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(54) **HEAT PUMP SYSTEM**

(57) The present application provides a heat pump system. The heat pump system comprises a main circulating refrigerant loop, an auxiliary circulating refrigerant loop, and a refrigerant management system; the main circulating refrigerant loop comprises a main compressor, a first main heat exchanger, a main throttling device, and a second main heat exchanger, the main compressor is configured to allow a refrigerant in the main circulating refrigerant loop to circulate in a main circulating refrigeration working condition flow direction or circulate in a main circulating heating working condition flow direction. The auxiliary circulating refrigerant loop comprises an auxiliary compressor, a first auxiliary heat exchanger, an

auxiliary throttling device, and a second auxiliary heat exchanger; the auxiliary compressor is configured to allow a refrigerant in the auxiliary circulating refrigerant loop to circulate in an auxiliary circulating heating working condition flow direction. The refrigerant management system is controllably connected to or disconnected from the main circulating refrigerant loop and the auxiliary circulating refrigerant loop, separately; the refrigerant management system is configured to be capable of distributing a refrigerant used for the main circulating refrigerant loop to the auxiliary circulating refrigerant loop. Less refrigerant is used in the heat pump system provided by the present application.

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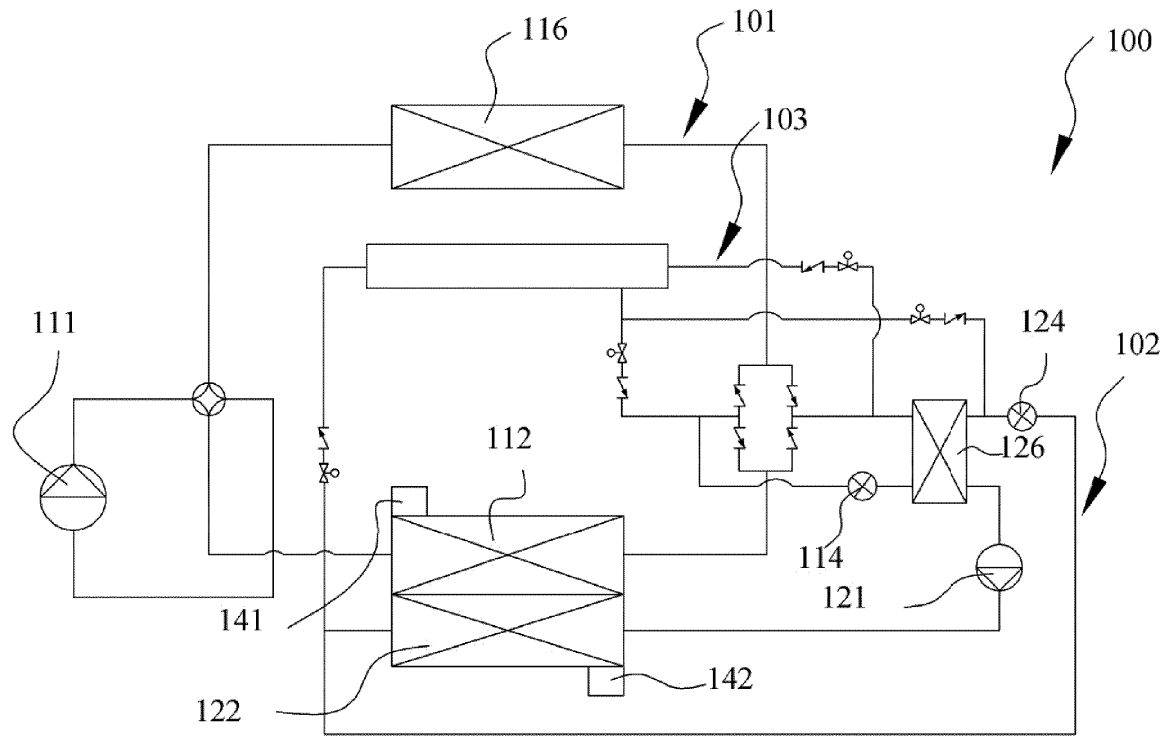


FIG. 1A

Description

Technical Field

[0001] The present application relates to a heat pump system, in particular to a heat pump system that meets the heating demand at a low ambient temperature.

Background Art

[0002] The heat pump system comprises a circulating system of a refrigerant consisting of a compressor, a throttling device and at least two heat exchangers. Heat exchange with the outside that is carried out by means of the heat exchangers allows the heat pump system to work in a refrigeration working mode or a heating working mode. When the heat pump system works in the heating working mode, the heating capacity is affected by the ambient temperature. Especially at low ambient temperatures, there is a gradual decay of the heating capacity of the heat pump system with the decrease of the ambient temperature, the decay exhibiting an increasing trend, however, the heat required by the customer side increases continuously with the decrease of the ambient temperature, so the existing heat pump system cannot meet the needs of the customer side.

Summary of the Invention

[0003] It is a new trend in the development of current units to meet the requirements of matching the heating capacity of the unit with the heat demand on the customer side and the requirements of energy efficiency at low ambient temperatures. The present application provides a heat pump system, which can work in multiple working modes, and can meet the matching of the heating capacity of the unit with the heat demand on the customer side at low ambient temperature, wherein the heat pump system comprises: a main circulating refrigerant loop, the main circulating refrigerant loop having a main compressor, a first main heat exchanger, a main throttling device and a second main heat exchanger, wherein the main compressor is configured to allow a refrigerant in the main circulating refrigerant loop to circulate in a main circulating refrigeration working condition flow direction or circulate in a main circulating heating working condition flow direction that is opposite to the main circulating refrigeration working condition flow direction; an auxiliary circulating refrigerant loop, the auxiliary circulating refrigerant loop comprising an auxiliary compressor, a first auxiliary heat exchanger, an auxiliary throttling device and a second auxiliary heat exchanger, wherein the auxiliary compressor is configured to allow a refrigerant in the auxiliary circulating refrigerant loop to circulate in an auxiliary circulating heating working condition flow direction; and a refrigerant management system, the refrigerant management system being controllably connected to or disconnected from the main circulating refrigerant loop and the

auxiliary circulating refrigerant loop, separately, wherein the refrigerant management system is configured to be capable of distributing a refrigerant used for the main circulating refrigerant loop to the auxiliary circulating refrigerant loop.

[0004] According to the heat pump system described above, the heat pump system has a refrigeration working mode, a heating working mode, and an auxiliary heating working mode. In the refrigeration working mode, the refrigerant in the main circulating refrigerant loop circulates in the main circulating refrigeration working condition flow direction, and the auxiliary compressor is turned off; in the heating working mode, the refrigerant in the main circulating refrigerant loop circulates in the main circulating heating working condition flow direction, and the auxiliary compressor is turned off; and in the auxiliary heating working mode, the refrigerant in the main circulating refrigerant loop circulates in the main circulating heating working condition flow direction, and the refrigerant in the auxiliary circulating refrigerant loop circulates in the auxiliary circulating heating working condition flow direction.

[0005] According to the heat pump system described above, the refrigerant management system is configured to be capable of introducing part of the refrigerant used in the main circulating refrigerant loop into the auxiliary circulating refrigerant loop when the auxiliary heating working mode is turned on.

[0006] According to the heat pump system described above, the refrigerant management system comprises a refrigerant storage device, and the refrigerant storage device is configured to be capable of collecting the refrigerant drawn from the main circulating refrigerant loop and introducing the collected refrigerant into the auxiliary circulating refrigerant loop.

[0007] According to the heat pump system described above, the refrigerant management system further comprises: a main liquid introduction pipeline connected between the refrigerant storage device and a low-pressure side of the main circulating refrigerant loop; a main liquid discharge pipeline connected between the refrigerant storage device and a high-pressure side of the main circulating refrigerant loop; an auxiliary liquid introduction pipeline connected between the refrigerant storage device and a low-pressure side of the auxiliary circulating refrigerant loop; and an auxiliary liquid discharge pipeline connected between the refrigerant storage device and a high-pressure side of the auxiliary circulating refrigerant loop.

[0008] According to the heat pump system described above, the second auxiliary heat exchanger has a first fluid channel and a second fluid channel, wherein the first fluid channel is connected in the main circulating refrigerant loop, the second fluid channel is connected in the auxiliary circulating refrigerant loop, and the refrigerants in the first fluid channel and the second fluid channel are capable of exchanging heat.

[0009] According to the heat pump system described

above, the first main heat exchanger and the first auxiliary heat exchanger are both water-side heat exchangers, the first main heat exchanger has a first water channel, the first auxiliary heat exchanger has a second water channel, and the first water channel communicates with the second water channel, so that water can flow from the first water channel to the second water channel.

[0010] According to the heat pump system described above, the main liquid introduction pipeline, the main liquid discharge pipeline, the auxiliary liquid introduction pipeline and the auxiliary liquid discharge pipeline are respectively provided with corresponding solenoid valves for respectively controlling the connection and disconnection of the pipelines; and the main liquid introduction pipeline and the auxiliary liquid introduction pipeline are respectively provided with a liquid introduction one-way valve being configured to allow the refrigerant can only flow in a direction discharging from the refrigerant storage device, the main liquid discharge pipeline and the auxiliary liquid discharge pipeline are respectively provided with a liquid discharge one-way valve, and the liquid discharge one-way valve is configured to allow the refrigerant can only flow in a direction discharging toward the refrigerant storage device.

[0011] According to the heat pump system described above, the heat pump system further comprises: a control device, wherein the control device is respectively connected to respective corresponding solenoid valves on the main liquid introduction pipeline, the main liquid discharge pipeline, the auxiliary liquid introduction pipeline and the auxiliary liquid discharge pipeline, and can control the connection and disconnection of each solenoid valve; and the control device is connected to the main compressor and the auxiliary compressor, and can control the on and off of the main compressor and the auxiliary compressor.

[0012] According to the heat pump system described above, the ratio range of the air displacement of the main compressor to the air displacement of the auxiliary compressor is (2-4): 1.

[0013] In the present application, the heat pump system has a refrigeration working mode, a heating working mode and an auxiliary heating working mode, and the heat pump system has a main circulating refrigerant loop, an auxiliary circulating refrigerant loop and a refrigerant management system. In the auxiliary heating working mode, the main circulating refrigerant loop and the auxiliary circulating refrigerant loop work simultaneously. The main circulating refrigerant loop and the auxiliary circulating refrigerant loop share one set of refrigerant management system. In the auxiliary heating working mode, the refrigerant management system is capable of distributing an idle part of a refrigerant used in the main circulating refrigerant loop to the auxiliary circulating refrigerant loop, so that there is no need to separately configure a refrigerant for the auxiliary circulating refrigerant loop, thus saving the amount of the refrigerant used in the entire heat pump system. In the auxiliary heating

working mode, two fluid channels in a second auxiliary heat exchanger can exchange heat, which can improve the efficiency of the heat pump system. The first main heat exchanger and the second main heat exchanger share a water channel, which can quickly increase the outlet temperature of hot water.

