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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 expansion device 113, and a heat source-side heat exchanger 114 are annularly connected, a heat medium circuit 120 for circulating a heat medium cooled or heated by the use-side heat exchanger 112 using refrigerant discharged from the compressor 111, and a control device 130. The heat medium circuit 120 includes a circulation device for circulating the heat medium, a heating device 127 for electrically heating the heat medium, and a deaerating device 128 for discharging gas from inside the heat medium circuit 120 to outside the heat medium circuit 120.The circulation device is placed upstream of the use-side heat exchanger 112, the heating device 127 is placed downstream of the use-side heat exchanger 112 and on a side higher than the use-side heat exchanger 112, and the deaerating device 128 is placed downstream of the heating device 127 and on a side higher than the heating device 127, thereby providing a heat medium circulation system 100 that safely diffuses leaked refrigerant into the outdoor atmosphere and enhances safety.

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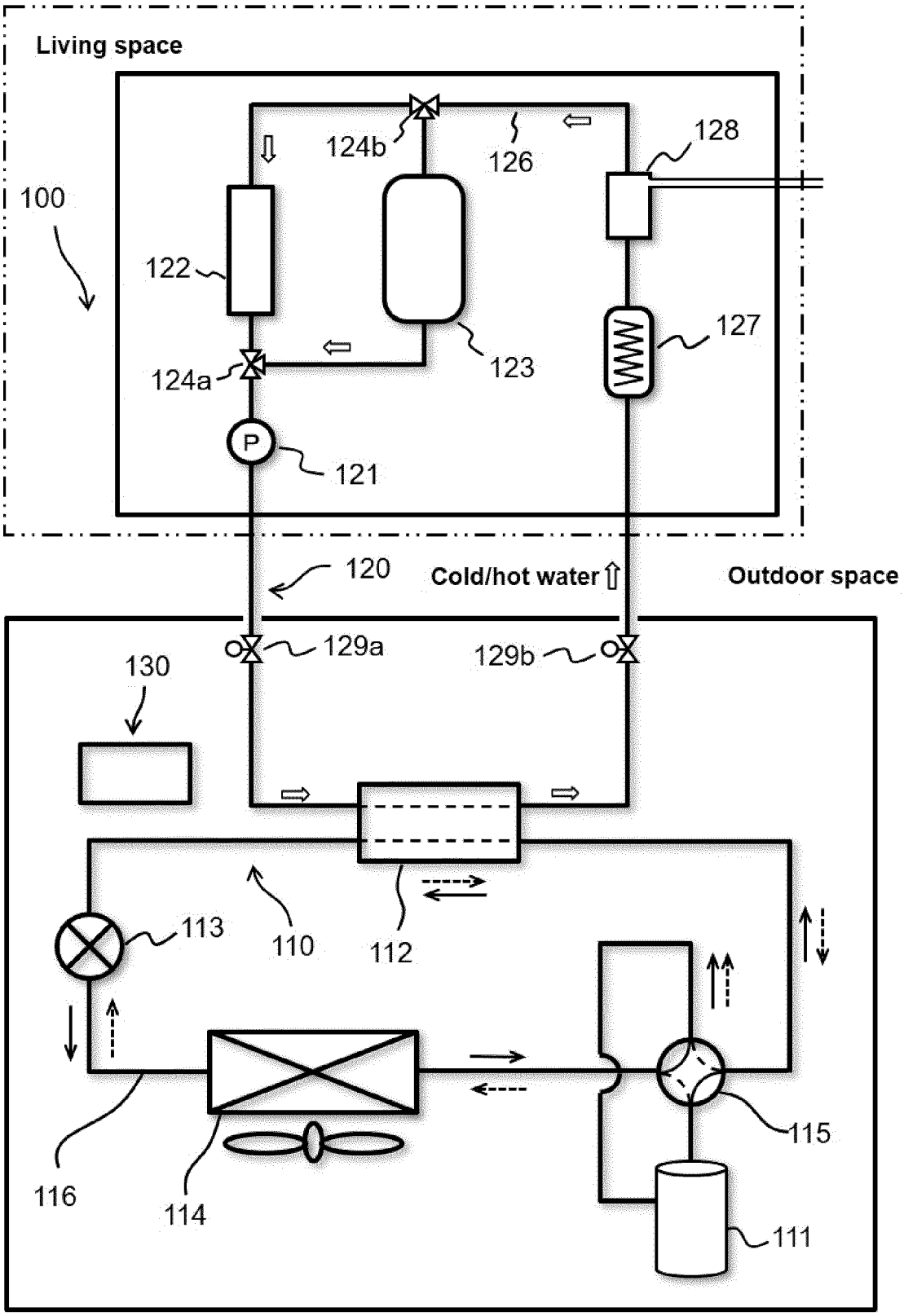
[Fig. 1]


Living space
100
122
124a
124b
126
128
123
127
P
121
120
Cold/hot water
Outdoor space
129a
129b
130
113
110
112
116
114
115
111

Description

[TECHNICAL FIELD]

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

[BACKGROUND TECHNIQUE]

[0002] Patent document 1 discloses a heat pump device which refrigerant discharge valve provided in a heat medium circuit is provided outside a casing.

[PRIOR ART DOCUMENT]

[PATENT DOCUMENT]

[0003] [Patent Document 1] PCT International Publication No. WO2018/047265

[SUMMARY OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0004] The present disclosure provides a heat medium circulation system which safely disperses, into outside atmosphere, flammable refrigerant which leaks into a use-side heat medium circuit, in the event that flammable refrigerant leaks into the use-side heat medium circuit.

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0005] A heat medium circulation system of the present disclosure comprises: a refrigerant circuit which is formed by annularly connecting a compressor, a use-side heat exchanger, an expansion device and a heat source-side heat exchanger to one another, and in which flammable refrigerant is used; a heat medium circuit through which heat medium cooled or heated by the use-side heat exchanger by means of refrigerant discharged from the compressor circulates; and a control device, and the heat medium circuit is provided therein at least with a circulation device through which the heat medium in the heat medium circuit circulates, a heating device for electrically heating the heat medium, and a deaerating device which separates gas in the heat medium circuit and discharges the gas to outside. The circulation device is placed upstream of the use-side heat exchanger. The heating device is placed downstream of the use-side heat exchanger and on a side higher than the use-side heat exchanger. The deaerating device is placed downstream of the heating device and on a side higher than the heating device.

[0006] A heat medium exit of the heating device is placed on a side higher than a heating portion of the heating device. A heat medium entrance of the heating device is placed on a side lower than the heat medium exit.

