factories, etc. Therefore, the energy efficiency of factories can be improved.

[0078] In this embodiment, a refrigerant concentration sensor is described as an example of a leak sensor. The leak sensor may be any sensor that can detect the leakage of refrigerant from the refrigerant circuit 110 to the heat medium circuit 120. Therefore, the leak sensor is not limited to a refrigerant concentration sensor. However, if a refrigerant concentration sensor is used as a leak sensor, it can be realized with a simple configuration. A pressure sensor that detects the pressure of the refrigerant circuit 110 or a thermistor that detects the operating temperature of the refrigerant can also be used as a leak sensor. If the pressure or temperature of the refrigerant circuit 110 is detected, the sensor for operating control can be shared. Therefore, it can be manufactured inexpensively.

[0079] In this embodiment, an example of the installation position of the electric heating device 143 is described, in which it is installed on the surface of the bottom plate 141 of the casing 140. The installation position of the electric heating device 143 may be any position where the temperature of the bottom plate 141 rises when the electric heating device 143 is energized, and the drain water does not freeze. Therefore, the installation position of the electric heating device 143 is not limited to the surface of the bottom plate 141.

[0080] However, if the electric heating device 143 is installed on the surface of the bottom plate 141, the bottom plate 141 and the drain water can be directly heated, so that the heat exchange efficiency can be improved. Further, the electric heating device 143 may also be installed on the back surface of the bottom plate 141. If the electric heating device 143 is installed on the back surface of the bottom plate 141, the refrigerant gas will not come into direct contact with it in case of a short circuit and sparking of the electric heating device 143. Therefore, it has the effect of more reliably preventing ignition, such as in the event of sparking.

[0081] In this embodiment, a circuit is described as an

example of the installation position of shut-off valves 129a and 129b, which is installed between the conveying device 121 and the user-side heat exchanger 112 or between the user-side heat exchanger 112 and the water heating device 127. The shut-off valves 129a and 129b should be installed in a position where the refrigerant does not flow into the living space when the refrigerant leaks into the heat medium circuit 120. Therefore, the installation position of the shut-off valves 129a and 129b is not limited to between the conveying device 121 and the user-side heat exchanger 112 or between the user-side heat exchanger 112 and the water heating device 127. However, by installing the shut-off valves 129a and 129b downstream of the discharge device, the leaked refrigerant that exists in the heat medium circuit 120 between the shut-off valves 129a and 129b can be discharged into the atmosphere even after the shut-off. Therefore, safety is further improved.

[INDUSTRIAL APPLICABILITY]

[0082] The present disclosure is applicable to a heat medium circulation system using a flammable refrigerant in a refrigerant circuit. Specifically, the present disclosure is applicable to hot water heaters, commercial chillers, and the like.

[EXPLANATION OF SYMBOLS]

[0083]

100 heat medium circulation system
 110 refrigerant circuit
 111 compressor
 112 use-side heat exchanger
 113 expander
 114 heat source-side heat exchanger
 115 four-way valve
 116 pipe
 117 air blower
 120 heat medium circuit
 121 conveying pump
 122 use-side terminal
 123 hot water tank
 124a switching valve
 124b switching valve B
 126 heat medium pipe
 127 water heating device
 128 deaerating device
 129a shut-off valve
 129b switching valve
 130 control device
 131 controller
 132 user interface
 133 high pressure-side pressure sensor
 134 discharge temperature sensor
 135 heat source-side heat exchange temperature sensor

136 outside air temperature sensor
 137 water-entering temperature sensor
 138 water-going temperature sensor
 139 gas sensor
 140 casing
 141 bottom plate
 142 drain hole
 143 electric heating device

Claims

1. A heat medium circulation system comprising:

a refrigerant circuit in which a compressor, a use-side heat exchanger, an expander, and a heat source-side heat exchanger are connected annularly and a flammable refrigerant is used; an air blower for flowing air to the heat source-side heat exchanger; a casing accommodating at least the refrigerant circuit and the air blower; an electric heating device provided on a surface of a bottom plate of the casing; and a control device, wherein the control device simultaneously starts operation of the air blower and energization of the electric heating device, and controls such that power consumption of the electric heating device is lower than power consumption in a stable state for a predetermined time from start of energization of the electric heating device.