Brief Description of the Drawings

[0014]

FIG. 1A is a block diagram of a heat pump system according to one embodiment of the present application;

FIG. 1B is a block diagram of a main circulating refrigerant loop and an auxiliary circulating refrigerant loop in FIG. 1A;

FIG. 1C is a schematic diagram of a group of one-way valves in FIG. 1B;

FIG. 2 is a flow path diagram of the heat pump system in a refrigeration working mode;

FIG. 3 is a flow path diagram of the heat pump system in a heating working mode;

FIG. 4 is a flow path diagram of the heat pump system in the auxiliary working mode;

FIG. 5 is a block diagram of the heat pump system in FIG. 1A, showing a refrigerant management system; and

FIG. 6 is a schematic structural block diagram of a control device of the heat pump system.

Detailed Description of Embodiments

[0015] Various specific embodiments of the present application will be described below with reference to the accompanying drawings, which form a part of the present specification. It should be understood that although directional terms, such as "front", "rear", etc., are used herein to describe various exemplary structural parts and elements of the present application, these terms are used herein for convenience of description only, and are determined based on example orientations shown in the drawings. Since the embodiments disclosed in the present application can be arranged in different directions, these directional terms are for illustration only and should not be regarded as limiting. Wherever possible, the same or similar reference numerals are used in the present application to refer to the same components.

[0016] FIG. 1A is a block diagram of a heat pump system 100 according to one embodiment of the present application. As shown in FIG. 1A, the heat pump system

100 comprises a main circulating refrigerant loop 101, an auxiliary circulating refrigerant loop 102 and a refrigerant management system 103. The heat pump system 100 has a refrigeration working mode, a heating working mode and an auxiliary heating working mode. When the ambient temperature is too high in summer, the heat pump system starts the refrigeration working mode to reduce the temperature of an operational environment. When the temperature is low in winter, such as 0°C, the heat pump system starts the heating working mode to raise the temperature of the operational environment. When the temperature is too low in winter, such as below -15°C, the heating working mode of the heat pump system cannot meet the heat demand of the operational environment. The heat pump system starts the auxiliary heating working mode to increase the heating capacity and raise the temperature of the operational environment. In the refrigeration working mode and the heating working mode, the main circulating refrigerant loop 101 is turned on, and the auxiliary circulating refrigerant loop 102 is turned off; and in the auxiliary heating working mode, both the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 are turned on.

[0017] FIG. 1B is a block diagram of the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 in FIG. 1A, in which the refrigerant management system 103 is omitted, so that the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 can be shown more clearly. FIG. 1C is a schematic diagram of a group of one-way valves 140 in FIG. 1B for illustrating the structure of the group of the one-way valves 140. Referring to FIG. 1A and FIG. 1B, the auxiliary circulating refrigerant loop 102 comprises an auxiliary compressor 121, a first auxiliary heat exchanger 122, an auxiliary throttling device 124 and a second auxiliary heat exchanger 126, and the refrigerant in the auxiliary circulating refrigerant loop 102 can circulate in an auxiliary circulating heating working condition flow direction. The main circulating refrigerant loop 101 has: a main compressor 111, a first main heat exchanger 112, a second auxiliary heat exchanger 126, a main throttling device 114 and a second main heat exchanger 116; the refrigerant in the main circulating refrigerant loop 101 can circulate in a main circulating refrigeration working condition flow direction or circulate in a main circulating heating working condition flow direction, and wherein the second auxiliary heat exchanger 126 has two fluid channels, that is, a first fluid channel 137 and a second fluid channel 138, the first fluid channel 137 is connected in the main circulating refrigerant loop 101, and the second fluid channel 138 is connected in the auxiliary circulating refrigerant loop 102.

[0018] As shown in FIG. 1B, the main compressor 111 has an air suction end 106 and an air exhaust end 105, the first main heat exchanger 112 has a first flow port 133 and a second flow port 134, the main throttling device 114 has an inlet end 115 and an outlet end 117, and the

second main heat exchanger 116 has a first flow port 143 and a second flow port 144. The first fluid channel 137 of the second auxiliary heat exchanger 126 connected in the main circulating refrigerant loop 101 has an inlet 136 and an outlet 135.

[0019] A valve device in the main circulating refrigerant loop 101 comprises a main control valve group, which is used to control the refrigerant in the main circulating refrigerant loop 101 to circulate in the refrigeration working condition flow direction or the heating working condition flow direction. As an example, the main control valve group comprises a four-way reversing valve 118. The four-way reversing valve 118 has a first flow port 181, a second flow port 182, a third flow port 183 and a fourth flow port 184, and the four flow ports of the four-way reversing valve 118 can form two pairs of flow channels, wherein the first pair of flow channels enable the first flow port 181 and the second flow port 182 to be in fluid communication, and the third flow port 183 and the fourth flow port 184 to be in fluid communication; and the second pair of flow channels enable the first flow port 181 and the fourth flow port 184 to be in fluid communication and the second flow port 182 and the third flow port 183 to be in fluid communication. The first flow port 181 of the four-way reversing valve 118 is connected to the first flow port 133 of the first main heat exchanger 112, the second flow port 182 of the four-way reversing valve 118 is connected to the air suction end 106 of the main compressor 111, the third flow port 183 of the four-way reversing valve 118 is connected to the second flow port 144 of the second main heat exchanger 116, and the fourth flow port 184 of the four-way reversing valve 118 is connected to the air exhaust end 105 of the main compressor 111.

[0020] The valve device in the main circulating refrigerant loop 101 further comprises a group of one-way valves 140. Referring to FIG. 1B and FIG. 1C, the group of one-way valves 140 comprises a first valve 151, a second valve 152, a third valve 153 and a fourth valve 154. The first valve 151, the second valve 152, the third valve 153 and the fourth valve 154 are connected in sequence through pipelines, thus forming an annular shape. The second flow port 134 of the first main heat exchanger 112 is connected on the pipeline between the first valve 151 and the second valve 152, the inlet 136 of the first fluid channel 137 of the second auxiliary heat exchanger 126 is connected on the pipeline between the valve 152 and the third valve 153, the first flow port 143 of the second main heat exchanger 116 is connected on the pipeline between the third valve 153 and the fourth valve 154, and the outlet end 117 of the main throttling device 114 is connected on the pipeline between the first valve 151 and the fourth valve 154.

[0021] As an example, the first valve 151, the second valve 152, the third valve 153 and the fourth valve 154 are one-way valves, so that the refrigerant fluid can only flow in one direction from the inlet end of each valve to the outlet end thereof. Those skilled in the art may know that in other embodiments, other control valves or control

valve groups may also be used to realize the function of the one-way valve.

[0022] Specifically, the inlet end of the first valve 151 is in fluid communication with the outlet end 117 of the main throttling device 114, and the outlet end of the first valve 151 is in fluid communication with the second flow port 134 of the first main heat exchanger 112, so that the refrigerant in the first valve 151 can only flow in the direction from the main throttling device 114 to the first main heat exchanger 112. The inlet end of the second valve 152 is in fluid communication with the second flow port 134 of the first main heat exchanger 112, and the outlet end of the second valve 152 is in fluid communication with the inlet 136 of the first fluid channel 137 of the second auxiliary heat exchanger 126, so that the refrigerant in the second valve 152 can only flow in the direction from the first main heat exchanger 112 to the second auxiliary heat exchanger 126. The inlet end of the third valve 153 is in fluid communication with the first flow port 143 of the second main heat exchanger 116, and the outlet end of the third valve 153 is in fluid communication with the inlet 136 of the first fluid channel 137, so that the refrigerant in the third valve 153 can only flow in the direction from the second main heat exchanger 116 to the second auxiliary heat exchanger 126. The inlet end of the fourth valve 154 is in fluid communication with the outlet end 117 of the main throttling device 114, and the outlet end of the fourth valve 154 is in fluid communication with the first flow port 143 of the second main heat exchanger 116, so that the refrigerant in the fourth valve 154 can only flow in the direction from the main throttling device 114 to the second main heat exchanger 116. No matter whether the main circulating refrigerant loop 101 works in the refrigeration working mode or the heating working mode, the structural design of the group of one-way valves 140, the first fluid channel 137 of the second auxiliary heat exchanger 126 and the main throttling device 114 makes it possible for the refrigerant flowing to the group of one-way valves 140 from one heat exchanger (the first main heat exchanger 112 or the second main heat exchanger 116) must sequentially flow through the first fluid channel 137 of the second auxiliary heat exchanger 126 and the main throttling device 114, then flow back to the group of one-way valves 140, and finally flow to another heat exchanger (the second main heat exchanger 116 or the first main heat exchanger 112).

[0023] As shown in FIG. 1B, the auxiliary compressor 121, the first auxiliary heat exchanger 122, the auxiliary throttling device 124 and the second auxiliary heat exchanger 126 are connected in series through pipelines, so that the refrigerant can circulate in the auxiliary circulating refrigerant loop 102.

[0024] The auxiliary compressor 121 has an air suction end 166 and an air exhaust end 165, and the second fluid channel 138 of the second auxiliary heat exchanger 126 has an inlet 145 and an outlet 146. The refrigerant can pass through the air exhaust end 165 of the auxiliary

compressor 121, the first auxiliary heat exchanger 122, the auxiliary throttling device 124, the second fluid channel 138 of the second auxiliary heat exchanger 126, and then return to the air suction end 166 of the auxiliary compressor 121.

[0025] In the embodiment shown in FIGs. 1A-1B, the second auxiliary heat exchanger 126 is a liquid-to-liquid heat exchanger. In this embodiment, the liquid-liquid heat exchanger refers to a fluorine-fluorine heat exchanger in which a fluorine refrigerant flows. In other embodiments, other types of liquid refrigerants may also flow in the second auxiliary heat exchanger 126. Since the first fluid channel 137 of the second auxiliary heat exchanger 126 is connected to the main circulating refrigerant loop 101, and the second fluid channel 138 of the second auxiliary heat exchanger 126 is connected to the auxiliary circulating refrigerant loop 102, the refrigerant in the main circulating refrigerant loop 101 and the refrigerant in the auxiliary circulating refrigerant loop 102 can exchange heat through the second auxiliary heat exchanger 126. As an example, in order to enhance the heat exchange effect of the refrigerant fluid in the first fluid channel 137 and the second fluid channel 138, the inlets and outlets of the two fluid channels can be staggered so that the refrigerant in the first fluid channel 137 and the refrigerant fluid in the second fluid channel 138 flow in opposite directions. As shown in the figures, the outlet 135 of the first fluid channel 137 and the inlet 145 of the second fluid channel 138 are arranged on the same side of the second auxiliary heat exchanger 126, and the inlet 136 of the first fluid channel 137 and the outlet 146 of the second fluid channel 138 are arranged on the same side of the second auxiliary heat exchanger 126. Thus, as shown in the figures, the first fluid channel 137 is configured to be up-in and down-out, while the second fluid channel 138 is configured to be down-in and up-out. In other embodiments, the first fluid channel 137 may also be arranged to be left-in and right-out, and the second fluid channel 138 may be arranged to be right-in and left-out, as long as the flow directions of the two channels are opposite.

