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(54) **CHILLING UNIT, CONTROL METHOD, AND PROGRAM**

(57) Object

To provide a chilling unit that can quickly detect an anomaly in a water heat exchanger.

Solving Means

A chilling unit includes: a refrigerant circuit including a compressor that compresses a refrigerant, an air heat exchanger that performs heat exchange between the refrigerant and outside air, a water heat exchanger that performs heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that switches a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path; a water circuit including a water pipe inserted through the water heat exchanger, a water pump that sends the water to the water pipe, and a water valve provided closer to a downstream side of the water pipe than the water heat exchanger; and a control device configured to control the refrigerant circuit and the water circuit. The control device includes a detecting unit configured to detect an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

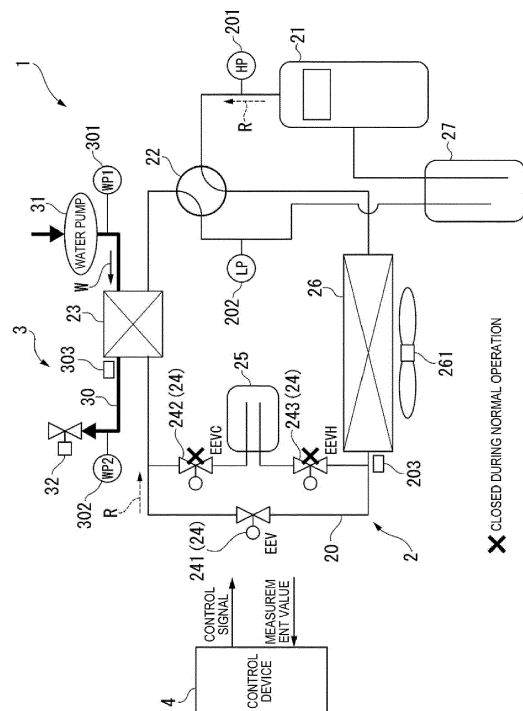


FIG. 1

Description

Technical Field

[0001] The present disclosure relates to a chilling unit, a control method, and a program.

Background Art

[0002] In a chilling unit, when a heat exchanger (hereinafter also described as a "water heat exchanger") configured to exchange heat between a refrigerant and water is damaged due to, for example, freezing or corrosion due to water quality, the refrigerant may leak from the refrigerant circuit to the water circuit. Patent Document 1 describes a technology of detecting refrigerant leakage when concentration of the refrigerant exceeds a reference value for a certain period of time or longer.

Citation List

Patent Document

[0003] Patent Document 1: JP 2020-51738 A

Summary of Invention

Technical Problem

[0004] If the chilling unit continues to operate in a state where the water heat exchanger is damaged, pressure in the refrigerant circuit and pressure in the water circuit may become equalized. In this case, water may enter the refrigerant circuit. When water enters the refrigerant circuit, each device connected to the refrigerant circuit, including a compressor, an accumulator, a receiver, and valves (e.g., an expansion valve and a four-way valve), in addition to the water heat exchanger, may need to be replaced during repair, and it may cost to repair and take days until restoration. Therefore, an anomaly such as damage to the water heat exchanger is preferably quickly detected such that the damage does not spread.

[0005] The present disclosure has been made in view of such a problem, and provides a chilling unit, a control method, and a program that can quickly detect an anomaly in a water heat exchanger.

Solution to Problem

[0006] According to one aspect of the present disclosure, a chilling unit includes: a refrigerant circuit including a compressor that is configured to compress a refrigerant, an air heat exchanger that is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger that is configured to perform heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that is

configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path; a water circuit including a water pipe inserted through the water heat exchanger, a water pump that is configured to send the water to the water pipe, and a water valve provided closer to a downstream side of the water pipe than the water heat exchanger; and a control device configured to control the refrigerant circuit and the water circuit, wherein the control device includes a detecting unit configured to detect an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

[0007] According to one aspect of the present disclosure, a control method is a method for controlling a chilling unit including a refrigerant circuit including a compressor that is configured to compress a refrigerant, an air heat exchanger that is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger that is configured to perform heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that is configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, a water circuit including a water pipe inserted through the water heat exchanger, a water pump that is configured to send the water to the water pipe, and a water valve provided closer to a downstream side of the water pipe than the water heat exchanger, and a control device configured to control the refrigerant circuit and the water circuit, in which the control method includes detecting, by the control device, an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

[0008] According to one aspect of the present disclosure, a program causes a control device of a chilling unit including a refrigerant circuit including a compressor that is configured to compress a refrigerant, an air heat exchanger that is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger that is configured to perform heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that is configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, and a water circuit including a water pipe inserted through the water heat exchanger, a water pump that is configured to send the water to the water pipe, and a water valve provided closer to a downstream side of the water pipe than the water heat exchanger, to execute detecting an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined satu-

ration temperature lower limit value.

Advantageous Effects of Invention

[0009] A chilling unit, a control method, and a program according to the present disclosure can quickly detect an anomaly in a water heat exchanger.

Brief Description of Drawings

[0010]

FIG. 1 is a first diagram illustrating a configuration of a chilling unit according to a first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during a cooling operation.

FIG. 2 is a second diagram illustrating the configuration of the chilling unit according to the first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during a heating operation.

FIG. 3 is a third diagram illustrating the configuration of the chilling unit according to the first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during an operation stop.

FIG. 4 is a diagram illustrating a functional configuration of a control device according to the first embodiment of the present disclosure.

FIG. 5 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the cooling operation.

FIG. 6 is a diagram illustrating an example of a control state when refrigerant leakage in the chilling unit according to the first embodiment of the present disclosure is detected.

FIG. 7 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the heating operation.

FIG. 8 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the operation stop.

Description of Embodiments

First Embodiment

[0011] Hereinafter, a chilling unit according to a first embodiment of the present disclosure will be described with reference to FIGS. 1 to 8.

Overall Configuration of Chilling Unit

[0012] FIG. 1 is a first diagram illustrating a configura-

tion of the chilling unit according to the first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during a cooling operation.

[0013] FIG. 2 is a second diagram illustrating the configuration of the chilling unit according to the first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during a heating operation.

[0014] FIG. 3 is a third diagram illustrating the configuration of the chilling unit according to the first embodiment of the present disclosure, and is a diagram illustrating an example of a control state during an operation stop.

[0015] As illustrated in FIGS. 1 to 3, a chilling unit 1 includes a refrigerant circuit 2, a water circuit 3, and a control device 4.

[0016] The refrigerant circuit 2 includes a compressor 21, a four-way valve 22, a water heat exchanger 23, an expansion valve 24, a receiver 25, an air heat exchanger 26, and an accumulator 27. Each device of the refrigerant circuit 2 is connected by a refrigerant pipe 20.

[0017] The compressor 21 compresses a refrigerant R and supplies the compressed refrigerant R to the refrigerant circuit 2.

[0018] The four-way valve 22 switches between the cooling operation and the heating operation by switching the flow path of the refrigerant circuit 2. As illustrated in FIG. 1, the four-way valve 22 feeds, to the air heat exchanger 26, the refrigerant R discharged from the compressor 21 during the cooling operation. Further, as illustrated in FIG. 2, the four-way valve 22 feeds, to the water heat exchanger 23, the refrigerant R discharged from the compressor 21 during the heating operation.

[0019] The water heat exchanger 23 cools or heats water W by performing heat exchange between the refrigerant R and the water W.

[0020] The expansion valve 24 includes a mechanism for reducing pressure of the refrigerant R when the refrigerant R passes through the expansion valve 24. As illustrated in FIG. 1, the expansion valve 24 includes a first expansion valve 241, a second expansion valve 242, and a third expansion valve 243. The first expansion valve 241 is an expansion valve for the cooling operation. The second expansion valve 242 and the third expansion valve 243 are expansion valves for the heating operation. The second expansion valve 242 is provided between the water heat exchanger 23 and the receiver 25, and the third expansion valve 243 is provided between the receiver 25 and the air heat exchanger 26.

[0021] As illustrated in FIG. 1, during the cooling operation, the first expansion valve 241 is in an open state, and the second expansion valve 242 and the third expansion valve 243 are in a closed state. As illustrated in FIG. 2, during the heating operation, the first expansion valve 241 is in the closed state, and the second expansion valve 242 and the third expansion valve 243 are in the open state. Further, as illustrated in FIG. 3, during an operation stop, the first expansion valve 241 and the third expansion valve 243 are in a closed state, and the second

expansion valve 242 is in an open state.

[0022] The receiver 25 is a container for storing at least some of a liquid refrigerant that passes through the second expansion valve 242 or the third expansion valve 243.

[0023] The air heat exchanger 26 performs heat exchange between the refrigerant R and outside air taken in by a propeller fan 261.

[0024] The accumulator 27 is a device that is provided on an upstream side of the compressor 21 and separates liquid refrigerant and gas refrigerant. Only the gas refrigerant of the refrigerant separated by the accumulator 27 is sent to the compressor 21.

[0025] A plurality of sensors for measuring the pressure and temperature of the refrigerant R are provided in the refrigerant circuit 2. A high-pressure-side sensor 201 that measures pressure (HP) of the refrigerant R on a high-pressure side is provided in the refrigerant pipe 20 between the compressor 21 and the four-way valve 22 (on a downstream side of the compressor 21). A low-pressure-side sensor 202 that measures pressure (LP) of the refrigerant R on a low-pressure side is provided in the refrigerant pipe 20 between the accumulator 27 and the four-way valve 22 (on an upstream side of the accumulator 27). Further, a first temperature sensor 203 that measures a temperature of the refrigerant R is provided in the refrigerant pipe 20 between the expansion valve 24 and the air heat exchanger 26. Measurement values measured by each of the sensors are sequentially transmitted to the control device 4.

