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(54) INTEGRATED HEAT PUMP SYSTEM AND CONTROL METHOD THEREFOR

(57) The present application provides an integrated heat pump system and a control method therefor. The integrated heat pump system (100) comprises: an air-conditioning indoor unit (110) having a first indoor heat exchanger set (111a, 111b) and a first throttle valve assembly (112a, 112b); a display cabinet indoor unit (120) having a second indoor heat exchanger set (121a, 121b) and a second throttle valve assembly (122a, 122b); and an outdoor unit (130) connected to the air-conditioning indoor unit and the display cabinet indoor unit through pipelines. The outdoor unit comprises: at least two compressors (133a, 133b); an outdoor heat exchanger set (131); a third throttle valve assembly (132); and a mode switch valve assembly configured to switch at least one of the first indoor heat exchanger set and the outdoor heat exchanger set to be connected to the downstream of at least two compressors.

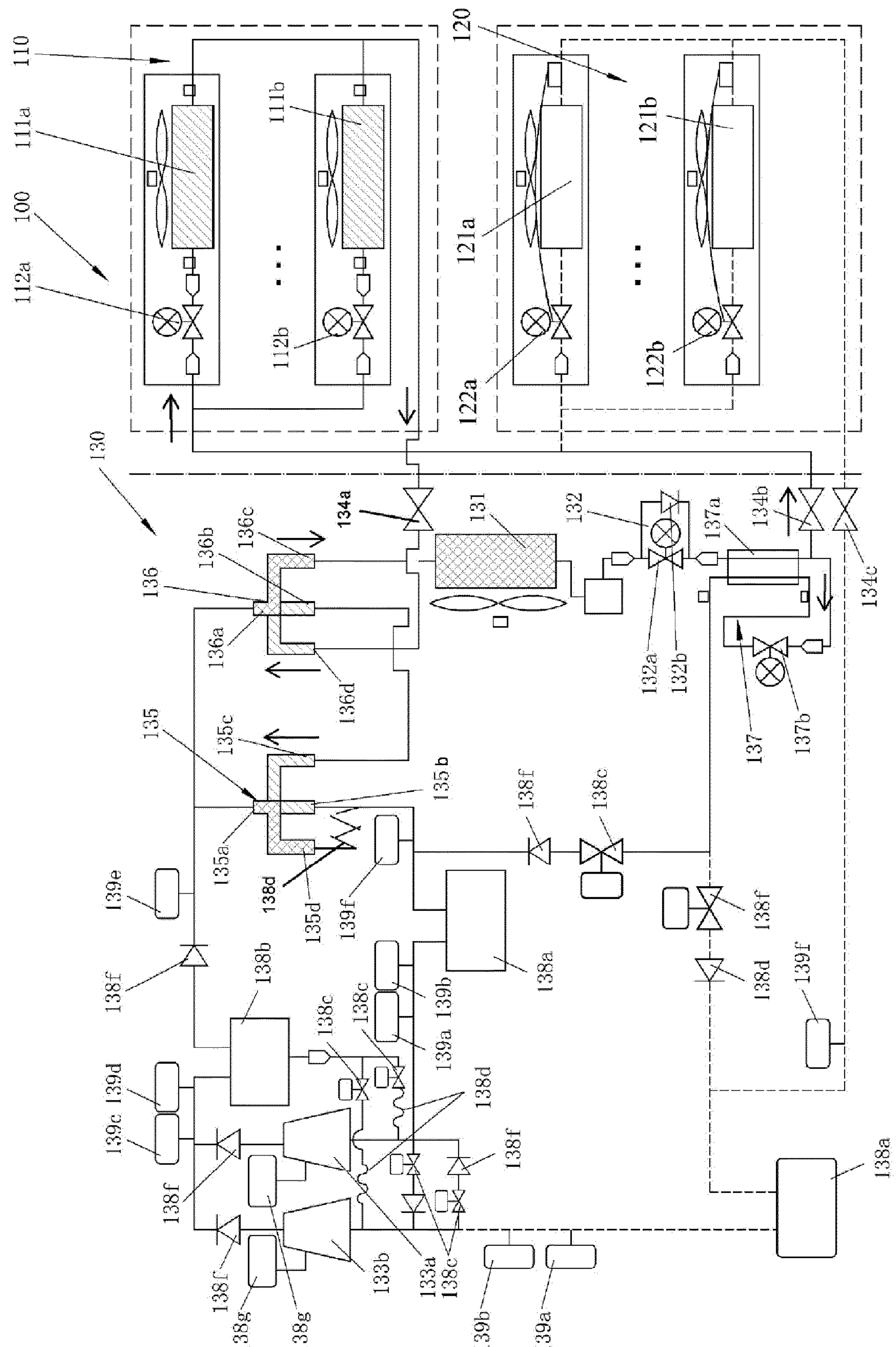
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Figure 1

Description

[0001] The present invention relates to the field of integrated equipment for air conditioning and refrigeration and freezing. More specifically, the present invention relates to an integrated heat pump system and a control method therefor.

[0002] At present, there are two types of refrigeration or heat pump systems with mature technologies that are widely applied. One is a refrigeration system with relatively low temperature used in the refrigeration and freezing field, and the other is a heat pump system that regulates air temperature by refrigeration and heating used in homes or commercial buildings. Considering that there is a constant demand for refrigeration for the equipment in the refrigeration and freezing field, whereas there may also be a demand for heating in the domestic or commercial field (i.e., there is the possibility of recycling the cold energy wasted when producing heat in the domestic or commercial field), the prior art has focused on integrating these two types of systems to recycle the heat to some extent, so as to improve system efficiency. A commonly used solution is to provide corresponding outdoor units and indoor units for the two systems, and to form pipeline connections between multiple outdoor units and indoor units, thereby achieving heat recovery in partial operating modes. However, the integration level of this type of equipment is low, and the units take up a lot of space, so it is not inconvenient in application.

[0003] The present invention provides an integrated heat pump system and a control method therefor, so as to improve the integration problem of the integrated heat pump system.

[0004] According to a first aspect of the present invention, an integrated heat pump system is provided, which comprises: an air-conditioning indoor unit having a first indoor heat exchanger set and a first throttle valve assembly for controlling the on-off of flow paths and throttling degree; a display cabinet indoor unit having a second indoor heat exchanger set and a second throttle valve assembly for controlling on-off of flow paths and throttling degree, wherein the second indoor heat exchange sets have a temperature regulating setpoint different from that of the first indoor heat exchanger set; and an outdoor unit connected to the air-conditioning indoor unit and the display cabinet indoor unit through pipelines. The outdoor unit comprises: at least two compressors connected in parallel and configured to provide different evaporation temperatures respectively; an outdoor heat exchanger set; a third throttle valve assembly configured to control the on-off of flow paths and throttling degree of the outdoor heat exchanger set; and a mode switch valve assembly configured to guide refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections.

[0005] Optionally, in a refrigeration mode: the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly is controlled.

[0006] Optionally, the refrigeration mode comprises one or more of the following modes: an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated; a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the first throttle valve assembly turns off the flow paths; and the second compressor of the at least two compressors is activated; a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly and the second throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; and an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode.

[0007] Optionally, in the heating mode: the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly are controlled to turn on the flow paths; and the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assemblies is controlled.

[0008] Optionally, the heating mode comprises one or more of the following modes: an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the third throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated; a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly turn on the flow paths, and the second throttle valve assembly provides a controlled throttling degree; and the at least two compressors are activated; a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, and the second throttle valve assembly and the third throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the third throttle valve assembly turns off the flow paths; and the at least two compressors are activated.

[0009] Optionally, the mode switch valve assembly comprises: a first four-way valve and a second four-way valve arranged in parallel; wherein, the first four-way valve has a first port connected to the exhaust ports of the at least two compressors, a second port connected to the suction ports of the at least two compressors, a third port connected to the second four-way valve, and a fourth port connected to the second port through capillary tubes; and wherein the second four-way valve has a fifth port connected to the exhaust ports of the at least two compressors, a sixth port connected to the first four-way valve, a seventh port connected to the outdoor heat exchanger set, and an eighth port connected to the first indoor heat exchanger set.

[0010] Optionally, the integrated heat pump system further comprises a subcooling branch provided with a subcooling heat exchanger and an additional throttle element. The subcooling branch is connected from the third throttle valve assembly to the suction ports of the at least two compressors through the first flow path of the subcooling heat exchanger, the additional throttle element, and the second flow path of the subcooling heat exchanger.

[0011] According to a second aspect of the present invention, a control method for the integrated heat pump system as described above is provided, which comprises: operating a refrigeration mode, guiding the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the third throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly; or operating a heating mode, guiding the refrigerant flowing out of the at least two compressors into at least the first indoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the first throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assembly.

[0012] Optionally, the refrigeration mode comprises one or more of the following modes: an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the first throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated; a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degree of the second throttle valve assembly is controlled; the first throttle valve assembly is controlled to turn off the flow paths; and the second compressor of the at least two compressors is activated; a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the first throttle valve assembly and the second throttle valve assembly are controlled respectively; and the at least two compressors are activated; an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode. And, the heating mode comprises one or more of the following modes: an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the third throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated; a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the a first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the a first throttle valve assembly and the third throttle valve assembly are controlled to turn on the flow paths, and the throttling degree of the second throttle valve assembly is controlled; and the at least two compressors are activated; a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degrees of the second throttle valve assembly and the third throttle valve assembly are controlled respectively; and the at least two compressors are activated; a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, and the throttling degree of the second throttle valve assembly is controlled; the third throttle valve assembly is controlled to turn off the flow paths; and the at least two compressors are activated.

[0013] According to a third aspect of the present invention, an integrated heat pump system is provided, which comprises: an air-conditioning indoor unit having a first indoor heat exchanger set and a first throttle valve assembly for controlling the on-off of flow paths and throttling degree; a display cabinet indoor unit having a second indoor heat exchanger set and a second throttle valve assembly for controlling the on-off of flow paths and throttling degree, wherein the second indoor heat exchange sets have a temperature regulating setpoint different from that of the first indoor heat exchanger set; and an outdoor unit connected to the air-conditioning indoor unit and the display cabinet indoor unit through pipelines. The outdoor unit comprises: at least two compressors connected in parallel and configured to provide different evaporation temperatures respectively; an outdoor heat exchanger set having a first heat exchange flow path and a second heat exchange that are not connected to each other, wherein the first heat exchange flow path is connected to the air-conditioning indoor unit, and the second heat exchange flow path is connected to the display cabinet indoor unit and the suction ports of the at least two compressors; a third throttle valve assembly configured to control the on-off of the first heat exchange flow path and the throttling degree; and a mode switch valve assembly configured to guide refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set, the first heat exchange flow path, and the second heat exchange flow path by switching pipeline connections.

[0014] Optionally, in the refrigeration mode: the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths; and the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly is controlled.

[0015] Optionally, the refrigeration mode comprises one or more of the following modes: an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated; a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly turn off the flow paths, and the second throttle valve assembly provides a controlled throttling degree; and the second compressor of the at least two compressors is activated; a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly and the second throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode.

[0016] Optionally, in the heating mode: the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths; and the throttling degree of the third throttle valve assembly is controlled.

[0017] Optionally, the heating mode comprises one or more of the following modes: an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the third throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated; a heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly and the third throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated.

[0018] Optionally, the mode switch valve assembly comprises: a first four-way valve and first solenoid valve arranged in parallel, and a second solenoid valve arranged in series with the first four-way valve; wherein the first four-way valve has a first port connected to the second solenoid valve, a second port connected to the suction ports of the at least two compressors, a third port connected to the first heat exchange flow path, and a fourth port connected to the first indoor heat exchanger set; and wherein the first solenoid valve has a fifth port connected to the exhaust ports of the at least two compressors, and a sixth port connected to the second heat exchange flow path; and the second solenoid valve has a seventh port connected to the exhaust ports of the at least two compressors and an eighth port connected to the first four-way valve.

[0019] Optionally, the integrated heat pump system further comprises a subcooling branch provided with a subcooling heat exchanger and an additional throttle element. The subcooling branch is connected to the suction ports of the at least two compressors through the second heat exchange flow path, the first flow path of the subcooling heat exchanger, the additional throttle element, and the second flow path of the subcooling heat exchanger.

[0020] Optionally, the first heat exchange flow path and the second heat exchange flow path of the outdoor heat exchanger sets are in the form of staggered arrangement through pipelines or in the form of staggered arrangement through stacking.

[0021] According to a fourth aspect of the present invention, a control method for the integrated heat pump system as described above is provided, which comprises: operating a refrigeration mode, guiding the refrigerant flowing out of the at least two compressors into at least one of the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections through control of the mode switch valve assembly; controlling the third throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly; or operating a heating mode, guiding the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections through control of the mode switch valve assembly; controlling the first throttle valve assembly to turn on the flow paths; and controlling the throttling degree of the third throttle valve assembly.

[0022] Optionally, the refrigeration mode comprises one or more of the following modes: an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the first throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated; a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly are controlled to turn off the flow paths, and the throttling degree of the second throttle valve assembly is controlled; and the second compressor of the at least two compressors is activated; a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the first throttle valve assembly and the second throttle valve assembly is controlled respectively; and the at least two compressors are activated; an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode. And, the heating mode comprises one or more of the following modes: an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the third throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated; a heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the second throttle valve assembly and the third throttle valve assembly are controlled respectively; and the at least two compressors are activated.