[0007] The control device controls the heating device to heat the heating portion of the heating device such that surface temperature of the heating portion becomes lower than temperature of ignition point of the flammable refrigerant.

[0008] The heat medium circulation system of the present disclosure further includes a refrigerant leakage detection sensor for detecting leakage of the flammable refrigerant into the heat medium circuit, and shut-off valves for shutting off a flow path of the heat medium which circulates in the heat medium circuit. When the control device determines that the flammable refrigerant leaks into the heat medium circuit, the control device operates the shut-off valves in a closing direction to stop flow of the heat medium.

[0009] The refrigerant leakage detection sensor is a refrigerant concentration sensor placed in a vicinity of an exhaust port of the deaerating device. When a detection value of the refrigerant concentration sensor becomes equal to or higher by a predetermined value, the control device determines that the flammable refrigerant leaks from the heat medium circuit.

[0010] The flammable refrigerant is R32, mixed refrigerant including 70% or more by weight of R32, propane, or mixed refrigerant including propane.

[EFFECT OF THE INVENTION]

[0011] According to the heat medium circulation system in the present disclosure, in the event that the flammable refrigerant leaks into the use-side heat medium circuit, the flammable refrigerant is safely discharged into the outdoor atmosphere. According to this, safety is further enhanced.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0012]

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

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

Fig. 3 is a block diagram of a control system of the heat medium circulation system in the embodiment;

Fig. 4 is a schematic diagram of a state where refrigerant gas in a heat medium circuit in the embodiment is discharged into outside atmosphere; and

Fig. 5 is a flowchart for describing detection of leakage of refrigerant of the heat medium circulation system and control operation of shut-off valves in the embodiment.

[MODE FOR CARRYING OUT THE INVENTION]

[0013] The present disclosure has such a configuration that a circulation device is placed upstream of a use-side heat exchanger, and a heating device is placed downstream of the use-side heat exchanger and on a side higher than the use-side heat exchanger, and a deaerating device is placed downstream of the heating device and on a side higher than the heating device.

[0014] According to this, even if flammable refrigerant leaks into the heat medium circuit by any chance, the leaked refrigerant is safely discharged into the outdoor atmosphere, so that a heat medium circulation system with further enhanced safety is provided.

[0015] An embodiment will be described in detail below with reference to the drawings. However, 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.

[0016] Note that the accompanying drawing and the following description are provided so that the person skilled in the art can sufficiently understand the present disclosure. Therefore, it is not intended that they limit the subject matter described in claims.

[0017] The 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]

[0018] In Fig. 1, a heat medium circulation system 100 comprises a refrigerant circuit 110, a heat medium circuit 120 and a control device 130.

[0019] The refrigerant circuit 110 is a vapor compression type refrigeration cycle. The refrigerant circuit 110 is configured by connecting a compressor 111, a use-side heat exchanger 112, an expansion device 113 and a heat source-side heat exchanger 114 to one another through a pipe 116. The refrigerant circuit 110 uses, as refrigerant, propane which is flammable refrigerant.

[0020] Further, the refrigerant circuit 110 is provided with a four-way valve 115 which switches between a heating operation and a cooling operation. Warm water is produced in the heating operation, and cold water is produced in the cooling operation.

[0021] The heat medium circuit 120 is configured by connecting to one another the use-side heat exchanger 112, a use-side terminal 122 such as a panel of a floor heating, a first switching valve 124a, a second switching valve 124b, and a conveying pump 121 through a heat medium pipe 126. The first switching valve 124a and the second switching valve 124b selectively switch the circuit of heat medium. The conveying pump 121 is a conveyance device for the heat medium. The heat medium circuit 120 uses water or antifreeze liquid as the heat medium.

[0022] The heat medium circuit 120 is provided with a hot water tank 123 in parallel with the use-side terminal 122. The use-side terminal 122 and the hot water tank 123 are connected to each other through the heat medium pipe 126. The heat medium pipe 126 branches off from the second switching valve 124b and joins the first switching valve 124a.

[0023] The heat medium circuit 120 includes a heating device 127 downstream of the use-side heat exchanger 112. In the heating device 127,a heater element 150 (see Fig. 4) is located at a position higher than an installation position of the use-side heat exchanger 112. The heat medium pipe 126 is connected to the heating device 127 such that heat medium which flows out from the use-side heat exchanger 112 flows in from a lower portion of the heating device 127 and flows out from an upper portion of the heating device 127.

[0024] A deaerating device 128 is provided downstream of a flowing direction of the heating device 127 and at the highest position (uppermost) of the heat medium circuit 120. The deaerating device 128 can discharge gas which circulates through the heat medium circuit 120 to outside. A discharge port of the deaerating device 128 opens into outside atmosphere.

[0025] A first shut-off valve 129a which stops flow of the heat medium is provided between the conveying pump 121 and the use-side heat exchanger 112 in the heat medium circuit 120. A second shut-off valve 129b is provided between the use-side heat exchanger 112 and the heating device 127.

[0026] In Fig. 1, solid arrows show a flowing direction of refrigerant at the time of heating operation, and broken arrows show the flowing direction of refrigerant at the time of cooling operation.

[0027] Change of a state of refrigerant at the time of the heating operation and the cooling operation will be described using Fig. 2.

[0028] 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 into the heat medium which flows through the use-side heat exchanger 112. The high pressure refrigerant (point b) after it radiates in the use-side heat exchanger 112 is decompressed and expanded in the expansion device 113 and then, the refrigerant flows into the heat source-side heat exchanger 114. 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 into a suction side (point d) of the compressor 111 through the four-way valve 115.

[0029] 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 into 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 in the expansion device 113 and then, the refrigerant flows into the use-side heat exchanger 112. 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.

[0030] Next, change of a state of heat medium in the heat medium circuit 120 will be described. First, at the time of the heating operation, heat medium is heated by the use-side heat exchanger 112 and circulated by the conveying pump 121. Then, the heat medium radiates heat in the use-side terminal 122 and 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.

[0031] Here, when an amount of heating in the use-side heat exchanger 112 is less than an amount of heat which can sufficiently heat the use-side load, the heater element 150 of the heating device 127 is energized, and the heat medium which flows into the heating device 127 is directly heated.

[0032] High temperature heat medium heated by the use-side heat exchanger 112 circulates through the hot water tank 123 by switching operations of the first switching valve 124a and the second 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.