[0026] The water circuit 3 includes a water pipe 30, a water pump 31, and a water valve 32. The water pipe 30 is inserted through the water heat exchanger 23. The water pump 31 is provided closer to an upstream side of the water pipe 30 than the water heat exchanger 23, and sends the water W from the outside to the water pipe 30. While passing through the water heat exchanger 23, the water W sent by the water pump 31 undergoes heat exchange with the refrigerant R so that the temperature of the water W is adjusted. The water valve 32 is provided closer to a downstream side of the water pipe 30 than the water heat exchanger 23. When the water valve 32 is opened, the water W after undergoing temperature adjustment is discharged to the outside through the water pipe 30. When the water valve 32 is closed, the discharge of the water W to the outside is stopped.

[0027] A plurality of sensors for measuring the pressure and temperature of the water W are provided in the water circuit 3. A first water pressure sensor 301 that measures pressure (WP1) of the water W on an inlet side of the water heat exchanger 23 is provided in the water pipe 30 on an upstream side of the water heat exchanger 23. A second water pressure sensor 302 that measures pressure (WP2) of the water W on an outlet side of the water heat exchanger 23 is provided in the water pipe 30 on a downstream side of the water heat exchanger 23. Further, a second temperature sensor 303 that measures a temperature of the water W is provided in the water

pipe 30 on the downstream side (near the outlet) of the water heat exchanger 23. Measurement values measured by each of the sensors are sequentially transmitted to the control device 4.

[0028] The control device 4 controls the operation of each device of the refrigerant circuit 2 and the water circuit 3, and brings the chilling unit 1 into any state of the cooling operation, the heating operation, and the operation stop.

[0029] The control device 4 according to the present embodiment detects an anomaly in the water heat exchanger 23 on the basis of a measurement value received from each of the sensors of the refrigerant circuit 2 and the water circuit 3. Further, the control device 4 performs processing of suppressing entry of the water W into the refrigerant circuit 2 when a sign of leakage of the refrigerant R is detected in the water heat exchanger 23. The details of this processing will be described later.

20 Functional Configuration of Control Device

[0030] FIG. 4 is a diagram illustrating a functional configuration of the control device according to the first embodiment of the present disclosure.

[0031] As illustrated in FIG. 4, the control device 4 includes a processor 40, a main memory 41, a storage 42, an interface 43, and a display unit 44.

[0032] The processor 40 operates according to a predetermined program to function as a detecting unit 401, a control unit 402, and an alarm unit 403.

[0033] The detecting unit 401 detects an anomaly in the water heat exchanger 23, based on a measurement value of each of the sensors provided in the refrigerant circuit 2 and the water circuit 3. Specifically, the detecting unit 401 detects a low-pressure anomaly in the water heat exchanger 23 when a saturation temperature of the refrigerant R is less than a predetermined saturation temperature lower limit value. The detecting unit 401 further detects presence or absence of a sign of leakage of the refrigerant R from the water heat exchanger 23 during each of the cooling operation, the heating operation, and the operation stop.

[0034] In a case where a sign of leakage of the refrigerant R from the water heat exchanger 23 is detected, the control unit 402 performs various types of processing for suppressing entry of the water W into the refrigerant circuit 2.

[0035] In a case where an anomaly in the water heat exchanger 23 is detected, the alarm unit 403 issues an anomaly alarm via the display unit 44. Note that the alarm unit 403 may issue an anomaly alarm to an external monitoring device (e.g., a computer, a smartphone, or a tablet) via the interface 43.

[0036] Commands and data for the processor 40 to operate based on a program are deployed to the main memory 41.

[0037] The storage 42 is a so-called auxiliary storage device, and may be, for example, an electrically erasable

programmable read-only memory (EEPROM), a hard disk drive (HDD), or a solid state drive (SSD).

[0038] The interface 43 is an interface (communication interface) for communicably connecting each device and sensor in the refrigerant circuit 2 and the water circuit 3.

[0039] The display unit 44 is a display that displays information such as the presence or absence of an anomaly in the chilling unit 1.

Processing Flow during Cooling Operation

[0040] FIG. 5 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the cooling operation.

[0041] Hereinafter, a flow of processing of monitoring an anomaly in the water heat exchanger 23 during a cooling operation and processing at the time of an anomaly will be described with reference to FIG. 5.

[0042] The control unit 402 controls the operating state of each device of the refrigerant circuit 2 and the water circuit 3 to perform the cooling operation of the chilling unit 1 (step S100). For example, as illustrated in FIG. 1, the control unit 402 switches the four-way valve 22 such that the refrigerant R discharged by the compressor 21 flows into the air heat exchanger 26, and also brings the first expansion valve 241 into the open state and brings the second expansion valve 242 and the third expansion valve 243 into the closed state. Then, when the compressor 21 is operated, the four-way valve 22 switches to serve as a refrigerant circuit for the cooling operation. Before the control unit 402 operates the compressor 21, the control unit 402 operates the water pump 31 in the water circuit 3, and also brings the water valve 32 into the open state if the water valve 32 is installed. In this way, the water W flowing through the water circuit 3 is cooled by the refrigerant R while passing through the water heat exchanger 23.

[0043] Further, the detecting unit 401 constantly monitors a measurement value (pressure LP of the refrigerant R on the low-pressure side) of the low-pressure-side sensor 202 of the refrigerant circuit 2 during the cooling operation to detect presence or absence of a pressure anomaly of the refrigerant. In the present embodiment, each time the detecting unit 401 receives a measurement value from the low-pressure-side sensor 202, the detecting unit 401 monitors whether a saturation temperature on the low-pressure side (hereinafter also described as an "LP saturation temperature") is less than a first saturation temperature lower limit value (e.g., $-A^{\circ}\text{C}$) (step S 101). For example, a correspondence table of saturation pressure and saturation temperature for each type of the refrigerant R is previously recorded in the storage 42, and the detecting unit 401 determines the LP saturation temperature with reference to the correspondence table. Further, the first saturation temperature lower limit value is preset according to the type of the refrigerant R or the like.

[0044] In a case where the LP saturation temperature is equal to or greater than the first saturation temperature lower limit value (step S101: NO), the detecting unit 401 determines that there is no anomaly in the pressure state of the refrigerant. In this case, the control device 4 continues the cooling operation of the chilling unit 1.

[0045] On the other hand, in a case where the LP saturation temperature is less than the first saturation temperature lower limit value (step S101: YES), the detecting unit 401 detects that an anomaly has occurred in low pressure of the refrigerant. In this case, the control unit 402 stops the cooling operation of the chilling unit 1. Further, the alarm unit 403 issues an anomaly alarm indicating an anomaly in the refrigerant circuit 2 (step S102). At this time, the alarm unit 403 may display a value of the LP saturation temperature or the like together with the anomaly alarm on the display unit 44. Further, the alarm unit 403 may issue the anomaly alarm to an external monitoring terminal or the like via the interface 43. When the low-pressure anomaly alarm for the refrigerant is issued, an administrator of the chilling unit 1 arranges for repair of the chilling unit 1.

[0046] Next, the detecting unit 401 confirms presence or absence of a sign of leakage of the refrigerant R into the water circuit 3 in the water heat exchanger 23. Specifically, first, the detecting unit 401 determines a subcooling degree at an outlet of the air heat exchanger 26, based on a measurement value of the first temperature sensor 203 immediately before the low-pressure anomaly occurs. Note that, in other embodiments, the first temperature sensor 203 may be a sensor that can measure a subcooling degree, and the detecting unit 401 may acquire the subcooling degree at the outlet of the air heat exchanger 26 from the first temperature sensor 203. Then, the detecting unit 401 determines whether the subcooling degree at the outlet of the air heat exchanger 26 is significantly lower than a predetermined subcooling degree reference value, and whether subcooling cannot be guaranteed (step S 103). Note that the subcooling degree reference value is preset according to the type of the refrigerant R or the like.

[0047] In a case where the subcooling degree at the outlet of the air heat exchanger 26 is not lower than the subcooling degree reference value (step S 103: NO), the detecting unit 401 determines that there is no sign of leakage of the refrigerant R (step S 105). In this case, the control unit 402 terminates the processing while the operation of the chilling unit 1 is stopped.

[0048] On the other hand, in a case where the subcooling degree at the outlet of the air heat exchanger 26 is lower than the subcooling degree reference value (step S 103: YES), the detecting unit 401 further confirms whether a water temperature at the outlet of the water heat exchanger 23 of the water circuit 3 immediately before the low-pressure anomaly occurs is less than a lower limit value (e.g., 3°C) in a water temperature control range (step S 104). The lower limit value in the water temperature control range indicates a set temperature in a set-

table temperature range in the chilling unit 1. For example, in a case where the settable temperature range is "from 4°C to 30°C", the lower limit value is "4°C" when the set temperature is "4°C", and the lower limit value is "7°C" when the set temperature is "7°C".

[0049] When there is no refrigerant leakage at the time of a low-temperature anomaly (the amount of the refrigerant R is sufficient in the refrigerant circuit 2), the water temperature decreases (reaches a subcooling temperature) as the pressure LP on the low-pressure side decreases. Thus, in a case where the water temperature at the outlet of the water heat exchanger 23 measured by the second temperature sensor 303 is less than the lower limit value in the water temperature control range (step S104: NO), the detecting unit 401 determines that there is no sign of leakage of the refrigerant R (step S105). In other words, the low-pressure anomaly of the refrigerant is determined to be due to a cause other than refrigerant leakage from the water heat exchanger 23, for example, clogging of the refrigerant circuit 2. In this case, the control unit 402 terminates the processing while the operation of the chilling unit 1 is stopped.

