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(54) HEAT PUMP SYSTEM AND CONTROL METHOD THEREFOR

(57) A heat pump system according to an embodiment of the disclosure in includes a compressor configured to compress a refrigerant, a refrigerant-water heat exchanger in which heat exchange occurs between the compressed refrigerant and water, an expansion valve configured to expand the refrigerant condensed in the refrigerant-water heat exchanger, an outdoor heat exchanger in which heat exchange occurs between the refrigerant expanded in the expansion valve and outdoor air, an outdoor fan arranged adjacent to the outdoor heat exchanger, and a controller configured to turn off the compressor and the outdoor fan based on an abnormal state of the refrigerant-water heat exchanger, and turn on the compressor in a turn-off state of the outdoor fan.

FIG. 6

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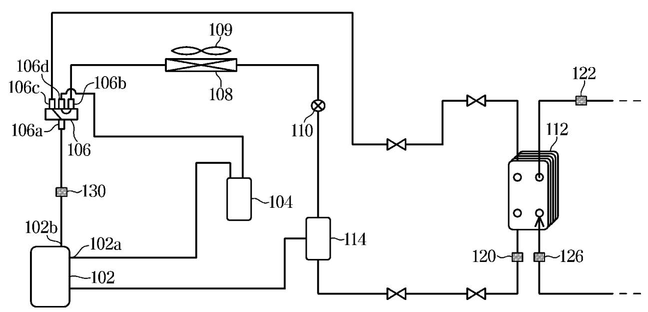

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Description

[Technical Field]

[0001] The disclosure relates to a heat pump system and a control method therefor, and more particularly to a heat pump type system capable of supplying hot water by heat exchange and a control method therefor.

[Background Art]

[0002] In general, heat moves naturally from a hotter side to a colder side, but in order to move heat from a colder side to a hotter side, some external action must be applied. This is the principle of a heat pump. Heat pumps perform cooling and heating (air to air), and water supply (air to water) by using heat generated and recovered through the cycle of compression, condensation, and evaporation of refrigerant.

[0003] A multi-type air heating and cooling device (hereinafter referred to as an 'air conditioning system') using the heat pump method includes an outdoor unit, an indoor unit, and a hydro unit, and uses the heat from the heat pump to heat the floor of the indoor or cool or heat the indoor air.

[0004] In the heat pump system of conventional air conditioners, during heating operation, the outdoor unit exchanges heat with the air through the evaporator, and the temperature of the indoor air is adjusted to the user's needs through the condenser of the indoor unit.

[0005] The Eco Heating/Cooling Solution (EHS) system is the same in that the outdoor unit exchanges heat with the air, but it exchanges heat between the refrigerant and water through the heat exchanger inside the indoor unit or the outdoor unit to supply water at the water temperature that meets the user's needs.

[0006] Based on heating operation, the EHS system is classified into a mono system that has both an evaporator and a condenser in the outdoor unit and a split system that has an evaporator in the outdoor unit and a condenser in the indoor side, and the supplied water is used for floor heating, radiators, water heating, fan coil units, and the like.

[0007] **In** the process of producing cold or hot water by heat exchange with refrigerant, the water temperature may drop below the freezing temperature, causing freezing damage to the heat exchanger.

[0008] Conventionally, in order to prevent freezing of such heat exchangers, antifreeze or anti-freeze valves were applied, or temperature sensors were embedded to detect freezing.

[Disclosure]

[Technical Problem]

[0009] An embodiment of the present disclosure provides a heat pump system and a control method therefor, wherein when a heat exchanger is operating abnormally, such as when a risk of freezing of a heat exchanger is detected, for example due to a malfunction of a flow diverter valve, the heat exchanger may be caused to operate normally by controlling an outdoor fan and an expansion valve to allow the flow diverter valve to operate normally upon restating the system after a shutdown.

[Technical Solution]

[0010] According to an example embodiment of the disclosure, a heat pump system includes a compressor configured to compress a refrigerant, a refrigerant-water heat exchanger in which heat exchange occurs between the compressed refrigerant and water, an expansion valve configured to expand the refrigerant condensed in the refrigerant-water heat exchanger, an outdoor heat exchanger in which heat exchange occurs between the refrigerant expanded in the expansion valve and outdoor air, an outdoor fan arranged adjacent to the outdoor heat exchanger, a condensation temperature sensor configured to detect the temperature of the refrigerant condensed in the refrigerant-water heat exchanger, an incoming water temperature sensor configured to detect the temperature of water entering the refrigerant-water heat exchanger, an outgoing water temperature sensor configured to detect the temperature of water in which heat exchange occurs in the refrigerant-water heat exchanger, and a controller configured to determine whether the refrigerant-water heat exchanger is in an abnormal state based on the detection results of the condensation temperature sensor, the incoming water temperature sensor, and the outgoing water temperature sensor, and turn off the compressor and the outdoor fan based on the abnormal state of the refrigerant-water heat exchanger, and turn on the compressor in a turn-off state of the outdoor fan.

[0011] The controller may determine that the refrigerant-water heat exchanger is operating normally in response to the detected temperature of the condensed refrigerant being higher than the incoming water temperature and the detected outgoing water temperature being higher than the detected incoming water temperature.

[0012] The controller may control an opening level of the expansion valve to be equal to or greater than a first opening level based on the abnormal state of the refrigerant-water heat exchanger.

[0013] The controller may determine whether the refrigerant-water heat exchanger is in the abnormal state based on the detection results of the condensation temperature sensor, the incoming water temperature sensor, and the outgoing water temperature sensor after controlling the compressor, the outdoor fan, and the expansion valve.

[0014] The controller may determine whether the temperature detected by the condensation temperature sensor exceeds a predetermined temperature in response to the refrigerant-water heat exchanger being in the abnormal state.

[0015] The controller may, upon determining that the temperature detected by the condensation temperature sensor exceeds the predetermined temperature, control the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and controls the expansion valve to open at a second opening level or greater.

[0016] The controller may turn off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

[0017] The heat pump system may further include a high pressure sensor to detect a high pressure of the refrigerant compressed in the compressor, wherein the controller may determine whether the high pressure detected by the high pressure sensor exceeds a predetermined pressure in response to the refrigerant-water heat exchanger being in the abnormal state.

[0018] The controller may, upon determining that the pressure detected by the high pressure sensor exceeds the predetermined pressure, control the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and control the expansion valve to open at a second opening level or greater.

[0019] The controller may turn off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

[0020] According to an example embodiment of the disclosure, a method of controlling a heat pump system is provided, the method comprising detecting the temperature of condensed refrigerant in a refrigerant-water heat exchanger, detecting the temperature of water entering the refrigerant-water heat exchanger, detecting the temperature of water in which heat exchange occurs in the refrigerant-water heat exchanger, determining whether the refrigerant-water heat exchanger is in an abnormal state based on the detection results of the plurality of temperatures, turning off a compressor and an outdoor fan in response to the determination that the refrigerant-water heat exchanger is in the abnormal state, and turning on the compressor while the outdoor fan is in a turn-off state.

[0021] The determining whether the refrigerant-water heat exchanger is in the abnormal state may include determining that the refrigerant-water heat exchanger is operating normally in response to the detected temperature of the condensed refrigerant being higher than the temperature of the water entering the heat exchanger and the detected temperature of the water in which heat exchange has occurred being higher than the temperature of the water entering the detected heat exchanger.

[0022] The method may further include controlling an opening level of the expansion valve to be equal to or greater than a first opening level based on the refrigerant-water heat exchanger being in the abnormal state.

[0023] The method may further include determining whether the refrigerant-water heat exchanger is in the abnormal state based on the detection results of the plurality of temperatures after controlling the compressor, the outdoor fan, and the expansion valve.

[0024] The method may further include determining whether the temperature detected by the condensation temperature sensor exceeds a predetermined temperature in response to the refrigerant-water heat exchanger being in the abnormal state.

[0025] The method may further include, upon determining that the detected temperature of the condensed refrigerant exceeds the predetermined temperature, controlling the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and controlling the expansion valve to open at a second opening level or greater.

[0026] The method may further include turning off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

[0027] The method may further include detecting high pressure of the refrigerant compressed in the compressor, and determining whether the high pressure of the detected refrigerant exceeds a predetermined pressure in response to the refrigerant-water heat exchanger being in the abnormal state.

[0028] The method may further include, upon determining that the high pressure of the detected refrigerant exceeds the predetermined pressure, controlling the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and controlling the expansion valve to open at a second opening level or greater.

[0029] The method further include turning off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

[Advantageous Effects]

[0030] According to various embodiments of the present disclosure, when the heat exchanger is operating abnormally, such as when a risk of freezing of the heat exchanger is detected, such as due to a malfunction of the flow diverter valve, the heat exchanger can be caused to operate normally by controlling the outdoor fan and the expansion valve to allow the flow diverter valve to operate normally when the system is restarted after a shutdown.

[Description of Drawings]

[0031]

FIG. 1 is a block diagram illustrating a heat pump system according to an embodiment.

FIG. 2 is a diagram illustrating a flow of refrigerant during heating operation of the heat pump system according to an embodiment.

FIG. 3 is a diagram illustrating a flow of refrigerant during cooling operation of the heat pump system according to an embodiment.

FIG. 4 is a diagram illustrating a structure of a flow diverter valve.

FIG. 5 is a control block diagram of the heat pump system according to an embodiment.