[0026] The first main heat exchanger 112 and the first auxiliary heat exchanger 122 are water-side heat exchangers. The first main heat exchanger 112 and the first auxiliary heat exchanger 122 are used for exchanging heat with water. The first main heat exchanger 112 and the first auxiliary heat exchanger 122 have respective independent refrigerant fluid channels, which communicate with the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102, respectively. The first main heat exchanger 112 has a first water channel 141, the first auxiliary heat exchanger 122 has a second water channel 142, the first water channel 141 and the second water channel 142 are connected, and the water passes through the first water channel 141 to exchange heat with the refrigerant in the first main heat exchanger 112, and then enters the second water channel 142 to exchange heat with the first auxiliary heat ex-

changer 122. That is to say, the first main heat exchanger 112 and the first auxiliary heat exchanger 122 share a water channel. After sequentially exchanging heat with the refrigerant, the first water channel 141 and the second water channel 142 supply heat or cold to the operational environment.

[0027] In some embodiments, the first main heat exchanger 112 and the first auxiliary heat exchanger 122 may also each have independent water channels. In other embodiments, the first main heat exchanger 112 and the first auxiliary heat exchanger 122 may also be other types of heat exchangers, such as air-side heat exchangers.

[0028] The second main heat exchanger 116 is an air-side heat exchanger that can exchange heat with air.

[0029] The heat pump system 100 in the present application has a refrigeration working mode, a heating working mode and an auxiliary heating working mode. These working modes will be described in detail below with reference to FIG. 2, FIG. 3 and FIG. 4.

[0030] FIG. 2 is a flow path diagram of the heat pump system 100 in the refrigeration working mode. As shown in FIG. 2, when the heat pump system 100 is in the refrigeration working mode, the main circulating refrigerant loop 101 is in a working state, the main compressor 111 is turned on, and the refrigerant circulates in the main circulating refrigerant loop 101. The auxiliary circulating refrigerant loop 102 is in an idle state and the auxiliary compressor 121 is turned off.

[0031] In the main circulating refrigerant loop 101, the first pair of flow channels of the four-way reversing valve 118 are connected, and the second pair of flow channels are disconnected, that is, the first flow port 181 and the second flow port 182 are in fluid communication, and the third flow port 183 and the fourth flow port 184 are connected, at the same time, the first flow port 181 and the fourth flow port 184 are disconnected, and the second flow port 182 and the third flow port 183 are disconnected. Thus, the high-pressure refrigerant gas discharged by the main compressor 111 first enters the second main heat exchanger 116 through the fourth flow port 184 and the third flow port 183. The first flow port 143 of the second main heat exchanger 116 is respectively connected to the third valve 153 and the fourth valve 154 in the group of one-way valves 140, wherein the flow direction of the third valve 153 is the same as the flow direction of the refrigerant, and the flow direction of the fourth valve 154 is opposite to the flow direction of the refrigerant. Therefore, the refrigerant condensed by the second main heat exchanger 116 enters the first fluid channel 137 of the second auxiliary heat exchanger 126 through the third valve 153, and then passes through the main throttling device 114 to become a low-pressure refrigerant. The outlet end 117 of the main throttling device 114 is connected to the first valve 151 and the fourth valve 154 in the group of one-way valves 140, wherein the flow direction of the first valve 151 and the fourth valve 154 is the same as the flow direction of the refrigerant, however,

the refrigerant can only pass through the first valve 151 but cannot pass through the fourth valve 154. This is because the outlet end of the fourth valve 154 is connected to the first flow port 143 of the second main heat exchanger 116, the inlet end of the fourth valve 154 is connected to the outlet end 117 of the main throttling device 114, and the second main heat exchanger 116 is located upstream of the main throttling device, and the pressure near the first flow port 143 of the second main heat exchanger 116 is higher than the pressure at the outlet end 117 of the main throttling device 114, that is, the pressure at the outlet end of the fourth valve 154 is higher than the pressure at the inlet end, so that the refrigerant cannot enter the fourth valve 154. Then the refrigerant enters the second flow port 134 of the first main heat exchanger 112 through the first valve 151. The refrigerant is evaporated into a low-pressure refrigerant gas in the first main heat exchanger 112, and finally flows from the first main heat exchanger 112 into the air suction end 106 of the main compressor 111 to complete the circulation of the refrigerant. That is to say, in the refrigeration working mode, the refrigerant fluid flow path in the main circulating refrigerant loop 101 is as follows: main compressor 111→second main heat exchanger 116→second auxiliary heat exchanger 126→main throttling device 114→first main heat exchanger 112→main compressor 111. In the refrigeration working mode, the water in the first water channel 141 in the first main heat exchanger 112 exchanges heat with the refrigerant and then lowers the temperature to realize the function of external cold supply of the main circulating refrigerant loop 101.

[0032] The auxiliary circulating refrigerant loop 102 is in an idle state, the auxiliary compressor 121 is turned off, and there is only a small amount of refrigerant in the auxiliary circulating refrigerant loop 102, and these refrigerants do not circulate.

[0033] In the refrigeration working mode, the second auxiliary heat exchanger 126 acts as a sub-cooler in the main circulating refrigerant loop 101 and does not participate in the circulation of the refrigerant of the auxiliary circulating refrigerant loop 102. It is worth mentioning that although in this refrigeration working mode, the second auxiliary heat exchanger 126 acts as a sub-cooler in the main circulating refrigerant loop 101, since there is no refrigerant circulating in the auxiliary circulating refrigerant loop 102, the auxiliary circulating refrigerant loop 102 cannot provide cooling capacity for the second auxiliary heat exchanger 126, and the second auxiliary heat exchanger 126 can only provide a small amount of subcooling capacity for the main circulating refrigerant loop 101 by relying on natural heat dissipation to the outside air. In order to reduce the flow resistance of the refrigerant in the main circulating refrigerant loop 101, the second auxiliary heat exchanger 126 may also be bypassed. For example, a pipeline having a valve is provided between the inlet 136 and the outlet 135 of the first fluid channel 137 of the second auxiliary heat exchanger 126, so that

the second auxiliary heat exchanger 126 may be bypassed when the auxiliary circulating refrigerant loop 102 is not in operation, and the refrigerant circulation resistance of the main circulating refrigerant loop 101 is reduced.

[0034] FIG. 3 is a flow path diagram of the heat pump system 100 in the heating working mode. As shown in FIG. 3, when the heat pump system 100 is in the heating working mode, the main circulating refrigerant loop 101 is in the working state, the main compressor 111 is turned on, and the refrigerant circulates in the main circulating refrigerant loop 101. The auxiliary circulating refrigerant loop 102 is in an idle state, and the auxiliary compressor 121 is turned off.

[0035] In the main circulating refrigerant loop 101, the first pair of flow channels of the four-way reversing valve 118 are disconnected, and the second pair of flow channels are connected, that is, the first flow port 181 and the second flow port 182 are disconnected, and the third flow port 183 and the fourth flow port 184 are disconnected, and the first flow port 181 and the fourth flow port 184 are in fluid communication and the second flow port 182 and the third flow port 183 are in fluid communication. The high-pressure refrigerant gas discharged from the air exhaust end 105 of the main compressor 111 enters the first main heat exchanger 112 for condensation, and the second flow port 134 of the first main heat exchanger 112 is in communication with the outlet port of the first valve 151 and the inlet end of the second valve 152 of the group of one-way valves 140, that is, the flow direction of the first valve 151 is opposite to the flow direction of the refrigerant, and the flow direction of the second valve 152 is the same as the flow direction of the refrigerant, and the refrigerant can only flow through the second valve 152 but cannot pass through the first valve 151. The refrigerant enters the first fluid channel 137 of the second auxiliary heat exchanger 126 through the second valve 152, and then passes through the main throttling device 114 to become a low-pressure refrigerant. The outlet port 117 of the main throttling device 114 is connected to the inlet port of the first valve 151 and the inlet port of the fourth valve 154 in the group of one-way valves 140, that is, the flow direction of the first valve 151 and the fourth valve 154 are both same as the flow direction of the refrigerant, but the refrigerant can only pass through the fourth valve 154 but cannot pass through the first valve 151. This is because the outlet end of the first valve 151 is connected to the second flow port 134 of the first main heat exchanger 112, the inlet end of the first valve 151 is connected to the outlet end 117 of the main throttling device 114, and the first main heat exchanger 112 is located upstream of the main throttling device 114, and the pressure near the second flow port 134 of the first main heat exchanger 112 is higher than the pressure near the outlet end 117 of the main throttling device 114, that is, the pressure at the outlet end of the first valve 151 is higher than the pressure at the inlet end, so that the refrigerant cannot enter the first valve 151. The refrigerant

enters the first flow port 143 of the second main heat exchanger 116 through the fourth valve 154. The refrigerant is evaporated into a low-pressure refrigerant gas in the second main heat exchanger 116, and finally flows from the second main heat exchanger 116 into the main compressor 111 to complete the circulation of the refrigerant. That is to say, in the heating working mode, the refrigerant fluid flow path in the main circulating refrigerant loop 101 is as follows: main compressor 111→first main heat exchanger 112→second auxiliary heat exchanger 126→main throttling device 114→second main heat exchanger 116→main compressor 111. In the heating working mode, the water in the first water channel 141 in the first main heat exchanger 112 exchanges heat with the refrigerant to raise the temperature so as to realize the function of the external heat supply of the main circulating refrigerant loop 101.

[0036] The auxiliary circulating refrigerant loop 102 is in an idle state, the auxiliary compressor 121 is turned off, there is no or only a small amount of refrigerants in the auxiliary circulating refrigerant loop 102, and this small amount of refrigerants do not circulate.

[0037] In the heating working mode, the second auxiliary heat exchanger 126 acts as a sub-cooler in the main circulating refrigerant loop 101 and does not participate in the circulation of the refrigerant of the auxiliary circulating refrigerant loop 102. It is worth mentioning that although in this heating working mode, the second auxiliary heat exchanger 126 acts as a sub-cooler in the main circulating refrigerant loop 101, since there is no refrigerant circulating in the auxiliary circulating refrigerant loop 102, the auxiliary circulating refrigerant loop 102 cannot provide cooling capacity for the second auxiliary heat exchanger 126, and the second auxiliary heat exchanger 126 can only provide a small amount of super-cooling capacity for the main circulating refrigerant loop 101 by relying on natural heat dissipation to the outside air. In order to reduce the flow resistance of the refrigerant in the main circulating refrigerant loop 101, the second auxiliary heat exchanger 126 may also be bypassed. For example, a pipeline having a valve is provided between the inlet 136 and the outlet 135 of the first fluid channel 137 of the second auxiliary heat exchanger 126, so that the second auxiliary heat exchanger 126 may be bypassed when the auxiliary circulating refrigerant loop 102 is not in operation, and the refrigerant circulation resistance of the main circulating refrigerant loop 101 is reduced.