[0050] On the other hand, in a case where there is refrigerant leakage at the time of the low-pressure anomaly, the amount of the refrigerant R is insufficient, and thus it is difficult to sufficiently perform cooling until the lower limit value (set temperature) is reached. Thus, in a case where the water temperature at the outlet of the water heat exchanger 23 is equal to or greater than the lower limit value in the water temperature control range (step S104: YES), the detecting unit 401 determines that leakage has already occurred in the water heat exchanger 23, and the refrigerant and water are mixed and the water temperature cannot be controlled. In this case, the alarm unit 403 issues an anomaly alarm indicating the refrigerant leakage in the water heat exchanger 23 (step S106). When the anomaly alarm indicating the refrigerant leakage from the water heat exchanger 23 is issued, an administrator of the chilling unit 1 arranges for repair of the chilling unit 1.

[0051] The refrigerant circuit 2 normally has a pressure higher than that of the water circuit 3. However, when leakage of the refrigerant R advances and pressure in the refrigerant circuit 2 and pressure in the water circuit 3 are equalized, the water W of the water circuit 3 may enter the refrigerant circuit 2. In addition, it may take a long time from when repair is arranged to when repair of the chilling unit 1 is actually performed. Therefore, when the leakage of the refrigerant R is left until the repair of the chilling unit 1 is performed, the water W enters the refrigerant circuit 2, and damage to the chilling unit 1, such as failure of the compressor 21, may spread.

[0052] In order to reduce the likelihood of such damage to the chilling unit 1 spreading, the control unit 402 according to the present embodiment performs automatic processing of suppressing entry of the water W into the refrigerant circuit 2 when the refrigerant leakage is detected. Details of this processing will be described with

reference to FIGS. 5 and 6.

[0053] FIG. 6 is a diagram illustrating an example of a control state when refrigerant leakage in the chilling unit according to the first embodiment of the present disclosure is detected.

[0054] First, processing in the water circuit 3 will be described. In a case where the water heat exchanger 23 is damaged, when the water W flows on the water circuit 3 side, the water W may leak into the refrigerant circuit 2. Thus, as illustrated in FIG. 6, the control unit 402 performs third processing of stopping the water pump 31 of the water circuit 3 and bringing the water valve 32 into the closed state (step S107). In this way, entry of the water W into the refrigerant circuit 2 can be suppressed. Further, in a system in which a plurality of the chilling units 1 are coupled with one water circuit 3, when the refrigerant R leaks into the water circuit 3 of a certain chilling unit 1, the water W mixed with the refrigerant R can be prevented from circulating in another chilling unit.

[0055] Further, processing in the refrigerant circuit 2 will be described. The control unit 402 performs first processing (steps S108 and S109) of increasing pressure in the refrigerant circuit 2 such that the pressure in the refrigerant circuit 2 is not equalized with the pressure in the water circuit 3. Specifically, as illustrated in FIG. 6, the control unit 402 brings the first expansion valve 241 and the second expansion valve 242 into the closed state, brings the third expansion valve 243 into the open state, and also operates the four-way valve 22 to switch to a heating operation flow path (step S108). Further, the control unit 402 starts up the compressor 21 (step S109). In this way, the control unit 402 sends the refrigerant R compressed by the compressor 21 while limiting the flow path on a downstream side of the compressor 21 to a short section ending at the second expansion valve 242, and thus increases pressure in the section from the compressor 21 to the second expansion valve 242 in the refrigerant circuit 2, that is, a section around the water heat exchanger 23.

[0056] Furthermore, the control unit 402 performs second processing (steps S110 to S112) of maintaining the pressure in the section around the water heat exchanger 23 in the refrigerant circuit 2 within a fixed range.

[0057] First, the control unit 402 confirms whether the high-pressure-side pressure HP of the refrigerant circuit 2 measured by the high-pressure-side sensor 201 after the compressor 21 starts up exceeds a pressure upper limit value (step S110). The pressure upper limit value is, for example, a value acquired by adding a predetermined margin $\alpha 1$ to the inlet-side pressure WP1 of the water circuit 3 measured by the first water pressure sensor 301. The value of the margin $\alpha 1$ is preset according to the type of the refrigerant R, a characteristic of the compressor 21, or the like.

[0058] In a case where the high-pressure-side pressure HP is equal to or less than the pressure upper limit value (step S110: NO), the control unit 402 continues the operation of the compressor 21.

[0059] On the other hand, in a case where the high-pressure-side pressure HP exceeds the pressure upper limit value (step S110: YES), the control unit 402 stops the compressor 21 (step S111). In this way, the control unit 402 can suppress an increase more than necessary in the pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 with respect to the pressure in the water circuit 3.

[0060] Further, after the control unit 402 stops the compressor 21, the control unit 402 confirms whether the high-pressure-side pressure HP is less than the pressure lower limit value (step S112). The pressure upper limit value is, for example, a value acquired by adding a predetermined margin $\alpha 2$ to the inlet-side pressure WP1 of the water circuit 3 measured by the first water pressure sensor 301. The value of the margin $\alpha 2$ is preset according to the type of the refrigerant R, a characteristic of the compressor 21, or the like. Note that the values of the margins $\alpha 1$ and $\alpha 2$ may be the same, or may be different.

[0061] In a case where the high-pressure-side pressure HP is equal to or greater than the pressure lower limit value (step S112: NO), the control unit 402 causes the compressor 21 to remain stopped.

[0062] On the other hand, in a case where the high-pressure-side pressure HP is less than the pressure lower limit value (step S112: YES), the control unit 402 starts up the compressor 21 (returns to step S109). In this way, the control unit 402 can suppress entry of the water W into the refrigerant circuit 2 because the pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 is equalized with the pressure in the water circuit 3.

[0063] In this way, when a sign of leakage of the refrigerant R is detected during the cooling operation, the control unit 402 performs the first to third processing as illustrated in FIG. 5, and suppresses entry of the water W in the water circuit 3 into the refrigerant circuit 2 to prevent the spread of damage in the chilling unit 1.

Processing Flow during Heating Operation

[0064] FIG. 7 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the heating operation.

[0065] Hereinafter, a flow of processing of monitoring an anomaly in the water heat exchanger 23 during the heating operation and processing at the time of the anomaly will be described with reference to FIG. 7.

[0066] The control unit 402 controls the operation state of each device of the refrigerant circuit 2 and the water circuit 3, and performs the heating operation of the chilling unit 1 (step S200). For example, as illustrated in FIG. 2, the control unit 402 switches the four-way valve 22 such that the refrigerant R discharged by the compressor 21 flows into the water heat exchanger 23, and also brings the first expansion valve 241 into the closed state and brings the second expansion valve 242 and the third ex-

pansion valve 243 into the open state. When the control unit 402 switches the refrigerant circuit 2 to a heating operation flow path in such a manner, the control unit 402 operates the compressor 21. Before the control unit 402 operates the compressor 21, the control unit 402 operates the water pump 31 in the water circuit 3, and also brings the water valve 32 into the open state if the water valve 32 is installed. In this way, the water W flowing through the water circuit 3 is heated by the refrigerant R while passing through the water heat exchanger 23.

[0067] Further, the detecting unit 401 constantly monitors the pressure LP of the refrigerant R on the low-pressure side during the heating operation to detect presence or absence of an anomaly in the water heat exchanger 23. Specifically, the detecting unit 401 monitors whether an outside temperature is equal to or greater than 0°C and whether the LP saturation temperature is less than a second saturation temperature lower limit value (e.g., -B°C) (step S201). Note that the second saturation temperature lower limit value is preset according to the type of the refrigerant R or the like.

[0068] In a case where the outside temperature is less than 0°C or the LP saturation temperature is equal to or greater than the second saturation temperature lower limit value (step S201: NO), the detecting unit 401 determines that there is no anomaly (no leakage) in the refrigerant circuit 2. In this case, the control device 4 continues the heating operation of the chilling unit 1.

[0069] On the other hand, in a case where the outside temperature is equal to or greater than 0°C and the LP saturation temperature is less than the second saturation temperature lower limit value (step S201: YES), the detecting unit 401 detects that leakage from the refrigerant circuit 2 may occur and there may be a sign of leakage of the refrigerant R in the water heat exchanger 23. In this case, the control unit 402 stops the heating operation of the chilling unit 1. Further, the alarm unit 403 issues an anomaly alarm indicating the sign of refrigerant leakage in the water heat exchanger 23 (step S202).

[0070] When the sign of refrigerant leakage is detected, the control unit 402 performs processing of suppressing entry of the water W into the refrigerant circuit 2 similarly to the cooling operation.

[0071] For the water circuit 3, the control unit 402 performs third processing of stopping the water pump 31 of the water circuit 3 and bringing the water valve 32 into the closed state (step S203). This processing is the same as that in step S107 in FIG. 5.

[0072] For the refrigerant circuit 2, first, the control unit 402 performs first processing (steps S204 and S205) of increasing pressure in the refrigerant circuit 2 such that the pressure in the refrigerant circuit 2 is not equalized with pressure in the water circuit 3. When the heating operation is stopped in step S202, the flow path may switch to the flow path during the operation stop illustrated in FIG. 3. Thus, as illustrated in FIG. 6, the control unit 402 brings the first expansion valve 241 and the second expansion valve 242 into the closed state, brings the

third expansion valve 243 into the open state, and also operates the four-way valve 22 to switch to the heating operation flow path (step S204). Further, the control unit 402 starts up the compressor 21 (step S205), and increases pressure in the section from the compressor 21 to the second expansion valve 242 in the refrigerant circuit 2, that is, the section around the water heat exchanger 23. This processing is the same as that in steps S108 to S109 in FIG. 5.

[0073] Furthermore, the control unit 402 performs second processing (steps S206 to S208) of maintaining the pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 within a fixed range. This processing is the same as that in steps S110 to S112 in FIG. 5.

[0074] When a sign of leakage of the refrigerant R is detected during the heating operation, the control unit 402 performs the first to third processing as illustrated in FIG. 7, and suppresses a decrease in the pressure in the refrigerant circuit 2 and entry of the water W in the water circuit 3 into the refrigerant circuit 2.