[0033] On the other hand, during cooling operation, heat medium is cooled by the use-side heat exchanger 112 and circulated by the conveying pump 121, so that the heat medium absorbs heat at the use-side terminal 122 and is used to cool the 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.

[0034] The control device 130 is provided in a casing of the heat medium circulation system 100. The control device 130 controls a number of rotations of the compressor 111, a throttle amount of the expansion device 113, a number of rotations of the conveying pump 121, and an applied voltage of the heating device 127, and also switches the four-way valve 115, and switches between the first switching valve 124a and the second switching valve 124b. By doing so, an efficiency of the vapor compression type refrigeration cycle is increased.

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

[0035] Next, configuration of the control device 130 will be described using Fig. 3. The control device 130 is composed of a controller 131 and a user interface 132. The controller 131 is connected to a high pressure side pressure sensor 133, a discharge temperature sensor 134, a heat source-side heat exchange 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 mounted with a microcomputer, a memory, and the like. The user interface 132 stops operation of the device and inputs temperature setting of heat medium to be produced. 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 sensor 135 is provided in a refrigerant pipe of the heat source-side heat exchanger 114, and detects saturation temperature of the 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 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 detects concentration of flammable gas discharged from the deaerating device 128.

[1-2. Action]

[0036] Action of the heat medium circulation system 100 having the above-described configuration will be described below.

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

[0037] The controller 131 carries out the heating operation or the cooling operation based on input information of the user interface 132. At the time of the operation, the controller 131 controls the compressor 111 based on a detection value of the outside air temperature sensor 136, a detection value of the water-going temperature sensor 138, and the number of rotations determined from a water-going temperature set value of the user interface 132. Further, the controller 131 controls a throttle amount of the expansion device 113 while comparing with a detection value of the discharge temperature sensor 134 such that the discharged refrigerant temperature becomes equal to a discharge temperature target value which is determined based on a detection value of the high pressure side pressure sensor 133 and a detection value of the heat source-side heat exchange sensor 135.

[0038] The controller 131 controls the number of rotations of the conveying pump 121 such that a difference between the detection value of the water-going temper-

ature sensor 138 and a detection value of the water-entering temperature sensor 137 becomes equal to a predetermined temperature difference.

[0039] Further, at the time of the heating operation, the controller 131 controls an applied voltage of the heater element 150 of the heating device 127 such that the detection value of the water-going temperature sensor 138 becomes equal to the water-going temperature set value.

[1-2-2. Discharging action of refrigerant and operating action when refrigerant leaks]

[0040] Based on Fig. 4, the operational actions in the event of a refrigerant leak in the heat medium circuit 120 are described.

[0041] Fig. 4 schematically shows the flow of refrigerant gas when the refrigerant gas mixed in the heat medium is separated by the deaerating device 128 and is discharged into outside atmosphere.

[0042] For example, when a partition wall between a flow path of refrigerant and a flow path of heat medium in the use-side heat exchanger 112 is cracked and the refrigerant leaks into the heat medium circuit 120, the refrigerant gas is circulated in the heat medium circuit 120 by the conveying pump 121 in a state where the refrigerant gas is mixed in the heat medium. The refrigerant gas which flows out from the use-side heat exchanger 112 flows through the heating device 127 and then flows into the deaerating device 128. The refrigerant gas which flows into the deaerating device 128 is separated from the heat medium by reduction in flowing speed caused by enlargement of a diameter of the flow path and by buoyancy force of gas, and the refrigerant gas stays in an upper portion of the deaerating device 128. According to this, liquid level of the heat medium in the deaerating device 128 is lowered, and a float valve is lowered. Then, the refrigerant gas which stays is discharged from the discharge port into the outside atmosphere.

[0043] Then, the refrigerant gas discharged into the outside atmosphere is dispersed, and generation of flammable space is more reliably suppressed.

[0044] A heat medium exit 152 of the heating device 127 may be provided at a position (higher side) higher than the heater element 150 of the heating device 127. Further, the heat medium entrance 151 of the heating device 127 may be provided at a position (lower side) lower than the heat medium exit 152.

[0045] Further, it is preferable that the heater element 150 of the heating device 127 is heated such that surface temperature of the heater element 150 becomes lower than temperature of an ignition point of the refrigerant.

[0046] Next, shut-off action of refrigerant will be described. The first shut-off valve 129a and the second shut-off valve 129b are solenoid on-off valves. When the control device 130 detects that the refrigerant leaks, an electromagnetic coil is energized, the first shut-off valve 129a and the second shut-off valve 129b are closed, and circulation of the heat medium in the heat medium circuit 120 is stopped.

[0047] Action at this time will be described in more detail using a flowchart in Fig. 5. First, start of the heating operation or the cooling operation is instructed by user's operation of the user interface 132 (step S1). By the instruction, the control device 130 operates the compressor 111 and the conveying pump 121, controls the number of rotations thereof, and adjusts an opening degree of the expansion device 113 (step S2). Next, the control device 130 makes the gas sensor 139 detect refrigerant concentration Cr in the vicinity of the discharge port of the deaerating device 128 (step S3). The control device 130 compares preset refrigerant concentration Ca and the refrigerant concentration Cr, and determines whether the refrigerant concentration Cr is equal to or higher than the refrigerant concentration Ca (step S4).

[0048] When the refrigerant concentration Cr is lower than the refrigerant concentration Ca (NO in step S4), the refrigerant is not discharged from the deaerating device 128. Therefore, the control device 130 determines that the refrigerant does not leak into the heat medium circuit 120, and continues the operation.

[0049] On the other hand, when the refrigerant concentration Cr is equal to or higher than the Ca (YES in step S4), the state is such that the refrigerant is being discharged from the deaerating device 128. Therefore, the control device 130 determines that the refrigerant gas is leaking into the heat medium circuit 120. The control device 130 then stops the operations of the compressor 111 and the conveying pump 121 (step S5). Subsequently, the control device 130 energizes both the first shut-off valve 129a and the second shut-off valve 129bto operate the first shut-off valve 129a and the second shut-off valve 129b in the closing direction, thereby stopping the flow of the heat medium (step S6).

[1-3. Effect and the like]

[0050] As described above, in the embodiment, the heat medium circulation system 100 comprises the refrigerant circuit 110, the heat medium circuit 120, the conveying pump 121, the heating device 127 and the deaerating device 128. The refrigerant circuit 110 is the vapor compression type refrigeration cycle of the flammable refrigerant. The refrigerant circuit 110 is formed by annularly connecting the compressor 111, the use-side heat exchanger 112, the expansion device 113 and the heat source-side heat exchanger 114 to one another. Liquid heat medium which heats and cools the use-side load circulates through the heat medium circuit 120. The conveying pump 121 circulates heat medium in the heat medium circuit 120. The heating device 127 electrically heats the heat medium. The deaerating device 128 selectively discharges gas in the heat medium circuit 120 to outside atmosphere outside the heat medium circuit 120.