[0038] FIG. 4 is a flow path diagram of the heat pump system 100 in the auxiliary heating working mode. As shown in FIG. 4, when the heat pump system 100 is in the heating working mode, the main circulating refrigerant loop 101 is in the working state, the main compressor 111 is turned on, and the refrigerant circulates in the main circulating refrigerant loop 101. The auxiliary circulating refrigerant loop 102 is also in the working state, the auxiliary compressor 121 is turned on, and the refrigerant circulates in the auxiliary circulating refrigerant loop 102.

[0039] In the auxiliary heating working mode shown in FIG. 4, the main circulating refrigerant loop 101 is the same as the heating working mode of the main circulating refrigerant loop 101 shown in FIG. 3, and the refrigerant fluid flow path in the main circulating refrigerant loop 101 is as follows: main compressor 111→first main heat exchanger 112→second auxiliary heat exchanger 126→main throttling device 114→second main heat exchanger 116→main compressor 111. In the auxiliary heating working mode, the water in the first water channel 141 in the first main heat exchanger 112 exchanges heat with the refrigerant to raise the temperature so as to realize the function of the external heat supply of the main circulating refrigerant loop 101.

[0040] The auxiliary circulating refrigerant loop 102 is in the working state, the refrigerant enters the first auxiliary heat exchanger 122 from the air exhaust end 165 of the auxiliary compressor 121 for condensation, and the condensed refrigerant enters the auxiliary throttling device 124 to become a low-pressure refrigerant, the low-pressure refrigerant enters the second fluid channel 138 of the second auxiliary heat exchanger 126, exchanges heat with the fluid in the first fluid channel 137 of the second auxiliary heat exchanger 126 and is evaporated, then enters the air suction end 166 of the auxiliary compressor 121 to complete the circulation of the refrigerant. That is, in the auxiliary heating working mode, the refrigerant fluid flow path in the auxiliary circulating refrigerant loop 102 is as follows: auxiliary compressor 121→first auxiliary heat exchanger 122→auxiliary throttling device 124→second auxiliary heat exchanger 126→auxiliary compressor 121. In the auxiliary heating working mode, the water in the second water channel 142 in the first auxiliary heat exchanger 122 exchanges heat with the refrigerant to raise the temperature so as to realize the function of the external heat supply of the auxiliary circulating refrigerant loop 102. For the heat pump system 100, the external heat supply is jointly completed by the first main heat exchanger 112 and the first auxiliary heat exchanger 122.

[0041] In the auxiliary heating working mode, the second auxiliary heat exchanger 126 acts as a sub-cooler in the main circulating refrigerant loop 101 and acts as an evaporator in the auxiliary circulating refrigerant loop 102. The refrigerant in the first fluid channel 137 of the second auxiliary heat exchanger 126 is a high-temperature and high-pressure refrigerant in the main circulating refrigerant loop 101; the refrigerant in the second fluid channel 138 of the second auxiliary heat exchanger 126 is a low-temperature and low-pressure refrigerant in the auxiliary circulating refrigerant loop 102, and the two can exchange heat therebetween, so that the heat in the main circulating refrigerant loop 101 can be transferred to the auxiliary circulating refrigerant loop 102, so that in the auxiliary circulating refrigerant loop 102, the evaporation temperature of the second auxiliary heat exchanger 126 is less affected by the environment or not affected by the ambient temperature, and the heat exchange efficiency

is higher.

[0042] In the auxiliary heating working mode, the air displacement of the main compressor 111 is configured to be greater than the air displacement of the auxiliary compressor 121. In some embodiments of the present application, in the auxiliary heating working mode, the ratio range of the air displacement of the main compressor 111 to the air displacement of the auxiliary compressor 121 is (2-4): 1. In an embodiment of the present application, the ratio of the air displacement of the main compressor 111 to the air displacement of the auxiliary compressor 121 is 3:1.

[0043] In the auxiliary heating working mode, the first water channel 141 of the first main heat exchanger 112 is in communication with the second water channel 142 of the first auxiliary heat exchanger 122, and the water exchanges heat with the first main heat exchanger 112 and continues to enter the first auxiliary heat exchanger 122 for heat exchange after the temperature is raised. When the ambient temperature is low, the temperature of the water after heat exchange through the first main heat exchanger 112 is still low, which cannot meet the heating demand, and the heat exchange again through the first auxiliary heat exchanger 122 can further raise the temperature, which can meet the heating demand, realize the auxiliary heating function, and save water consumption at the same time.

[0044] FIG. 5 is a block diagram of the heat pump system 100 in FIG. 1A, showing the refrigerant management system 103 and the control device 550. When the heat pump system 100 operates in the refrigeration working mode, the ambient temperature is relatively high, the amount of the refrigerant that can be evaporated by the evaporator is relatively large, and the amount of the refrigerant circulating in the refrigeration working condition is relatively large; however, when the heat pump system operates in the heating working mode, the ambient temperature is relatively low, the amount of the refrigerant that can be evaporated by the evaporator is relatively small, and the amount of the refrigerant circulating in the heating working condition is relatively small. That is to say, in the same circulating refrigerant loop, the amount of the refrigerant required for the refrigeration working condition is greater than the amount of the refrigerant required for the heating working condition. When designing a heat pump system capable of generating cold and heat, the amount of the refrigerant is usually designed according to the parameters of the refrigeration working condition. When running the heating working condition, a part of the refrigerant will not participate in the circulation. In the present application, the refrigerant management system 103 is used to manage the amount of the refrigerant in the main circulating refrigerant loop 101 under different working conditions. The heat pump system 100 is communicably connected to the control device 550, and the refrigerant management system 103, the main compressor 111, the auxiliary compressor 121 and the four-way reversing valve 118 in the heat pump system

100 are controlled by the control device 550.

[0045] As shown in FIG. 5, the refrigerant management system 103 comprises a refrigerant storage device 531, and a main liquid introduction pipeline 511 connected between the refrigerant storage device 531 and a low-pressure side of the main circulating refrigerant loop 101; a main liquid discharge pipeline 512 connected between the refrigerant storage device 531 and a high-pressure side of the main circulating refrigerant loop 101; an auxiliary liquid introduction pipeline 513 connected between the refrigerant storage device 531 and a low-pressure side of the auxiliary circulating refrigerant loop 102; and an auxiliary liquid discharge pipeline 514 connected between the refrigerant storage device 531 and a high-pressure side of the auxiliary circulating refrigerant loop 102. In one embodiment of the present application, the main liquid introduction pipeline 511 is connected to the outlet end of the main throttling device 114, and the main liquid discharge pipeline 512 is connected to the inlet end of the first fluid channel 137 of the second auxiliary heat exchanger 126, the auxiliary liquid introduction pipeline 513 is connected to the outlet end of the auxiliary throttling device 124, and the auxiliary liquid discharge pipeline 514 is connected to the inlet end of the auxiliary throttling device 124.

[0046] The main liquid introduction pipeline 511 is provided with a main liquid introduction solenoid valve 521; the main liquid discharge pipeline 512 is provided with a main liquid discharge solenoid valve 522; the auxiliary liquid introduction pipeline 513 is provided with an auxiliary liquid introduction solenoid valve 523; and the auxiliary liquid discharge pipeline 514 is provided with an auxiliary liquid discharge solenoid valve 524. The main liquid introduction solenoid valve 521, the main liquid discharge solenoid valve 522, the auxiliary liquid introduction solenoid valve 523 and the auxiliary liquid discharge solenoid valve 524 are respectively connected to the control device 550, so as to receive control signals from the control device 550 for respectively controlling the connection and disconnection of each pipeline.

[0047] When the heat pump system starts the refrigeration working mode, the control device 550 sends a signal so that the main compressor 111 is turned on, the main liquid introduction solenoid valve 521 is turned on, the main liquid discharge solenoid valve 522 is turned off, and the refrigerant storage device 531 is in communication with the main circulating refrigerant loop 101. The pressure in the refrigerant storage device 531 is greater than the pressure at the outlet end 117 of the main throttling device 114, so that the refrigerant in the refrigerant storage device 531 enters the main circulating refrigerant loop 101, when the refrigerant in the main circulating refrigerant loop 101 can meet the requirements for a set working condition, the main liquid introduction solenoid valve 521 is turned off, and the refrigerant storage device 531 is disconnected from the main circulating refrigerant loop 101. The refrigerant in the main circulating refrigerant loop 101 circulates in the refrigeration

working condition direction. At this time, there is no or only a small amount of refrigerant in the refrigerant storage device 531, and the pressure in the refrigerant storage device 531 is reduced.

[0048] When the heat pump system is shut down from the refrigeration working mode, the main liquid discharge solenoid valve 522 is turned on, the main liquid introduction solenoid valve 521 is turned off, and the pressure at the inlet 136 of the first fluid channel 137 of the second auxiliary heat exchanger 126 connected to the main liquid discharge pipeline 512 in the main circulating refrigerant loop 101 is greater than the pressure in the refrigerant storage device 531, so that the refrigerant enters the refrigerant storage device 531 from the main liquid discharge pipeline. Next, the main compressor 111 and the main liquid discharge solenoid valve 522 are turned off, and most of the refrigerants in the heat pump system 100 are stored in the refrigerant storage device 531.

[0049] During the operation of the refrigeration working mode, with the change of the actual working conditions, the refrigerant in the main circulating refrigerant loop 101 may be too little or too much, and the control device 550 can control the main liquid introduction solenoid valve 521 and the main liquid discharge solenoid valve 522 to adjust the amount of the refrigerant participating in the circulation in the main circulating refrigerant loop 101.

[0050] Similarly, when the heat pump system starts the heating working mode, the control device sends a signal so that the main compressor 111 is turned on, the main liquid introduction solenoid valve 521 is turned on, the main liquid discharge solenoid valve 522 is turned off, and the refrigerant storage device 531 is in communication with the main circulating refrigerant loop 101. The pressure in the refrigerant storage device 531 is greater than the pressure at the outlet end 117 of the main throttling device 114, so that the refrigerant in the refrigerant storage device 531 enters the main circulating refrigerant loop 101 from the main liquid introduction pipeline 511, and when the refrigerant in the main circulating refrigerant loop 101 meets the requirements for a set working condition, the main liquid introduction solenoid valve 521 is turned off, and the refrigerant storage device 531 is disconnected from the main circulating refrigerant loop 101. The refrigerant in the main circulating refrigerant loop 101 circulates in the heating working condition direction. Since the refrigerant required in the heating working condition is less than the refrigerant required in the refrigeration working condition, after the refrigerant storage device 531 provides enough refrigerant to the main circulating refrigerant loop 101, a certain amount of refrigerant is stored in the refrigerant storage device 531.