Processing Flow during Operation Stop

[0075] FIG. 8 is a flowchart illustrating an example of processing of the control device according to the first embodiment of the present disclosure during the operation stop.

[0076] Hereinafter, a flow of processing of monitoring an anomaly in the water heat exchanger 23 during the operation stop and processing at the time of the anomaly will be described with reference to FIG. 8.

[0077] The control unit 402 brings the chilling unit 1 into a state of operation stop according to an operation by an administrator or the like of the chilling unit 1 (step S300). At this time, as illustrated in FIG. 3, the control unit 402 brings the first expansion valve 241 and the third expansion valve 243 into the closed state and brings the second expansion valve 242 into the open state to stop the compressor 21. Further, the control unit 402 stops the water pump 31 and brings the water valve 32 into the closed state. Note that, in other embodiments, for protection control, the control unit 402 may operate the water pump 31 and bring the water valve 32 into the open state even during the operation stop.

[0078] Further, the detecting unit 401 constantly monitors the low-pressure-side pressure LP or the high-pressure-side pressure HP of the refrigerant R during the operation stop to detect presence or absence of an anomaly in the water heat exchanger 23. Specifically, the detecting unit 401 monitors whether an outside temperature is equal to or greater than 0°C and whether the LP saturation temperature or a saturation temperature on the high-pressure side (hereinafter also described as an "HP saturation temperature") is less than a third saturation temperature lower limit value (e.g., -C°C) (step S301). Note that the third saturation temperature lower limit value is preset according to the type of the refrigerant R or the like.

[0079] In a case where the outside temperature is less than 0°C, or the LP saturation temperature or the HP saturation temperature is equal to or greater than the third saturation temperature lower limit value (step S301: NO), the detecting unit 401 determines that there is no problem in the refrigerant circuit 2 and there is no anomaly in the water heat exchanger 23. In this case, the control device 4 causes the chilling unit 1 to remain in the state of the operation stop.

[0080] On the other hand, in a case where the outside temperature is equal to or greater than 0°C, and the LP saturation temperature or the HP saturation temperature is less than the third saturation temperature lower limit value (step S301: YES), the detecting unit 401 detects that leakage from the refrigerant circuit 2 may occur and there may be a sign of leakage of the refrigerant R in the water heat exchanger 23. In this case, the alarm unit 403 issues an anomaly alarm indicating a sign of the refrigerant leakage from the refrigerant circuit 2 (step S302).

[0081] When the sign of refrigerant leakage is detected, the control unit 402 performs processing of suppressing entry of the water W into the refrigerant circuit 2 similarly to the cooling operation.

[0082] In a case of operation of operating the water pump 31 even during the operation stop, the control unit 402 performs third processing of stopping the water pump 31 of the water circuit 3, and also bringing the water valve 32 into the closed state (step S303). This processing is the same as that in step S107 in FIG. 5. Note that, in a case of an operation of stopping the water pump 31 during the operation stop, step S303 may be omitted.

[0083] For the refrigerant circuit 2, first, the control unit 402 performs first processing (steps S304 and S305) of increasing pressure in the refrigerant circuit 2 such that the pressure in the refrigerant circuit 2 is not equalized with pressure in the water circuit 3. This processing is the same as that in steps S108 to S109 in FIG. 5.

[0084] Furthermore, the control unit 402 performs second processing (steps S306 to S308) of maintaining the pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 within a fixed range. This processing is the same as that in steps S110 to S112 in FIG. 5.

[0085] When a sign of leakage of the refrigerant R is detected during the operation stop, the control unit 402 performs the first to third processing as illustrated in FIG. 8, and suppresses a decrease in the pressure in the refrigerant circuit 2 and entry of the water W in the water circuit 3 into the refrigerant circuit 2.

[0086] Note that, in step S301 in FIG. 8, when the outside temperature is equal to or greater than 0°C, and the LP saturation temperature or the HP saturation temperature is less than the third saturation temperature lower limit value (when a first condition is satisfied), the detecting unit 401 according to the present embodiment detects that a sign of leakage of the refrigerant R has occurred, and, in steps S303 to S308, the detecting unit 401 assumes leakage from the water heat exchanger 23 and

performs maintenance control, which is not limited thereto. In other embodiments, when another condition (second condition) is satisfied in step S301 instead of the first condition or in addition to the first condition, the detecting unit 401 may detect that a sign of leakage of the refrigerant R has occurred in the water heat exchanger 23. A case in which the second condition is satisfied is, for example, a case in which the outside temperature is equal to or greater than 0°C and a difference between the LP saturation temperature (or the HP saturation temperature) and the outside temperature is equal to or greater than a predetermined temperature differential (e.g., 10 degrees), and a change in the LP saturation temperature (or the HP saturation temperature) does not follow a temperature change of the outside temperature. The detecting unit 401 can detect the refrigerant leakage of the refrigerant R by confirming whether the second condition is satisfied.

[0087] Note that FIGS. 5, 7, and 8 illustrate an example in which the control unit 402 performs the first processing (steps S108 and S109, S204 and S205, and S304 and S305) after the third processing (steps S107, S203, and S303), but the order of the processing is not limited thereto. The control unit 402 may perform the third processing after the first processing or simultaneously with the first processing.

Operational Effects

[0088] As described above, in the chilling unit 1 according to the present embodiment, the control device 4 includes the detecting unit 401 configured to detect an anomaly in the water heat exchanger 23 when an LP saturation temperature or an HP saturation temperature of the refrigerant circuit 2 is less than a predetermined saturation temperature lower limit value.

[0089] With this configuration, the chilling unit 1 can quickly detect an anomaly in the water heat exchanger 23.

[0090] Further, the detecting unit 401 of the control device 4 detects an anomaly indicating refrigerant leakage in the water heat exchanger 23 when, during a cooling operation, the LP saturation temperature of the refrigerant circuit 2 is less than a first saturation temperature lower limit value, a subcooling degree at an outlet of the air heat exchanger 26 is lower than a subcooling degree reference value, and a water temperature at an outlet of the water heat exchanger 23 of the water circuit 3 is equal to or greater than a lower limit value in a water temperature control range.

[0091] With this configuration, the chilling unit 1 can quickly detect refrigerant leakage during the cooling operation.

[0092] Further, the detecting unit 401 of the control device 4 detects an anomaly indicating a sign of refrigerant leakage in the water heat exchanger 23 when the LP saturation temperature of the refrigerant circuit 2 is less than a second saturation temperature lower limit value

during a heating operation.

[0093] With this configuration, the chilling unit 1 can quickly detect a sign of refrigerant leakage during the heating operation.

5 **[0094]** Further, the detecting unit 401 of the control device 4 detects an anomaly indicating a sign of refrigerant leakage in the water heat exchanger 23 when the LP saturation temperature or the HP saturation temperature of the refrigerant circuit 2 is less than a third saturation temperature lower limit value during an operation stop.

10 **[0095]** With this configuration, the chilling unit 1 can quickly detect a sign of refrigerant leakage during the operation stop.

15 **[0096]** In addition, the control device 4 further includes the control unit 402 that performs first processing of closing the first expansion valve 241 and the second expansion valve 242, switching the four-way valve 22 so as to set the heating operation flow path, and starting up the compressor 21 when a sign of the refrigerant leakage is detected.

20 **[0097]** With this configuration, for a period until the water heat exchanger 23 is repaired or replaced, the chilling unit 1 can maintain a state where the refrigerant circuit 2 has pressure greater than that of the water circuit 3, and can suppress entry of the water W into the refrigerant circuit 2. In this way, the likelihood of each device connected to the refrigerant circuit 2 being damaged by the water that enters the refrigerant circuit 2 can be reduced.

25 **[0098]** In addition, the control unit 402 of the control device 4 further performs second processing of, after the first processing is performed, stopping the compressor 21 when the high-pressure-side pressure HP of the refrigerant circuit 2 is equal to or greater than a pressure upper limit value, and starting up the compressor 21 when the high-pressure-side pressure HP of the refrigerant circuit 2 is less than a pressure lower limit value.

30 **[0099]** With this configuration, the chilling unit 1 can maintain pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 within a fixed range. In this way, entry of the water W from the water circuit 3 into the refrigerant circuit 2 can be suppressed.

35 **[0100]** Further, the control unit 402 of the control device 4 sets, as the pressure lower limit value, a value acquired by adding the predetermined margin $\alpha 2$ to the inlet-side pressure WP1 of the water circuit 3.

40 **[0101]** With this configuration, the chilling unit 1 can maintain pressure in the section around the water heat exchanger 23 of the refrigerant circuit 2 in a state of being higher than pressure in the water circuit 3. In this way, entry of the water W from the water circuit 3 into the refrigerant circuit 2 can be more reliably suppressed.

45 **[0102]** Further, the control unit 402 of the control device 4 further performs third processing of stopping the water pump 31 and closing the water valve 32 when a sign of the refrigerant leakage is detected.

50 **[0103]** With this configuration, flow of the water W in the water circuit 3 can be reliably stopped, and thus entry of the water W into the refrigerant circuit 2 can be sup-

pressed. Further, in a system in which a plurality of the chilling units 1 are coupled with one water circuit 3, when the refrigerant R leaks into the water circuit 3 of a certain chilling unit 1, circulation of the water W mixed with the refrigerant R in another chilling unit can be suppressed.

[0104] In the foregoing, certain embodiments of the present disclosure have been described, but all of these embodiments are merely illustrative and are not intended to limit the scope of the invention. These embodiments may be implemented in various other forms, and various omissions, substitutions, and alterations may be made without departing from the invention. These embodiments and modifications are included in the scope of the invention and are also included in the scope of the invention described in the claims and equivalents thereof.

Notes

[0105] The chilling unit, the control method, and the program described in the embodiment above are understood as follows, for example.