[0051] The conveying pump 121 is placed upstream

of the use-side heat exchanger 112, the heating device 127 is placed downstream of the use-side heat exchanger 112 and on a side higher than the use-side heat exchanger 112, and the deaerating device 128 is placed downstream of the heating device 127 and on a side higher than the heating device 127.

[0052] As a result, the conveying pump 121 is located upstream of the use-side heat exchanger 112. Therefore, it is possible to more reliably suppress the staying of flammable gas which is caused when leaked refrigerant from the use-side heat exchanger 112 flows into the conveying pump 121 and air biting occurs, and the conveying pump 112 is stopped due to the air biting.

[0053] Further, the heating device 127 is located downstream of the use-side heat exchanger 112 and on the side higher than the use-side heat exchanger 112, and the deaerating device 128 is located downstream of the heating device 127 and on the side higher than the heating device 127. Therefore, the precipitated flammable gas does not stay in the heating device 127, the gas is derived into the deaerating device 128 and the gas can be discharged outside.

[0054] Hence, in the event of flammable refrigerant leak from the use-side heat exchanger 112 into the heat medium circuit 120, it is possible to reliably discharge the flammable refrigerant into the outside atmosphere. According to this, safety is further enhanced.

[0055] As in the present embodiment, the heat medium exit 152 of the heating device 127 may be placed on the side higher than the heater element 150 of the heating device 127. Further, the heat medium entrance 151 of the heating device 127 may be placed on the side lower than the heat medium exit 152.

[0056] As a result, the heat medium flows toward the upper side of the heating device 127. Therefore, when the flammable refrigerant leaks from the use-side heat exchanger 112 into the heat medium circuit 120, the flammable refrigerant and air are prevented from the staying in an upper portion of the heating device 127. Further, even when the staying occurs, the flammable refrigerant and the air only stay up to a position higher than the heater element 150.

[0057] Hence, the staying flammable refrigerant does not directly come into contact with a surface of the heater element 150. According to this, safety is further enhanced.

[0058] As in the embodiment, the surface temperature of the heater element 150 of the heating device 127 may be heated so as to be lower than the temperature of ignition point of the flammable refrigerant enclosed in the refrigerant circuit 110.

[0059] According to this, even if the flammable refrigerant leaks from the use-side heat exchanger 112 into the heat medium circuit 120, the safety is further enhanced.

[0060] As in the embodiment, the control device 130 may control the first shut-off valve 129a and the second shut-off valve 129b to close when it is determined that the flammable refrigerant has leaked into the heat medium circuit 120.

[0061] According to this, since the first shut-off valve 129a and the second shut-off valve 129b are closed, the circulation of the heat medium in which refrigerant gas is mixed is more swiftly stopped, and the flammable refrigerant is prevented from moving toward the use-side terminal 122. Hence, the safety is further enhanced.

[0062] As in the embodiment, when a gas concentration detection value of the gas sensor 139 placed in the vicinity of an exhaust port of the deaerating device 128 becomes higher than preset gas concentration, the control device 130 may determine that the flammable refrigerant leaks into the heat medium circuit 120.

[0063] According to this, since it is possible to more reliably determine that the flammable refrigerant leaks, the safety is further enhanced.

[0064] As in the embodiment, the flammable refrigerant may be R32, mixed refrigerant including 70% or more by weight of R32, propane or mixed refrigerant including propane.

[0065] As a result, the global warming potential (GWP) is low, and it is possible to suppress adverse effects on the environment even when the refrigerant leaks. Therefore, environmental performance is enhanced.

(Other embodiments)

[0066] As described above, the present embodiment has been described as an example of a technique disclosed in the present application. However, the technique in the present disclosure is not limited to this, and the technique can also be applied to embodiments which are subjected to change, replacement, addition or omission. Constituent elements described in the above embodiment can be combined as new embodiments.

[0067] Hereinafter, other embodiments will be described below.

[0068] In the embodiment, a cooling/heating hot water supply system was described as one example of the heat medium circulation system 100. It is only necessary that the heat medium circulation system 100 can cool or heat liquid. Therefore, the heat medium circulation system 100 is not limited to the cooling/heating hot water supply system. However, if the cooling/heating hot water supply system is used as the heat medium circulation system 100, it can meet annual heat demand of residential houses. Further, a cool water/hot water chiller may be used as the heat medium circulation system 100. If the cool water/hot water chiller is used as the heat medium circulation system 100, since it can meet a cooling/heating heat load used in a factory, energy saving performance in the factory can be enhanced.

[0069] In the embodiment, an air purge valve using a float valve was described as one example of the deaerating device 128. It is only necessary that in the deaerating device 128, when gas is mixed in heat medium, the gas is discharged from the heat medium circuit 120.

Therefore, the deaerating device 128 is not limited to the air purge valve. However, if the air purge valve is used as the deaerating device 128, the air in the heat medium circuit 120 can be removed during filling of the heat medium in the installation work, so that the work is inexpensive. Further, as the deaerating device 128, a pressure relief valve that discharges heat medium and refrigerant gas at the same time when the pressure of the heat medium circuit 120 is increased may be used. If the pressure relief valve is used as the deaerating device 128, the pressure rise at the time of refrigerant leakage into the heat medium circuit 120 can be suppressed, and damage of pipes can be prevented. Therefore, it has the effect of increasing reliability.

[0070] In the embodiment, the gas sensor 139 was described as one example of a refrigerant leakage detection sensor. It is only necessary that the leakage detection sensor can determine that refrigerant leaks from the refrigerant circuit 110 into the heat medium circuit 120. Therefore, the refrigerant leakage detection sensor is not limited to the gas sensor 139, that is, a refrigerant concentration sensor. However, if the refrigerant concentration sensor is used as the refrigerant leakage detection sensor, it can be realized with a simple configuration. Further, as the refrigerant leakage detection sensor, a valve-opening action of a refrigerant discharge device may be detected by a microswitch or a hall IC. If the valve-opening action of the refrigerant discharge device is detected, since its structure is simple, there is effect that the device can be made small and light in weight.