FIG. 6 is a diagram illustrating a plurality of sensors included in the heat pump system according to an embodiment.

FIG. 7 is a flowchart illustrating detecting an abnormal state of a refrigerant-water heat exchanger and controlling the heat pump system based on the detected abnormal state, according to an embodiment.

FIG. 8 is a flowchart illustrating re-determining whether the refrigerant-water heat exchanger is operating normally after the controlling of FIG. 7.

FIG. 9 is a control block diagram illustrating the heat pump system according to an embodiment.

FIG. 10 is a flowchart illustrating a method of controlling a heat pump system to protect the heat pump system based on a condensing temperature, according to an embodiment.

FIG. 11 is a control block diagram illustrating a heat pump system, according to another embodiment.

FIG. 12 is a flow chart illustrating a method of controlling a heat pump system to protect the heat pump system based on a high pressure, according to another embodiment.

[Modes of the Invention]

[0032] Embodiments described in the disclosure and configurations shown in the drawings are merely examples of various example embodiments of the disclosure and may be used in various different ways at the time of filing of the present application.

[0033] **In** addition, the same reference numerals or signs shown in the drawings of the disclosure indicate like elements or components performing substantially the same function.

[0034] The terms used herein are used to describe the embodiments and are not intended to limit and/or restrict the disclosure. The singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. **In** this disclosure, the terms "including", "having", and the like are used to specify features, figures, steps, operations, elements, components, or combinations thereof, but do not preclude the presence or addition of one or more of the features, figures, steps, operations, elements, components, or combinations thereof.

[0035] When a given element is referred to as being "connected to", "coupled to", "supported by" or "in contact with" another element, it is to be understood that it may be directly or indirectly connected to, coupled to, supported by, or in contact with the other element.

[0036] It will be understood that, although the terms "first", "second", "primary", "secondary", etc., may be used herein to describe various elements, but elements are not limited by these terms. These terms are simply used to distinguish one element from another element. For example, without departing from the scope of the disclosure, a first element may be termed as a second element, and a second element may be termed as a first element. The term of "and/or" includes a plurality of combinations of relevant items or any one item among a plurality of relevant items.

[0037] Hereinafter, various embodiments according to the disclosure will be described with reference to the accompanying drawings.

[0038] FIG. 1 illustrates a block diagram of a heat pump system according to an embodiment.

[0039] A heat pump system 1 may include a compressor 102, a refrigerant-water heat exchanger 112, an expansion valve 110, an outdoor heat exchanger 108, a flow diverter valve 106, and an accumulator 104.

[0040] The compressor 102 may compress a low-temperature, low-pressure refrigerant that is drawn in through an inlet side 102a to form a high-temperature, high-pressure refrigerant, and then discharge the high-temperature, high-pressure refrigerant through an outlet side 102b. The compressor 102 may be configured as an inverter compressor whose compression capacity varies depending on the input frequency, or may be configured as a combination of a plurality of constant speed compressors whose compression capacity is constant. The inlet side 102a of the compressor 102 may be connected to the accumulator 104, and the outlet side 102b of the compressor 102 may be connected to the flow diverter valve 106. The flow diverter valve 106 may also be connected to the accumulator 104.

[0041] The accumulator 104 may be installed between the inlet side 102a of the compressor 102 and the flow diverter valve 106. The accumulator 104 may temporarily store a mixture of oil and refrigerant in response to condensed liquid refrigerant flowing in through the flow diverter valve 106, and may prevent damage to the compressor 102 by separating the non-vaporized liquid refrigerant and preventing the liquid refrigerant from being drawn into the compressor 102. The gaseous refrigerant separated from the accumulator 104 may be drawn into the inlet side 102a of the compressor 102.

[0042] The flow diverter valve 106, which may be configured as a four-way valve, and may divert a flow of refrigerant discharged from the compressor 102 according to an operating mode (cooling or heating), thereby forming a refrigerant flow path required for operation of the corresponding mode. The flow diverter valve 106 may have a first port 106a connected to the outlet side 102b of the compressor 102, a second port 106b connected to the outdoor heat exchanger 108 side, a third port 106c connected to the refrigerant-water heat exchanger 112 side, and a fourth port 106d connected to the accumulator 104, which is the inlet side 102a of the compressor 102.

[0043] The outdoor heat exchanger 108 may operate as a condenser in a cooling mode, and as an evaporator in a heating mode. A first expansion valve 110 may be connected to one side of the outdoor heat exchanger 108. An outdoor fan 109 may be installed in the outdoor heat exchanger 108 to increase the heat exchange efficiency between the refrigerant and the outdoor air.

[0044] The expansion valve 110 may be configured as an electronic expansion valve, and may expand the refrigerant, regulate the flow rate of the refrigerant, and block the flow of the refrigerant if necessary. The expansion valve 110 may also be replaced by an expansion device of any other structure that performs these functions.

[0045] Within the hot water supply heat exchanger 112, a plurality of heat exchange plates through which refrigerant passes and heat exchange plates through which water passes may be installed alternately, and cold/hot water may be generated by heat exchange between the heat exchange plates through which refrigerant passes and the heat exchange plates through which water passes. The refrigerant compressed by the compressor 102 may be delivered to the refrigerant-water heat exchanger 112. The cold/hot water generated by the refrigerant-water heat exchanger 112 may be supplied to a water tank, a fan coil unit, a floor cooling/heating device, and the like and thus may be used for cold/hot water supply and cooling/heating.

[0046] FIG. 2 is a diagram showing a flow of refrigerant during heating operation of the heat pump system according to an embodiment.

[0047] A controller 10 may operate the flow diverter valve 106 to form a refrigerant flow path in which the first port 106a and the third port 106c are connected, and the second port 106b and the fourth port 106d are connected.

[0048] Accordingly, the refrigerant discharged from the compressor 102 may flow through the flow diverter valve 106 to the refrigerant-water heat exchanger 112.

[0049] The refrigerant entering the refrigerant-water heat exchanger 112 may flow to the outdoor heat exchanger 108 through the hot water supply heat exchanger 112. The refrigerant passing through the outdoor heat exchanger 108 may be drawn back through the flow diverter valve 106 and into the compressor 102.

[0050] Accordingly, the heat pump system 1 may perform a heating operation by configuring a refrigerant cycle that circulates in the order of the compressor 102 → the flow diverter valve 106 → the hot water supply heat exchanger 112 → the expansion valve 110 → the outdoor heat exchanger 108 → the flow diverter valve 106 → the accumulator 104 → the compressor 102.

[0051] The heat pump system 1 of the present disclosure may further include a subcooling heat exchanger 114.

[0052] The subcooling heat exchanger 114 may be located between the refrigerant-water heat exchanger 112 and the expansion valve 110 to allow the refrigerant to flow to the compressor 102.

[0053] **In** other words, in this case, the compressor 102 may perform two stages of refrigerant compression.

[0054] The compressor 102 may include a first compression unit in which the refrigerant passing through the refrigerant-water heat exchanger 112 is introduced and compressed, and a second compression unit in which the refrigerant passing through the first compression unit and the refrigerant branched and injected from the subcooling heat exchanger 114 located between the refrigerant-water heat exchanger 112 and the expansion valve 110 are introduced and compressed together.

[0055] **In** other words, refrigerant injection into the compressor 102 according to the subcooling heat exchanger 114 may be achieved by extracting the refrigerant passing through the refrigerant-water heat exchanger 112 and injecting only vapor refrigerant into an injection port of the compressor 102.

[0056] As a result, the compressor 102 may further compress the refrigerant branched and injected from the subcooling heat exchanger 114, in addition to the refrigerant passing through the refrigerant-water heat exchanger 112 in a conventional cycle.

[0057] Accordingly, the efficiency of the compressor 102 may be improved by supplying the vapor refrigerant to the injection port of the compressor 102, and the capacity of the condenser may be increased by increasing the flow rate of the refrigerant on the condenser side. **In** addition, efficient operation may be performed by further ensuring the subcooling level of the refrigerant of the discharge side in the refrigerant-water heat exchanger 112 (internal heat exchanger).

[0058] FIG. 3 is a diagram illustrating a flow of refrigerant during cooling operation of the heat pump system according to an embodiment.

[0059] The controller 10 may operate the flow diverter valve 106 to form a refrigerant flow path in which the first port 106a and the second port 106b are connected, and the third port 106c and the fourth port 106d are connected.

[0060] Accordingly, the refrigerant discharged from the compressor 102 may flow through the flow diverter valve 106 and the outdoor heat exchanger 108 to the indoor unit. **In** this case, the outdoor heat exchanger 108 may function as a condenser.

[0061] The refrigerant entering the indoor unit may pass through the refrigerant-water heat exchanger 112, and the refrigerant passing through the refrigerant-water heat exchanger 112 may be introduced back into the compressor 102 through the flow diverter valve 106.

[0062] As a result, the heat pump system 1 may perform a cooling operation by configuring a refrigerant cycle that circulates in the order of the compressor 102 → the flow diverter valve 106 → the outdoor heat exchanger 108 → the hot water supply heat exchanger 112 → the flow diverter valve 106 → the accumulator 104 → the compressor 102.

[0063] The above describes the basic configuration of the heat pump system 1 and the flow of the refrigerant.

[0064] FIG. 4 is a view illustrating a structure of the flow diverter valve.