(1) According to a first aspect of the present disclosure, a chilling unit (1) includes: a refrigerant circuit (2) including a compressor (21) that compresses or that is configured to compress a refrigerant, an air heat exchanger (26) that performs or that is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger (23) that performs or that is configured to perform heat exchange between the refrigerant and water, an expansion valve (24) provided between the air heat exchanger (26) and the water heat exchanger (23), and a four-way valve (22) that switches or that is configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path; a water circuit (3) including a water pipe (30) inserted through the water heat exchanger (23), a water pump (31) that sends or that is configured to send the water to the water pipe (30), and a water valve (32) provided closer to a downstream side of the water pipe (30) than the water heat exchanger (23); and a control device (4) configured to control the refrigerant circuit (2) and the water circuit (3), in which the control device (4) includes a detecting unit (401) configured to detect an anomaly in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

With this configuration, the chilling unit can quickly detect an anomaly in the water heat exchanger.

(2) According to a second aspect of the present disclosure, in the chilling unit (1) according to the first aspect, the detecting unit (401) of the control device (4) detects or is configured to detect an anomaly indicating refrigerant leakage in the water heat exchanger (23) when, during a cooling operation, a sat-

uration temperature of the refrigerant circuit (2) on a low-pressure side is less than a first saturation temperature lower limit value, a subcooling degree at an outlet of the air heat exchanger (26) is lower than a subcooling degree reference value, and a water temperature at an outlet of the water heat exchanger (23) in the water circuit (3) is equal to or greater than a lower limit value in a water temperature control range.

With this configuration, the chilling unit can quickly detect refrigerant leakage during the cooling operation.

(3) According to a third aspect of the present disclosure, in the chilling unit (1) according to the first or second aspect, the detecting unit (401) of the control device (4) detects or is configured to detect an anomaly indicating a sign of refrigerant leakage in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side is less than a second saturation temperature lower limit value during a heating operation.

With this configuration, the chilling unit can quickly detect a sign of refrigerant leakage during the heating operation.

(4) According to a fourth aspect of the present disclosure, in the chilling unit (1) according to any one of the first to third aspects, the detecting unit (401) of the control device (4) detects or is configured to detect an anomaly indicating a sign of refrigerant leakage in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a third saturation temperature lower limit value during an operation stop.

With this configuration, the chilling unit can quickly detect a sign of refrigerant leakage during the operation stop.

(5) According to a fifth aspect of the present disclosure, in the chilling unit (1) according to any one of the second to fourth aspects, the control device (4) further includes a control unit (402) configured to, when a sign of the refrigerant leakage is detected, perform first processing of closing the expansion valve (24), switching the four-way valve (22) so as to set the heating operation flow path, and starting up the compressor (21).

With this configuration, for a period until the water heat exchanger is repaired or replaced, the chilling unit can maintain a state where the refrigerant circuit has pressure higher than that of the water circuit, and can suppress entry of the water into the refrigerant circuit. In this way, the likelihood of each device connected to the refrigerant circuit being damaged by the water that enters the refrigerant circuit can be reduced.

(6) According to a sixth aspect of the present disclosure, in the chilling unit (1) according to the fifth aspect, the control unit (402) of the control device (4)

performs or is configured to further perform second processing of, after the first processing is performed, stopping the compressor (21) when pressure in the refrigerant circuit (2) on a high-pressure side is equal to or greater than a pressure upper limit value, and starting up the compressor (21) when pressure in the refrigerant circuit (2) on a high-pressure side is less than a pressure lower limit value.

With this configuration, the chilling unit can maintain pressure in the section around the water heat exchanger of the refrigerant circuit within a fixed range. In this way, entry of the water into the refrigerant circuit from the water circuit can be suppressed.

(7) According to a seventh aspect of the present disclosure, in the chilling unit (1) according to the sixth aspect, the control unit (402) of the control device (4) sets or is configured to set, as the pressure lower limit value, a value acquired by adding a predetermined margin to a measurement value of pressure in the water circuit (3) on an inlet side.

With this configuration, the chilling unit can maintain pressure in the section around the water heat exchanger of the refrigerant circuit in a state of being higher than pressure in the water circuit. In this way, entry of the water from the water circuit into the refrigerant circuit can be more reliably suppressed.

(8) According to an eighth aspect of the present disclosure, in the chilling unit (1) according to any one of the fifth to seventh aspects, the control unit (402) of the control device (4) performs or is configured to further perform third processing of, when a sign of the refrigerant leakage is detected, stopping the water pump (31) and closing the water valve (32).

With this configuration, flow of the water in the water circuit can be reliably stopped, and thus entry of the water into the refrigerant circuit can be suppressed. Further, in a system in which a plurality of the chilling units are coupled with one water circuit, when the refrigerant leaks into the water circuit of a certain chilling unit, circulation of water mixed with the refrigerant in another chilling unit can be suppressed.

(9) According to a ninth aspect of the present disclosure, a control method is a method for controlling a chilling unit including a refrigerant circuit including a compressor that compresses or is configured to compress a refrigerant, an air heat exchanger that performs or is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger that performs or is configured to perform heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that switches or is configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, a water circuit including a water pipe inserted through the water heat exchanger, a water pump that sends or is configured to send the water to the water pipe, and a

water valve provided closer to a downstream side of the water pipe than the water heat exchanger, and a control device configured to control the refrigerant circuit and the water circuit, and the control method includes detecting, by the control device, an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

(10) According to a tenth aspect of the present disclosure, a program causes a control device of a chilling unit including a refrigerant circuit including a compressor that compresses or is configured to compress a refrigerant, an air heat exchanger that performs or is configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger that performs or is configured to perform heat exchange between the refrigerant and water, an expansion valve provided between the air heat exchanger and the water heat exchanger, and a four-way valve that switches or is configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, and a water circuit including a water pipe inserted through the water heat exchanger, a water pump that sends or is configured to send the water to the water pipe, and a water valve provided closer to a downstream side of the water pipe than the water heat exchanger, to execute detecting an anomaly in the water heat exchanger when a saturation temperature of the refrigerant circuit on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

Reference Signs List

[0106]

- 1 Chilling unit
- 2 Refrigerant circuit
- 20 Refrigerant pipe
- 201 High-pressure-side sensor
- 202 Low-pressure-side sensor
- 203 First temperature sensor
- 21 Compressor
- 22 Four-way valve
- 23 Water heat exchanger
- 24 Expansion valve
- 241 First expansion valve
- 242 Second expansion valve
- 243 Third expansion valve
- 25 Receiver
- 26 Air heat exchanger
- 261 Propeller fan
- 27 Accumulator
- 3 Water circuit
- 301 First water pressure sensor
- 302 Second water pressure sensor

303 Second temperature sensor
 30 Water pipe
 31 Water pump
 32 Water valve
 4 Control device
 40 Processor
 401 Detecting unit
 402 Control unit
 403 Alarm unit
 41 Main memory
 42 Storage
 43 Interface
 44 Display unit

Claims

1. A chilling unit (1) comprising:

a refrigerant circuit (2) including a compressor (21) configured to compress a refrigerant, an air heat exchanger (26) configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger (23) configured to perform heat exchange between the refrigerant and water, an expansion valve (24) provided between the air heat exchanger (26) and the water heat exchanger (23), and a four-way valve (22) configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path;
 a water circuit (3) including a water pipe (30) inserted through the water heat exchanger (23), a water pump (31) configured to send the water to the water pipe (30), and a water valve (32) provided closer to a downstream side of the water pipe (30) than the water heat exchanger (23); and
 a control device (4) configured to control the refrigerant circuit (2) and the water circuit (3), wherein
 the control device (4) includes a detecting unit (401) configured to detect an anomaly in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value.

2. The chilling unit (1) according to claim 1, wherein the detecting unit (401) of the control device (4) is configured to detect an anomaly indicating refrigerant leakage in the water heat exchanger (23) when, during a cooling operation, a saturation temperature of the refrigerant circuit (2) on a low-pressure side is less than a first saturation temperature lower limit value, a subcooling degree at an outlet of the air heat exchanger (26) is lower than a subcooling degree

reference value, and a water temperature at an outlet of the water heat exchanger (23) in the water circuit (3) is equal to or greater than a lower limit value in a water temperature control range.

5 3. The chilling unit (1) according to claim 1 or 2, wherein the detecting unit (401) of the control device (4) is configured to detect an anomaly indicating a sign of refrigerant leakage in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side is less than a second saturation temperature lower limit value during a heating operation.

10 4. The chilling unit (1) according to any one of claims 1 to 3, wherein the detecting unit (401) of the control device (4) is configured to detect an anomaly indicating a sign of refrigerant leakage in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a third saturation temperature lower limit value during an operation stop.

15 5. The chilling unit (1) according to any one of claims 2 to 4, wherein the control device (4) further includes a control unit (402) configured to, when a sign of the refrigerant leakage is detected, perform first processing of closing the expansion valve (24), switching the four-way valve (22) so as to set the heating operation flow path, and starting up the compressor (21).

20 6. The chilling unit (1) according to claim 5, wherein the control unit (402) of the control device (4) is configured to further perform second processing of, after the first processing is performed, stopping the compressor (21) when pressure in the refrigerant circuit (2) on a high-pressure side is equal to or greater than a pressure upper limit value, and starting up the compressor (21) when pressure in the refrigerant circuit (2) on a high-pressure side is less than a pressure lower limit value.

25 7. The chilling unit (1) according to claim 6, wherein the control unit (402) of the control device (2) is configured to set, as the pressure lower limit value, a value acquired by adding a predetermined margin to a measurement value of pressure in the water circuit (3) on an inlet side.

30 8. The chilling unit (1) according to any one of claims 5 to 7, wherein the control unit (402) of the control device (4) is configured to further perform third processing of, when a sign of the refrigerant leakage is detected, stopping the water pump (31) and closing the water valve (32).