[0051] When the heat pump system is turned off from the heating working mode, the main liquid discharge solenoid valve 522 is turned on, the main liquid introduction solenoid valve 521 is turned off, and the pressure at the inlet 136 of the first fluid channel 137 of the second auxiliary heat exchanger 126 connected to the main liquid discharge pipeline 512 in the main circulating refrigerant

loop 101 is greater than the pressure in the refrigerant storage device 531, so that the refrigerant enters the refrigerant storage device 531 from the main liquid discharge pipeline 512. Next, the main compressor 111 and the main liquid discharge solenoid valve 522 are turned off, and most of the refrigerants in the main circulating refrigerant loop 101 are stored in the refrigerant storage device 531.

[0052] Similarly, during the operation of the heating working mode, with the change of the actual working conditions, the refrigerant in the main circulating refrigerant loop 101 may be too little or too much, and the control device 550 can control the main liquid introduction solenoid valve 521 and the main liquid discharge solenoid valve 522 to adjust the amount of the refrigerant participating in the circulation in the main circulating refrigerant loop 101.

[0053] When the ambient temperature is too low and the heating capacity of the main circulating refrigerant loop 101 cannot meet the demand, the auxiliary heating working mode needs to be turned on. In the auxiliary heating working mode, the main circulating refrigerant loop 101 is turned on first, and then the auxiliary circulating refrigerant loop 102 is turned on. The control device sends a signal so that the main compressor 111 is turned on, the main liquid introduction solenoid valve 521 is turned on, the main liquid discharge solenoid valve 522 is turned off, and the refrigerant storage device 531 is in communication with the main circulating refrigerant loop 101. The pressure in the refrigerant storage device 531 is greater than the pressure at the outlet end 117 of the main throttling device 114, so that the refrigerant in the refrigerant storage device 531 enters the main circulating refrigerant loop 101 from the main liquid introduction pipeline 511, and when the refrigerant in the main circulating refrigerant loop 101 meets the requirements for a set working condition, the main liquid introduction solenoid valve 521 is turned off, and the refrigerant storage device 531 is disconnected from the main circulating refrigerant loop 101. At the same time that the main compressor 111 is turned on, the control device sends a signal so that the auxiliary compressor 121 is turned on, the auxiliary liquid introduction solenoid valve 523 is turned on, the auxiliary liquid discharge solenoid valve 524 is turned off, and the refrigerant storage device 531 is in communication with the auxiliary circulating refrigerant loop 102. The pressure in the refrigerant storage device 531 is greater than the pressure at the outlet end of the auxiliary throttling device 124, so that the refrigerant in the refrigerant storage device 531 enters the auxiliary circulating refrigerant loop 102 from the auxiliary liquid introduction pipeline 513, and when the refrigerant in the auxiliary circulating refrigerant loop 102 can meet the requirements for a set working condition, the auxiliary liquid introduction solenoid valve 523 is turned off, and the refrigerant storage device 531 is disconnected from the auxiliary circulating refrigerant loop 102. In the auxiliary heating working mode, the refrigerant in the refrigerant

storage device 531 can be used by the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102.

[0054] When the heat pump system is turned off from the auxiliary heating working mode, the auxiliary circulating refrigerant loop 102 is turned off first, and then the main circulating refrigerant loop 101 is turned off. When the auxiliary circulating refrigerant loop 102 is turned off, the auxiliary liquid discharge solenoid valve 524 is turned on, the auxiliary liquid introduction solenoid valve 523 is turned off, and the pressure at the inlet end of the auxiliary throttling device 124 in the auxiliary circulating refrigerant loop 102 is greater than the pressure in the refrigerant storage device 531, so that the refrigerant enters the refrigerant storage device 531 from the auxiliary liquid discharge pipeline. Next, the auxiliary compressor 121 and the auxiliary liquid discharge solenoid valve 524 are turned off, and most of the refrigerants in the auxiliary circulating refrigerant loop 102 are also stored in the refrigerant storage device 531. Subsequently, when the main circulating refrigerant loop 101 is turned off, the main liquid discharge solenoid valve 522 is turned on, the main liquid introduction solenoid valve 521 is turned off, and the pressure at the inlet end of the first fluid channel 137 of the second auxiliary heat exchanger 126 connected to the main liquid discharge pipeline 512 in the main circulating refrigerant loop 101 is greater than the pressure in the refrigerant storage device 531, so that the refrigerant enters the refrigerant storage device 531 from the liquid discharge pipeline. Next, the main compressor 111 and the main liquid discharge solenoid valve 522 are turned off, and most of the refrigerants in the main circulating refrigerant loop 101 are stored in the refrigerant storage device 531, so that most of the refrigerants in the heat pump system 100 are stored in the refrigerant storage device 531.

[0055] Similarly, during the operation of the auxiliary heating working mode, with the change of the actual working conditions, the refrigerant in the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 may be too little or too much, and the control device 550 can control the main liquid introduction solenoid valve 521, the main liquid discharge solenoid valve 522, the auxiliary liquid introduction solenoid valve 523 and the auxiliary liquid discharge solenoid valve 524 to adjust the amount of the refrigerant participating in the circulation in the main circulating refrigerant loop 101.

[0056] The main liquid introduction pipeline 511 is provided with a liquid introduction one-way valve 551, and the auxiliary liquid introduction pipeline 513 is provided with a liquid introduction one-way valve 553, and the liquid introduction one-way valve 551 and the liquid introduction one-way valve 553 are configured to allow the refrigerant can only flow in a direction discharging from the refrigerant storage device 531 to prevent the refrigerant from flowing backward during the liquid introduction. The main liquid discharge line 512 is provided with a liquid discharge one-way valve 552, and the auxiliary

liquid discharge pipeline 514 is provided with a liquid discharge one-way valve 554, and the liquid discharge one-way valve 552 and the liquid discharge one-way valve 554 are configured to allow the refrigerant can only flow in a direction discharging to the refrigerant storage device 531 to prevent the refrigerant from flowing backward during the liquid introduction.

[0057] When the heat pump system is turned off, most of the refrigerants are stored in the refrigerant storage device 531, and there is a small amount of refrigerant in the main circulating refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 to prevent the refrigerant in the water-side heat exchanger from exchanging heat with the water pipeline to cause the water to freeze due to the change of the ambient temperature. And the trace loss of the refrigerant caused by complicated pipelines can be reduced.

[0058] FIG. 6 is a schematic structural block diagram of the control device 550 of the heat pump system 100. As shown in FIG. 6, the heat pump system further comprises a control device 550. The control device 550 comprises a bus 686, a processor 684, an input interface 688, an output interface 692 and a memory 698 having a control program 687. All components in the control device 550, including the processor 684, the input interface 688, the output interface 692 and the memory 698 are communicatively connected to the bus 686, so that the processor 684 can control the operation of the input interface 688, the output interface 692 and the memory 698. Specifically, the memory 698 is used to store programs, instructions and data, and the processor 684 reads programs, instructions and data from the memory 698 and can write data to the memory 698. The processor 684 controls the operation of the input interface 688 and the output interface 692 by executing programs and instructions read from the memory 698.

[0059] As shown in FIG. 6, the output interface 692 is respectively in communication connection with the main compressor 111, the auxiliary compressor 121, the four-way reversing valve 118, the main throttling device 114, the main liquid introduction solenoid valve 521, and the main liquid discharge solenoid valve 522, the auxiliary liquid introduction solenoid valve 523 and the auxiliary liquid discharge solenoid valve 524 through respective connections. The processor 684 controls the operation of the heat pump system 100 by executing programs and instructions in the memory 698. More specifically, the control device 550 can receive a signal 689 through the input interface 688, such as receive an operation request signal (such as sending a request through a control panel) or a system status signal (such as whether the actual amount of the refrigerant in the refrigerant loop matches the refrigerant demand) for controlling the heat pump system 100, so as to perform corresponding control, and send a control signal to each controlled component through the output interface 692, so that the heat pump system 100 can operate in multiple working modes.

[0060] In the present application, the main circulating

refrigerant loop 101 and the auxiliary circulating refrigerant loop 102 share one set of refrigerant management system, so that in the auxiliary heating working mode, the refrigerant management system can distribute the idle refrigerant in the main circulating refrigerant loop 101 to the auxiliary circulating refrigerant loop 102 to save the amount of refrigerant used in the heat pump system. In the auxiliary heating working mode, the two fluid channels in the second auxiliary heat exchanger can exchange heat, which can improve the heat exchange efficiency of the heat pump system. The first main heat exchanger and the second main heat exchanger share a water channel, which can rapidly raise the water temperature.

[0061] Although only some of the features of the present application have been illustrated and described herein, various modifications and changes will occur to those skilled in the art. It is therefore to be understood that the appended claims are intended to cover all such improvements and changes as fall within the true spirit of the present application.

Claims

1. A heat pump system, **characterized by** comprising:

- a main circulating refrigerant loop (101), the main circulating refrigerant loop (101) having a main compressor (111), a first main heat exchanger (112), a main throttling device (114) and a second main heat exchanger (116), wherein the main compressor (111) is configured to allow a refrigerant in the main circulating refrigerant loop (101) to circulate in a main circulating refrigeration working condition flow direction or circulate in a main circulating heating working condition flow direction that is opposite to the main circulating refrigeration working condition flow direction;
- an auxiliary circulating refrigerant loop (102), the auxiliary circulating refrigerant loop (102) comprising an auxiliary compressor (121), a first auxiliary heat exchanger (122), an auxiliary throttling device (124) and a second auxiliary heat exchanger (126), wherein the auxiliary compressor (121) is configured to allow a refrigerant in the auxiliary circulating refrigerant loop (102) to circulate in an auxiliary circulating heating working condition flow direction; and
- a refrigerant management system (103), wherein the refrigerant management system (103) is controllably connected to or disconnected from the main circulating refrigerant loop (101) and the auxiliary circulating refrigerant loop (102), separately; and the refrigerant management system (103) is configured to be capable of distributing a refrigerant used for the main

circulating refrigerant loop (101) to the auxiliary circulating refrigerant loop (102).

2. The heat pump system according to Claim 1, characterized in that:

- the heat pump system has a refrigeration working mode, a heating working mode and an auxiliary heating working mode;
- in the refrigeration working mode, the refrigerant in the main circulating refrigerant loop (101) circulates in the main circulating refrigeration working condition flow direction, and the auxiliary compressor (121) is turned off;
- in the heating working mode, the refrigerant in the main circulating refrigerant loop (101) circulates in the main circulating heating working condition flow direction, and the auxiliary compressor (121) is turned off; and
- in the auxiliary heating working mode, the refrigerant in the main circulating refrigerant loop (101) circulates in the main circulating heating working condition flow direction, and the refrigerant in the auxiliary circulating refrigerant loop (102) circulates in the auxiliary circulating heating working condition flow direction.

3. The heat pump system according to Claim 2, characterized in that:

- the refrigerant management system (103) is configured to be capable of introducing part of the refrigerant used in the main circulating refrigerant loop (101) into the auxiliary circulating refrigerant loop (102) when the auxiliary heating working mode is turned on.

4. The heat pump system according to Claim 3, characterized in that:

- the refrigerant management system (103) comprises a refrigerant storage device (531), the refrigerant storage device (531) being configured to be capable of collecting the refrigerant drawn from the main circulating refrigerant loop (101) and introducing the collected refrigerant into the auxiliary circulating refrigerant loop (102).