[0065] As described above, the heating operation and cooling operation of the heat pump system 1 may be controlled according to the operation of the flow diverter valve 106.

[0066] More particularly, by inputting an electrical signal to a pilot valve 107 within the flow diverter valve 106, the pilot valve 107 may apply pressure to a slider within the flow diverter valve 106 to control the position of the slider, thereby switching the flow path.

[0067] **In** a case where foreign matter or the like is present within the pilot valve 107 and the pressure applied by the pilot valve 107 is not properly transmitted to the slider, an error in the flow path switching may occur.

[0068] **In** a winter season or the like, i.e., when the outdoor temperature is low, users may wish to operate the heat pump system 1 as a heating operation in order to raise the indoor temperature, and accordingly, a refrigerant flow path for the heating operation must be formed, but the pressure is not transmitted, and consequently a refrigerant flow path in which the first port 106a and the second port 106b are connected and the third port 106c and the fourth port 106d are connected in the flow diverter valve 106 may be formed.

[0069] **In** this case, the temperature of the water passing through the refrigerant-water heat exchanger 112 may drop below the freezing temperature, causing the water to freeze, and the freezing of the water may cause the refrigerant-water heat exchanger 112 to freeze.

[0070] Accordingly, it is necessary to remove foreign matter in the pilot valve 107 to ensure normal operation of the flow diverter valve 106.

[0071] **In** the following, a process of controlling the configuration within the heat pump system 1 to address an abnormal state of the refrigerant-water heat exchanger 112 due to an abnormal operation of the refrigerant-water heat exchanger 106 will be described in detail.

[0072] FIG. 5 is a control block diagram of the heat pump system according to an embodiment, and FIG. 6 is a diagram illustrating a plurality of sensors included in the heat pump system according to an embodiment.

[0073] Further, FIG. 7 is a flow chart illustrating detecting an abnormal state of the refrigerant-water heat exchanger and controlling the heat pump system based on the detected abnormal state, and FIG. 8 is a flow chart illustrating re-determining whether the refrigerant-water heat exchanger is operating normally after the controlling of FIG. 7.

[0074] The heat pump system 1 may include the compressor 102, the refrigerant-water heat exchanger 112, the outdoor heat exchanger 108, the outdoor fan 109, the expansion valve 110, and the controller 10, and the controller 10 may include a processor 11 and a memory 12.

[0075] The heat pump system 1 may further include a condensation temperature sensor 120, an outgoing water temperature sensor 122, and an incoming water temperature sensor 126. The condensation temperature sensor 120 may detect the condensed refrigerant temperature as it exchanges heat with water during the process of passing through the refrigerant-water heat exchanger 112.

[0076] The outgoing water temperature sensor 122 may detect the temperature of the water that has exchanged heat with the refrigerant during the process of passing through the refrigerant-water heat exchanger 112.

[0077] The incoming water temperature sensor 126 may detect the temperature of the water flowing into the refrigerant-water heat exchanger 112 prior to heat exchange with the refrigerant in the refrigerant-water heat exchanger 112.

[0078] Various information detected by the plurality of sensors may be used in a control process of the controller 10 described later, which will be described in detail below.

[0079] The compressor 102 may compress the refrigerant, and the refrigerant-water heat exchanger may perform heat exchange between the compressed refrigerant and the incoming water. The expansion valve 110 may expand the refrigerant that has condensed while passing through the refrigerant-water heat exchanger 112.

[0080] The outdoor heat exchanger 108 may perform heat exchange between the refrigerant expanded in the expansion valve and outdoor air, and the outdoor heat exchanger 108 may be provided with the outdoor fan 109 to increase the efficiency of the heat exchange between the refrigerant and the outdoor air.

[0081] The controller 10 may include the memory 12 for storing control programs and control data for controlling the expansion valve 110, the outdoor fan 109, and the compressor 102, and the processor 11 for generating control signals according to the control programs and control data stored in the memory 12. The memory 12 and the processor 11 may be formed integrally or separately.

[0082] The memory 12 may store temperature and pressure detected by various sensors, and may store programs and data for controlling the expansion valve 110, the outdoor fan 109, and the compressor 102.

[0083] The memory 12 may include volatile memory, such as static random access memory (S-RAM), dynamic random access memory (DRAM), or the like, for temporarily storing data. The memory 12 may also include non-volatile memory, such as read only memory (ROM), erasable programmable read only memory (EPROM), electrically erasable programmable read only memory (EEPROM), or the like, for storing data for a long period of time.

[0084] The processor 11 may include various logic circuitry and operation circuitry, and may process data according to programs provided from the memory 12 and generate control signals according to the processing result.

[0085] Referring to FIG. 7, the controller 10 may determine whether the refrigerant-water heat exchanger is in an abnormal state based on the detection results of the condensation temperature sensor, the incoming water temperature sensor, and the outgoing water temperature sensor (701).

[0086] As described above, in a case where foreign matter or the like occurs in the pilot valve 107 to prevent the flow path switching of the flow diverter valve 106 from being performed normally, the flow path for the heating operation may not be formed properly, such as in winter when the outdoor temperature is low.

[0087] In this case, the controller 10 may determine whether the refrigerant-water heat exchanger 112 is operating normally by comparing the temperature of the water exchanging heat with the refrigerant-water heat exchanger 112.

[0088] More particularly, in response to the condensed refrigerant temperature detected by the condensation temperature sensor 120 being higher than the incoming water temperature detected by the incoming water temperature sensor (Yes in 703), and the outgoing water temperature detected by the outgoing water temperature sensor being higher than the incoming water temperature detected by the incoming water temperature sensor (Yes in 705), the controller 10 may determine that the refrigerant-water heat exchanger 112 is operating normally.

[0089] In other words, in response to the condensed refrigerant temperature detected by the condensation temperature sensor 120 being lower than the incoming water temperature detected by the incoming water temperature sensor (No in 703), or the outgoing water temperature detected by the outgoing water temperature sensor being lower than the incoming water temperature detected by the incoming water temperature sensor (No in 705), the controller 10 may determine that the refrigerant-water heat exchanger 112 is operating abnormally.

[0090] The controller 10 may turn off the compressor and the outdoor fan based on the abnormal state of the refrigerant-water heat exchanger 112 (707).

[0091] In other words, upon determining that the refrigerant-water heat exchanger 112 is in the abnormal state, such as detecting a risk of freezing of the refrigerant-water heat exchanger 112 as described above, the controller 10 may turn off the compressor 102 and the outdoor fan 109 to protect the heat pump system.

[0092] Thereafter, upon restarting the heat pump system 1, only the compressor 102 may be turned on while the outdoor fan 109 is in a turn-off state (709).

[0093] In response to only the compressor 102 being turned on while the outdoor fan 109 is stopped, the amount of air discharged to the outside of the outdoor heat exchanger 108 may decrease and the internal high pressure may increase as the temperature increases.

[0094] The increase in the temperature and internal high pressure may cause the viscosity of the foreign matter generated in the pilot valve 107 inside the flow diverter valve 106 to weaken, and as the pressure is applied, the foreign matter in the pilot valve 107 may be removed.

[0095] The removal of the foreign matter in the pilot valve 107 may allow pressure to be applied normally to the slider in the flow diverter valve 106, thereby changing the existing cooling operation flow path to the heating operation flow path.

[0096] In other words, the state in which the first port 106a and the second port 106b are connected and the third port 106c and the fourth port 106d are connected may be changed to the state in which the first port 106a and the third port 106c are connected and the second port 106b and the fourth port 106d are connected, so that the heating operation refrigerant path may be formed.

[0097] The controller 10 may control an opening level of the expansion valve 110 to be equal to or greater than a first opening level based on the abnormal state of the refrigerant-water heat exchanger 112 (711).

[0098] In this case, the first opening level may refer to an opening level of 20% based on the maximum opening level of the expansion valve 110. However, the present disclosure is not limited thereto, and may be set to an appropriate ratio to resolve the abnormal state of the refrigerant-water heat exchanger 112.

[0099] By controlling the opening level of the expansion valve 110 to be equal to or greater than the first opening level, the internal high pressure may be increased.

[0100] As described above, as the temperature and the internal high pressure increase, the viscosity of the foreign matter generated in the pilot valve 107 inside the flow diverter valve 106 may be weakened, and thus the foreign matter in the pilot valve 107 may be removed by applying pressure.

[0101] As the foreign matter in the pilot valve 107 is removed and the pressure is normally applied to the slider in the flow diverter valve 106, the existing cooling operation flow path may be changed to the heating operation flow path.

[0102] The controller 10 may then determine whether the refrigerant-water heat exchanger 112 is operating normally, and based on the determination result, control the expansion valve 110, the outdoor fan 109, and the compressor 102.

[0103] Referring to FIG. 8, the controller 10 may re-determine whether the refrigerant-water heat exchanger 112 is in the abnormal state based on the detection results (801) of the condensation temperature sensor 120, the incoming water temperature sensor, and the outgoing water temperature sensor after controlling the compressor 102, the outdoor fan 109, and the expansion valve 110.

[0104] More particularly, in response to the condensed refrigerant temperature detected by the condensation temperature sensor 120 being higher than the incoming water temperature detected by the incoming water temperature sensor (Yes in 803) and the outgoing water temperature detected by the outgoing water temperature sensor being higher than the incoming water temperature detected by the incoming water temperature sensor (Yes in 805), the controller 10 may determine that the refrigerant-water heat exchanger 112 is operating normally (807).