[0071] In the embodiment, the configuration in which the heater element 150 is incorporated is described as one example of the heating device 127. It is only necessary that the heater element 150 of the heating device 127 is configured such that heat medium which flows into the heating device 127 is heated. Therefore, the installation position of the heater element 150 is not limited to the interior of the heating device 127. However, if the heater element 150 is placed in the heating device 127, since the heat medium can directly be heated, heat exchanging efficiency can be enhanced. Further, the heater element 150 of the heating device 127 may be placed on an outer surface of the heating device 127. If the heater element 150 is placed on the outer surface of the heating device 127, when the refrigerant leaks into the heat medium circuit 120, the refrigerant gas does not come into direct contact with the surface of the heater element 150.

[0072] In the embodiment, the circuit which is placed between the conveying pump 121 and the use-side heat exchanger 112, or between the use-side heat exchanger 112 and the switching valves 124a and 124b is described as one example of the installation positions of the shut-off valves 129a and 129b. The shut-off valves 129a and 129b may be placed at positions where the refrigerant does not flow into living spaces when the refrigerant leaks into the heat medium circuit 120. Therefore, the installation positions of the shut-off valves 129a and 129b are not limited to the positions between the conveying pump 121 and the use-side heat exchanger 112 or between the use-side heat exchanger 112 and the switching valves 124a and 124b. However, if the shut-off valves 129a and 129b are placed downstream of the discharge device, leaked refrigerant existing in the heat medium circuit 120 between the shut-off valves 129a and 129b can be discharged into atmosphere even after the shut-off valves 129a and 129b are shut off. Therefore, the safety is further enhanced.

[INDUSTRIAL APPLICABILITY]

[0073] The present disclosure can be applied to a heat medium circulation system where flammable refrigerant may leak into a heat medium circuit. More specifically, the present disclosure can be applied to a hot water supply heater, a professional-use chiller and the like.

[DESCRIPTION OF SYMBOLS]

[0074]

100 heat medium circulation system

110 refrigerant circuit

111 compressor

112 use-side heat exchanger

113 expansion device

114 heat source-side heat exchanger

115 four-way valve

116 pipe

120 heat medium circuit

121 conveying pump (conveying device)

122 use-side terminal

123 hot water tank

124a first switching valve

124b second switching valve

126 heat medium pipe

127 heating device

128 deaerating device

129a first shut-off valve

129b second shut-off 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 sensor

136 outside air temperature sensor

137 water-entering temperature sensor

138 water-going temperature sensor

139 gas sensor

150 heater element

151 heat medium entrance

152 heat medium exit

Claims

1. A heat medium circulation system comprising:

a refrigerant circuit which is formed by annularly connecting a compressor, a use-side heat exchanger, an expansion device and a heat source-side heat exchanger to one another, and in which flammable refrigerant is used;
a heat medium circuit through which heat medium cooled or heated by the use-side heat exchanger by means of refrigerant discharged from the compressor circulates; and
a control device, wherein
the heat medium circuit is provided therein at least with a circulation device through which the heat medium in the heat medium circuit circulates, a heating device for electrically heating the heat medium, and a deaerating device which separates gas in the heat medium circuit and discharges the gas to outside, and
the circulation device is placed upstream of the use-side heat exchanger, the heating device is placed downstream of the use-side heat exchanger and on a side higher than the use-side heat exchanger, and the deaerating device is placed downstream of the heating device and on a side higher than the heating device.

2. The heat medium circulation system according to claim 1, wherein a heat medium exit of the heating device is placed on a side higher than a heating portion of the heating device, and a heat medium entrance of the heating device is placed on a side lower than the heat medium exit.

3. The heat medium circulation system according to claim 2, wherein the control device controls the heating device to heat the heating portion of the heating device so that a surface temperature of the heating portion is less than a temperature of an ignition point of the flammable refrigerant.

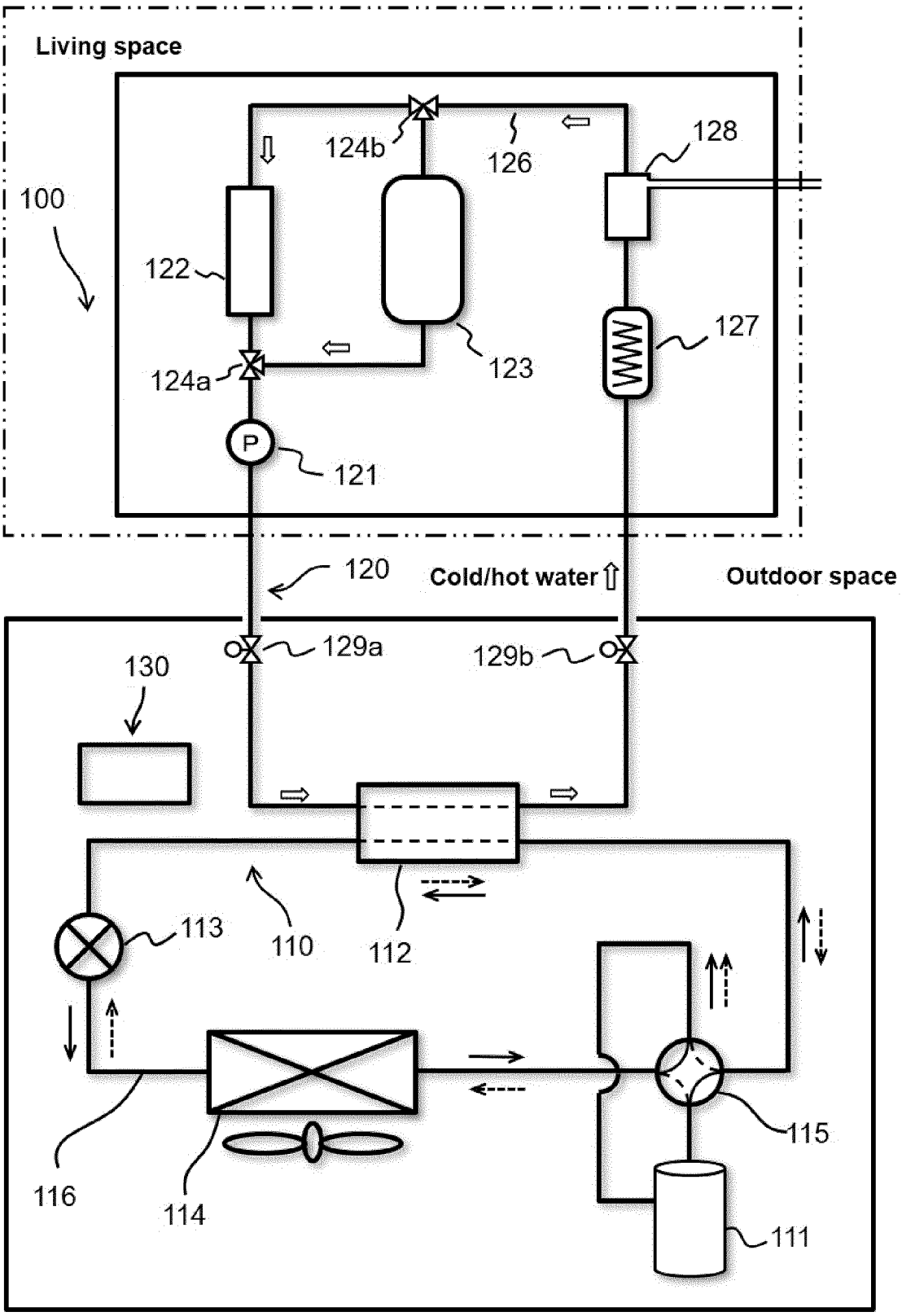
4. The heat medium circulation system according to any one of claims 1 to 3, further comprising a refrigerant leakage detection sensor for detecting leakage of the flammable refrigerant into the heat medium circuit, and shut-off valves for shutting off a flow path of the heat medium circulating in the heat medium circuit, wherein
when the control device determines that the flammable refrigerant leaks into the heat medium circuit, the control device operates the shut-off valves in a closing direction to stop flow of the heat medium.