9. A method for controlling a chilling unit (1) including

a refrigerant circuit (2) including a compressor (21) configured to compress a refrigerant, an air heat exchanger (26) configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger (23) configured to perform heat exchange between the refrigerant and water, an expansion valve (24) provided between the air heat exchanger and the water heat exchanger, and a four-way valve (22) configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, 5

a water circuit (3) including a water pipe (30) inserted through the water heat exchanger (23), a water pump (31) configured to send the water to the water pipe (30), and a water valve (32) provided closer to a downstream side of the water pipe (30) than the water heat exchanger (23), 10

and 15

a control device (4) configured to control the refrigerant circuit (2) and the water circuit (3), the control method comprising detecting, by the control device (4), an anomaly in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value. 20 25 30

10. A program causing a control device of a chilling unit (1) including

a refrigerant circuit (2) including a compressor (21) configured to compress a refrigerant, an air heat exchanger (26) configured to perform heat exchange between the refrigerant and outside air, a water heat exchanger (23) configured to perform heat exchange between the refrigerant and water, an expansion valve (24) provided between the air heat exchanger (26) and the water heat exchanger (23), and a four-way valve (22) configured to switch a flow path of the refrigerant to a cooling operation flow path or a heating operation flow path, and 35 40 45

a water circuit (3) including a water pipe (30) inserted through the water heat exchanger (23), a water pump (31) configured to send the water to the water pipe (30), and a water valve (32) provided closer to a downstream side of the water pipe (30) than the water heat exchanger (23), to execute detecting an anomaly in the water heat exchanger (23) when a saturation temperature of the refrigerant circuit (2) on a low-pressure side or a high-pressure side is less than a predetermined saturation temperature lower limit value. 50 55