2. The heat medium circulation system according to claim 1, wherein a power density of the electric heating device is 2 W/cm² or less, and the control device controls the power density to be less than 1 W/cm² during the predetermined time.

3. The heat medium circulation system according to claim 1 or claim 2, wherein the predetermined time is a time until an air volume generated by the air blower becomes a predetermined air volume or more.

4. The heat medium circulation system according to any one of claims 1 to 3, comprising:

a leak sensor which detects leakage of the flammable refrigerant in the casing, wherein when the leak sensor detects the leakage of the flammable refrigerant, the control device continues operation of the air blower and stops energization of the electric heating device.

5. The heat medium circulation system according to any one of claims 1 to 4, wherein the flammable refrigerant is propane or a mixed refrigerant containing

the propane.

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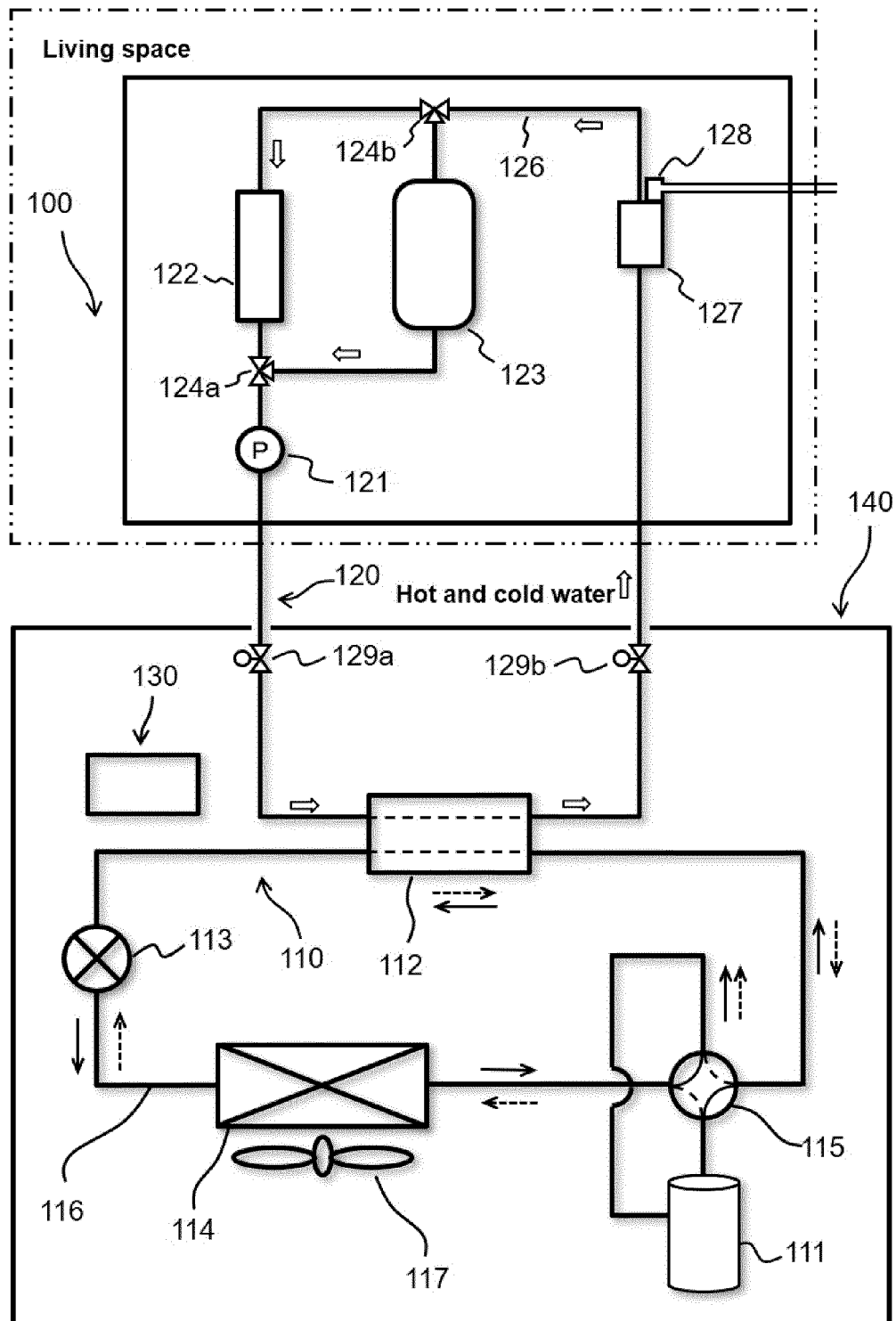
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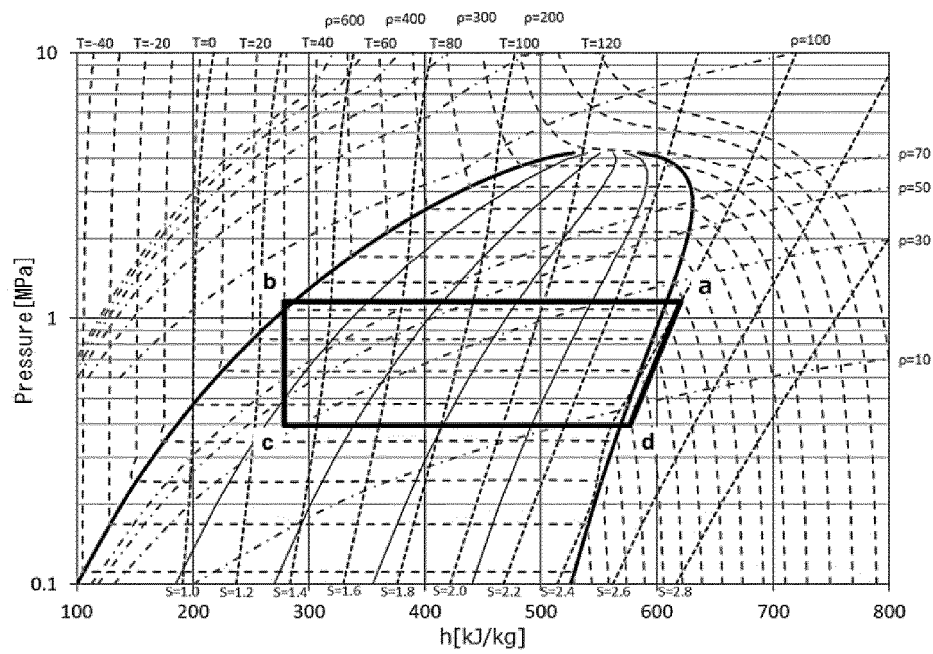
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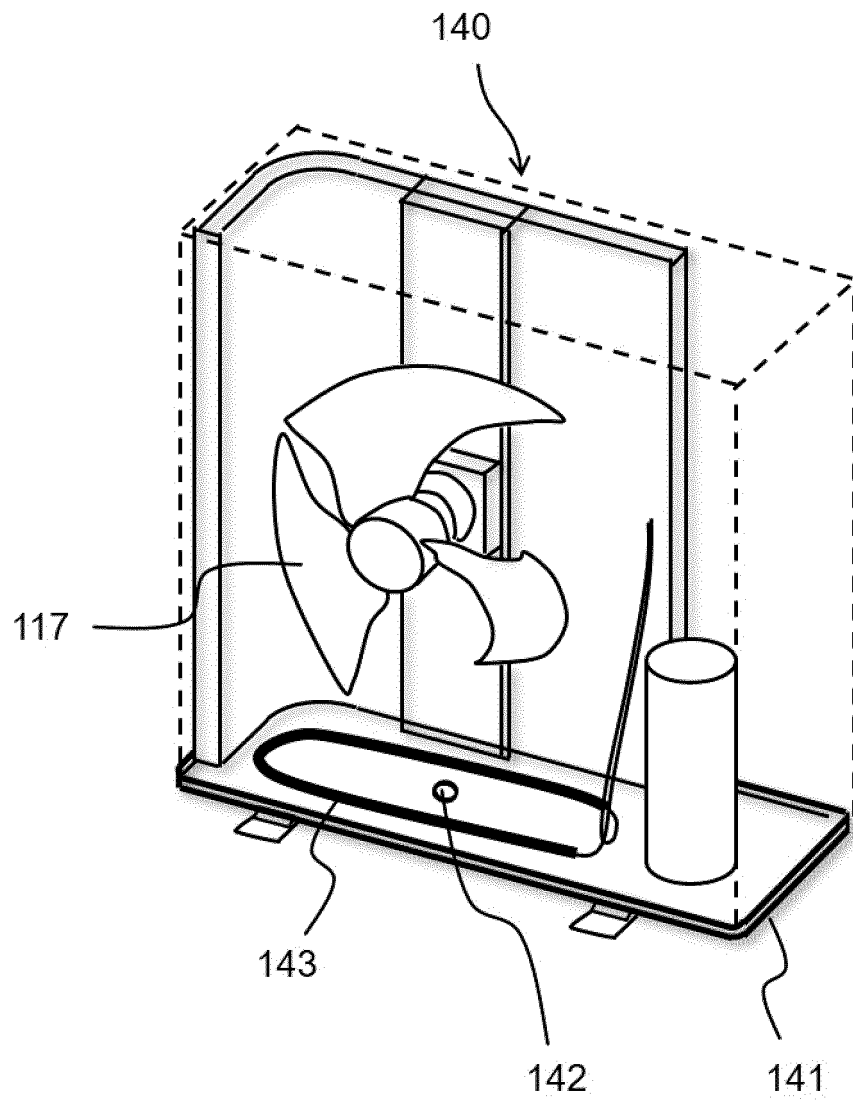
[Fig. 1]