5. The heat medium circulation system according to claim 4, wherein

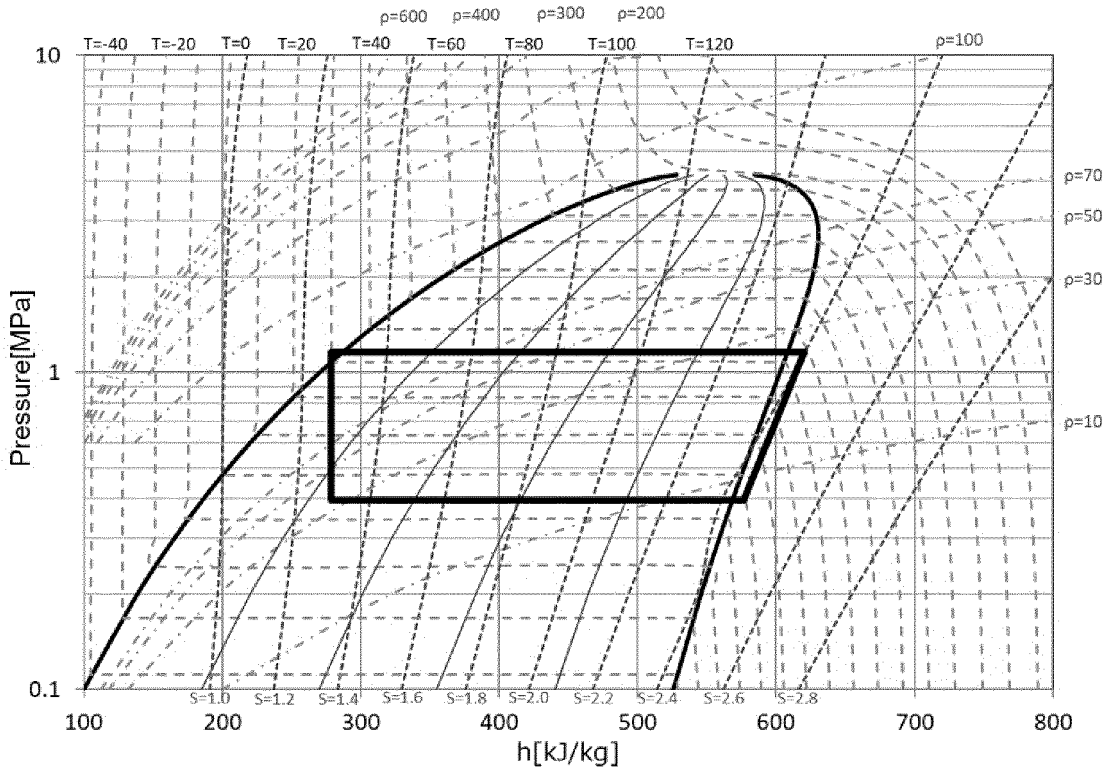
the refrigerant leakage detection sensor is a refrigerant concentration sensor placed in a vicinity of an exhaust port of the deaerating device, and
the control device determines that the flammable refrigerant leaks from the heat medium circuit when a detection value of the refrigerant concentration sensor becomes equal to or higher than a predetermined value.

6. The heat medium circulation system according to any one of claims 1 to 5, wherein the flammable refrigerant is R32, mixed refrigerant including 70% or more by weight of R32, propane, or mixed refrigerant including propane.