[0105] In this case, in comparing and determining the detected temperatures, factors such as the deviation between the actual temperature and the detected temperature may lead to inaccurate results. Accordingly, the controller 10 may determine that the refrigerant-water heat exchanger 112 is operating normally in response to the condensed refrigerant temperature detected by the condensation temperature sensor 120 being higher than a value obtained by subtracting a first constant from the incoming water temperature detected by the incoming water temperature sensor, and the outgoing water temperature detected by the outgoing water temperature sensor being higher than a value obtained by subtracting a second constant from the incoming water temperature detected by the incoming water temperature sensor.

[0106] In this case, the first constant and the second constant may be constants determined based on the deviation between the actual temperature and the detected temperature and the optimum condensing temperature.

[0107] In response to the condensed refrigerant temperature detected by the condensation temperature sensor 120 being lower than the incoming water temperature detected by the incoming water temperature sensor (No in 805) or the outgoing water temperature detected by the outgoing water temperature sensor being lower than the incoming water temperature detected by the incoming water temperature sensor (No in 807), the controller 10 may determine that the refrigerant-water heat exchanger 112 is operating abnormally and perform the control described later.

[0108] FIG. 9 is a control block diagram illustrating the heat pump system according to an embodiment, and FIG. 10 is a flow chart illustrating a method of controlling a heat pump system to protect the heat pump system based on the condensing temperature, according to an embodiment.

[0109] As described above, upon determining that the refrigerant-water heat exchanger 112 is in the abnormal state even after the control of the outdoor fan 109 and the expansion valve 110 by the controller 10, it may be necessary to stop the operation of the heat pump system 1.

[0110] In this case, when the internal high pressure is too high due to the stopping of the outdoor fan 109 and the control of the low opening of the expansion valve 110, damage to the heat pump system 1 may occur, so that it is necessary to reduce the pressure in response to the internal high pressure being detected to be high.

[0111] Accordingly, the controller 10 may determine whether the temperature detected by the condensation temperature sensor 120 exceeds a predetermined temperature.

[0112] The predetermined temperature may be set at a suitable temperature to protect the heat pump system 1 by preventing damage to the heat pump system 1, or the like.

[0113] In response to the temperature detected by the condensation temperature sensor 120 exceeding the predetermined temperature (Yes in 1001), the controller 10 may control the outdoor fan 109 to rotate at a rotational speed equal to or greater than a reference rotational speed (1003) and control the expansion valve 110 to have an opening level equal to or greater than a second opening level (1005).

[0114] Here, the reference rotational speed and the second opening level may be a suitable rotational speed and opening level value that reduces the high pressure inside the heat pump system 1 to protect the heat pump system 1.

[0115] The outdoor fan 109 may be rotated at a rotational speed equal to or greater than the reference rotational speed and the expansion valve 110 may be opened at the second opening level or greater to reduce the internal high pressure, thereby protecting the heat pump system 1.

[0116] The controller 10 may then turn off the operation of the compressor 102 and the outdoor fan 109 upon determining that the internal high pressure has been sufficiently reduced.

[0117] The controller 10 may then perform the control again to resolve the abnormal state of the refrigerant-water heat exchanger 112 described above.

[0118] FIG. 11 is a control block diagram illustrating a heat pump system according to an embodiment, and FIG. 12 is a flow chart illustrating a method of controlling a heat pump system to protect the heat pump system based on a high pressure according to an embodiment.

[0119] The heat pump system 1 may further include a high pressure sensor 130 that detects the high pressure of the refrigerant compressed in the compressor 102.

[0120] FIGS. 9 and 10 describe a case in which the internal high pressure is detected using the condensation temperature sensor 120 because such a high pressure sensor 130 is not separately included, and in the present embodiment, a case in which a high pressure sensor 130 that may directly detect the high pressure is included will be described.

[0121] The controller 10 may determine whether the high pressure detected by the high pressure sensor 130 exceeds a predetermined pressure in response to the refrigerant-water heat exchanger 112 being in the abnormal state.

[0122] In this case, the predetermined pressure may be set to an appropriate pressure to protect the heat pump system 1 by preventing damage to the heat pump system 1, or the like.

[0123] Upon determining that the high pressure detected by the high pressure sensor 130 exceeds the predetermined pressure (Yes in 1201), the controller 10 may control the outdoor fan 109 to rotate at the rotational speed equal to or greater than the reference rotational speed (1203) and control the expansion valve 110 to open at the second opening lever or greater (1205).

[0124] The heat pump system 1 may be protected by reducing the internal high pressure by rotating the outdoor fan 109 at the rotational speed equal to or greater than the reference rotational speed and by making the expansion valve 110 at the second opening level or greater.

[0125] Thereafter, upon determining that the internal high pressure has been sufficiently reduced, the controller 10 may turn off the operation of the compressor 102 and the outdoor fan 109.

[0126] Thereafter, the controller 10 may perform the control again to resolve the abnormal state of the refrigerant-water heat exchanger 112 described above.

[0127] According to the heat pump system and the method of controlling the same described above, when the heat exchanger is operating abnormally, such as when a risk of freezing of the heat exchanger is detected, such as due to a malfunction of the flow diverter valve, the heat exchanger may be caused to operate normally by controlling the outdoor fan and the expansion valve to allow the flow diverter valve to operate normally when the system is restarted after being stopped.

[0128] Meanwhile, the embodiments disclosed herein can be implemented in the form of a recording medium storing executable instructions for a computer. The instructions can be stored in the form of program code, and, when executed by the processor, can produce a program module that performs the operation of the disclosed embodiments. The recording medium can be implemented as a computer-readable storage medium.

[0129] The computer-readable storage medium includes all types of storage media that store instructions that can be decoded by a computer. These may include, for example, read only memory (ROM), random access memory (RAM), magnetic tape, magnetic disc, flash memory, optical data storage devices, and the like.

[0130] As described above, the embodiments disclosed herein have been described with reference to the accompanying drawings. Those skilled in the art to which the present disclosure pertains will understand that the present disclosure may be implemented in forms other than the disclosed embodiments without altering the technical ideas or essential features of the present disclosure. The disclosed embodiments are exemplary and should not be construed as limiting.

Claims

1. A heat pump system, comprising:

a compressor configured to compress a refrigerant;
a refrigerant-water heat exchanger in which heat exchange occurs between the compressed refrigerant and water;
an expansion valve configured to expand the refrigerant condensed in the refrigerant-water heat exchanger;
an outdoor heat exchanger in which heat exchange occurs between the refrigerant expanded in the expansion valve and outdoor air;
an outdoor fan arranged adjacent to the outdoor heat exchanger;
a condensation temperature sensor configured to detect the temperature of the refrigerant condensed in the refrigerant-water heat exchanger;
an incoming water temperature sensor configured to detect the temperature of water entering the refrigerant-water heat exchanger;
an outgoing water temperature sensor configured to detect the temperature of water in which heat exchange occurs in the refrigerant-water heat exchanger; and
a controller configured to:

determine whether the refrigerant-water heat exchanger is in an abnormal state based on the detection results of the condensation temperature sensor, the incoming water temperature sensor, and the outgoing water temperature sensor, and
turn off the compressor and the outdoor fan based on the abnormal state of the refrigerant-water heat exchanger, and turn on the compressor in a turn-off state of the outdoor fan.

2. The heat pump system of claim 1, wherein the controller determines that the refrigerant-water heat exchanger is operating normally in response to the detected temperature of the condensed refrigerant being higher than the incoming water temperature and the detected outgoing water temperature being higher than the detected incoming water temperature.

3. The heat pump system of claim 2, wherein the controller controls an opening level of the expansion valve to be equal to or greater than a first opening level based on the abnormal state of the refrigerant-water heat exchanger.

4. The heat pump system of claim 3, wherein the controller determines whether the refrigerant-water heat exchanger is in the abnormal state based on the detection results of the condensation temperature sensor, the incoming water temperature sensor, and the outgoing water temperature sensor after controlling the compressor, the outdoor fan, and the expansion valve.

5. The heat pump system of claim 4, wherein the controller determines whether the temperature detected by the condensation temperature sensor exceeds a predetermined temperature in response to the refrigerant-water heat exchanger being in the abnormal state.

6. The heat pump system of claim 5, wherein the controller,

upon determining that the temperature detected by the condensation temperature sensor exceeds the predetermined temperature,
controls the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and controls the expansion valve to open at a second opening level or greater.

7. The heat pump system of claim 6, wherein the controller turns off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

8. The heat pump system of claim 4, further comprising a high pressure sensor to detect a high pressure of the refrigerant compressed in the compressor,
wherein the controller determines whether the high pressure detected by the high pressure sensor exceeds a predetermined pressure in response to the refrigerant-water heat exchanger being in the abnormal state.

9. The heat pump system of claim 8, wherein the controller,

upon determining that the pressure detected by the high pressure sensor exceeds the predetermined pressure,
controls the outdoor fan to rotate at a rotational speed equal to or greater than a reference rotational speed and controls the expansion valve to open at a second opening level or greater.

10. The heat pump system of claim 9, wherein the controller turns off the compressor and the outdoor fan in response to the predetermined time having elapsed after controlling the outdoor fan to rotate at the rotational speed equal to or greater than the reference rotational speed and controlling the expansion valve to open at the second opening level or greater.