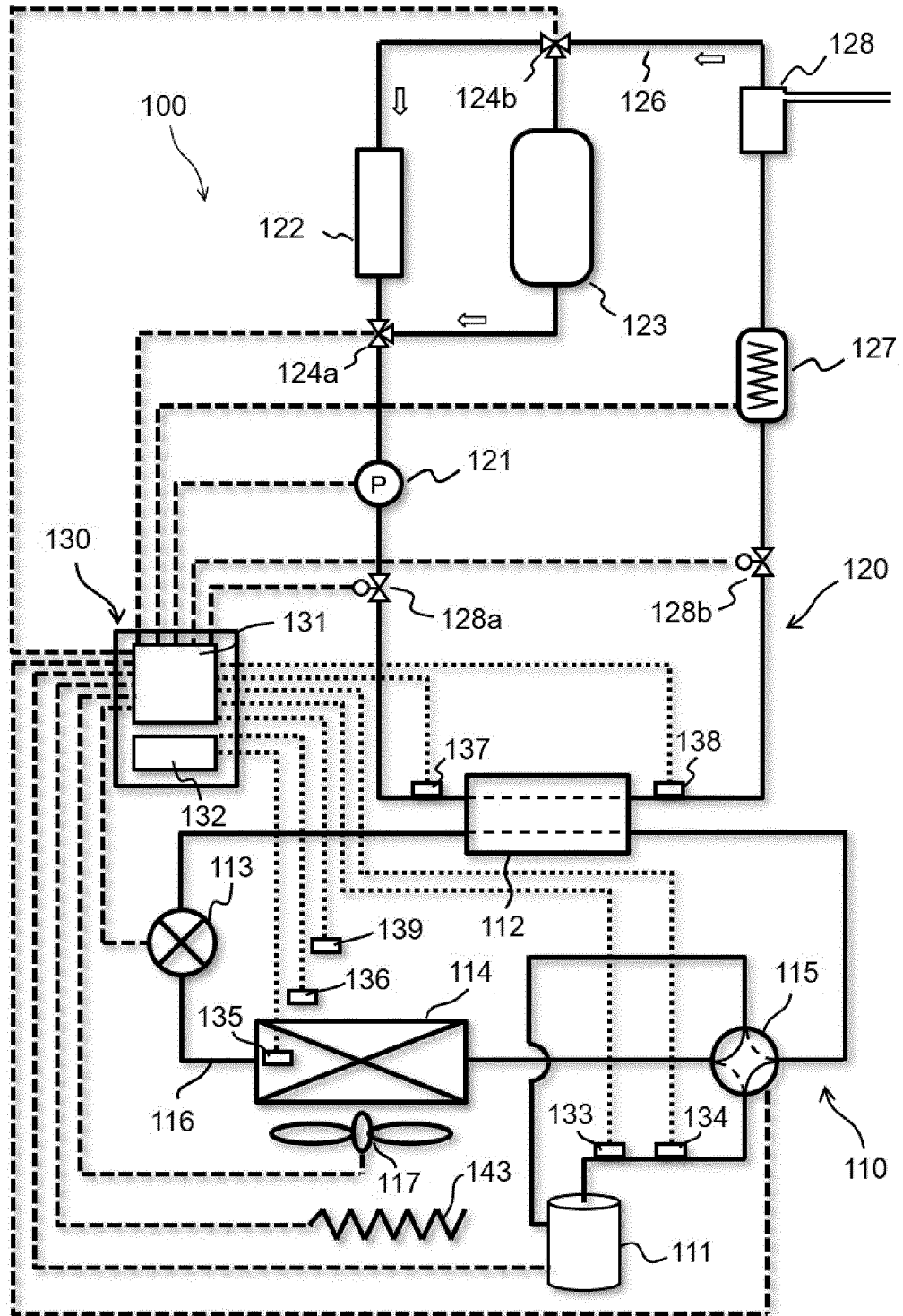
[Fig. 2]