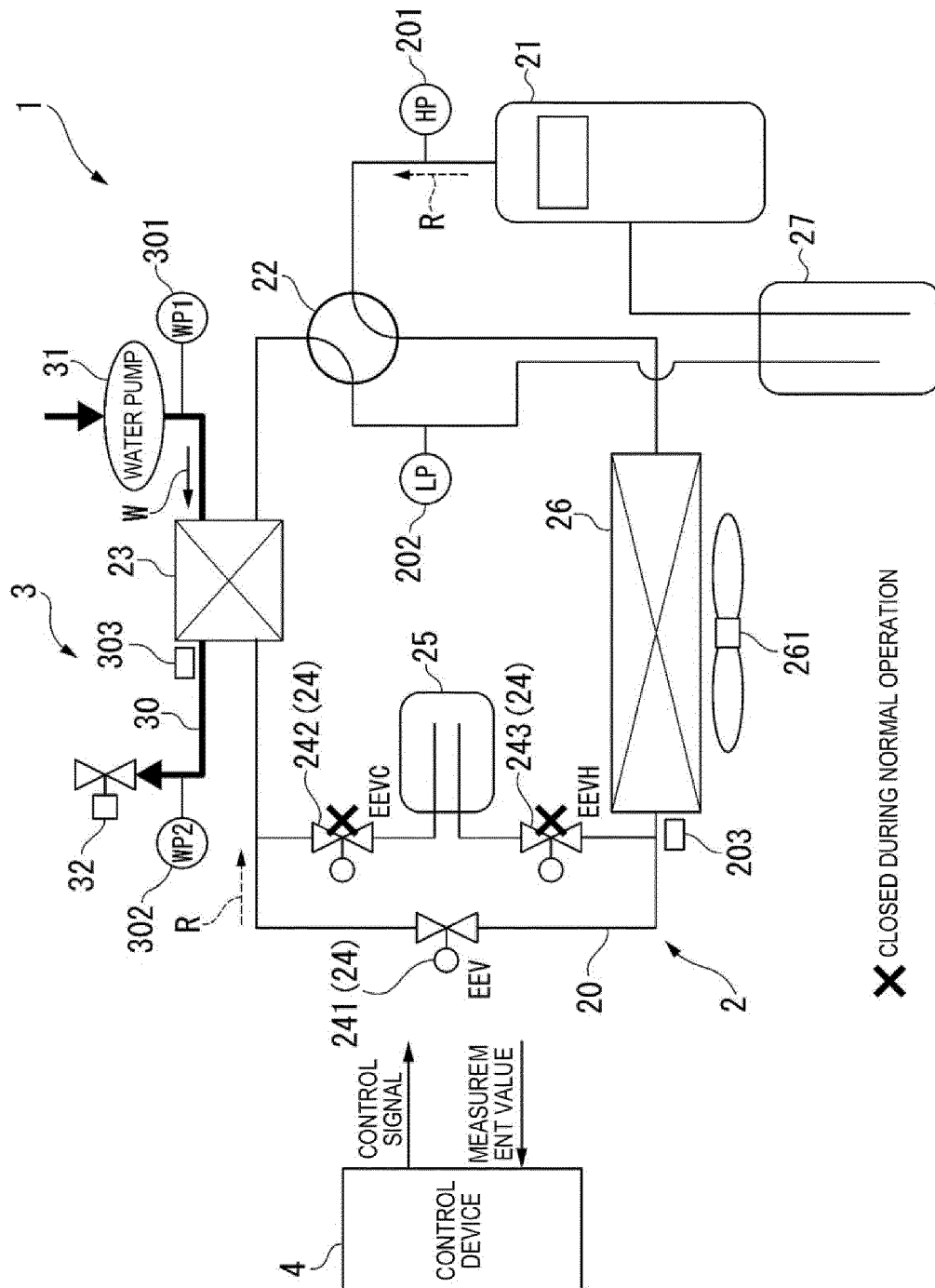


FIG. 1

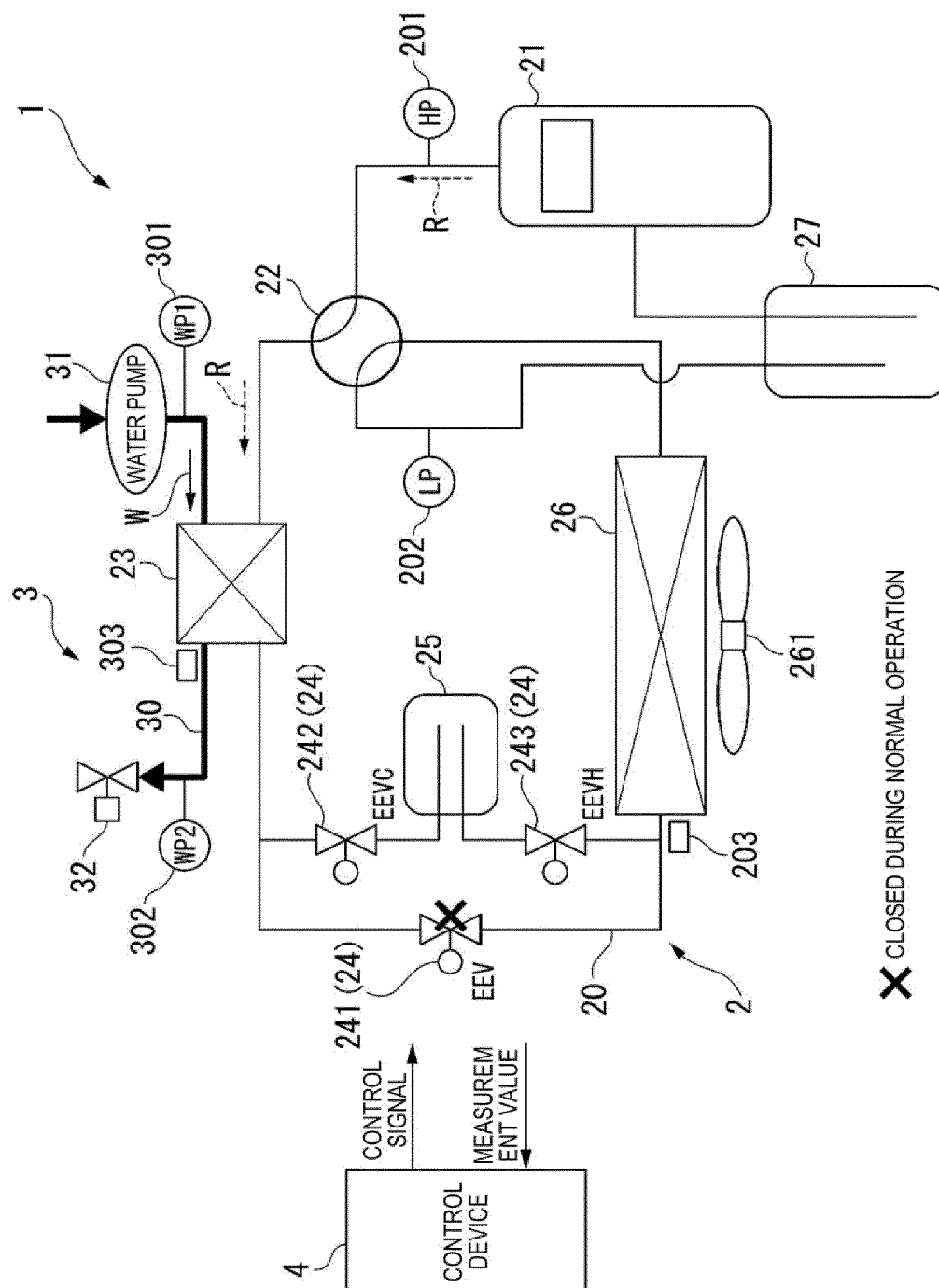


FIG. 2

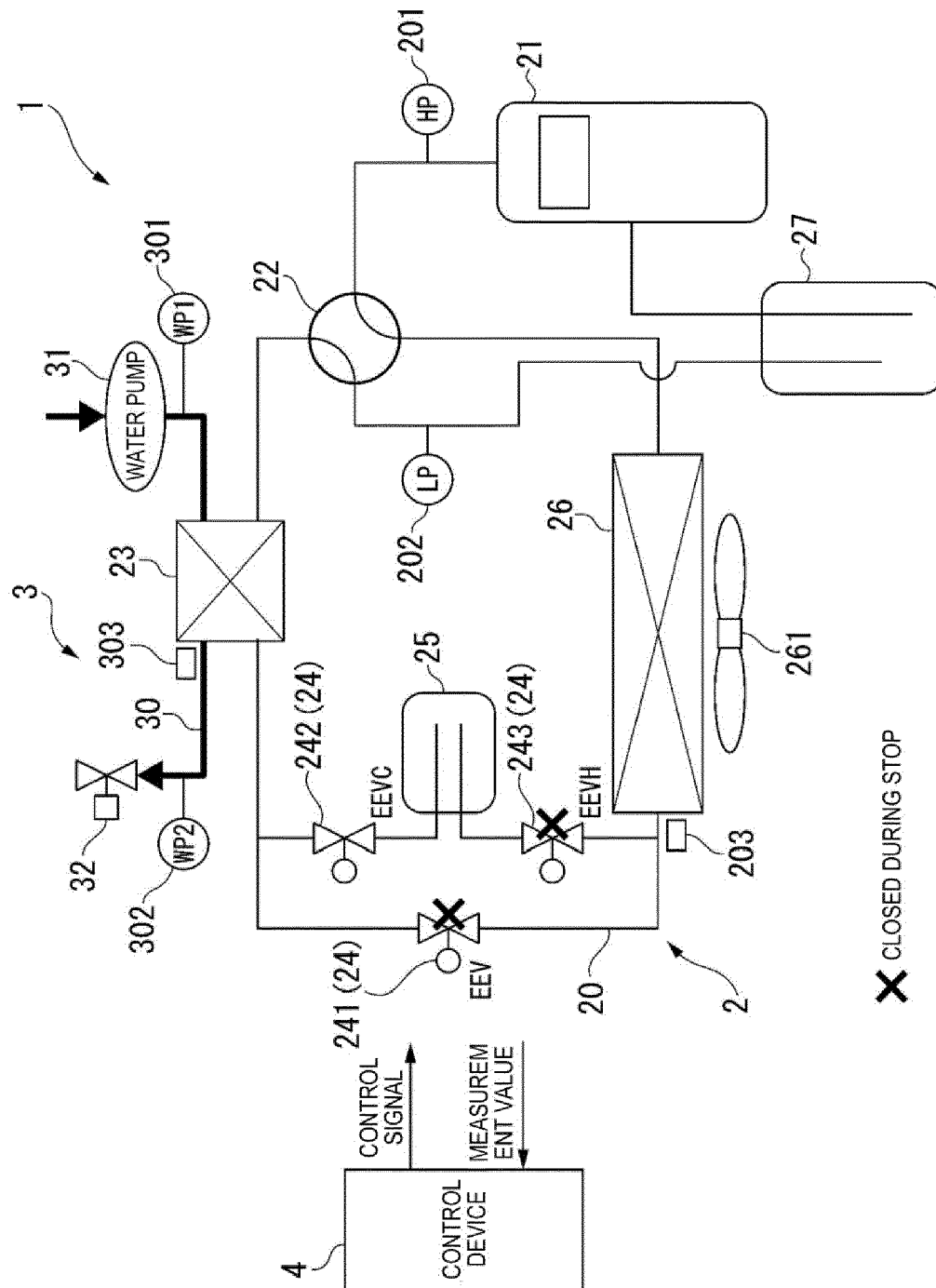


FIG. 3

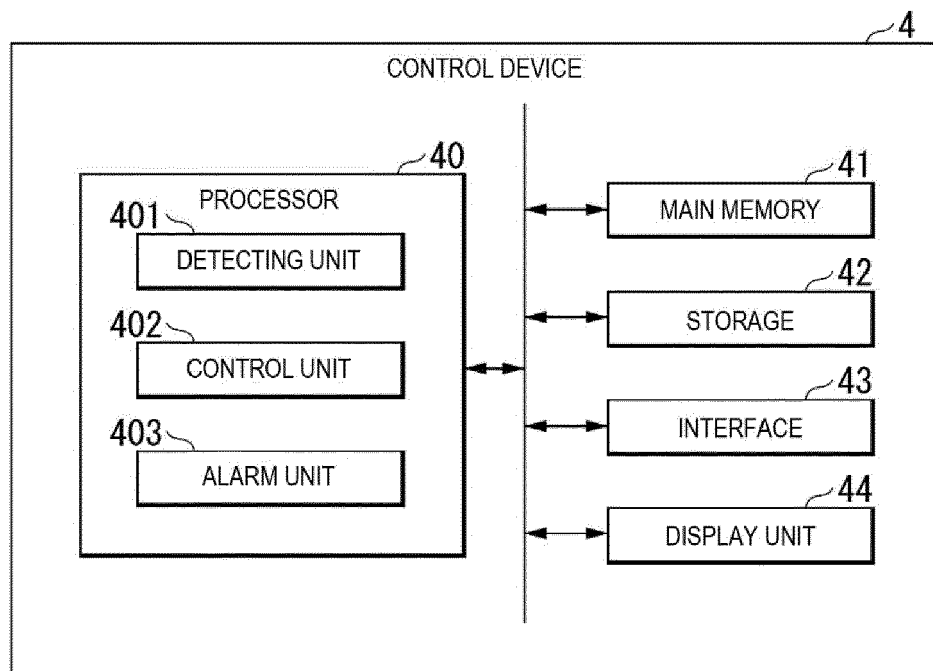


FIG. 4

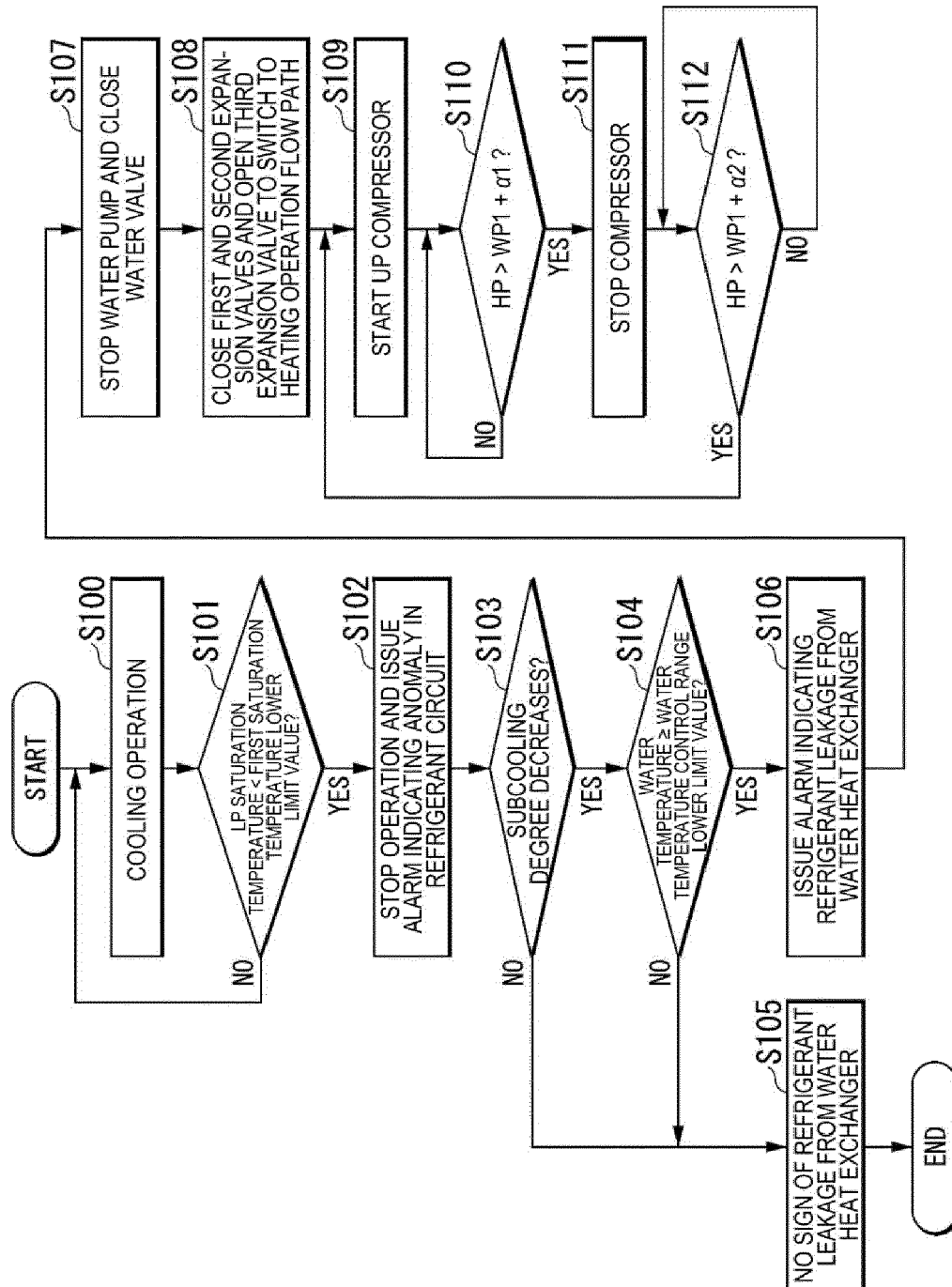


FIG. 5

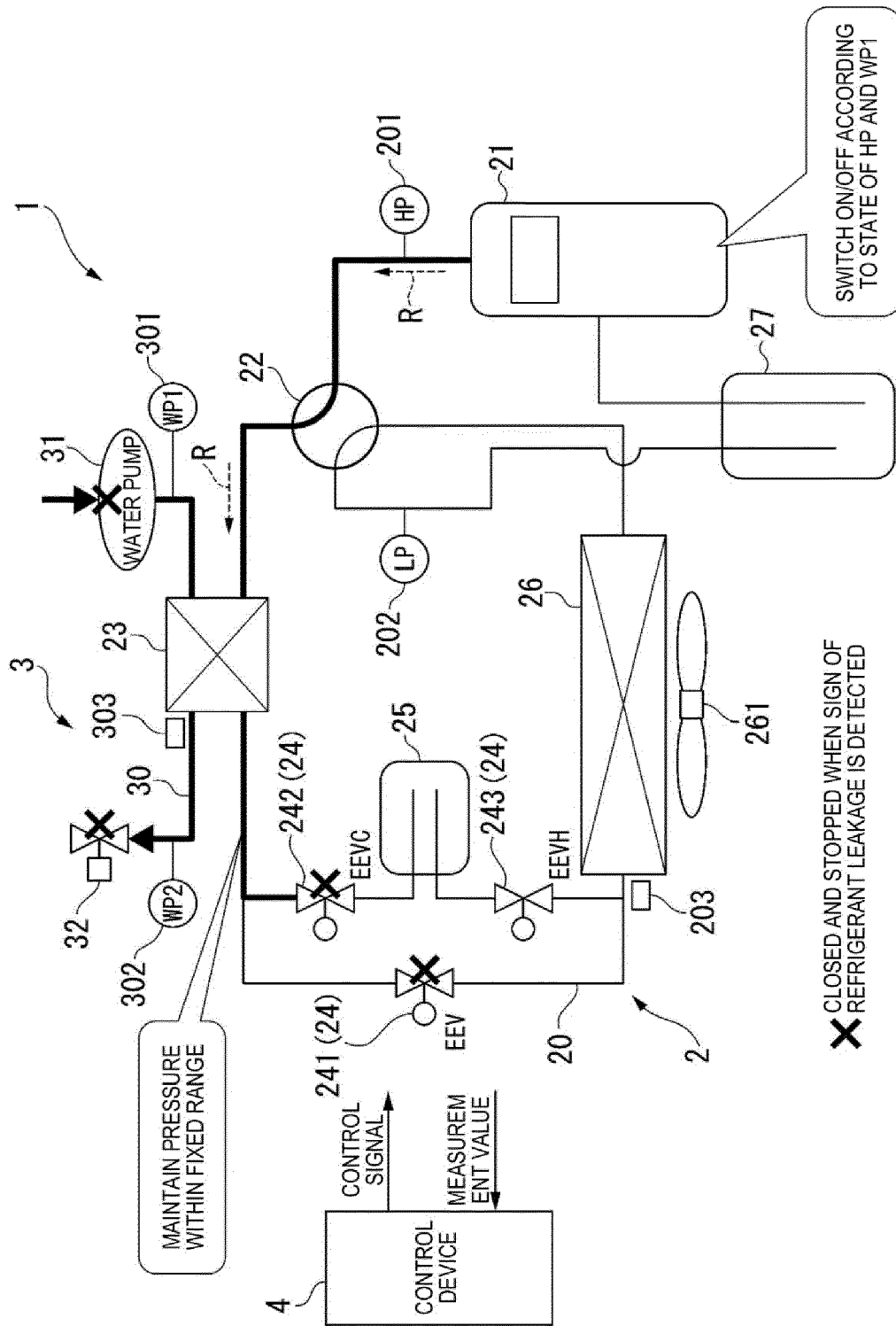


FIG. 6

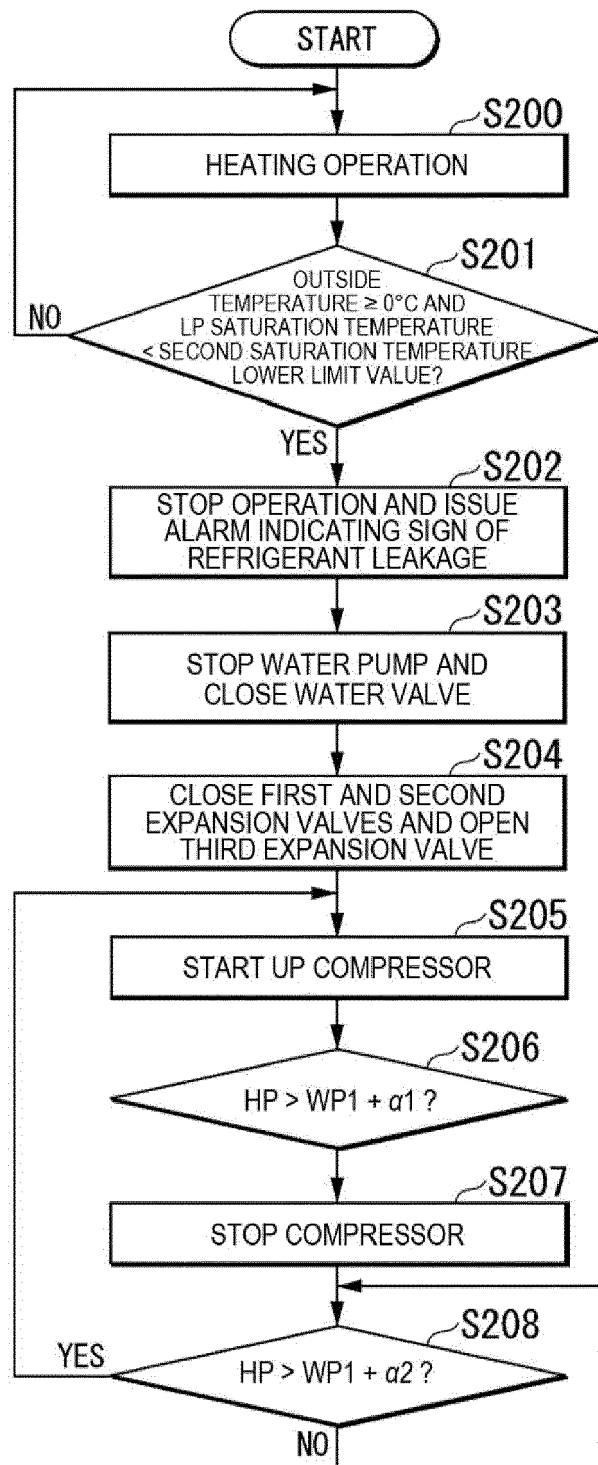


FIG. 7

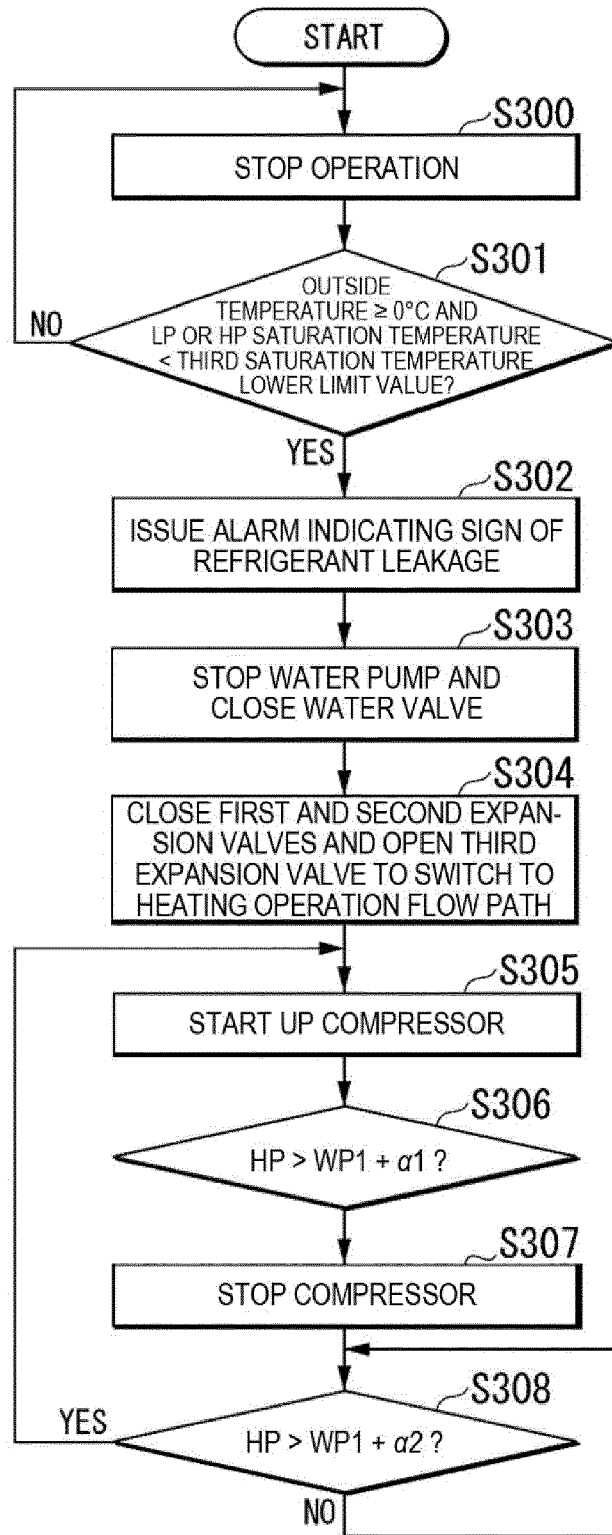


FIG. 8



EUROPEAN SEARCH REPORT

Application Number

EP 23 15 1111

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	CN 203 837 315 U (GUANDONG MIDEA HVAC EQUIPMENT; MIDEA GROUP CO LTD) 17 September 2014 (2014-09-17) * the whole document *	1-4, 9, 10	INV. F25B49/00 F25B49/02
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) F25B

1

EPO FORM 1503 03.82 (P04C01)

Place of search Munich	Date of completion of the search 24 August 2023	Examiner Weisser, Meinrad
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 23 15 1111

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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24-08-2023

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