[0023] According to the integrated heat pump system and the control method therefor of the present invention, the switching of pipeline connections through the mode switch valve assembly is coordinated with the on-off of pipelines through the multiple on-off valve assemblies to improve pipeline connections, thereby providing an outdoor unit that can be shared by a variety of indoor units with different functions, which improves the integration of the units, saves footprint, provides a variety of operating modes at the same time, broadens application scope and improves heat utilization.

[0024] Certain exemplary embodiments will now be described in greater detail by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a schematic view of the system flow of an integrated heat pump system of the present invention in the air-conditioning refrigeration mode.

FIG. 2 is a schematic view of the system flow of integrated heat pump system of the present invention in the display cabinet refrigeration mode.

FIG. 3 is a schematic view of the system flow of an integrated heat pump system of the present invention in the cooperative refrigeration mode.

FIG. 4 is a schematic view of the system flow of an integrated heat pump system of the present invention in the air-conditioning heating mode.

FIG. 5 is a schematic view of the system flow of an integrated heat pump system of the present invention in the heat rejection and heat recovery mode.

FIG. 6 is a schematic view of the system flow of an integrated heat pump system of the present invention in the compensation heat recovery mode.

FIG. 7 is a schematic view of the system flow of an integrated heat pump system of the present invention in the total heat recovery mode.

FIG. 8 is a schematic view of the system flow of an integrated heat pump system of the present invention in the air-conditioning refrigeration mode.

FIG. 9 is a schematic view of the system flow of an integrated heat pump system of the present invention in the display cabinet refrigeration mode.

FIG. 10 is a schematic view of the system flow of an integrated heat pump system of the present invention in the cooperative refrigeration mode.

FIG. 11 is a schematic view of the system flow of an integrated heat pump system of the present invention in the air-conditioning heating mode.

FIG. 12 is a schematic view of the system flow of an integrated heat pump system of the present invention in the heat recovery mode.

[0025] The present application will be described in detail hereinafter with reference to the exemplary embodiments shown in the accompanying drawings. However, it should be understood that the present application can be implemented in many different forms, and should not be construed as being limited to the embodiments set forth herein. These embodiments are provided here for the purpose of making the disclosure of the present application more complete and comprehensive, and fully conveying the concept of the present application to those skilled in the art.

[0026] The term "integrated heat pump system" defined in the text means that the heat pump system is sufficiently compact in terms of pipeline connection and spatial arrangement. For example, it can realize as many operating modes as possible with as few pipeline connections as possible, and its outdoor working parts can be basically arranged in the same outdoor unit housing in a compact manner.

[0027] The term "set" defined in the text refers to a set of the same devices or components, which have structural and functional similarities. Unless explicitly stated otherwise, the "set" mentioned in the text means that there are one or more devices or components.

[0028] Referring to FIGS. 1 to 7, which shows an integrated heat pump system according to the present invention. Among them, each figure respectively shows the flow direction of the refrigerant of the integrated heat pump system in different operating modes. Specifically, the solid line shows the flow direction of the refrigerant in the current operating mode, and the dotted line shows the pipelines that are currently turned off so that the refrigerant cannot flow through.

[0029] Taking FIG. 1 as an example, the integrated heat pump system 100 comprises three major components: an air-conditioning indoor unit 110, a display cabinet indoor unit 120, and an outdoor unit 130. Among them, the air-conditioning indoor unit 110 is used to provide air temperature regulating for the indoor space, such as refrigeration or heating. The display cabinet indoor unit 120 is used to provide temperature regulating for commodities stored and displayed therein, usually refrigeration or freezing. The outdoor unit 130 is usually used to provide heat dissipation or heat absorption functions to the integrated heat pump system 100 accordingly to ensure the normal operation of the entire circulation, or to provide heat recovery functions under certain circumstances to improve system efficiency.

[0030] Specifically, the air-conditioning indoor unit 110 has first indoor heat exchanger sets 111a, 111b for heat exchange with indoor air, and first throttle valve assemblies 112a, 112b for controlling the on-off of flow paths and throttling degree, thereby allowing or not allowing the refrigerant to flow through all or part of the first indoor heat exchanger sets 111a, 111b, and expanding the refrigerant flowing through the first indoor heat exchanger sets 111a, 111b to a desired throttling degree. Since the first indoor heat exchanger sets are usually arranged in different rooms, the control of the on-off of the flow paths and throttling degree by the first throttle valve assemblies 112a, 112b can realize temperature regulating of each room. In addition, it should be understood that although the figure exemplarily provides two sets of heat exchangers 111a, 111b and a corresponding number of electronic expansion valves as the first indoor heat exchanger sets and the first throttle valve assemblies respectively, as a matter of fact however, the number can be increased or decreased according to demand. For example, multiple sets of heat exchangers can be arranged in series or parallel in the same room, or multiple sets of heat exchangers can be arranged in parallel in more different rooms to achieve similar air conditioning functions.

[0031] Furthermore, the display cabinet indoor unit 120 has second indoor heat exchanger sets 121a, 121b for heat exchange with the stored commodities, and second throttle valve assemblies 122a, 122b for controlling the on-off of flow paths and throttling degree, thereby allowing or not allowing the refrigerant to flow through all or part of the second indoor heat exchanger sets 121a, 121b, and expanding the refrigerant flowing through the second indoor heat exchanger sets 121a, 121b to a desired throttling degree. Since the second indoor heat exchanger sets are usually arranged in different refrigerating or freezing storage spaces, at this time, the control of the on-off of the flow paths and throttling degree by the second throttle valve assemblies 122a, 122b can realize temperature regulating of each storage space. In addition, since the refrigeration/freezing of commodities and the air conditioning in the room usually have large differences in temperature requirements, the second indoor heat exchanger sets 121a, 121b have a temperature regulating setpoint different from that of the first indoor heat exchanger sets 111a, 111b. Accordingly, compressors that can provide different evaporation temperatures are usually required to perform the system circulation separately. In addition, it should be understood that although the figure exemplarily provides two sets of heat exchangers 121a, 121b and a corresponding number of thermal expansion valves as the second indoor heat exchanger sets and the second throttle valve assemblies respectively, as a matter of fact however, the number can be increased or decreased according to demand. For example, multiple sets of heat exchangers can be arranged in series or in parallel in the same storage space, or multiple sets of heat exchangers can be arranged in parallel in more different storage spaces to achieve similar commodity temperature regulating functions.

[0032] In addition, more importantly, the integrated heat pump system has an outdoor unit 130 integrated in a housing. The outdoor unit 130 is connected to the air-conditioning indoor unit 110 and the display cabinet indoor unit 120 through pipelines to form a loop, so as to perform air conditioning of the air-conditioning indoor unit 110 and temperature regulating of the commodities in the display cabinet indoor unit 120, respectively. In order to complete the circulation of a conventional refrigeration system, the outdoor unit 130 comprises at least compressors 133a, 133b, an outdoor heat exchanger set 131, and a third throttle valve assembly 132 for controlling the on-off of flow paths and throttling degree of the outdoor heat exchanger set 131, thereby forming the four major components of the refrigeration circulation together with the first indoor heat exchanger sets or the second indoor heat exchanger sets.

[0033] On this basis, the outdoor unit 130 further comprises a mode switch valve assembly, wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the compressors 133a, 133b into at least one of the first indoor heat exchanger sets 111a, 111b and the outdoor heat exchanger set 131 by switching pipeline connection.

[0034] The heat pump system with this configuration realizes the improvement of pipeline connections through the cooperation of pipeline connection switching through the mode switch valve assembly and control of the on-off of the flow paths through the multiple throttle valve assemblies (used as on-off valves respectively), thereby providing an outdoor unit that can be shared by a variety of indoor units with different functions, which improves the integration of the units, saves footprint, provides a variety of operating modes at the same time, broadens application scope and improves heat utilization.

[0035] In addition, in order to adapt to the different evaporation temperature requirements of the air-conditioning indoor unit 110 and the display cabinet indoor unit 120, two compressors 133a, 133b connected in parallel are provided here to achieve this purpose.

[0036] It should be understood that, although two compressors 121a, 121b are exemplarily provided in the figures, as a matter of fact however, the number of compressors can be increased or decreased according to demand. Similarly, although one outdoor heat exchanger 131 is exemplarily provided in the figures, the number of heat exchanger sets can also be increased or decreased according to demand.

[0037] Similarly, according to the foregoing configuration, it can be seen that in the connection of components forming the refrigeration cycle, there may be two throttle valve assemblies between any two heat exchangers. In order to meet the throttling requirements of the refrigerant between different indoor heat exchanger sets and outdoor heat exchanger sets, as an embodiment, the throttle valve assembly close to the heat exchanger used as a condenser can be kept fully opened, while the throttle valve assembly close to the heat exchanger used as an evaporator is adjusted to provide a throttling effect. This point can be understood more clearly through the description of the system operation status in various modes provided later.

[0038] The structure of each part of the integrated heat pump system will be continued to be introduced below. In addition, in order to further improve the efficiency or reliability of the system, some additional parts can be added, which are also exemplified below.

[0039] For example, the mode switch valve assembly may comprise a first four-way valve 135 and a second four-way valve 136 arranged in parallel; wherein the first four-way valve 135 has a first port 135a connected to the exhaust ports of two compressors 133a, 133b, a second port 135b connected to the suction ports of the two compressors 133a, 133b, a third port 135c connected to the second four-way valve 136, and a fourth port 135d connected to the second port 135b through capillary tubes 138d; and wherein the second four-way valve 136 has a fifth port 136a connected to the exhaust ports of the two compressors 133a, 133b, a sixth port 136b connected to the first four-way valve 135, and a seventh port 136c connected to the outdoor heat exchanger set 131, and an eighth port 136d connected to the first indoor heat exchanger sets 111a and 111b. Such an example of the mode switch valve assembly can switch the pipeline connections, thereby selectively connecting the first indoor heat exchanger sets 111a, 111b, the second indoor heat exchanger sets 121a, 121b, and the outdoor heat exchanger set 131 to the loop of the refrigerant circulation so as to run the corresponding operating mode.

[0040] Of course, it should be understood that the mode switch valve assembly mentioned in the present application can be a single valve or a combination of multiple valves as described above, as long as the mode switch valve assembly can switch the pipelines between the aforementioned components to make them circulate as needed. As for the specific connection modes, there can be multiple, and the present embodiment provides one of the preferred solutions. However, according to the teachings and exemplary embodiments of the present application about the functions to be performed by the flow switch valve assembly, those skilled in the art can easily modify or adjust the connection mode thereof, and such modifications or adjustments should be included in the protection scope of the present application.

[0041] For another example, the throttle valve assembly can use either a single electronic expansion valve 112a (as shown in the air-conditioning indoor unit), or a single thermal expansion valve 122a (as shown in the display cabinet indoor unit), or a parallel combination of the electronic expansion valve 132a and the one-way valve 132b (as shown in the outdoor unit). The selection of these valves mainly stems from the control accuracy requirements or cost considerations of the current units.

[0042] In addition, series combinations of solenoid valves 138c and one-way valves 138f are also provided in multiple places in the flow path of the system. Among them, the one-way valve has a fluid stop direction opposite to that of the solenoid valve. The example of this combination is mainly based on the considerations of valve structure design and material cost constraints. Because the solenoid valve currently used usually only has the one-way "turned off" function, in order to ensure the turn off of the flow path, it is necessary to accordingly arrange a one-way stop valve in the flow direction where the solenoid valve cannot be completely "turned off" for coordinated use. Of course, it should be understood that the combination can also be other single valve, or a combination of multiple valves as described above, as long as it can control the on and off of the flow paths. As for the specific connection mode, there can be multiple, and the present embodiment provides one of the preferred solutions. However, according to the teachings and exemplary embodiments of the present application regarding the functions to be performed by the switch valve assembly, those skilled in the art can easily modify or adjust the connection mode thereof, and such modifications or adjustments should be included in the protection scope of the present application.

[0043] For still another example, stop valves 134a, 134b, 134c may also be arranged at each interface between the outdoor unit and the air-conditioning indoor unit and the display cabinet indoor unit, so that the outdoor unit can be sold, transported or installed as a single device. Before being assembled into a system (that is, before being connected to be a circulation loop), the stop valves 134a, 134b, 134c can be turned off separately, so that the pipelines of the outdoor unit are closed to the outside, so as to prevent impurities or dust from entering the pipelines of the outdoor unit. After the assembly is completed, however, the stop valves 134a, 134b, 134c can be kept open under normal operating conditions, or the stop valves 134a, 134b, 134c can be turned off again during maintenance.

[0044] Furthermore, other conventional components can also be provided in the system in order to further improve system reliability or performance. These components can be some devices. For example, a gas-liquid separator 138a can be arranged at the suction port of the compressor to perform gas-liquid separation so as to prevent liquid hammer in the compressor. For another example, an oil separator 138b, and also solenoid valves 138c and capillary tubes 138d in the corresponding flow paths can be arranged at the exhaust port of the compressor, such that the lubricating oil carried by the refrigerant can be recovered and the refrigerant can be prevented from being sucked in. For still another example, oil heating wires can be arranged in the compressor to heat the lubricating oil to improve its viscosity. These components can also be some sensors and control equipment, such as a low pressure sensor 139a, a suction temperature sensor 139f, and a low pressure switch 139b arranged at the suction port of the compressor, or an exhaust temperature sensor 139c, a high pressure sensor 139e, and a high pressure switch 139d arranged at the exhaust port of the compressor, and so on. The conventional functions thereof will not be described in detail here.