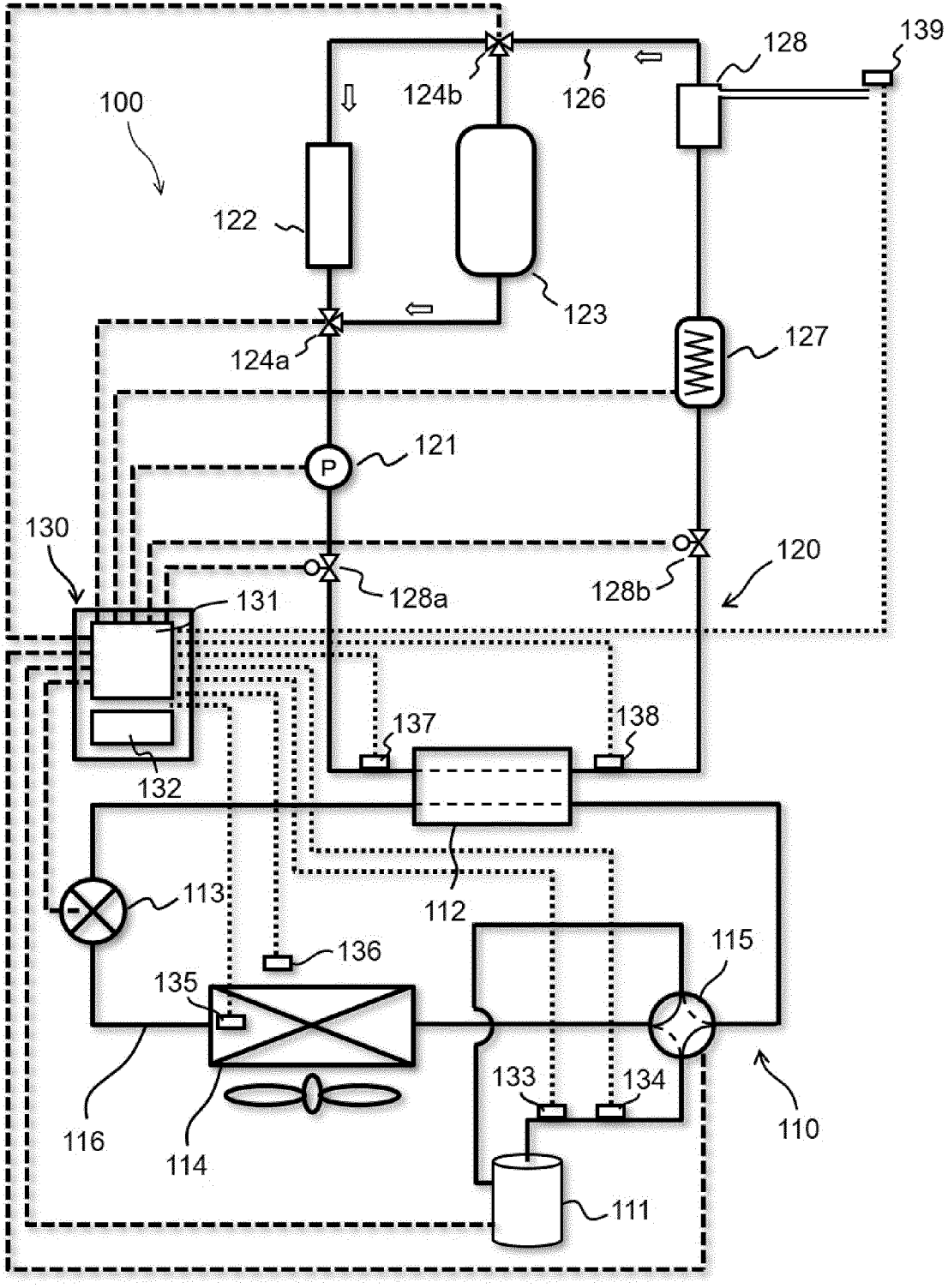
[Fig. 1]


Living space
100
122
124b
126
128
123
127
124a
P
121
120
Cold/hot water
Outdoor space
129a
129b
130
113
110
112
116
114
115
111

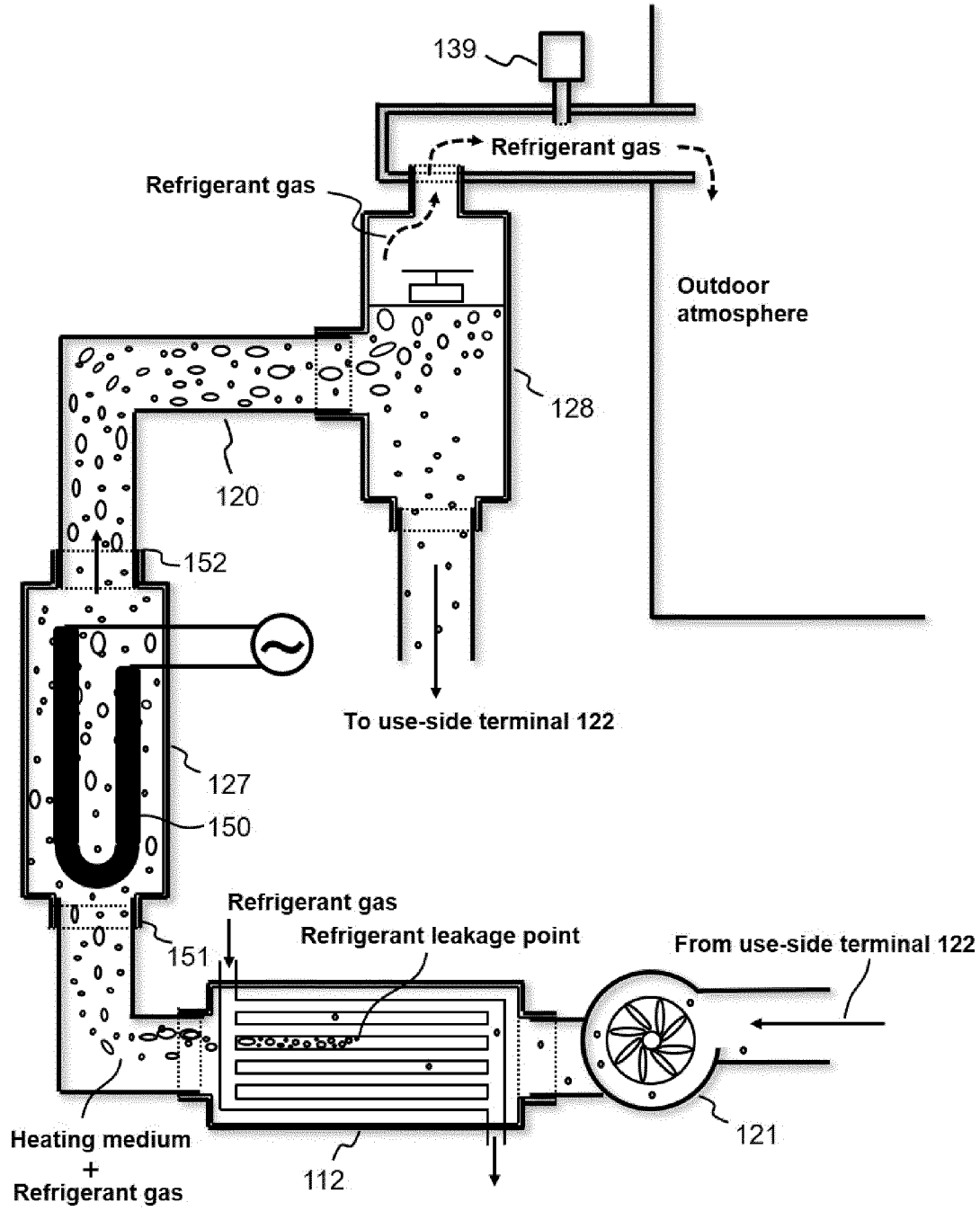
[Fig. 2]