5. The heat pump system according to Claim 4, characterized in that:

- the refrigerant management system (103) further comprises:
- a main liquid introduction pipeline (511) connected between the refrigerant storage device (531) and a low-pressure side of the main circulating refrigerant loop (101);

- a main liquid discharge pipeline (512) connected between the refrigerant storage device (531) and a high-pressure side of the main circulating refrigerant loop (101);

- an auxiliary liquid introduction pipeline (513) connected between the refrigerant storage device (531) and a low-pressure side of the auxiliary circulating refrigerant loop (102); and
- an auxiliary liquid discharge pipeline (514) connected between the refrigerant storage device (531) and a high-pressure side of the auxiliary circulating refrigerant loop (102).

6. The heat pump system according to Claim 1, characterized in that:

- the second auxiliary heat exchanger (126) has a first fluid channel (137) and a second fluid channel (138), wherein the first fluid channel (137) is connected in the main circulating refrigerant loop (101), the second fluid channel (138) is connected in the auxiliary circulating refrigerant loop (102), and wherein the refrigerants in the first fluid channel (137) and the second fluid channel (138) are capable of exchanging heat.

7. The heat pump system according to Claim 1, characterized in that:

- the first main heat exchanger (112) and the first auxiliary heat exchanger (122) are both water-side heat exchangers, the first main heat exchanger (112) has a first water channel (141), the first auxiliary heat exchanger (122) has a second water channel (142), and the first water channel (141) connects with the second water channel (142), so that water can flow from the first water channel (141) to the second water channel (142).

8. The heat pump system according to Claim 5, characterized in that:

- the main liquid introduction pipeline (511), the main liquid discharge pipeline (512), the auxiliary liquid introduction pipeline (513) and the auxiliary liquid discharge pipeline (514) are respectively provided with corresponding solenoid valves for respectively controlling connection and disconnection of the pipeline; and
- the main liquid introduction pipeline (511) and the auxiliary liquid introduction pipeline (513) are respectively provided with a liquid introduction one-way valve being configured to allow the refrigerant to flow only in a direction of discharging from the refrigerant storage device (531), and the main liquid discharge pipeline (512) and the auxiliary liquid discharge pipeline (514) are re-

spectively provided with a liquid discharge one-way valve being configured to allow the refrigerant to flow only in a direction of discharging toward the refrigerant storage device (531).

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9. The heat pump system according to Claim 8, **characterized by** further comprising:

- a control device (550), wherein the control device (550) is connected to corresponding solenoid valves on the main liquid introduction pipeline (511), the main liquid discharge pipeline (512), the auxiliary liquid introduction pipeline (513) and the auxiliary liquid discharge pipeline (514), respectively, and can control the connection and disconnection of each solenoid valve; and the control device (550) is connected to the main compressor (111) and the auxiliary compressor (121), and can control the on and off of the main compressor (111) and the auxiliary compressor (121).

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10. The heat pump system according to Claim 1, **characterized in that:**

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- the ratio range of the air displacement of the main compressor (111) to the air displacement of the auxiliary compressor (121) is (2-4): 1.

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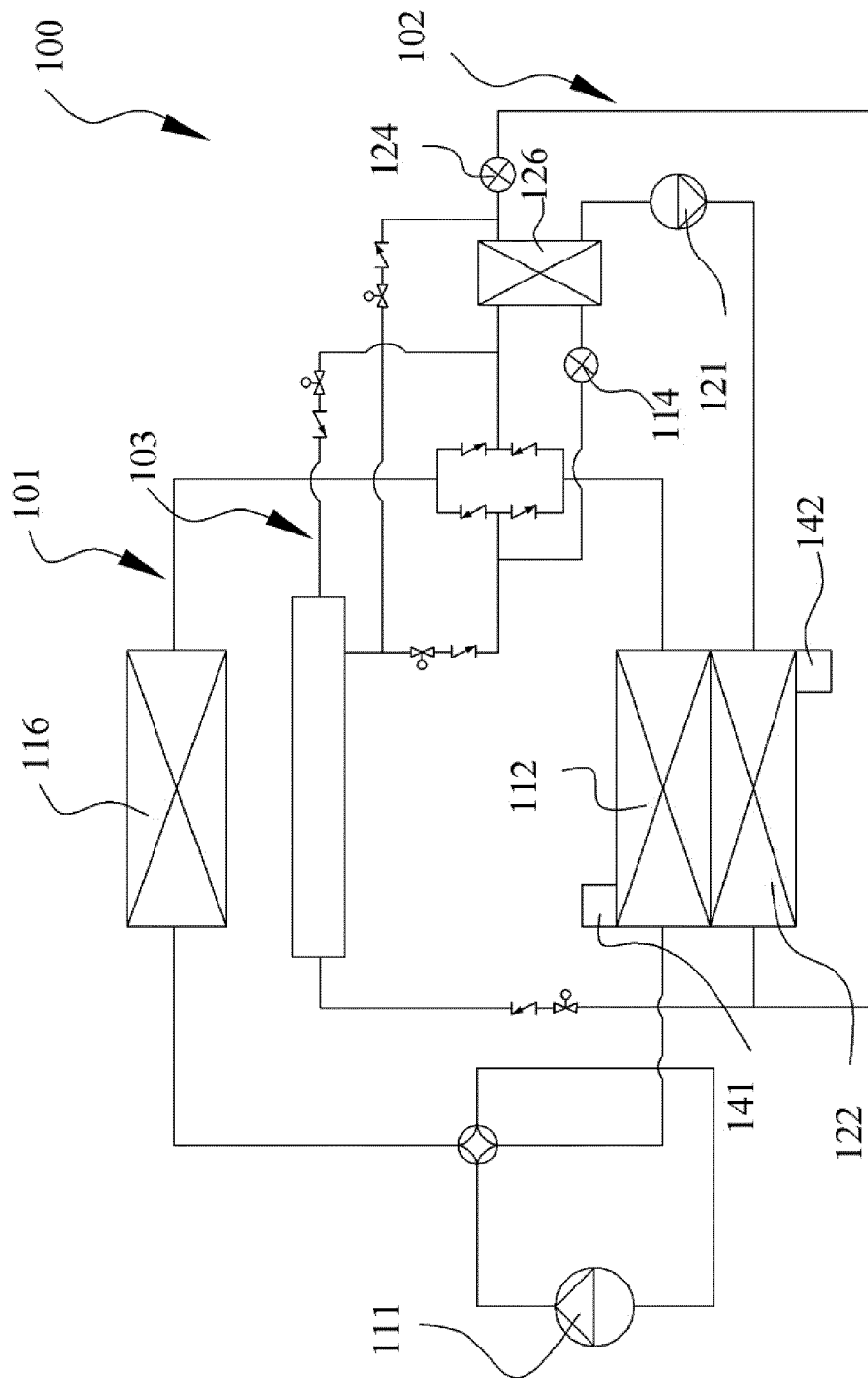