[0045] For another example, in order to further improve the system efficiency, the integrated heat pump system can further be provided with a subcooling branch 137 provided with a subcooling heat exchanger 137a and an additional throttle element 137b. The subcooling branch 137 is connected from the outdoor heat exchanger set 131 to the suction ports of the two compressors 133a, 133b through the third throttle valve assembly 132, the first flow path of the subcooling heat exchanger 137a, the additional throttle element 137b, and the second flow path of the subcooling heat exchanger 137a. At this time, the high-pressure refrigerant flowing through the first flow path of the subcooling heat exchanger 137a exchanges heat with the low-pressure refrigerant flowing through the second flow path of the subcooling heat exchanger 137a after being throttled, so that the high-pressure refrigerant in the first flow path can be subcooled, thereby improving the heat exchange efficiency of the system.

[0046] Combining the connection relationships of the various components and the possibility of switching pipelines, the integrated heat pump system can perform a variety of refrigeration modes and heating modes for different purposes. The control methods for operating different refrigeration modes and heating modes by the integrated heat pump system will be described below in conjunction with the actions of the various components in the integrated heat pump system.

[0047] First, when the integrated heat pump system is operating in the refrigeration mode, the refrigerant flowing out of the two compressors 133a and 133b can be guided into the outdoor heat exchanger set 131 by switching pipeline connections through control of the mode switch valve assembly. At the same time, the third throttle valve assembly 132 is controlled to turn on the flow paths. And, the throttling degree of at least one of the first throttle valve assemblies 112a, 112b and the second throttle valve assemblies 122a, 122b is controlled. In this way, it can be ensured that in any refrigeration mode, the outdoor heat exchanger set 131 performs the function of a condenser, while at least one of the first indoor heat exchanger sets 111a, 111b or the second indoor heat exchanger sets 121a, 121b performs the function of an evaporator, so as to provide refrigeration temperature regulating for the corresponding indoor air or provide refrigeration/freezing temperature regulating for stored commodities.

[0048] In addition, when the integrated heat pump system is operating in the heating mode, the refrigerant flowing out of the two compressors 133a and 133b is guided at least into the first indoor heat exchanger sets 111a, 111b by switching pipeline connections through control of the mode switch valve assembly. The first throttle valve assemblies 122a, 122b are controlled to turn on the flow paths. And, the throttling degree of at least one of the second throttle valve assemblies 122a, 122b and the third throttle valve assembly 132 is controlled. In this way, it can be ensured that in any heating mode, the first indoor heat exchanger sets 111a, 111b perform the function of a condenser, at least one of the outdoor heat exchanger set 131 or the second indoor heat exchanger sets 121a, 121b performs the function of an evaporator, and the outdoor heat exchanger set 131 can optionally assist in performing the function of a condenser as well, so as to provide heating temperature regulating for the corresponding indoor air or provide refrigeration/freezing temperature regulating for stored commodities.

[0049] Various exemplary operating modes in the heat pump system will be described respectively below with reference to FIGS. 1 to 7.

[0050] Referring to FIG. 1, when the air-conditioning refrigeration mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the seventh port 136c, and its sixth port 136b is connected to the eighth port 136d. And, the third throttle valve assembly 132 is configured to turn on the flow paths; the first throttle valve assemblies 112a, 112b are controlled to provide a controlled throttling degree; and at the same time the second throttle valve assemblies 122a, 122b are configured to turn off the flow paths. At this time, only the first compressor 133a for providing an air conditioning evaporation temperature is activated. After being compressed by the first compressor 133a, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve is turned off, so the refrigerant will pass through the second four-way valve 136 and continue to flow into the outdoor heat exchanger set 131 to be condensed. It then passes through the third throttle valve assembly 132 and enters the subcooling heat exchanger 137a to be subcooled. The refrigerant is then throttled by the first throttle valve assemblies 112a, 112b and flows into the first indoor heat exchanger sets 111a, 111b to be evaporated. Thus, refrigeration conditioning for indoor air temperature is completed. The refrigerant that has completed temperature regulating will return to the first compressor 133a through the second four-way valve 136 and the first four-way valve 135, thereby completing the entire circulation.

[0051] Referring to FIG. 2, when the display cabinet refrigeration mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the seventh port 136c, and its sixth port 136b is connected to the eighth port 136d. And, the third throttle valve assembly 132 is configured to turn on the flow paths; the second throttle valve assemblies 122a, 122b are configured to be turned on to provide a controlled throttling degree; and at the same time the first throttle valve assemblies 112a, 112b are configured to turn off the flow paths. At this time, only the second compressor 133b for providing an evaporation temperature for commodity refrigeration/freezing conditioning is activated. After being compressed by the second compressor 133b, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve is turned off, so the refrigerant will pass through the second four-way valve 136 and continue to flow into the outdoor heat exchanger set 131 to be condensed. It then passes through the third throttle valve assembly 132 and enters the subcooling heat exchanger 137a to be subcooled. The refrigerant is then throttled by the second throttle valve assemblies 122a, 122b and flows into the second indoor heat exchanger sets 211a, 211b to be evaporated. Thus, refrigeration/freezing temperature regulating for the commodities in the storage space is completed. The refrigerant that has completed temperature regulating will return to the second compressor 133b, thereby completing the entire circulation.

[0052] Referring to FIG. 3, when the cooperative refrigeration mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the seventh port 136c, and its sixth port 136b is connected to the eighth port 136d. And, the third throttle valve assembly 132 is configured to turn on the flow paths; the first throttle valve assemblies 112a, 112b and the second throttle valve assemblies 122a, 122b are configured to provide a controlled throttling degree respectively. At this time, the two compressors 133a and 133b are activated simultaneously. After being compressed by the compressors 133a and 133b, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve is turned off, so the refrigerant will pass through the second four-way valve 136 and continue to flow into the outdoor heat exchanger set 131 to be condensed. It then passes through the third throttle valve assembly 132 and enters the subcooling heat exchanger 137a to be subcooled. Then, a part of the refrigerant is throttled by the second throttle valve assemblies 122a, 122b and flows into the second indoor heat exchanger sets 211a, 211b to be evaporated. Thus, refrigeration/freezing temperature regulating for the commodities in the storage space is completed. The refrigerant that has completed temperature regulating will directly return to the two compressors 133a, 133b, thereby completing this part of the circulation. The other part of the refrigerant is throttled by the first throttle valve assemblies 112a, 112b and flows into the first indoor heat exchanger sets 111a, 111b to be evaporated, thereby completing refrigeration temperature regulating for the indoor air. The refrigerant that has completed temperature regulating will return to the two compressors 133a, 133b through the second four-way valve 136 and the first four-way valve 135 in turn, thereby completing the other part of the circulation. Thus, the entire circulation is completed.

[0053] When operating a conventional air-conditioning heating mode, an outdoor heat exchanger set is usually required to serve as an evaporator to absorb heat. Since this mode is usually applied in winter when the outdoor temperature is very low, at this time, the outdoor heat exchanger set is prone to frost, which affects the system efficiency. At this time, operating the outdoor unit defrost mode can be considered, i.e., operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode, so that the high-temperature refrigerant flows through the outdoor heat exchanger set to dissipate heat and defrost, thereby eliminate frost.

[0054] Referring to FIG. 4, when the air-conditioning heating mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the eighth port 136d, and its sixth port 136b is connected to the seventh port 136c. And, the first throttle valve assemblies 112a, 112b are configured to turn on the flow paths; the third throttle valve assembly 132 is configured to provide a controlled throttling degree, and the second throttle valve assemblies 122a, 122b are configured to turn off the flow paths. At this time, only the first compressor 133a for providing an air conditioning evaporation temperature is activated. After being compressed by the first compressor 133a, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve is turned off, so the refrigerant will pass through the second four-way valve 136 and continue to flow into the first indoor heat exchanger sets 111a, 111b to be condensed. Thus, heating conditioning for the indoor air temperature is completed. The refrigerant flows through the first throttle valve assemblies 112a, 112b and then enters the subcooling heat exchanger 137a to be subcooled. Then, it is throttled by the third throttle valve assembly 132 and flows into the outdoor heat exchanger set 131 to be evaporated. The refrigerant then returns to the first compressor 133a through the second four-way valve 136 and the first four-way valve 135 in turn, thereby completing the entire circulation.

[0055] Referring to FIG. 5, when the heat rejection and heat recovery mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the third port 135c, and its second port 135b is connected to the fourth port 135d. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the seventh port 136c, and its sixth port 136b is connected to the eighth port 136d. And, the first throttle valve assemblies 112a, 112b and the third throttle valve assembly 132 are configured to turn on the flow paths simultaneously. At the same time, the second throttle valve assemblies 122a, 122b are configured to provide a controlled throttling degree. At this time, the two compressors 133a and 133b are activated simultaneously. After being compressed by the compressors 133a and 133b, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. Apart of the refrigerant flows into the first indoor heat exchanger sets 111a, 111b through the first four-way valve 135 to be condensed, so as to perform heating conditioning for the indoor air temperature. The other part of the refrigerant flows into the outdoor heat exchanger set 131 through the second four-way valve 136 to be condensed, and then enters the subcooling heat exchanger 137a through the third throttle valve assembly 132 to be subcooled. After that, the two parts of refrigerant merge. The merged refrigerant are throttled by the second throttle valve assemblies 122a, 122b, and flow into the second indoor heat exchanger sets 211a, 211b to be evaporated. Thus, refrigeration/freezing temperature regulating for the commodities in the storage space is completed. The refrigerant then returns to the two compressors 133a, 133b, there by completing the entire circulation.

[0056] Referring to FIG. 6, when the compensation heat recovery mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the eighth port 136d, and its sixth port 136b is connected to the seventh port 136c. The first throttle valve assemblies 112a, 112b is configured to turn on the flow paths. The second throttle valve assemblies 122a, 122b and the third throttle valve assembly 132 are configured to provide a controlled throttling degree respectively. At this time, the two compressors 133a and 133b are activated simultaneously. After being compressed by the compressors 133a and 133b, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve 135 is turned off, so the refrigerant will pass through the second four-way valve 136 and flow into the first indoor heat exchanger sets 111a, 111b to be condensed. Thus, heating conditioning for the indoor air temperature is completed. After the refrigerant passes through the first throttle valve assemblies, a part of the refrigerant is throttled by the second throttle valve assemblies 122a, 122b and flows into the second indoor heat exchanger sets 211a, 211b to be evaporated, so as to perform refrigeration/freezing temperature regulating for the commodities in the storage space. Finally, the refrigerant returns to the compressors 133a, 133b. The other part of the refrigerant enters the subcooling heat exchange 137a to be subcooled, and then is throttled by the third throttle valve assembly 132 and flows into the outdoor heat exchanger set 131 to be evaporated. The refrigerant then returns to the two compressors 133a, 133b through the second four-way valve 136 and the first four-way valve 135 in turn, thereby completing the entire circulation.

[0057] Referring to FIG. 7, when the total heat recovery mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and its second port 135b is connected to the third port 135c. At the same time, the second four-way valve 136 is switched so that its fifth port 136a is connected to the eighth port 136d, and its sixth port 136b is connected to the seventh port 136c. The first throttle valve assemblies 112a, 112b are configured to turn on the flow paths. The second throttle valve assemblies 122a, 122b are configured to provide a controlled throttling degree, and the third throttle valve assembly 132 is configured to turn off the flow paths. At this time, the two compressors 133a and 133b are activated simultaneously. After being compressed by the compressors 133a and 133b, the refrigerant will flow into the first four-way valve 135 and the second four-way valve 136 respectively. The corresponding flow path of the first four-way valve 135 is turned off, so the refrigerant will pass through the second four-way valve 136 and flow into the first indoor heat exchanger sets 111a, 111b to be condensed. Thus, heating conditioning for the indoor air temperature is completed. After passing through the first throttle valve assemblies, the refrigerant is throttled by the second throttle valve assemblies 122a, 122b and flows into the second indoor heat exchanger sets 211a, 211b to be evaporated, so as to perform refrigeration/freezing temperature regulating for the commodities in the storage space. The refrigerant then returns to the compressors 133a, 133b. Thus, the entire circulation is completed.

[0058] It should be understood that although the embodiments of the control method for the integrated heat pump system are described in a certain order, these steps are not necessarily performed in sequence in the described order. Unless explicitly stated herein, there is no strict order for the execution of these steps, and they can be executed in other orders. Moreover, at least a part of the steps of the method may include multiple substeps or multiple stages. These sub-steps or stages are not necessarily executed at the same time, but can be executed at different times, and the order of execution is not necessarily sequential. Instead, they can be performed in turn or alternately with at least a part of other steps or the sub-steps or stages of other steps.

[0059] With continued reference to FIGS. 8 to 12, another integrated heat pump system according to the present invention is shown. Among them, each figure respectively shows the refrigerant flow directions of the integrated heat pump system in different operating modes. Specifically, the solid line shows the flow direction of the refrigerant in the current operating mode, and the dotted line shows the pipelines that are currently turned off so that the refrigerant cannot flow.