ρ=600
ρ=400
ρ=300
ρ=200
T=-40
T=-20
T=0
T=20
T=40
T=60
T=80
T=100
T=120
ρ=100
ρ=70
ρ=50
ρ=30
ρ=10
10
1
0.1
Pressure[MPa]
S=1.0
S=1.2
S=1.4
S=1.6
S=1.8
S=2.0
S=2.2
S=2.4
S=2.6
S=2.8
100
200
300
400
500
600
700
800
h[kJ/kg]

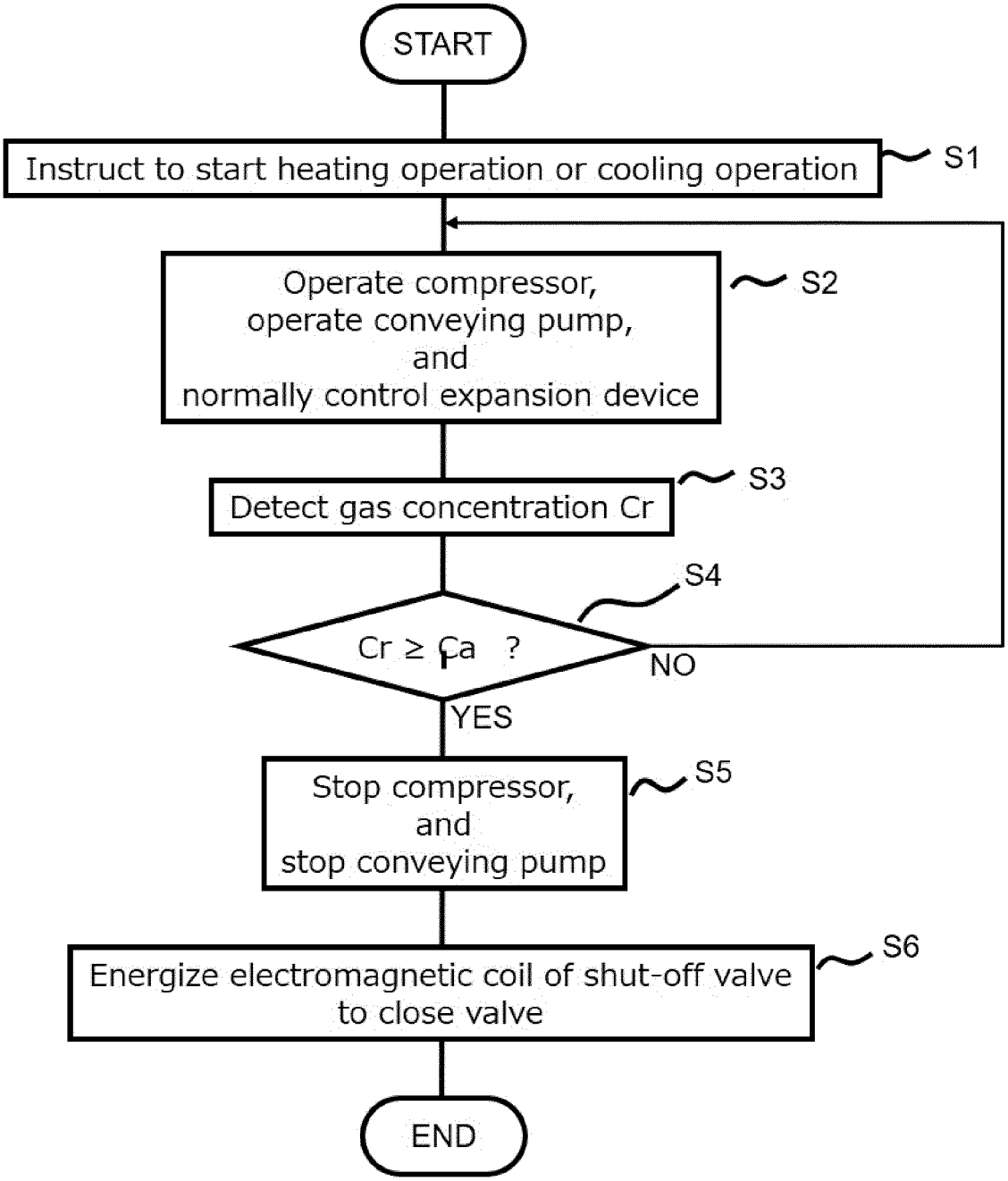
[Fig. 3]


100
122
123
124a
124b
126
127
128
139
121
P
130
131
120
128a
128b
132
137
138
112
113
136
135
115
116
114
133
134
110
111

[Fig. 4]


139
Refrigerant gas
Refrigerant gas
Outdoor atmosphere
128
120
152
To use-side terminal 122
127
150
Refrigerant gas
Refrigerant leakage point
From use-side terminal 122
151
121
Heating medium + Refrigerant gas
112

[Fig. 5]


START
Instruct to start heating operation or cooling operation
S1
Operate compressor, operate conveying pump, and normally control expansion device
S2
Detect gas concentration Cr
S3
S4
Cr ≥ Ca ?
NO
YES
Stop compressor, and stop conveying pump
S5
Energize electromagnetic coil of shut-off valve to close valve
S6
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/034874

A. CLASSIFICATION OF SUBJECT MATTER

F25B 1/00(2006.01)i; ***F24H 15/375***(2022.01)i; ***F25B 49/02***(2006.01)i
FI: F25B1/00 399Y; F24H15/375; F25B49/02 520M

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; F25B49/00-49/02; F24H15/37-15/39

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 2021-55866 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 08 April 2021 (2021-04-08) paragraphs [0004]-[0032], fig. 1-4	1–6
A	JP 2020-128833 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 27 August 2020 (2020-08-27) paragraph [0048], fig. 1	1–6
A	WO 2013/038577 A1 (MITSUBISHI ELECTRIC CORP.) 21 March 2013 (2013-03-21) paragraphs [0020], [0022], fig. 1	1–6
A	WO 2018/235125 A1 (MITSUBISHI ELECTRIC CORP.) 27 December 2018 (2018-12-27) entire text, all drawings	1-6

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

* Special categories of cited documents:
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"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
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 2022	**01 November 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/034874

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2021-55866 A	08 April 2021	(Family: none)	
JP 2020-128833 A	27 August 2020	EP 3693670 A1 paragraph [0048], fig. 1	
WO 2013/038577 A1	21 March 2013	US 2014/0196483 A1 paragraphs [0050], [0053]-[0056], fig. 1 EP 2759787 A1 CN 103797317 A	
WO 2018/235125 A1	27 December 2018	US 2020/0109881 A1 EP 3467399 A1 CN 110741210 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2018047265 A **[0003]**