FIG. 1A

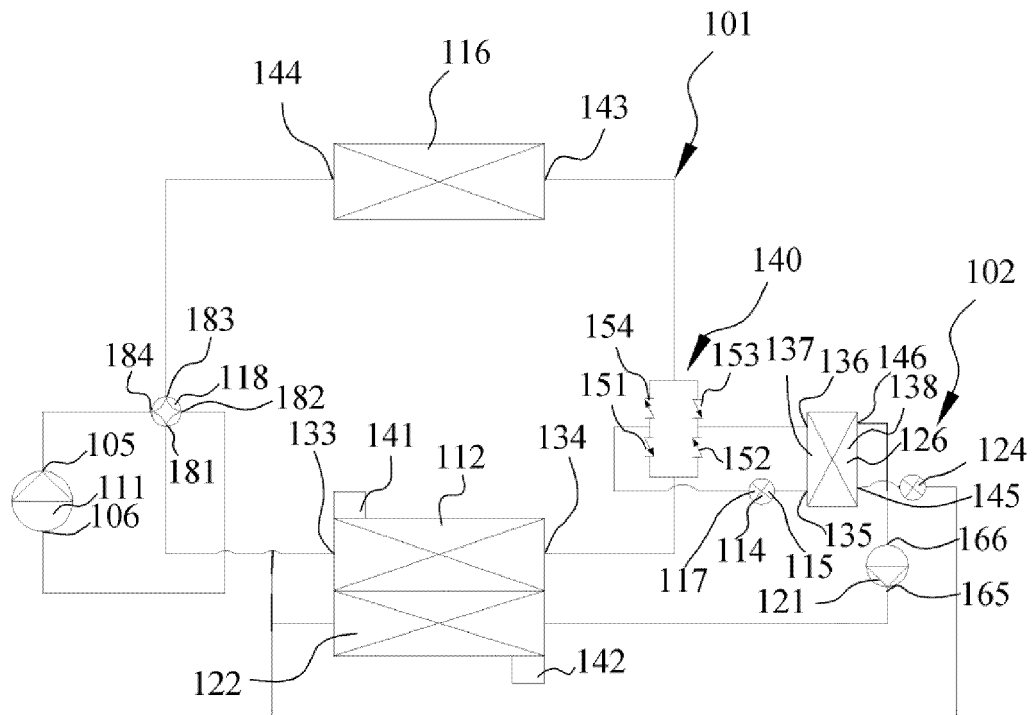


FIG. 1B

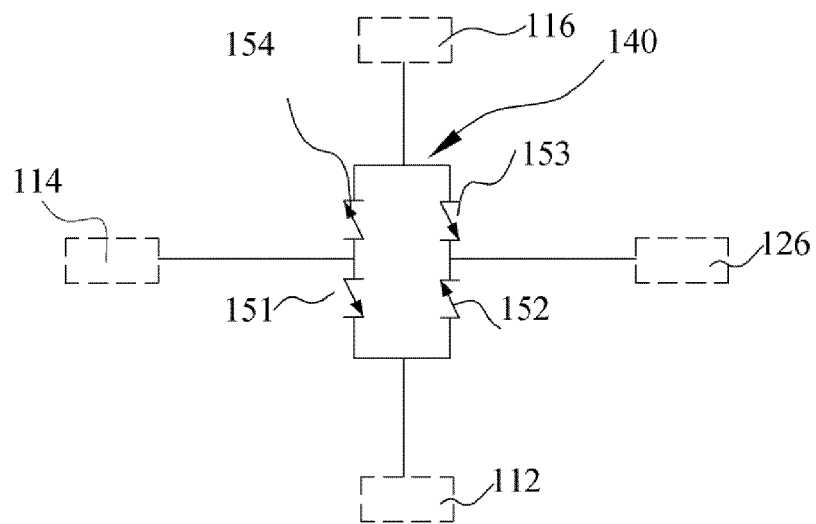


FIG. 1C

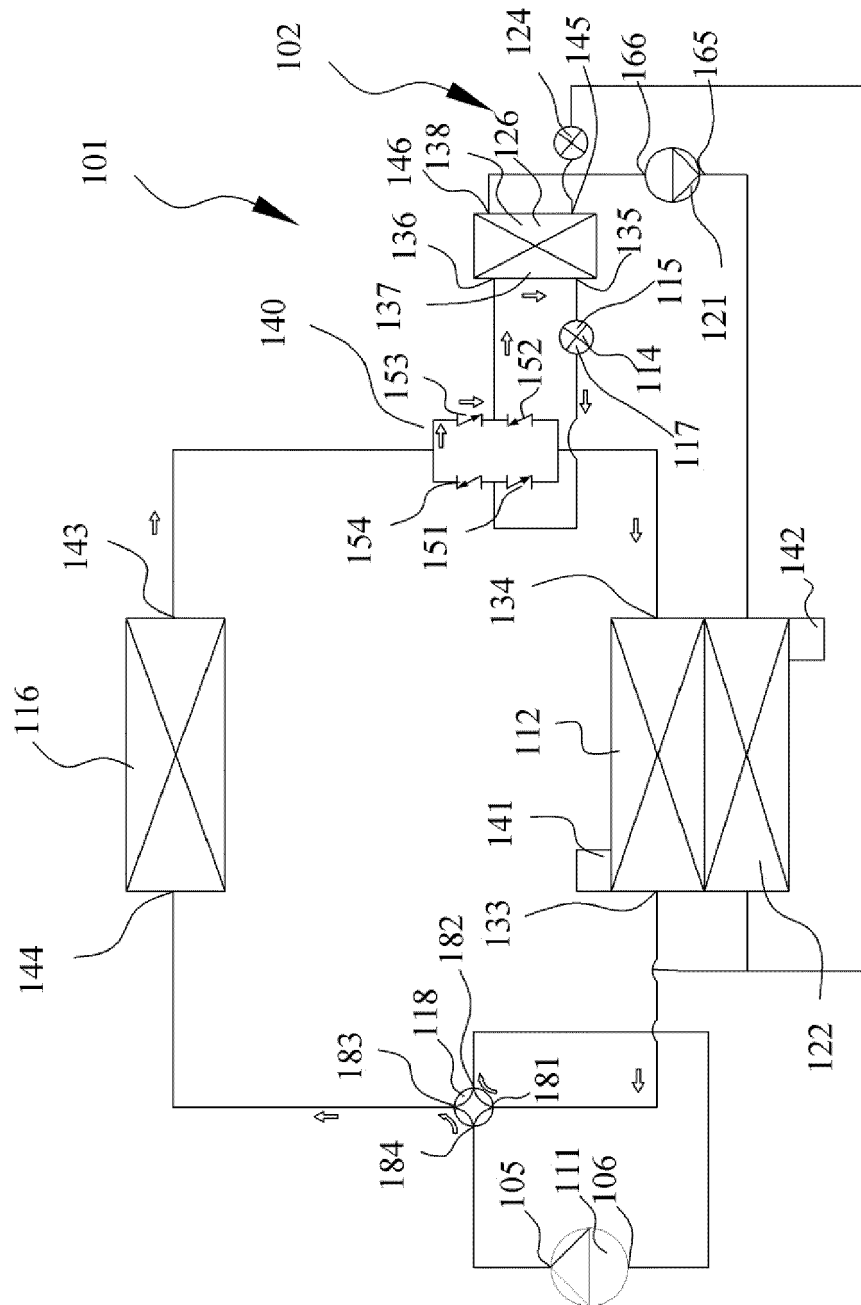


FIG. 2

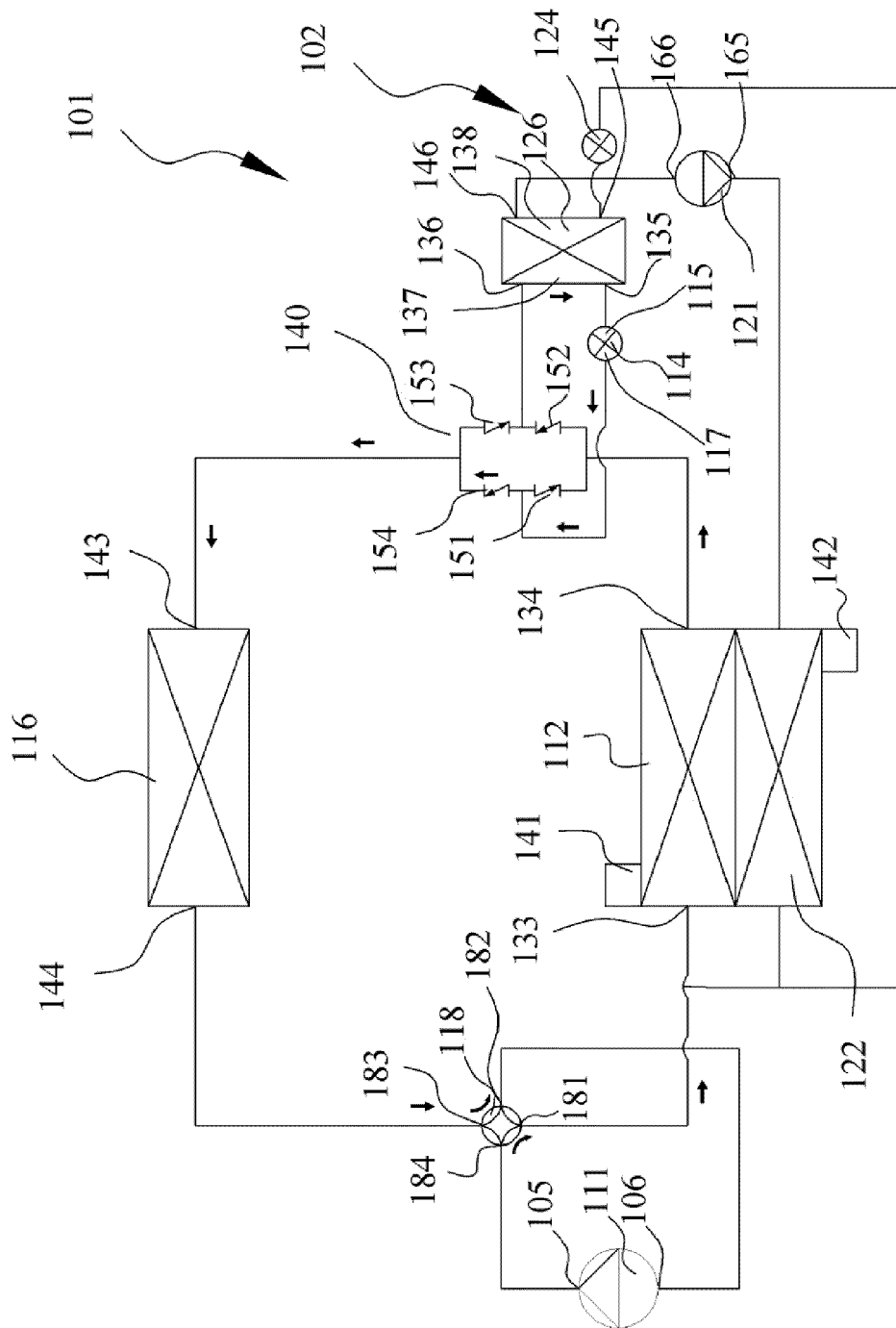


FIG. 3

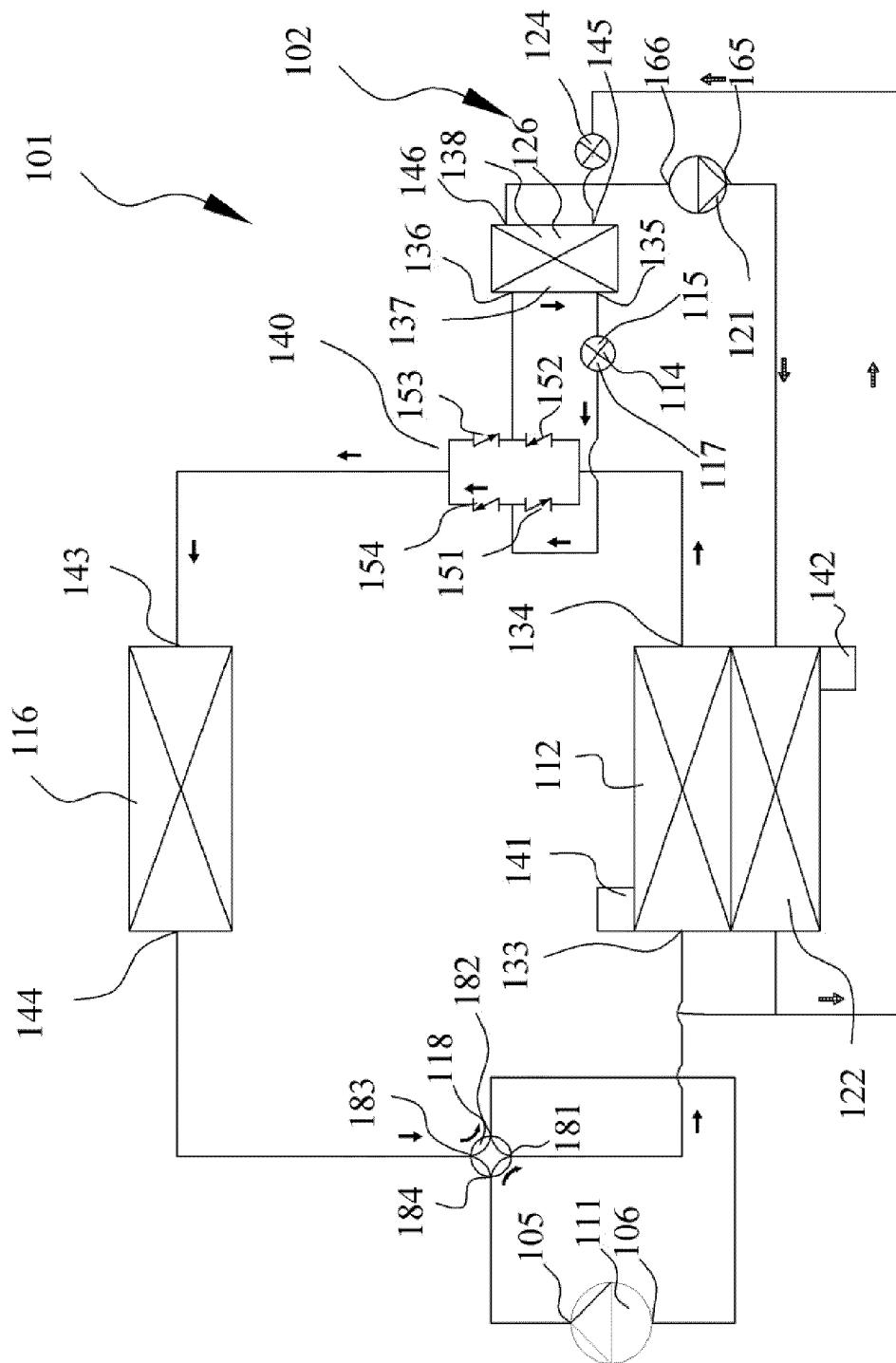
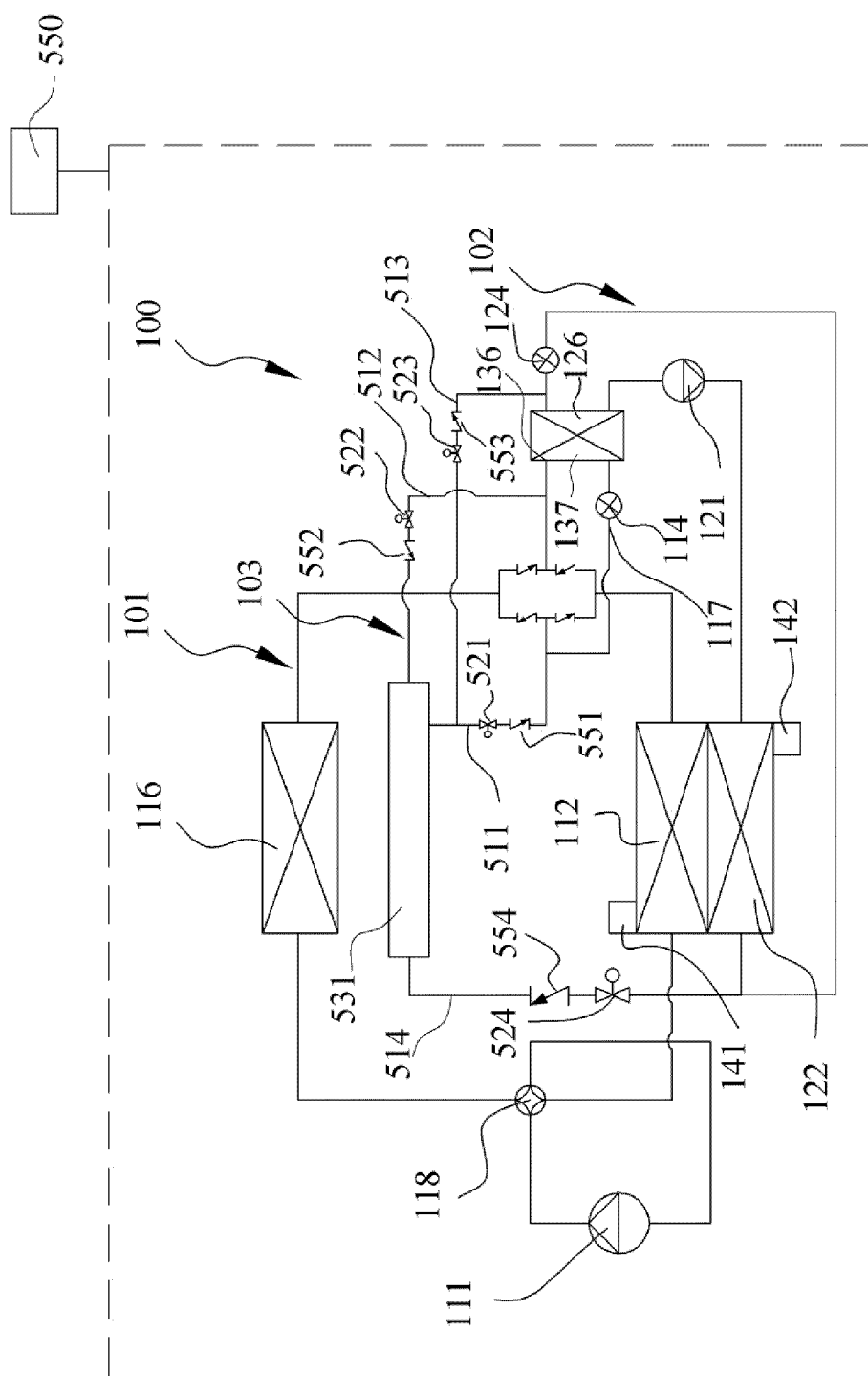


FIG. 4



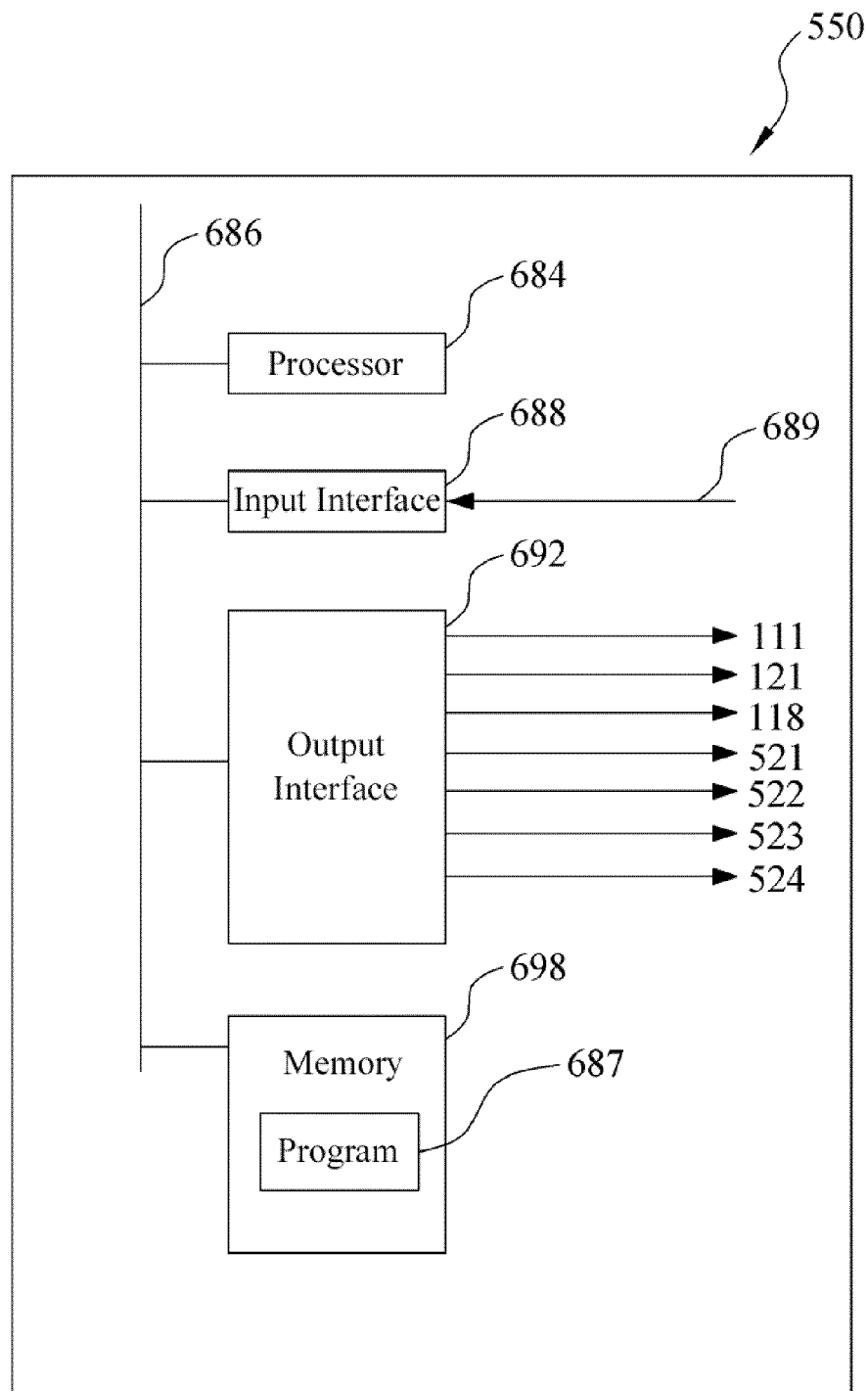


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/104465

5	A. CLASSIFICATION OF SUBJECT MATTER F25B 30/02(2006.01)i; F25B 49/02(2006.01)i; F25B 41/20(2021.01)i; F25B 1/00(2006.01)i; F24H 4/02(2006.01)i; F25B 13/00(2006.01)i; F25B 30/06(2006.01)i; F25B 43/00(2006.01)i; F25B 29/00(2006.01)i; F25B 9/00(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC																	
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F25B; F24H Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																	
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNABS; CNTXT; CNKI; VEN; WOTXT; USTXT; EPTXT: 主循环, 主流路, 主制冷, 主回路, 第一循环, 第一流路, 第一制冷, 第一回路, 第1循环, 第1流路, 第1制冷, 第1回路, 压缩机, 制热, 制冷, 空调, 热泵, 制冷, 辅助, 制冷剂, 冷媒, main, first, refrigerant, heat pump, air condition, compressor																	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>CN 106871479 A (JIANGSU TENSUN ELECTRICAL APPLIANCE CO., LTD.) 20 June 2017 (2017-06-20) description, paragraphs [0037]-[0057], and figures 2-5</td> <td>1-10</td> </tr> <tr> <td>X</td> <td>CN 2890744 Y (SUN, Yingzhen) 18 April 2007 (2007-04-18) description page 3 line 7 - page 6 line 21, figure 1</td> <td>1-10</td> </tr> <tr> <td>X</td> <td>CN 206618147 U (JIANGSU TENSUN ELECTRICAL APPLIANCE CO., LTD.) 07 November 2017 (2017-11-07) description, paragraphs [0037]-[0057], and