[0060] Taking FIG. 8 as an example, the integrated heat pump system 200 comprises three major components: an air-conditioning indoor unit 210, a display cabinet indoor unit 220, and an outdoor unit 230. Among them, the air-conditioning indoor unit 210 is used to provide air temperature regulating for the indoor space, such as refrigeration or heating. The display cabinet indoor unit 220 is used to provide temperature regulating for commodities stored and displayed therein, usually refrigeration or freezing. The outdoor unit 230 is usually used to provide heat dissipation or heat absorption functions for the integrated heat pump system 200 accordingly, so as to ensure the normal operation of the entire circulation, or to provide heat recovery functions under certain circumstances to improve system efficiency.

[0061] Specifically, the air-conditioning indoor unit 210 has first indoor heat exchanger sets 211a and 211b for heat exchange with indoor air, and first throttle valve assemblies 212a, 212b for controlling the on-off of the flow paths and the throttling degree, thereby allowing or not allowing the refrigerant to flow through all or part of the first indoor heat exchanger sets 211a, 211b, and expanding the refrigerant flowing through the first indoor heat exchanger sets 111a, 111b to a desired throttling degree. Since the first indoor heat exchanger sets are usually arranged in different rooms, the control of the on-off of the flow paths and throttling degree by the first throttle valve assemblies 212a, 212b can realize temperature regulating of each room. In addition, it should be understood that although the figure exemplarily provides two sets of heat exchangers 211a, 211b and a corresponding number of electronic expansion valves as the first indoor heat exchanger sets and the first throttle valve assemblies, respectively, as a matter of fact however, the number can be increased or decreased according to demand. For example, multiple sets of heat exchangers can be arranged in series or parallel in the same room, or multiple sets of heat exchangers can be arranged in parallel in more different rooms to achieve similar air conditioning functions.

[0062] Furthermore, the display cabinet indoor unit 220 has second indoor heat exchanger sets 221a, 221b for heat exchange with the stored commodities, and second throttle valve assemblies 222a, 222b for controlling the on-off of flow paths and throttling degree, thereby allowing or not allowing the refrigerant to flow through all or part of the second indoor heat exchanger sets 221a, 221b, and expanding the refrigerant flowing through the second indoor heat exchanger sets 221a, 221b to a desired throttling degree. Since the second indoor heat exchanger sets are usually arranged in different refrigerating or freezing storage spaces, at this time, the control of the on-off of the flow paths and throttling degree by the second throttle valve assemblies 222a, 222b can realize temperature regulating of each storage space. In addition, since the refrigeration/freezing of commodities and the air conditioning in the room usually have large differences in temperature requirements, the second indoor heat exchanger sets 221a, 221b have a temperature regulating setpoint different from that of the first indoor heat exchanger sets 211a, 211b. Accordingly, compressors that can provide different evaporation temperatures are usually required to perform the system circulation separately. In addition, it should be understood that although the figure exemplarily provides two sets of heat exchangers 221a, 221b and a corresponding number of thermal expansion valves as the second indoor heat exchanger sets and the second throttle valve assemblies, respectively, as a matter of fact however, the number can be increased or decreased according to demand. For example, multiple sets of heat exchangers can be arranged in series or in parallel in the same storage space, or multiple sets of heat exchangers can be arranged in parallel in more different storage spaces to achieve similar commodity temperature regulating functions.

[0063] In addition, more importantly, the integrated heat pump system has an outdoor unit 230 integrated in a housing. The outdoor unit 230 is connected to the air-conditioning indoor unit 210 and the display cabinet indoor unit 220 through pipelines to form a loop, so as to perform air conditioning of the air-conditioning indoor unit 210 and temperature regulating of the commodities in the display cabinet indoor unit 220, respectively. In order to complete the circulation of a conventional refrigeration system, the outdoor unit 230 comprises at least compressors 233a, 233b, and an outdoor heat exchanger set 231, thereby forming the four major components of the refrigeration cycle together with the first indoor heat exchanger sets or the second indoor heat exchanger sets.

[0064] On this basis, the outdoor heat exchanger set 231 has a first heat exchange flow path 231a and a second heat exchange flow path 231b that are not connected to each other, wherein the first heat exchange flow path 231a is connected to the air-conditioning indoor unit 210, and the second heat exchange flow path 231b is connected to the display cabinet indoor unit 220 and the suction ports of the two compressors 233a and 233b. In addition, the outdoor unit 230 further comprises a third throttle valve assembly 232 and a mode switch valve assembly. Among them, the third throttle valve assembly 232 is used to control the on-off of the first heat exchange flow path 231a and throttling degree, while the mode switch valve assembly is configured to guide the refrigerant flowing out of the compressors 233a, 233b into at least one of the first indoor heat exchanger sets 211a, 211b, the first heat exchange flow path 231a, and the second heat exchange flow path 231b by switching pipeline connections.

[0065] The heat pump system with this configuration realizes the improvement of pipeline connections through the cooperation of pipeline connection switching through the mode switch valve assembly and control of the on-off of the flow paths through the multiple throttle valve assemblies (used as on-off valves respectively), thereby providing an outdoor unit that can be shared by a variety of indoor units with different functions, which improves the integration of the units, saves footprint, provides a variety of operating modes at the same time, broadens application scope and improves heat utilization.

[0066] In addition, in order to adapt to the different evaporation temperature requirements of the air-conditioning indoor unit 210 and the display cabinet indoor unit 220, two compressors 233a, 233b connected in parallel are provided here to achieve this purpose.

[0067] It should be understood that, although two compressors 233a, 233b are exemplarily provided in the figures, as a matter of fact however, the number of compressors can be increased or decreased according to demand. Similarly, although one outdoor heat exchanger 231 is exemplarily provided in the figures, the number of heat exchanger sets can also be increased or decreased according to demand.

[0068] Similarly, according to the foregoing configuration, it can be seen that in the connection of components forming the refrigeration cycle, there may be two throttle valve assemblies between any two heat exchangers. In order to meet the throttling requirements of the refrigerant between different indoor heat exchanger sets and outdoor heat exchanger sets, as an embodiment, the throttle valve assembly close to the heat exchanger used as a condenser can be kept fully opened, while the throttle valve assembly close to the heat exchanger used as an evaporator is adjusted to provide a throttling effect. This point can be understood more clearly through the description of the system operation status in various modes provided later.

[0069] The structure of each part of the integrated heat pump system will be continued to be introduced below. In addition, in order to further improve the efficiency or reliability of the system, some additional parts can be added, which are also exemplified below.

[0070] For example, the mode switch valve assembly may comprise: a first four-way valve 235 and a first solenoid valve 236 arranged in parallel, and a second solenoid valve 238 arranged in series with the first four-way valve 235. Among them, the first four-way valve 235 has a first port 235a connected to the second solenoid valve 238, a second port 235b connected to the suction ports of the two compressors 233a, 233b, a third port 235c connected to the first heat exchange flow path 231a, and a fourth port 235d connected to the first indoor heat exchangers sets 211a, 211b. The first solenoid valve 236 has a fifth port 236a connected to the exhaust ports of the two compressors 233a, 233b, and a sixth port 236b connected to the second heat exchange flow path 231b; and the second solenoid valve 238 has a seventh port 238a connected to the exhaust ports of the at least two compressors 233a, 233b and an eighth port 238b connected to the first four-way valve 235. Such an example of the mode switch valve assembly can realize the switching of pipeline connections, thereby selectively connecting the first indoor heat exchanger sets 211a, 211b, the second indoor heat exchanger sets 221a, 221b, and the first heat exchange flow path 231a and the second heat exchange flow path 231b of the outdoor heat exchanger set 231 to the loop of the refrigerant circulation, so as to run the corresponding operating mode.

[0071] Of course, it should be understood that the mode switch valve assembly mentioned in the present application can be a single valve or a combination of multiple valves as described above, as long as the mode switch valve assembly can switch the pipelines between the aforementioned components to make them circulate as needed. As for the specific connection modes, there can be multiple, and the present embodiment provides one of the preferred solutions. However, according to the teachings and exemplary embodiments of the present application about the functions to be performed by the flow switch valve assembly, those skilled in the art can easily modify or adjust the connection mode thereof, and such modifications or adjustments should be included in the protection scope of the present application.

[0072] For another example, the throttle valve assembly can use either a single electronic expansion valve 212a (as shown in the air-conditioning indoor unit), or a single thermal expansion valve 222a (as shown in the display cabinet indoor unit), or a parallel combination of the electronic expansion valve 232a and the one-way valve 232b (as shown in the outdoor unit). The selection of these valves mainly stems from the control accuracy requirements or cost considerations of the current units.

[0073] In addition, series combinations of solenoid valves 238c and one-way valves 238f are also provided in multiple places in the flow path of the system. Among them, the one-way valve has a fluid stop direction opposite to that of the solenoid valve. The example of this combination is mainly based on the considerations of valve structure design and material cost constraints. Because the solenoid valve currently used usually only has the one-way "turned off" function, in order to ensure the turn off of the flow path, it is necessary to accordingly arrange a one-way stop valve in the flow direction where the solenoid valve cannot be completely "turned off" for coordinated use. Of course, it should be understood that the combination can also be other single valve, or a combination of multiple valves as described above, as long as it can control the on and off of the flow paths. As for the specific connection mode, there can be multiple, and the present embodiment provides one of the preferred solutions. However, according to the teachings and exemplary embodiments of the present application regarding the functions to be performed by the switch valve assembly, those skilled in the art can easily modify or adjust the connection mode thereof, and such modifications or adjustments should be included in the protection scope of the present application.

[0074] For still another example, stop valves 234a, 234b, 234c, 234d may also be arranged at each interface between the outdoor unit and the air-conditioning indoor unit and the display cabinet indoor unit, so that the outdoor unit can be sold, transported or installed as a single device. Before being assembled into a system (that is, before being connected to a circulation loop), the stop valves 234a, 234b, 234c, 234d can be turned off separately, so that the pipelines of the outdoor unit are closed to the outside, so as to prevent impurities or dust from entering the pipelines of the outdoor unit. After the assembly is completed, however, the stop valves 234a, 234b, 234c, 234d can be kept open under normal operating conditions, or the stop valves 234a, 234b, 234c, 234d can be turned off again during maintenance.

[0075] Furthermore, other conventional components can also be provided in the system in order to further improve system reliability or performance. These components can be some devices. For example, a gas-liquid separator 238a can be arranged at the suction port of the compressor to perform gas-liquid separation so as to prevent liquid hammer in the compressor. For another example, an oil separator 238b, and also solenoid valves 238c and capillary tubes 238d in the corresponding flow paths can be arranged at the exhaust port of the compressor, such that the lubricating oil carried by the refrigerant can be recovered and the refrigerant can be prevented from being sucked in. For still another example, oil heating wires can be arranged in the compressor to heat the lubricating oil to improve its viscosity. These components can also be some sensors and control equipment, such as a low pressure sensor 239a, a suction temperature sensor 239f, and a low pressure switch 239b arranged at the suction port of the compressor, or an exhaust temperature sensor 239c, a high pressure sensor 239e, and a high pressure switch 239d arranged at the exhaust port of the compressor, and so on. The conventional functions thereof will not be described in detail here.

[0076] For another example, in order to further improve system efficiency, the integrated heat pump system can further be provided with a subcooling branch 237 provided with a subcooling heat exchanger 237a and an additional throttle element 237b. The subcooling branch 237 is connected from the second heat exchange flow path 231b to the suction ports of the two compressors 233a, 233b through the first flow path of the subcooling heat exchanger 237a, the additional throttle element 237b, and the second flow path of the subcooling heat exchanger 237a. At this time, the high-pressure refrigerant flowing through the first flow path of the subcooling heat exchanger 237a exchanges heat again with the low-pressure refrigerant flowing through the second flow path of the subcooling heat exchanger 237a after being throttled, so that the high-pressure refrigerant in the first flow path can be subcooled, thereby improving the heat exchange efficiency of the system.

[0077] As still another example, as a specific type of heat exchanger in the present embodiment, the first heat exchange flow path 231a and the second heat exchange flow path 231b of the outdoor heat exchanger set 231 can be formed by staggered arrangement through pipelines, or be formed by staggered arrangement through stacking heat exchange plates with flow channels, as long as it has two flow paths that are not in fluid communication with each other but can perform heat exchange.

[0078] Combining the connection relationships of the various components and the possibility of switching pipelines in the foregoing embodiments, the integrated heat pump system can perform a variety of refrigeration modes and heating modes for different purposes. The control methods for operating different refrigeration modes and heating modes by the integrated heat pump system will be described below in conjunction with the actions of the various components in the integrated heat pump system.

[0079] First, when the integrated heat pump system is operating in the refrigeration mode, the refrigerant flowing out of the two compressors 233a and 233b can be guided into at least one of the first heat exchange flow path 231a and the second heat exchange flow path 231b by switching pipeline connections through control of the mode switch valve assembly. At the same time, the third throttle valve assembly 232 is controlled to turn on the flow paths. And, the throttling degree of at least one of the first throttle valve assemblies 212a, 212b and the second throttle valve assemblies 222a, 222b is controlled. In this way, it can be ensured that in any refrigeration mode, at least one of the first heat exchange flow path 231a and the second heat exchange flow path 231b of the outdoor heat exchanger set 231 performs the function of a condenser, while at least one of the first indoor heat exchanger sets 211a, 211b or the second indoor heat exchanger sets 221a, 221b performs the function of an evaporator, so as to provide refrigeration temperature regulating for the corresponding indoor air or provide refrigeration/freezing temperature regulating for stored commodities.