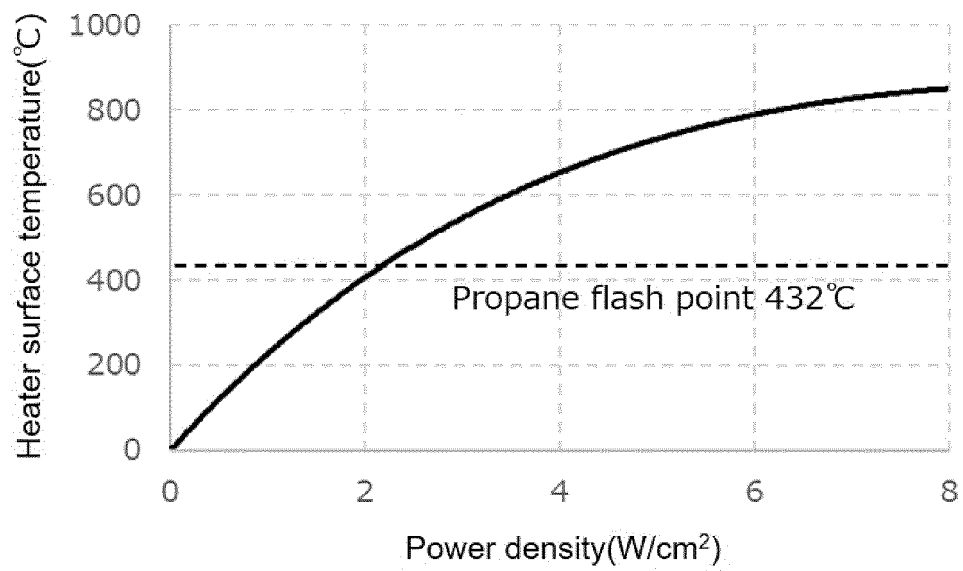
[Fig. 3]