11. A method of controlling a heat pump system, comprising:

detecting the temperature of condensed refrigerant in a refrigerant-water heat exchanger;
detecting the temperature of water entering the refrigerant-water heat exchanger;
detecting the temperature of water in which heat exchange occurs in the refrigerant-water heat exchanger;
determining whether the refrigerant-water heat exchanger is in an abnormal state based on the detection results of the plurality of temperatures;
turning off a compressor and an outdoor fan in response to the determination that the refrigerant-water heat exchanger is in the abnormal state; and
turning on the compressor while the outdoor fan is in a turn-off state.

12. The method of claim 11, wherein the determining whether the refrigerant-water heat exchanger is in the abnormal state comprises:
determining that the refrigerant-water heat exchanger is operating normally in response to the detected temperature of the condensed refrigerant being higher than the temperature of the water entering the heat exchanger and the detected temperature of the water in which heat exchange has occurred being higher than the temperature of the water entering the detected heat exchanger.

13. The method of claim 12, further comprising controlling an opening level of the expansion valve to be equal to or greater than a first opening level based on the refrigerant-water heat exchanger being in the abnormal state.

14. The method of claim 13, further comprising determining whether the refrigerant-water heat exchanger is in the abnormal state based on the detection results of the plurality of temperatures after controlling the compressor, the outdoor fan, and the expansion valve.

15. The method of claim 14, further comprising determining whether the temperature detected by the condensation temperature sensor exceeds a predetermined temperature in response to the refrigerant-water heat exchanger being in the abnormal state.