[0080] In addition, when the integrated heat pump system is operating in the heating mode, the refrigerant flowing out of the two compressors 233a and 233b is guided into at least one of the first indoor heat exchanger sets 211a, 211b and the second heat exchange flow path 231b by switching pipeline connections through control of the mode switch valve assembly. At the same time, the first throttle valve assemblies 212a, 212b are simultaneously controlled to turn on the flow paths. And, the throttling degree of the third throttle valve assembly 232 is controlled. In this way, it can be ensured that in any heating mode, the first indoor heat exchanger sets 211a, 211b perform the function of a condenser, at least one of the first heat exchange flow path 231a or the second indoor heat exchanger sets 221a, 221b performs the function of an evaporator, and the second heat exchange flow path 231b can optionally assist in performing the function of a condenser as well, so as to provide heating temperature regulating for the corresponding indoor air or provide refrigeration/freezing temperature regulating for stored commodities.

[0081] Various exemplary operating modes in the heat pump system of this embodiment will be described respectively below with reference to FIGS. 8 to 12.

[0082] Referring to FIG. 8, when the air-conditioning refrigeration mode is operated, the first four-way valve 235 can be switched so that its first port 235a is connected to the third port 235c, and its second port 235b is connected to the fourth port 235d. The second solenoid valve 238 is turned on, and the first solenoid valve 236 is turned off. At the same time, the third throttle valve assembly 232 is configured to turn on the flow paths, so that the first throttle valve assemblies 212a, 212b is configured to provide a controlled throttling degree, and the second throttle valve assemblies 222a, 222b are configured to turn off the flow paths. At this time, only the first compressor 233a for providing an air conditioning evaporation temperature is activated. After being compressed by the first compressor 233a, the refrigerant will flow into the first heat exchange flow path 231a through the first four-way valve 235 to be condensed. After passing through the third throttle valve assembly 232, the refrigerant is throttled by the first throttle valve assemblies 212a, 212b and flows into the first indoor heat exchanger sets 211a, 211b to be evaporated. Thus, refrigeration temperature regulating for the indoor air is completed. The refrigerant that has completed temperature regulating will return to the first compressor 233a through the first four-way valve 235, thereby completing the entire circulation.

[0083] Referring to FIG. 9, when the display cabinet refrigeration mode is operated, the second solenoid valve 238 can be turned off, and the first solenoid valve 236 can be turned on. At the same time, the second throttle valve assemblies 222a, 222b is configured to provide a controlled throttling degree, and the first throttle valve assemblies 212a, 212b and the third throttle valve assembly 232 are configured to turn off the flow paths. At this time, only the second compressor 233b for providing an evaporation temperature for commodity refrigeration/freezing conditioning is activated. After being compressed by the second compressor 233b, the refrigerant will flow into the second heat exchange flow path 231b through the first solenoid valve 236 to be condensed, and then enter the subcooling heat exchanger 237a to be subcooled. And then, the refrigerant is throttled by the second throttle valve assemblies 222a and 222b and flow into the second indoor heat exchanger sets 221a and 221b to be evaporated. Thus, refrigeration/freezing temperature regulating for the stored commodities is completed. The refrigerant that has completed temperature regulating will return to the second compressor 233b, thereby completing the entire circulation.

[0084] Referring to FIG. 10, when the cooperative refrigeration mode is operated, the first four-way valve 135 can be switched so that its first port 135a is connected to the fourth port 135d, and the second port 135b is connected to the third port 135c. The second solenoid valve 238 and the first solenoid valve 236 are turned on. At the same time, the first throttle valve assemblies 212a, 212b and the second throttle valve assemblies 222a, 222b are configured to provide a controlled throttling degree, respectively, and the third throttle valve assembly 232 is configured to turn on the flow paths. At this time, both compressors 233a and 233b are activated. After being compressed by the compressors 233a and 233b, a part of the refrigerant will flow into the first heat exchange flow path 231a through the first four-way valve 235 to be condensed. After passing through the third throttle valve assembly 232, the refrigerant is throttled by the first throttle valve assemblies 212a, 212b and flows into the first indoor heat exchanger sets 211a, 211b to be evaporated. Thus, refrigeration conditioning for indoor air temperature is completed. The refrigerant that has completed temperature regulating will return to the two compressors 233a, 233b through the first four-way valve 235 to complete this part of the circulation. Whereas, the other part of the refrigerant enters the second heat exchange flow path 231b through the first solenoid valve 236 to be condensed, and then enters the subcooling heat exchanger 237a to be subcooled. And then, the refrigerant is throttled by the second throttle valve assemblies 222a, 222b and flows into the second indoor heat exchanger sets 221a, 221b to be evaporated. Thus, refrigeration/freezing temperature regulating for the stored commodities is completed. The refrigerant that has completed temperature regulating will return to the two compressors 233a and 233b to complete this part of the circulation.

[0085] When operating a conventional air-conditioning heating mode, an outdoor heat exchanger set is usually required to serve as an evaporator to absorb heat. Since this mode is usually applied in winter when the outdoor temperature is very low, at this time, the outdoor heat exchanger set is prone to frost, which affects the system efficiency. At this time, operating the outdoor unit defrost mode can be considered, i.e., operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode, so that the high-temperature refrigerant flows through the outdoor heat exchanger set to dissipate heat and defrost, thereby eliminate frost.

[0086] Referring to FIG. 11, when the air-conditioning heating mode is operated, the first four-way valve 235 can be switched so that its first port 235a is connected to the fourth port 235d, and its second port 235b is connected to the third port 235c. The second solenoid valve 238 is turned on and the first solenoid valve 236 is turned off. The first throttle valve assemblies 212a, 212b are configured to turn on the flow paths, so that the third throttle valve assembly 232 is configured to provide a controlled throttling degree, and the second throttle valve assemblies 222a, 222b are configured to turn off the flow paths. At this time, only the first compressor 233a is activated. After being compressed by the first compressor 233a, the refrigerant will flow into the first indoor heat exchanger sets 211a, 211b through the first four-way valve 235 to be condensed. Thus, heating conditioning to the indoor air temperature is completed. After passing through the first throttle valve assemblies 212a and 212b, the refrigerant is throttled by the third throttle valve assembly 232 and flows into the first heat exchange flow path 231a of the outdoor heat exchanger set 231 to be evaporated. The refrigerant then returns to the first compressor 233a through the first four-way valve 235, thereby completing the entire circulation.

[0087] Referring to FIG. 12, when the heat recovery mode is operated, the first four-way valve 235 can be switched so that its first port 235a is connected to the fourth port 235d, and its second port 235b is connected to the third port 235c. The first solenoid valve 236 and the second solenoid valve 238 are turned on. The first throttle valve assemblies 212a, 212b are configured to turn on the flow paths, and the second throttle valve assemblies 222a, 222b and the third throttle valve assembly

232 are configured to provide a controlled throttling degree, respectively. At this time, both compressors 233a and 233b are activated. After being compressed by the two compressors 233a, 233b, the refrigerant will be divided into two parts, one of which flows into the first indoor heat exchanger sets 211a, 211b through the first four-way valve 235 to be condensed, thereby completing the heating conditioning for the indoor air temperature. After passing through the first throttle valve assemblies 212a, 212b, the refrigerant is throttled by the third throttle valve assembly 232 and enters the first heat exchange flow path 231a of the outdoor heat exchanger set 231 to be evaporated. The refrigerant then returns to the two compressors 233a, 233b through the first four-way valve 235, thereby completing this part of circulation. Whereas, the other part of the refrigerant flows into the second heat exchange flow path 231b through the first solenoid valve 236 to be condensed, and then enters the subcooling heat exchanger 237a to be subcooled. And then, the refrigerant is throttled by the second throttle valve assemblies 222a, 222b and flows into the second indoor heat exchanger sets 221a, 221b to be evaporated. Thus, refrigeration/freezing temperature regulating for the commodities in the storage space is completed. The refrigerant then returns to the two compressors 233a, 233b, thereby completing the entire circulation.

[0088] A number of conventional components for the refrigeration cycle can also be provided in the integrated heat pump system to achieve its basic functions. For example, a gas-liquid separator can be provided upstream of the suction port of the compressor to avoid liquid hammer caused by the suction of liquid. For another example, an oil separator can be provided at the exhaust port of the compressor to divert the dispatched lubricating oil back to the compressor. As still another example, pressure sensors and temperature sensors can be provided at various positions in the loop to collect the parameter trigger conditions corresponding to various operating modes, and so on. Since the application of these components in this field is very mature, and they are all aimed at realizing their basic functions, they will not be described in detail here.

[0089] The above examples mainly illustrate the integrated heat pump system and the control method therefor of the present invention. Although only some of the embodiments of the present invention have been described, those skilled in the art should understand that the present invention can, without departing from the scope of the appended claims, be implemented in many other forms. Therefore, the illustrated examples and embodiments are to be considered as illustrative but not restrictive, and the present invention may cover various modifications or replacements if not departed from the scope of the present invention as defined by the appended claims.

[0090] The following additional clauses set out features of the invention which may or may not presently be claimed in this application, but which may form basis for future amendment or a divisional application:

1. An integrated heat pump system (100), comprising:

an air-conditioning indoor unit (110) having a first indoor heat exchanger set (111a, 111b) and a first throttle valve assembly (112a, 112b) for controlling the on-off of flow paths and throttling degree;

a display cabinet indoor unit (120) having a second indoor heat exchanger set (121a, 121b) and a second throttle valve assembly (122a, 122b) for controlling the on-off of flow paths and throttling degree, wherein the second indoor heat exchanger set has a temperature regulating setpoint different from that of the first indoor heat exchanger set; and

an outdoor unit (130) connected to the air-conditioning indoor unit and the display cabinet indoor unit through pipelines, wherein the outdoor unit comprises:

at least two compressors (133a, 133b) connected in parallel and configured to provide different evaporation temperatures respectively;

an outdoor heat exchanger set (131);

a third throttle valve assembly (132) configured to control the on-off of flow paths and throttling degree of the outdoor heat exchanger set;

a mode switch valve assembly configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections.

2. The integrated heat pump system according to clause 1, wherein in a refrigeration mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections;

the third throttle valve assembly is controlled to turn on the flow paths; and

the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly is controlled,

optionally wherein the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated;

a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the first throttle valve assembly turns off the flow paths; and the second compressor of the at least two compressors is activated;

a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly and the second throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; and

an outdoor unit defrost mode: operate any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode.

3. The integrated heat pump system according to clause 1 or 2, wherein in a heating mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least the first indoor heat exchanger set by switching pipeline connections;

the first throttle valve assembly is controlled to turn on the flow paths; and

the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assembly is controlled,

optionally wherein the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the third throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated;

a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly turn on the flow paths, and the second throttle valve assembly provides a controlled throttling degree; and the at least two compressors are activated;

a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly and the third throttle valve assembly provide a controlled throttling degree respectively, and the at least two compressors are activated; and

a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the third throttle valve assembly turns off the flow paths; and the at least two compressors are activated.

4. The integrated heat pump system according to any of clauses 1 to 3, wherein the mode switch valve assembly comprises:

a first four-way valve (135) and a second four-way valve (136) arranged in parallel, wherein,

the first four-way valve has a first port (135a) connected to the exhaust ports of the at least two compressors, a second port (135b) connected to the suction ports of the at least two compressors, a third port (135c) connected to the second four-way valve, and a fourth port (135d) connected to the second port through capillary tubes (138d); and

the second four-way valve has a fifth port (136a) connected to the exhaust ports of the at least two compressors, a sixth port (136b) connected to the first four-way valve, and a seventh port

(136c) connected to the outdoor heat exchanger set, and an eighth port (136d) connected to the first indoor heat exchanger set.

5. The integrated heat pump system according to any of clauses 1 to 4, further comprising: a subcooling branch (137) provided with a subcooling heat exchanger (137a) and an additional throttle element (137b), wherein the subcooling branch is connected from the third throttle valve assembly to the suction ports of the at least two compressors through a first flow path of the subcooling heat exchanger, the additional throttle element, and a second flow path of the subcooling heat exchanger.

6. An integrated heat pump system (200) according to clause 1,

wherein the outdoor heat exchanger set (231) comprises a first heat exchange flow path (231a) and a second heat exchange flow path (231b) that are not connected to each other, wherein the first heat exchange flow path is connected to the air-conditioning indoor unit, and the second heat exchange flow path is connected to the display cabinet indoor unit and the suction ports of the at least two compressors;
wherein the third throttle valve assembly (232) is configured to control the on-off of the first heat exchange flow path as well as the throttling degree of the outdoor heat exchanger set;
and wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set, the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections.

7. The integrated heat pump system according to clause 6, wherein in a refrigeration mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections;
the third throttle valve assembly is controlled to turn on the flow paths; and
the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly is controlled,
optionally wherein the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated;
a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly turn off the flow paths, and the second throttle valve assembly provides a controlled throttling degree; and the second compressor of the at least two compressors is activated;
a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly and the second throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; and
an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode.

8. The integrated heat pump system according to clause 6 or 7, wherein in a heating mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections;
the first throttle valve assembly is controlled to turn on the flow paths; and
the throttling degree of the third throttle valve assembly is controlled,
optionally wherein the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the third throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated; and

a heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly turns on the flow paths, and the second throttle valve assembly and the third throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated.