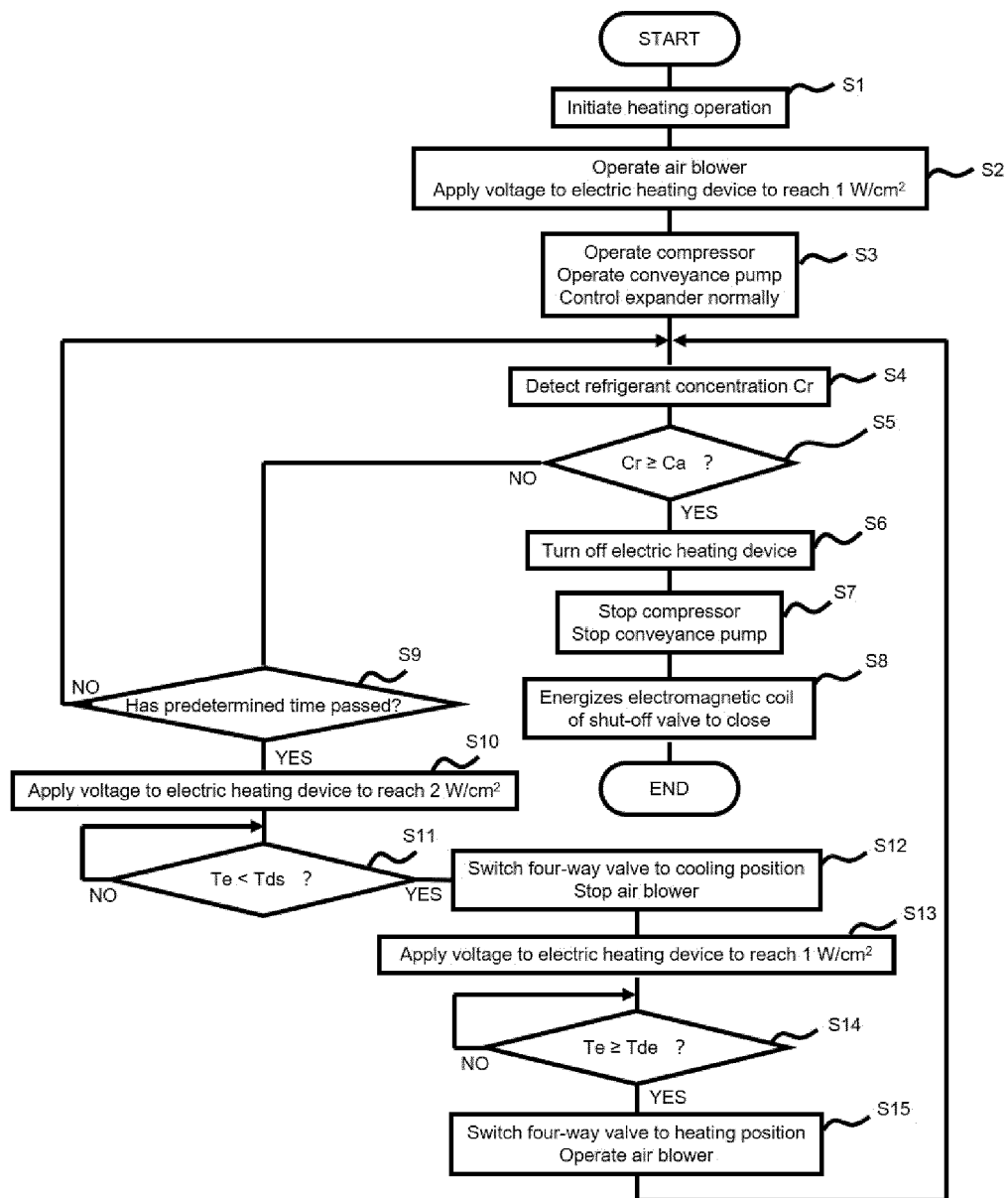
[Fig. 4]



[Fig. 5]



[Fig. 6]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/033866

A. CLASSIFICATION OF SUBJECT MATTER

F25B 1/00(2006.01)i; **F25B 47/02**(2006.01)i; **F25B 49/02**(2006.01)i
 FI: F25B1/00 351U; F25B1/00 396G; F25B49/02 520M; F25B47/02 E

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)

F25B1/00-49/04; F25D21/00-21/14; F24F1/00-13/32

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 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

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 2011-158183 A (MITSUBISHI HEAVY IND LTD) 18 August 2011 (2011-08-18) paragraphs [0084]-[0087], fig. 10	1-5
A	JP 2012-47362 A (HITACHI APPLIANCES INC) 08 March 2012 (2012-03-08) see paragraph [0057], fig. 13, 17	1-5
A	JP 2011-2228 A (HITACHI APPLIANCES INC) 06 January 2011 (2011-01-06) paragraphs [0088]-[0089], fig. 8, 11	1-5
A	JP 2005-135277 A (MATSUSHITA ELECTRIC IND CO LTD) 26 May 2005 (2005-05-26) paragraph [0022]	1-5
A	JP 2009-79818 A (PANASONIC CORP) 16 April 2009 (2009-04-16) paragraph [0045]	1-5
A	JP 2017-26252 A (SHARP KK) 02 February 2017 (2017-02-02) paragraphs [0049], [0060]-[0061]	1-5

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

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"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

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Date of mailing of the international search report

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Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/033866

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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JP 2012-47362 A	08 March 2012	(Family: none)	
JP 2011-2228 A	06 January 2011	(Family: none)	
JP 2005-135277 A	26 May 2005	(Family: none)	
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JP 2017-26252 A	02 February 2017	(Family: none)	

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REFERENCES CITED IN THE DESCRIPTION

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