FIG. 1

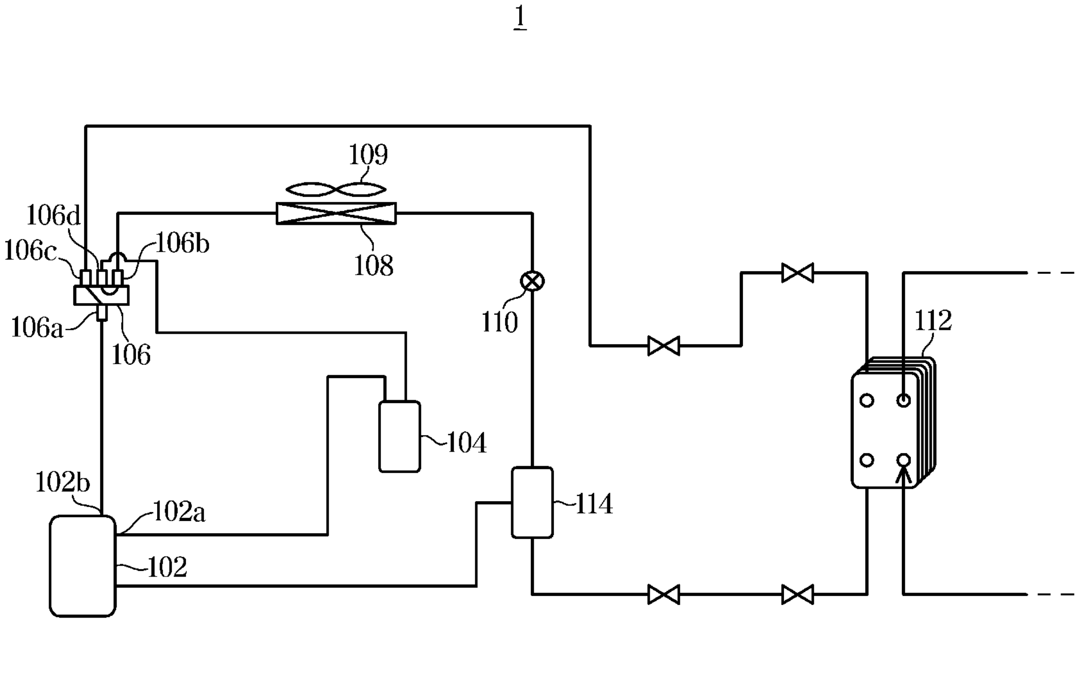


FIG. 2

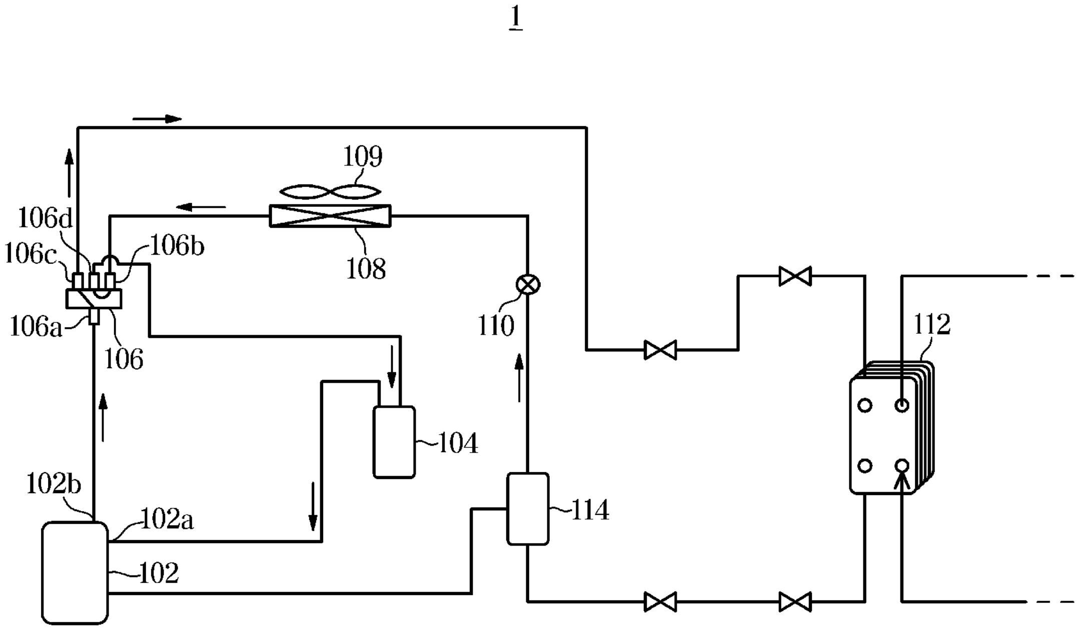


FIG. 3

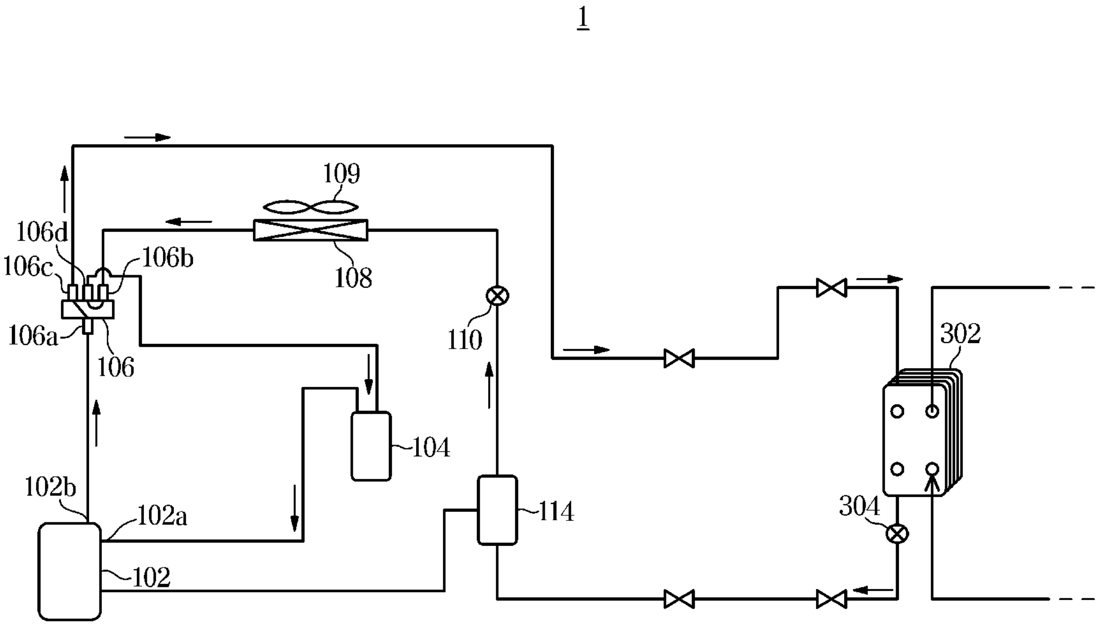

1
109
106d
106c
106b
108
106a
106
110
302
104
102b
102a
114
304
102

FIG. 4

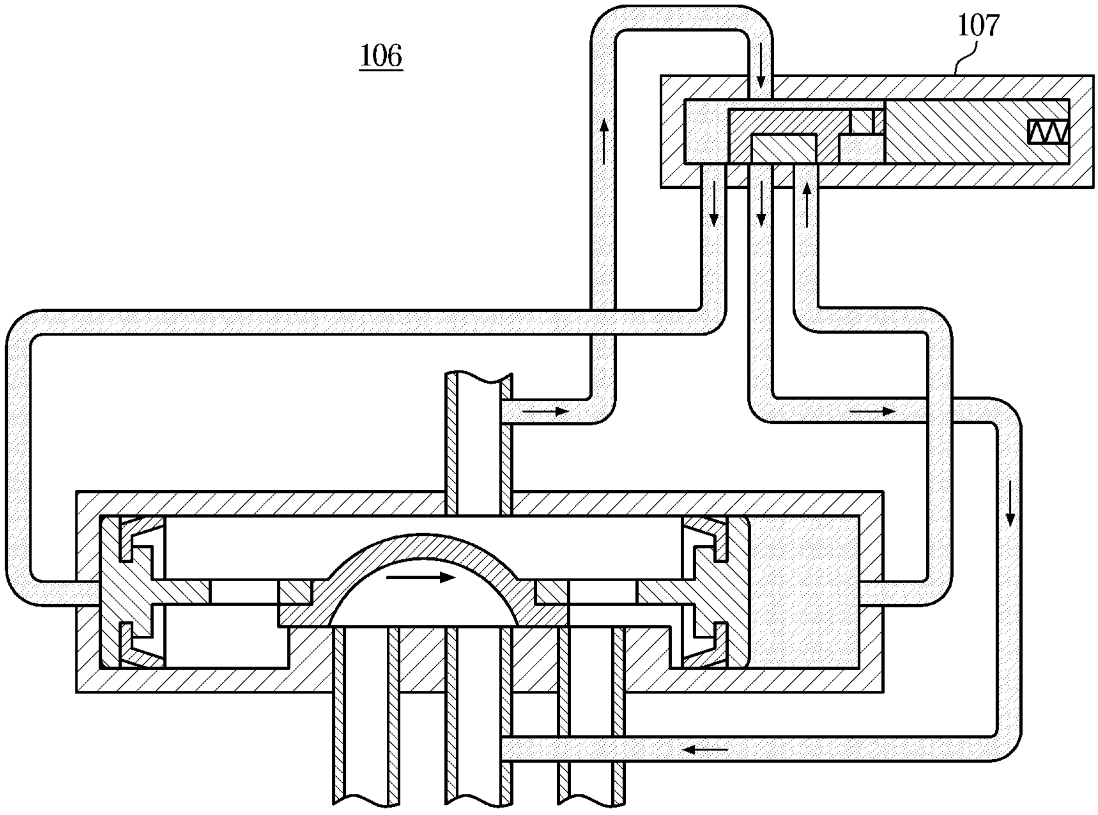


FIG. 5

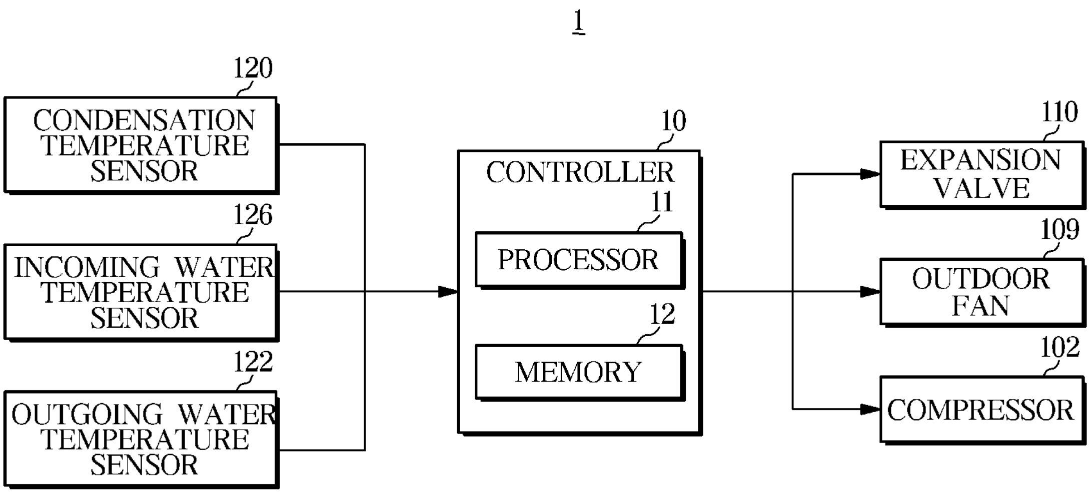

1
120
CONDENSATION TEMPERATURE SENSOR
126
INCOMING WATER TEMPERATURE SENSOR
122
OUTGOING WATER TEMPERATURE SENSOR
10
CONTROLLER
11
PROCESSOR
12
MEMORY
110
EXPANSION VALVE
109
OUTDOOR FAN
102
COMPRESSOR