9. The integrated heat pump system according to any of clauses 6 to 8, wherein the mode switch valve assembly comprises: a first four-way valve (235) and a first solenoid valve (236) arranged in parallel, and a second solenoid valve (238) arranged in series with the first four-way valve; wherein,

the first four-way valve has a first port (235a) connected to the second solenoid valve, a second port (235b) connected to the suction ports of the at least two compressors, a third port (235c) connected to the first heat exchange flow path, and a fourth port (235b) connected to the first indoor heat exchanger set;

the first solenoid valve has a fifth port (236a) connected to the exhaust ports of the at least two compressors and a sixth port (236b) connected to the second heat exchange flow path; and

the second solenoid valve has a seventh port (238a) connected to the exhaust ports of the at least two compressors and an eighth port (238b) connected to the first four-way valve.

10. The integrated heat pump system according to any of clauses 6 to 9, further comprising: a subcooling branch (237) provided with a subcooling heat exchanger (237a) and an additional throttle element (237b), wherein the subcooling branch is connected to the suction ports of the at least two compressors through the second heat exchange flow path, the first flow path of the subcooling heat exchanger, the additional throttle element, and the second flow path of the subcooling heat exchanger.

11. The integrated heat pump system according to any of clauses 6 to 10, wherein the first heat exchange flow path and the second heat exchange flow path of the outdoor heat exchanger set are in the form of staggered arrangement through pipelines or in the form of staggered arrangement through stacking.

12. A control method for the integrated heat pump system according to any of clauses 1 to 5, comprising:

operating a refrigeration mode: guiding the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the third throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly; or

operating a heating mode: guiding the refrigerant flowing out of the at least two compressors into at least the first indoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the first throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assembly.

13. The control method according to clause 12, wherein:

the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the first throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated;

a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the second throttle valve assembly is controlled, the first throttle valve assembly is controlled to turn off the flow paths, and the second compressor of the at least two compressors is activated;

a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the first throttle valve assembly and the second throttle valve assembly are controlled respectively; and the at least two compressors are activated;

an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode; and

the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the third throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated;

a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly are controlled to turn on the flow paths, and the throttling degree of the second throttle valve assembly is controlled; and the at least two compressors are activated;

a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the second throttle valve assembly and the third throttle valve assembly are controlled respectively; and the at least two compressors are activated; and

a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the second throttle valve assembly is controlled, and the third throttle valve assembly is controlled to turn off the flow paths; and the at least two compressors are activated.

14. A control method for the integrated heat pump system according to any of clauses 6 to 11, comprising:

operating a refrigeration mode: guiding the refrigerant flowing out of the at least two compressors into at least one of the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections through control of the mode switch valve assembly; controlling the third throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly; or

operating a heating mode: guiding the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections through control of the mode switch valve assembly; controlling the first throttle valve assembly to turn on the flow paths; and controlling the throttling degree of the third throttle valve assembly.

15. The control method according to clause 14, wherein:

the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the first throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated;

a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly are controlled to turn off the flow paths, and the throttling degree of the second throttle valve assembly is controlled; and the second compressor of the at least two compressors is activated;

a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first heat exchange flow path and the second heat exchange flow path by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the first throttle valve assembly and the second throttle valve assembly are controlled respectively; and the at least two compressors are activated;

an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode; and

the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the third throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated; and

a heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the second heat exchange flow path by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the second throttle valve assembly and the third throttle valve assembly are controlled respectively; and the at least two compressors are activated.

Claims

1. An integrated heat pump system (100), comprising:

an air-conditioning indoor unit (110) having a first indoor heat exchanger set (111a, 111b) and a first throttle valve assembly (112a, 112b) for controlling the on-off of flow paths and throttling degree;

a display cabinet indoor unit (120) having a second indoor heat exchanger set (121a, 121b) and a second throttle valve assembly (122a, 122b) for controlling the on-off of flow paths and throttling degree, wherein the second indoor heat exchanger set has a temperature regulating setpoint different from that of the first indoor heat exchanger set; and

an outdoor unit (130) connected to the air-conditioning indoor unit and the display cabinet indoor unit through pipelines, wherein the outdoor unit comprises:

at least two compressors (133a, 133b) connected in parallel and configured to provide different evaporation temperatures respectively;

an outdoor heat exchanger set (131);

a third throttle valve assembly (132) configured to control the on-off of flow paths and throttling degree of the outdoor heat exchanger set;

a mode switch valve assembly configured to guide the refrigerant flowing out of the at least two compressors into at least one of the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections.

2. The integrated heat pump system according to claim 1, wherein in a refrigeration mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections;

the third throttle valve assembly is controlled to turn on the flow paths; and

the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly is controlled,

optionally wherein the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated;
a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the first throttle valve assembly turns off the flow paths; and the second compressor of the at least two compressors is activated;
a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly turns on the flow paths, the first throttle valve assembly and the second throttle valve assembly provide a controlled throttling degree respectively; and the at least two compressors are activated; and
an outdoor unit defrost mode: operate any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode.

3. The integrated heat pump system according to claim 1 or 2, wherein in a heating mode:

the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into at least the first indoor heat exchanger set by switching pipeline connections;
the first throttle valve assembly is controlled to turn on the flow paths; and
the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assembly is controlled,
optionally wherein the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the third throttle valve assembly provides a controlled throttling degree, and the second throttle valve assembly turns off the flow paths; and the first compressor of the at least two compressors is activated;
a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly turn on the flow paths, and the second throttle valve assembly provides a controlled throttling degree; and the at least two compressors are activated;
a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly and the third throttle valve assembly provide a controlled throttling degree respectively, and the at least two compressors are activated; and
a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly turns on the flow paths, the second throttle valve assembly provides a controlled throttling degree, and the third throttle valve assembly turns off the flow paths; and the at least two compressors are activated.

4. The integrated heat pump system according to any of claims 1 to 3, wherein the mode switch valve assembly comprises:

a first four-way valve (135) and a second four-way valve (136) arranged in parallel, wherein,
the first four-way valve has a first port (135a) connected to the exhaust ports of the at least two compressors, a second port (135b) connected to the suction ports of the at least two compressors, a third port (135c) connected to the

second four-way valve, and a fourth port (135d) connected to the second port through capillary tubes (138d); and

the second four-way valve has a fifth port (136a) connected to the exhaust ports of the at least two compressors, a sixth port (136b) connected to the first four-way valve, and a seventh port (136c) connected to the outdoor heat exchanger set, and an eighth port (136d) connected to the first indoor heat exchanger set.

5. The integrated heat pump system according to any of claims 1 to 4, further comprising: a subcooling branch (137) provided with a subcooling heat exchanger (137a) and an additional throttle element (137b), wherein the subcooling branch is connected from the third throttle valve assembly to the suction ports of the at least two compressors through a first flow path of the subcooling heat exchanger, the additional throttle element, and a second flow path of the subcooling heat exchanger.

6. A control method for the integrated heat pump system according to any of claims 1 to 5, comprising:

operating a refrigeration mode: guiding the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the third throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the first throttle valve assembly and the second throttle valve assembly; or

operating a heating mode: guiding the refrigerant flowing out of the at least two compressors into at least the first indoor heat exchanger set by switching pipeline connections through control of the mode switch valve assembly; controlling the first throttle valve assembly to turn on the flow paths; and controlling the throttling degree of at least one of the second throttle valve assembly and the third throttle valve assembly.

7. The control method according to claim 6, wherein:

the refrigeration mode comprises one or more of the following modes:

an air-conditioning refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the first throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated;

a display cabinet refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the second throttle valve assembly is controlled, the first throttle valve assembly is controlled to turn off the flow paths, and the second compressor of the at least two compressors is activated;

a cooperative refrigeration mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the third throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the first throttle valve assembly and the second throttle valve assembly are controlled respectively; and the at least two compressors are activated;

an outdoor unit defrost mode: operating any one of the air-conditioning refrigeration mode, the display cabinet refrigeration mode, and the cooperative refrigeration mode; and

the heating mode comprises one or more of the following modes:

an air-conditioning heating mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the third throttle valve assembly is controlled, and the second throttle valve assembly is controlled to turn off the flow paths; and the first compressor of the at least two compressors is activated;

a heat rejection and heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set and the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly and the third throttle valve assembly are controlled to turn on the flow paths, and the throttling degree of the second throttle valve assembly is controlled; and the at least two compressors are activated;

a compensation heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the outdoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, and the throttling degrees of the second throttle valve assembly and the third throttle valve assembly are controlled respectively; and the at least two compressors are activated; and

a total heat recovery mode: wherein the mode switch valve assembly is configured to guide the refrigerant flowing out of the at least two compressors into the first indoor heat exchanger set by switching pipeline connections; the first throttle valve assembly is controlled to turn on the flow paths, the throttling degree of the second throttle valve assembly is controlled, and the third throttle valve assembly is controlled to turn off the flow paths; and the at least two compressors are activated.

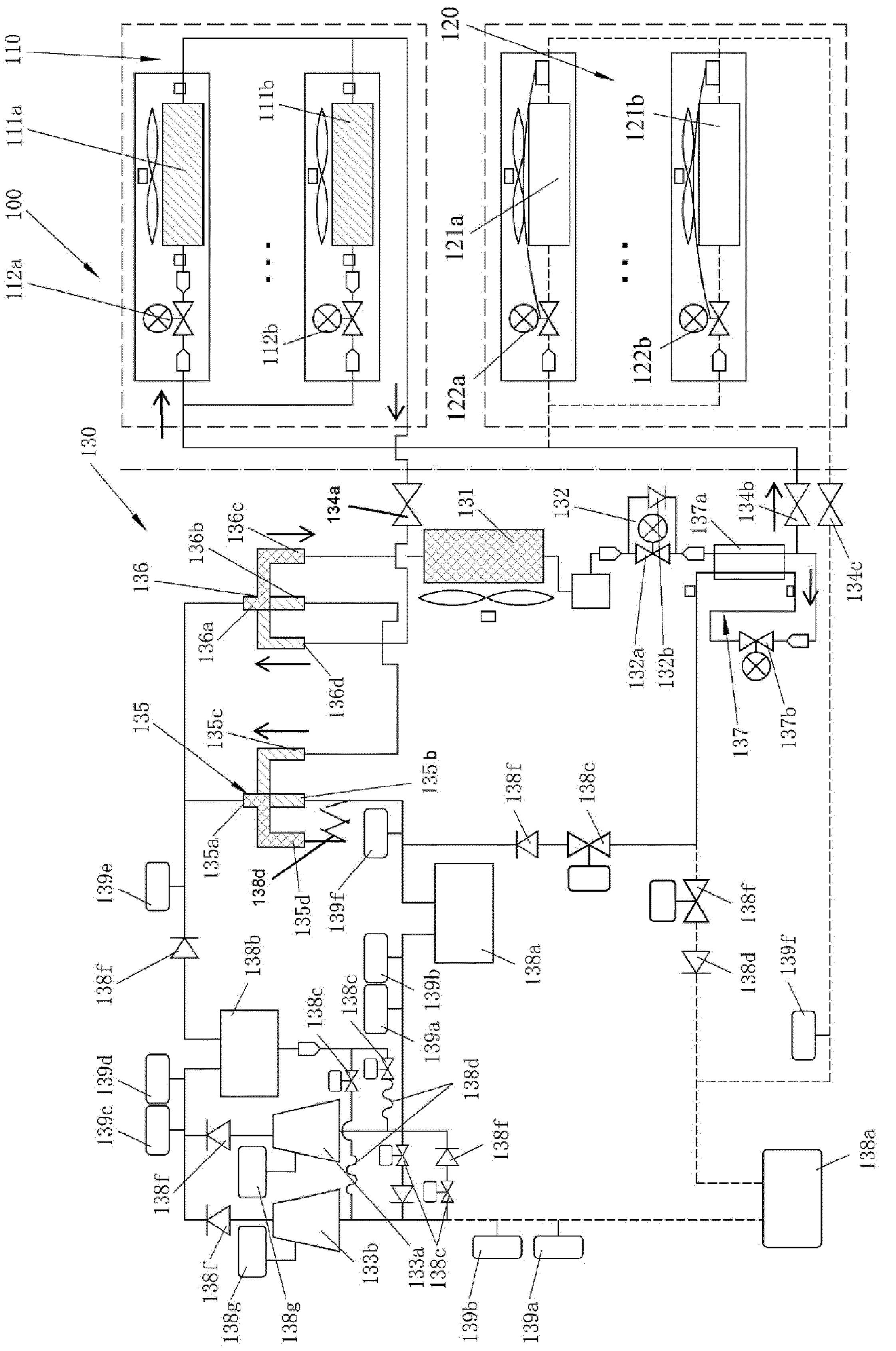
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Figure 1