figures 2-4</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 205119545 U (XI'AN JIAOTONG UNIVERSITY) 30 March 2016 (2016-03-30) entire document</td> <td>1-10</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	CN 106871479 A (JIANGSU TENSUN ELECTRICAL APPLIANCE CO., LTD.) 20 June 2017 (2017-06-20) description, paragraphs [0037]-[0057], and figures 2-5	1-10	X	CN 2890744 Y (SUN, Yingzhen) 18 April 2007 (2007-04-18) description page 3 line 7 - page 6 line 21, figure 1	1-10	X	CN 206618147 U (JIANGSU TENSUN ELECTRICAL APPLIANCE CO., LTD.) 07 November 2017 (2017-11-07) description, paragraphs [0037]-[0057], and figures 2-4	1-10	A	CN 205119545 U (XI'AN JIAOTONG UNIVERSITY) 30 March 2016 (2016-03-30) entire document	1-10
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																
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35	☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.																	
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45	Date of the actual completion of the international search 13 August 2021																	
50	Date of mailing of the international search report 09 September 2021																	
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	Authorized officer Facsimile No. (86-10)62019451 Telephone No.																	

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PCT/CN2021/104465

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	106871479	A	20 June 2017	CN	106871479	B	10 January 2020
				US	20200158386	A1	21 May 2020
				WO	2018188269	A1	18 October 2018
CN	2890744	Y	18 April 2007	None			
CN	206618147	U	07 November 2017	None			
CN	205119545	U	30 March 2016	None			