FIG. 6

1

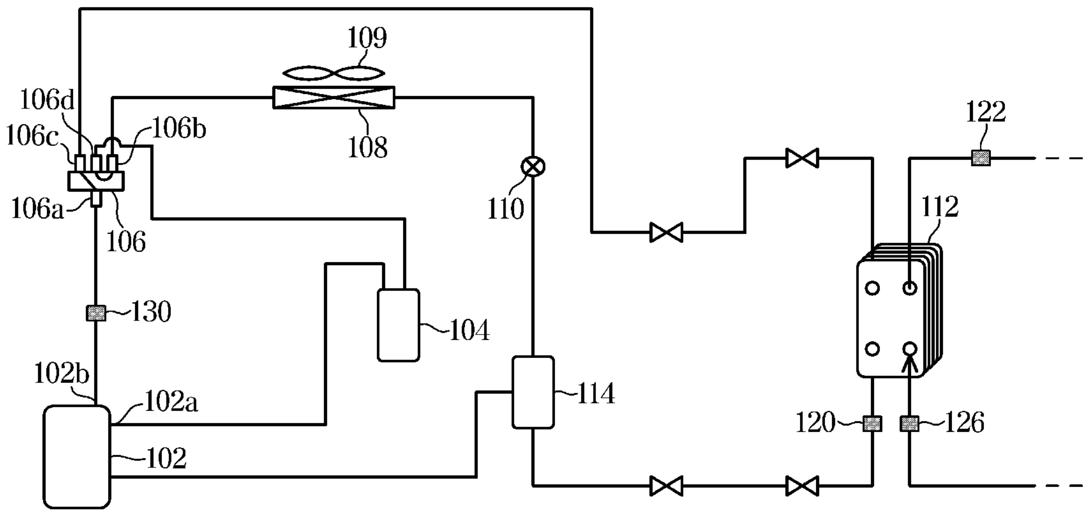

109
106d
106c
106b
108
122
106a
110
112
106
130
104
102b
114
102a
120
126
102

FIG. 7

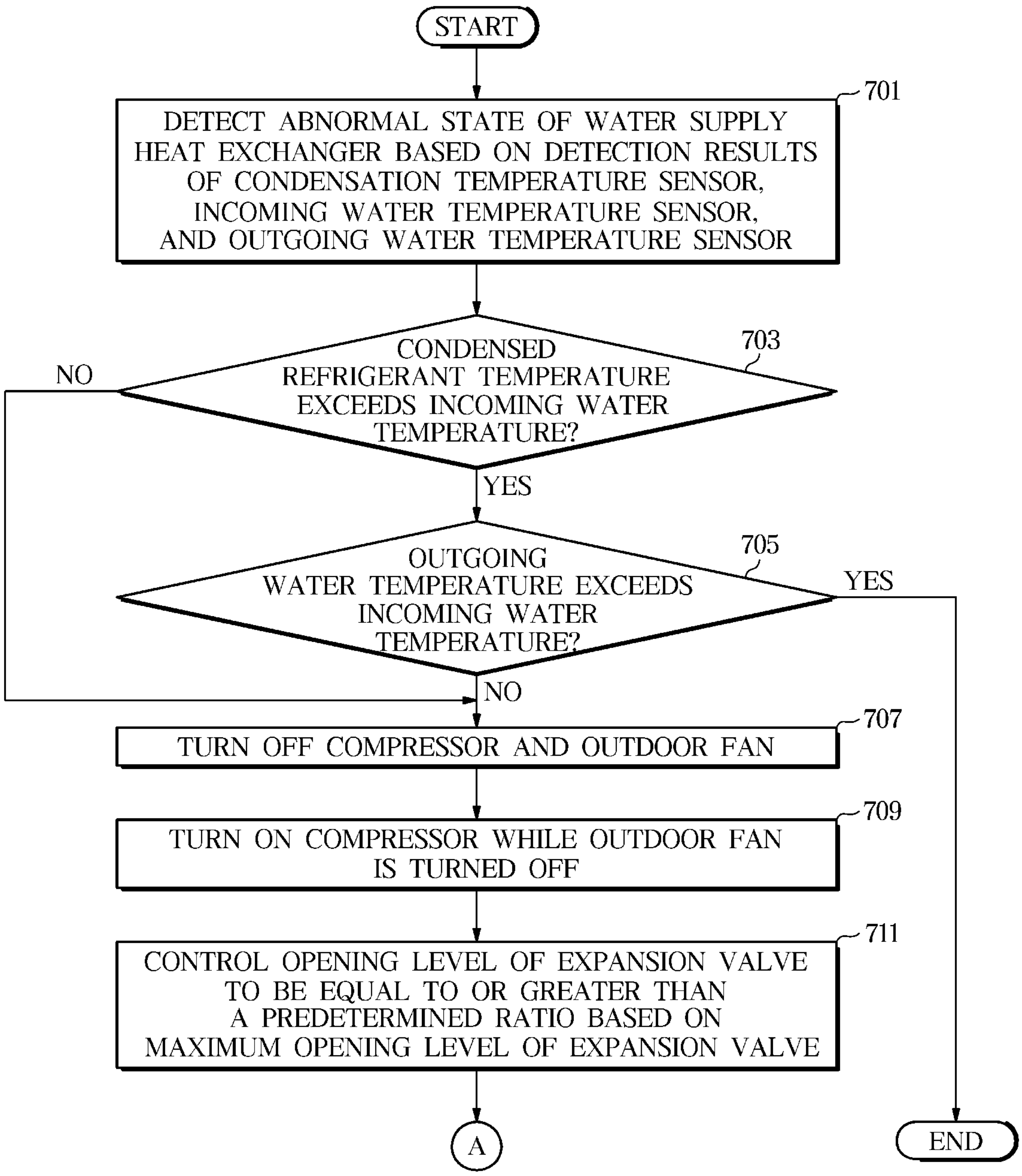

START
701
DETECT ABNORMAL STATE OF WATER SUPPLY HEAT EXCHANGER BASED ON DETECTION RESULTS OF CONDENSATION TEMPERATURE SENSOR, INCOMING WATER TEMPERATURE SENSOR, AND OUTGOING WATER TEMPERATURE SENSOR
703
CONDENSED REFRIGERANT TEMPERATURE EXCEEDS INCOMING WATER TEMPERATURE?
NO
YES
705
OUTGOING WATER TEMPERATURE EXCEEDS INCOMING WATER TEMPERATURE?
YES
NO
707
TURN OFF COMPRESSOR AND OUTDOOR FAN
709
TURN ON COMPRESSOR WHILE OUTDOOR FAN IS TURNED OFF
711
CONTROL OPENING LEVEL OF EXPANSION VALVE TO BE EQUAL TO OR GREATER THAN A PREDETERMINED RATIO BASED ON MAXIMUM OPENING LEVEL OF EXPANSION VALVE
A
END

FIG. 8

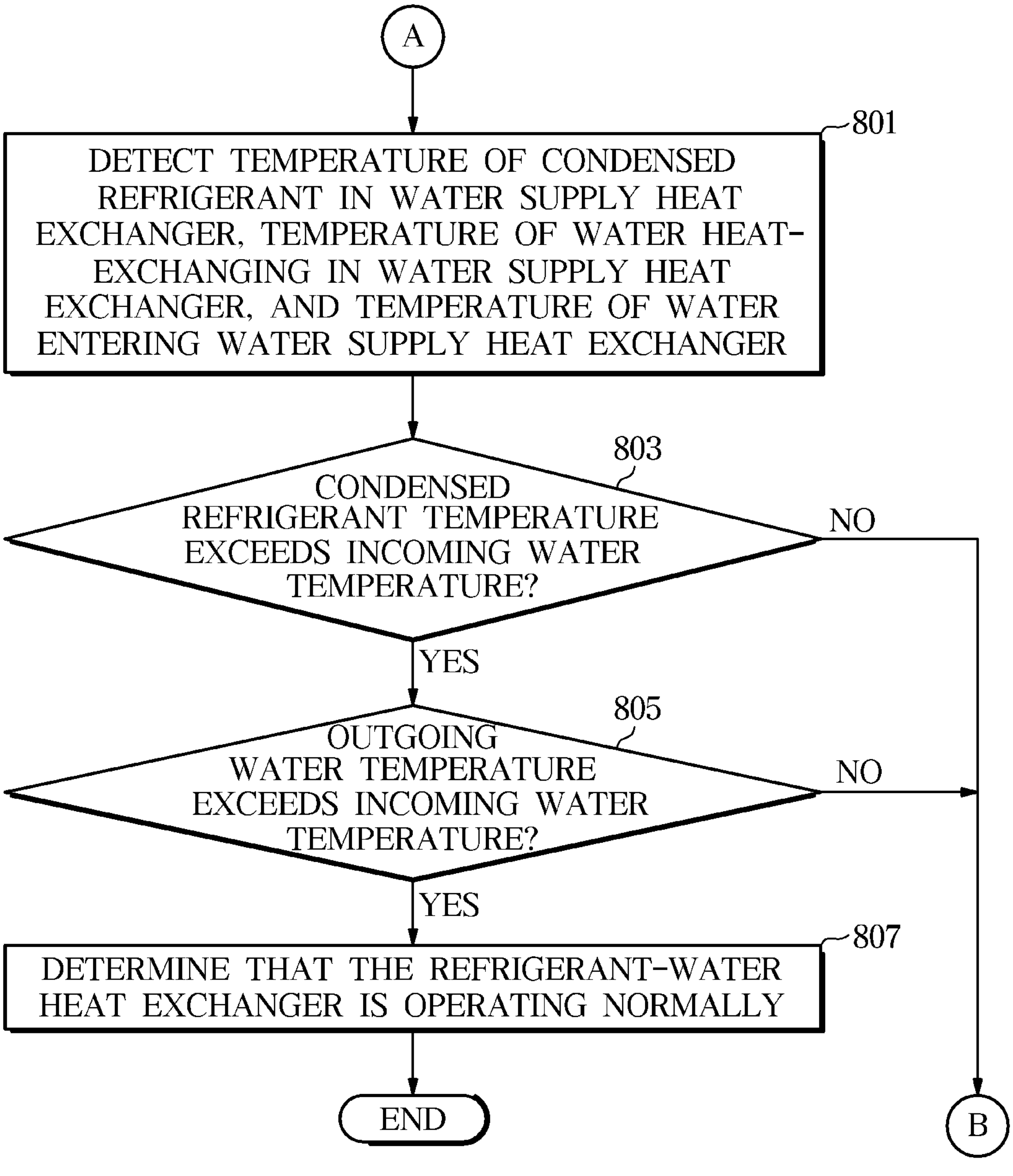

A
DETECT TEMPERATURE OF CONDENSED REFRIGERANT IN WATER SUPPLY HEAT EXCHANGER, TEMPERATURE OF WATER HEAT-EXCHANGING IN WATER SUPPLY HEAT EXCHANGER, AND TEMPERATURE OF WATER ENTERING WATER SUPPLY HEAT EXCHANGER
801
CONDENSED REFRIGERANT TEMPERATURE EXCEEDS INCOMING WATER TEMPERATURE?
803
NO
YES
OUTGOING WATER TEMPERATURE EXCEEDS INCOMING WATER TEMPERATURE?
805
NO
YES
DETERMINE THAT THE REFRIGERANT-WATER HEAT EXCHANGER IS OPERATING NORMALLY
807
END
B

FIG. 9

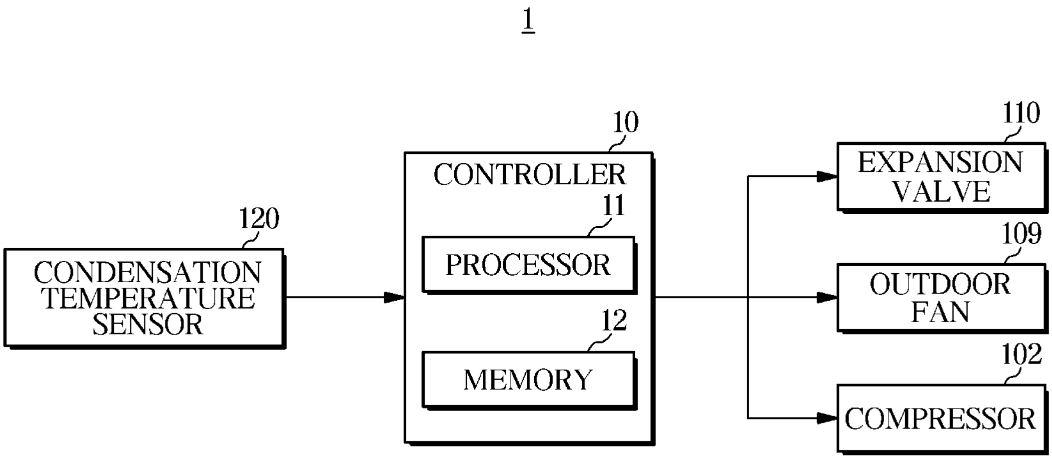

1
10
CONTROLLER
11
PROCESSOR
12
MEMORY
120
CONDENSATION TEMPERATURE SENSOR
110
EXPANSION VALVE
109
OUTDOOR FAN
102
COMPRESSOR