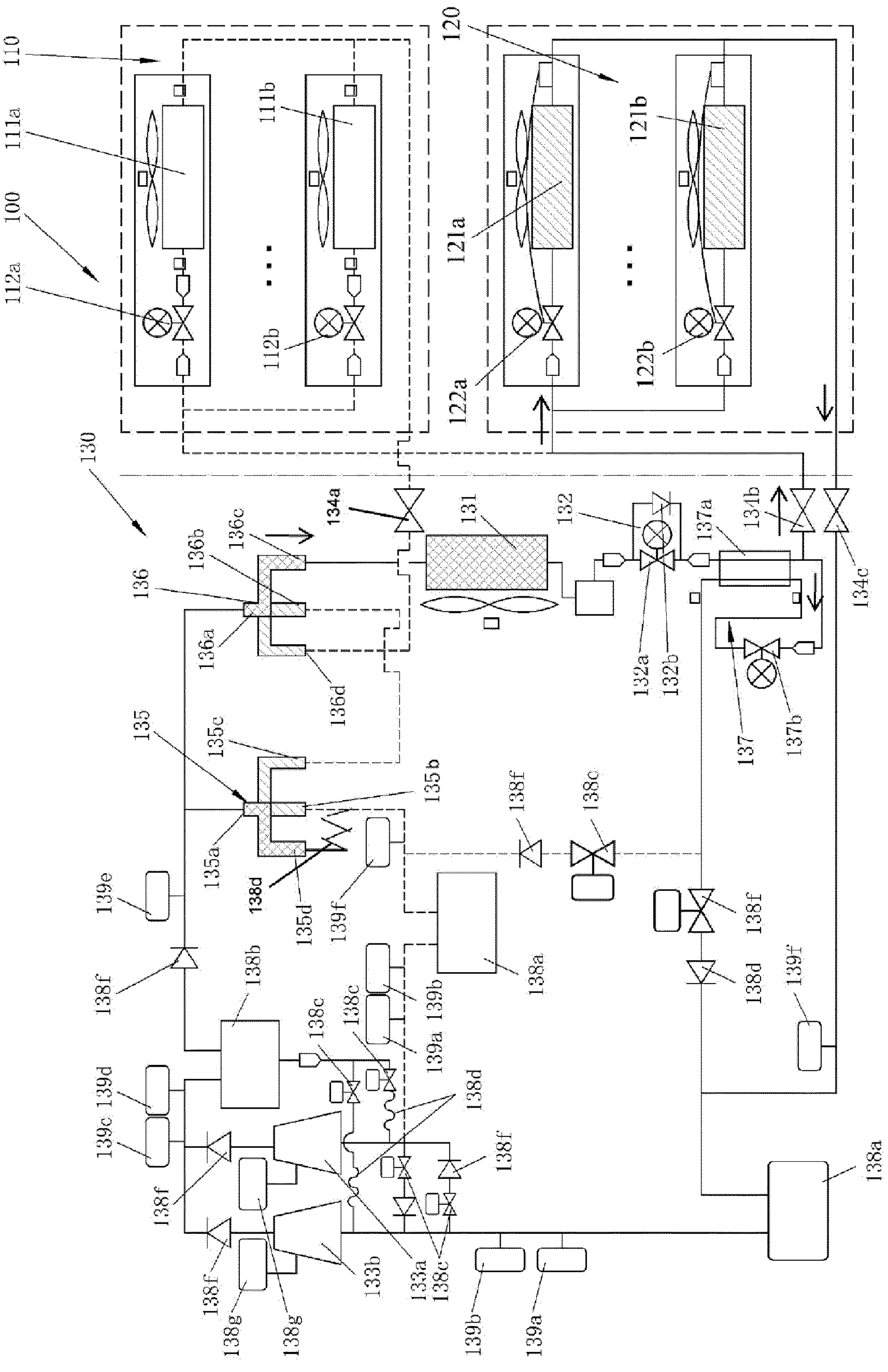
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Figure 2

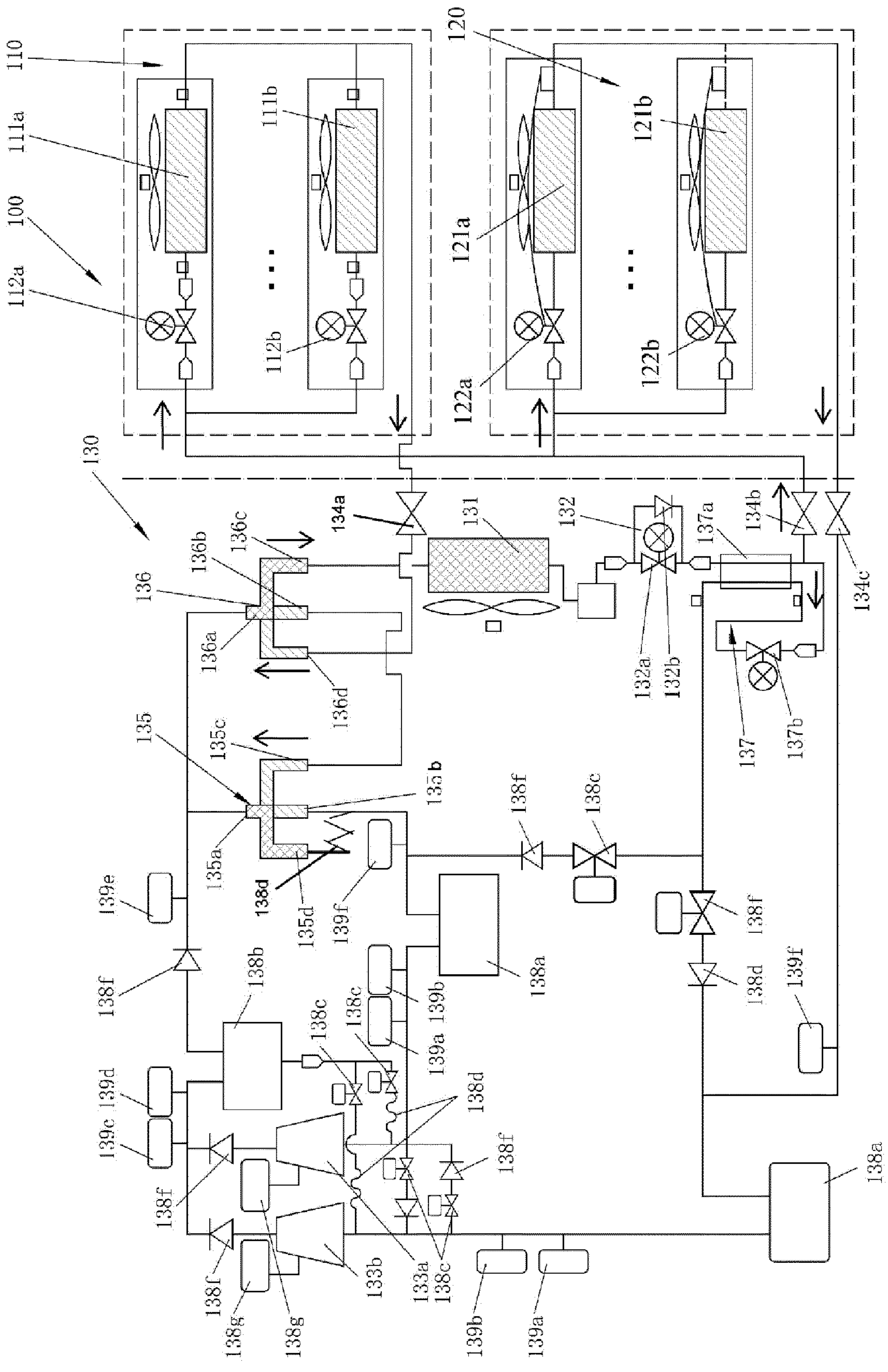
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Figure 3

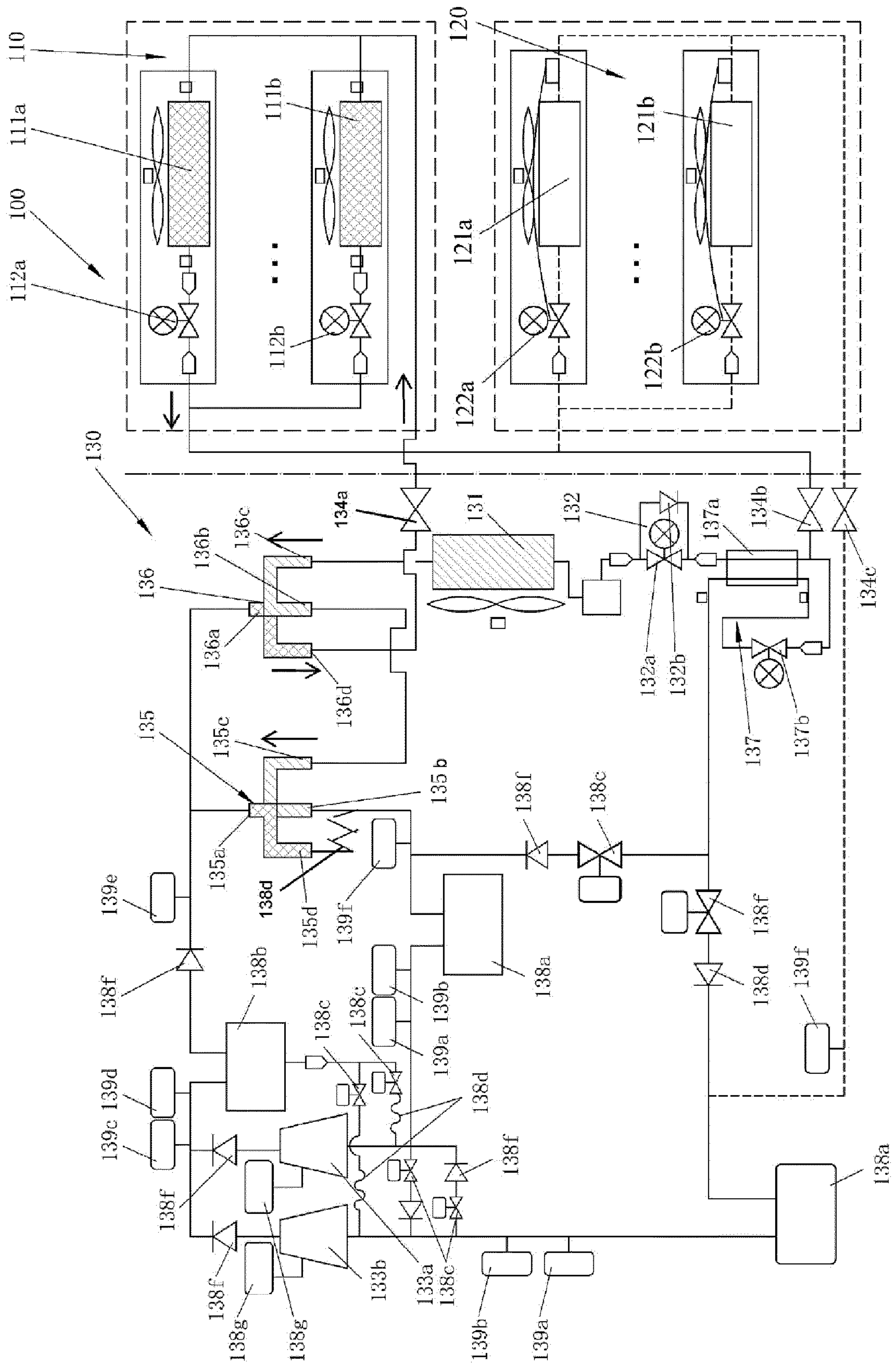
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Figure 4

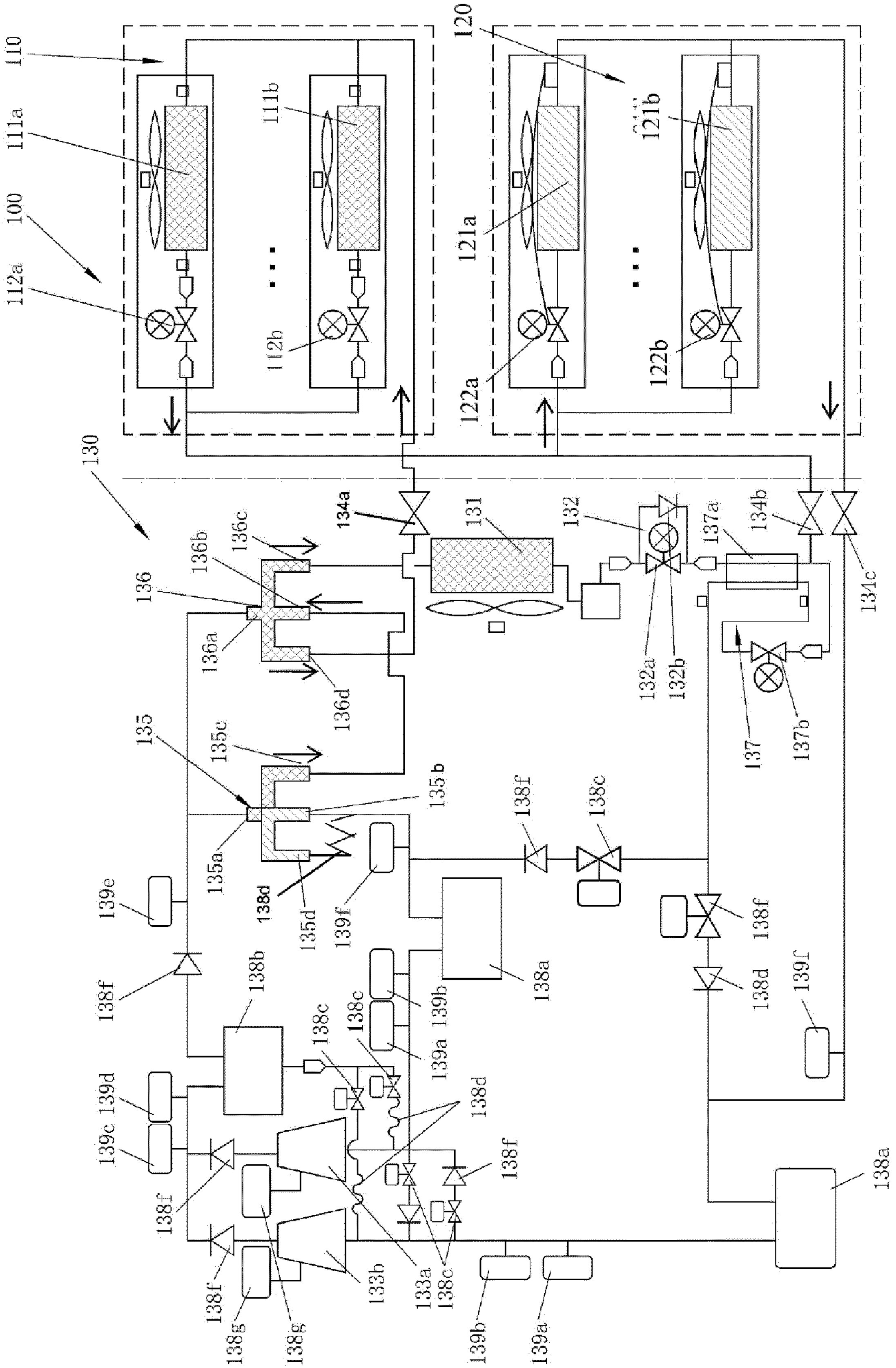
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Figure 5