FIG. 10

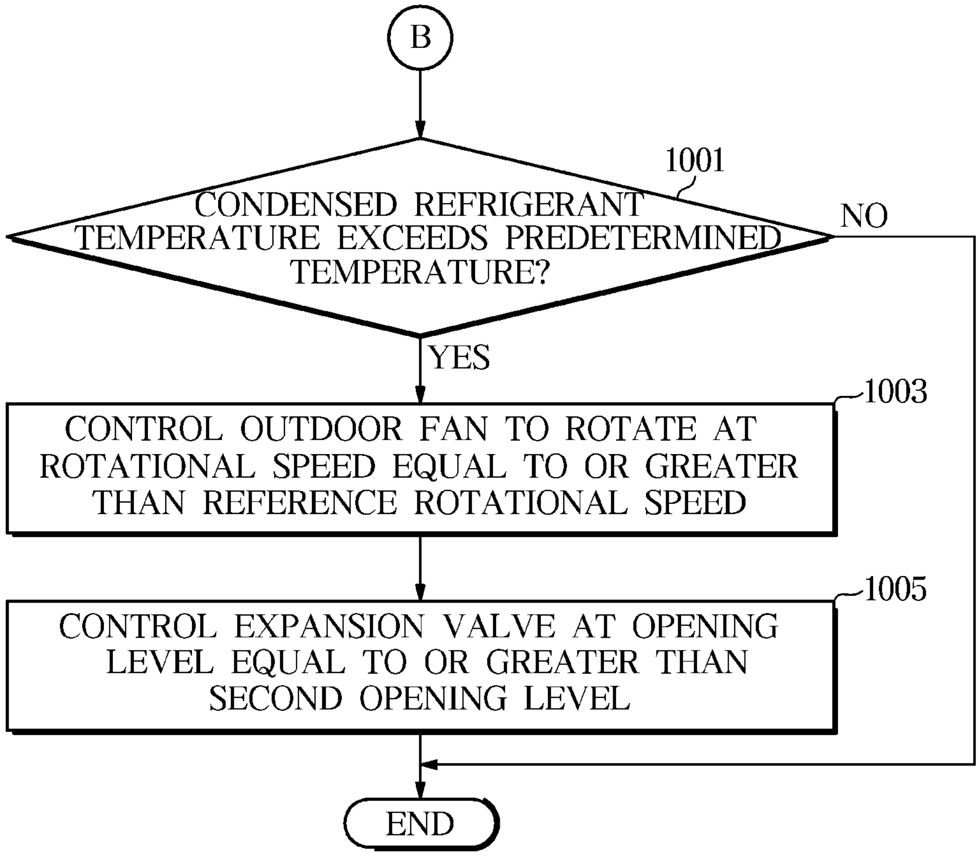

B
1001
CONDENSED REFRIGERANT TEMPERATURE EXCEEDS PREDETERMINED TEMPERATURE?
NO
YES
1003
CONTROL OUTDOOR FAN TO ROTATE AT ROTATIONAL SPEED EQUAL TO OR GREATER THAN REFERENCE ROTATIONAL SPEED
1005
CONTROL EXPANSION VALVE AT OPENING LEVEL EQUAL TO OR GREATER THAN SECOND OPENING LEVEL
END

FIG. 11

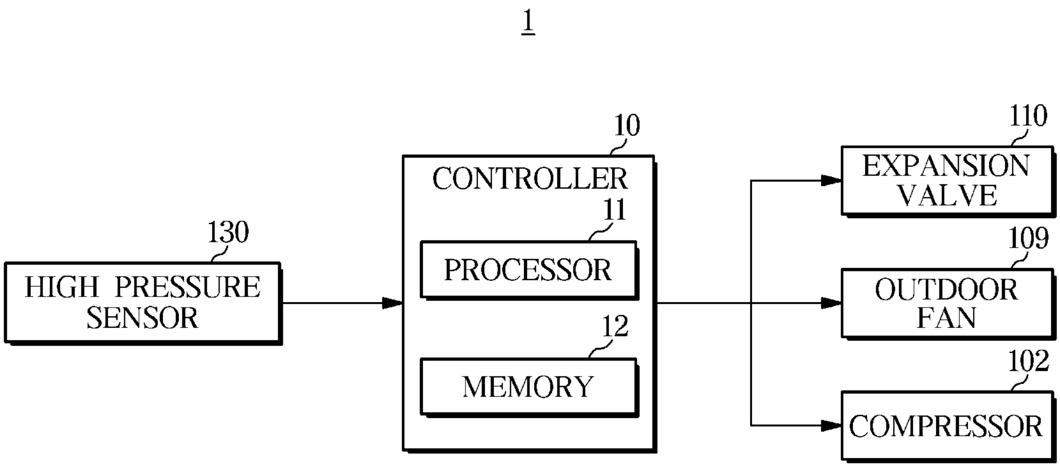
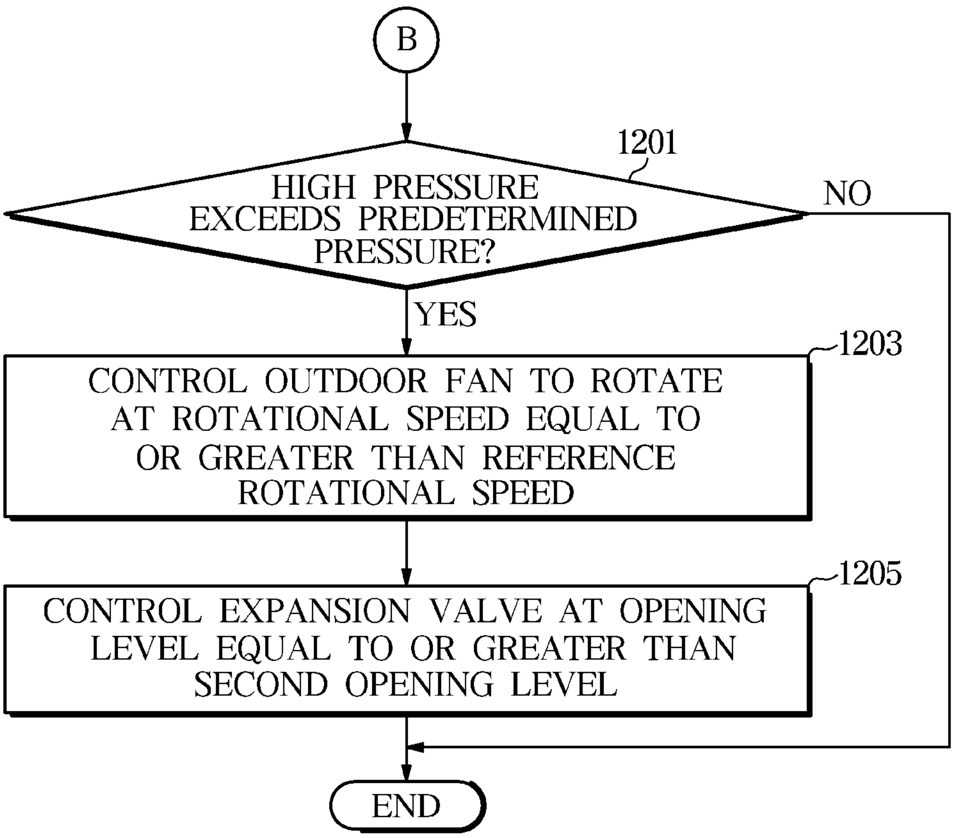

1
10
CONTROLLER
11
PROCESSOR
12
MEMORY
130
HIGH PRESSURE SENSOR
110
EXPANSION VALVE
109
OUTDOOR FAN
102
COMPRESSOR

FIG. 12


B
1201
HIGH PRESSURE EXCEEDS PREDETERMINED PRESSURE?
NO
YES
1203
CONTROL OUTDOOR FAN TO ROTATE AT ROTATIONAL SPEED EQUAL TO OR GREATER THAN REFERENCE ROTATIONAL SPEED
1205
CONTROL EXPANSION VALVE AT OPENING LEVEL EQUAL TO OR GREATER THAN SECOND OPENING LEVEL
END

INTERNATIONAL SEARCH REPORT

International application No. **PCT/KR2023/010287**

A. CLASSIFICATION OF SUBJECT MATTER

F25B 30/02(2006.01)i; **F25B 49/02**(2006.01)i; **F25B 13/00**(2006.01)i; **F25B 41/31**(2021.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B 30/02(2006.01); F24H 1/00(2006.01); F25B 1/00(2006.01); F25B 13/00(2006.01); F25B 25/00(2006.01); F25B 47/00(2006.01); F25B 49/02(2006.01)

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

Korean utility models and applications for utility models: IPC as above
Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & keywords: 히트 펌프(heat pump), 압축기(compressor), 냉매-물 열교환기(refrigerant-water heat exchanger), 팽창 밸브(expansion valve), 팬(fan), 온도 센서(temperature sensor), 비정상 상태(abnormal state), 제어(control)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5601885 B2 (MITSUBISHI HEAVY IND. LTD.) 08 October 2014 (2014-10-08) See paragraphs [0020]-[0021] and [0031] and figure 1.	1,11
A		2-10,12-15
Y	JP 4078036 B2 (TOSHIBA KYARIA K.K.) 23 April 2008 (2008-04-23) See paragraph [0034] and figure 1.	1,11
A	CN 110553439 A (ZHEJIANG ZHONGGUANG ELECTRIC APPLIANCE CO., LTD.) 10 December 2019 (2019-12-10) See claim 1 and figure 1.	1-15
A	JP 2008-075962 A (DENSO CORP.) 03 April 2008 (2008-04-03) See paragraphs [0016]-[0037] and figures 1-2 and 4.	1-15

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

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "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
13 November 2023	**14 November 2023**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsa-ro, Seo-gu, Daejeon 35208	
Facsimile No. **+82-42-481-8578**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2023/010287

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2413701 B1 (MTS CO., LTD.) 27 June 2022 (2022-06-27) See claim 1 and figure 1.	1-15

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2023/010287

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 5601885 B2	08 October 2014	JP 2011-252622 A	15 December 2011
JP 4078036 B2	23 April 2008	JP 2002-243276 A	28 August 2002
CN 110553439 A	10 December 2019	CN 110553439 B	20 July 2021
JP 2008-075962 A	03 April 2008	None	
KR 10-2413701 B1	27 June 2022	None	

Form PCT/ISA/210 (patent family annex) (July 2022)