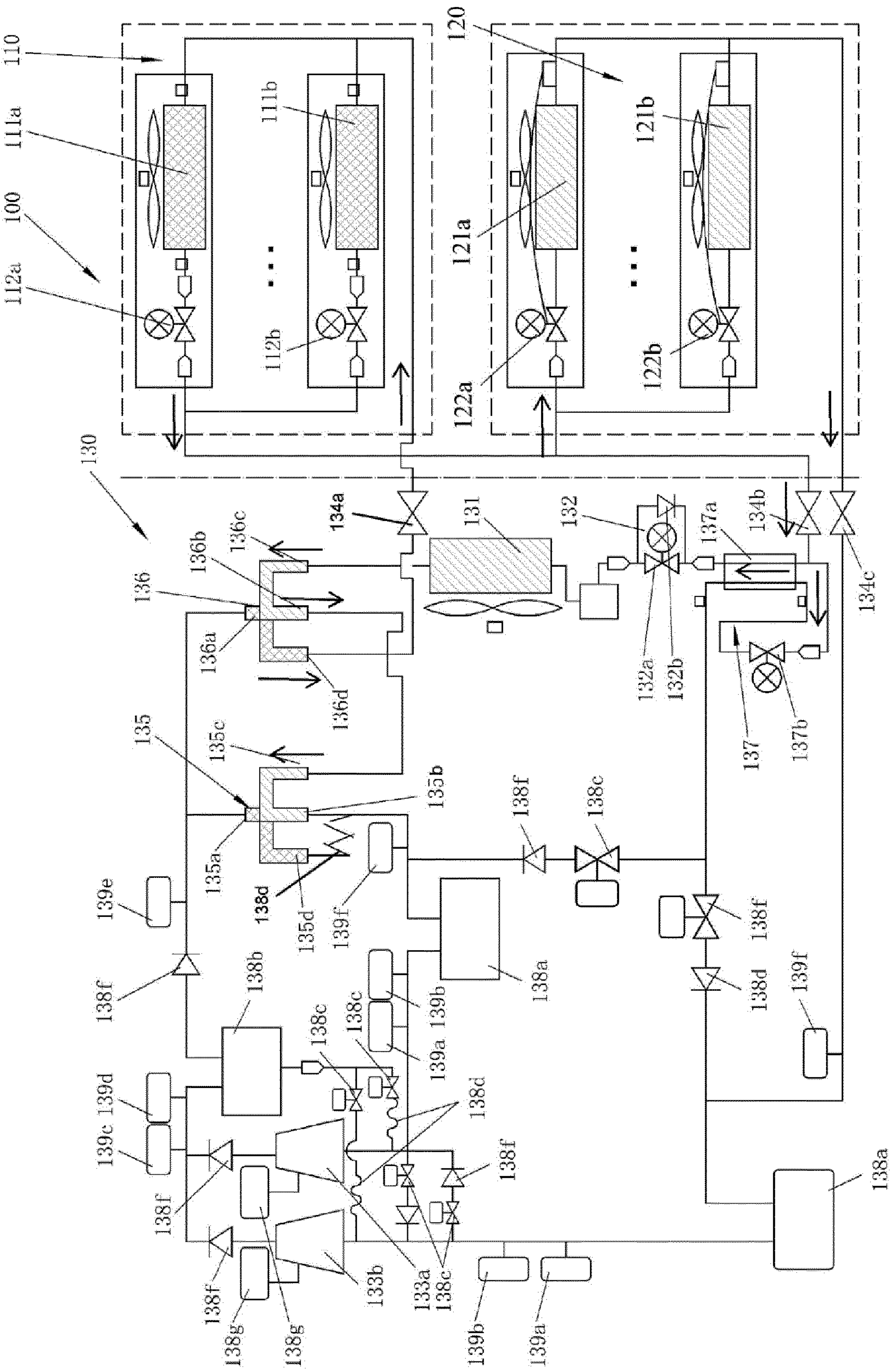
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Figure 6

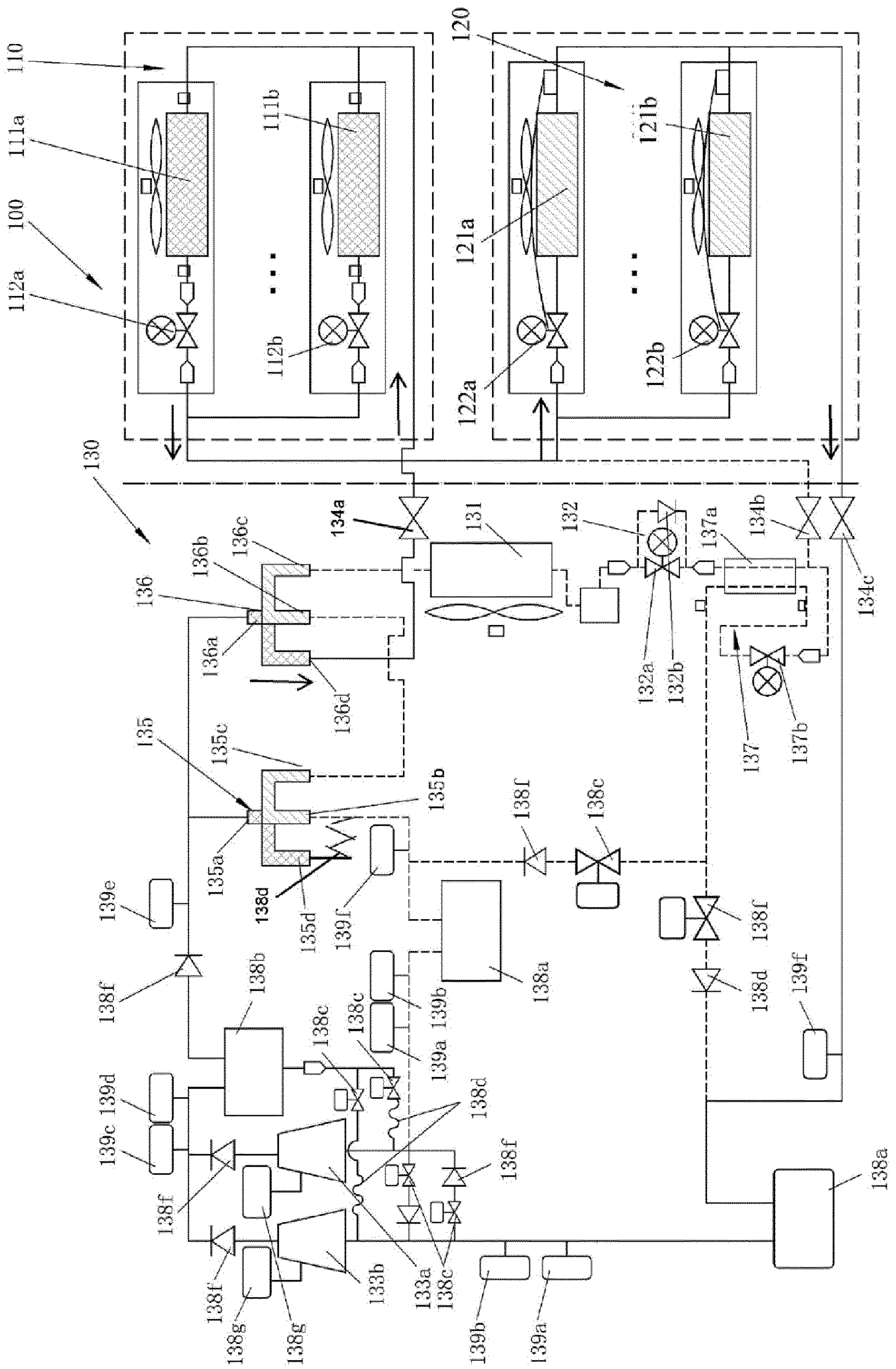

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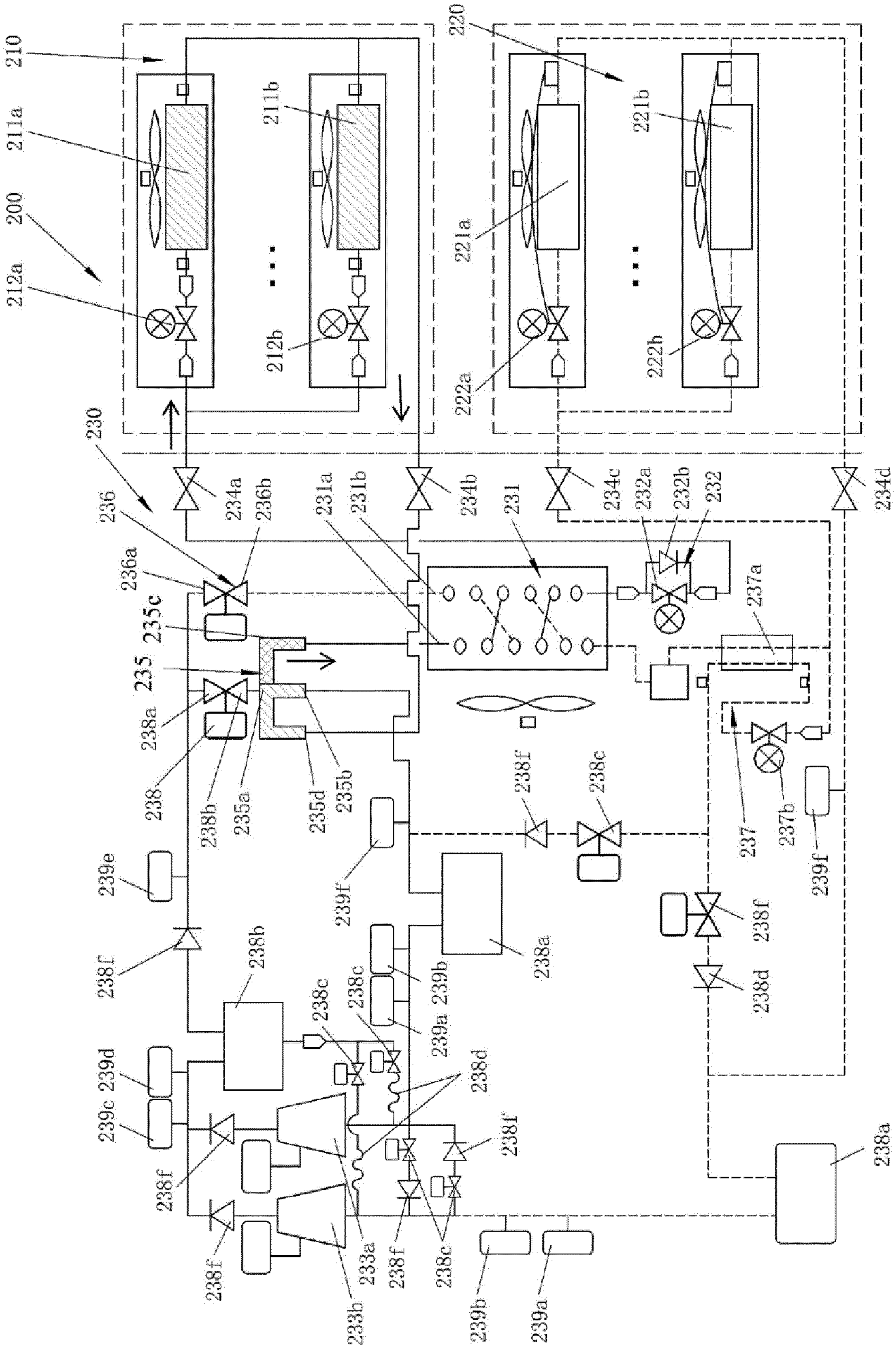
Figure 7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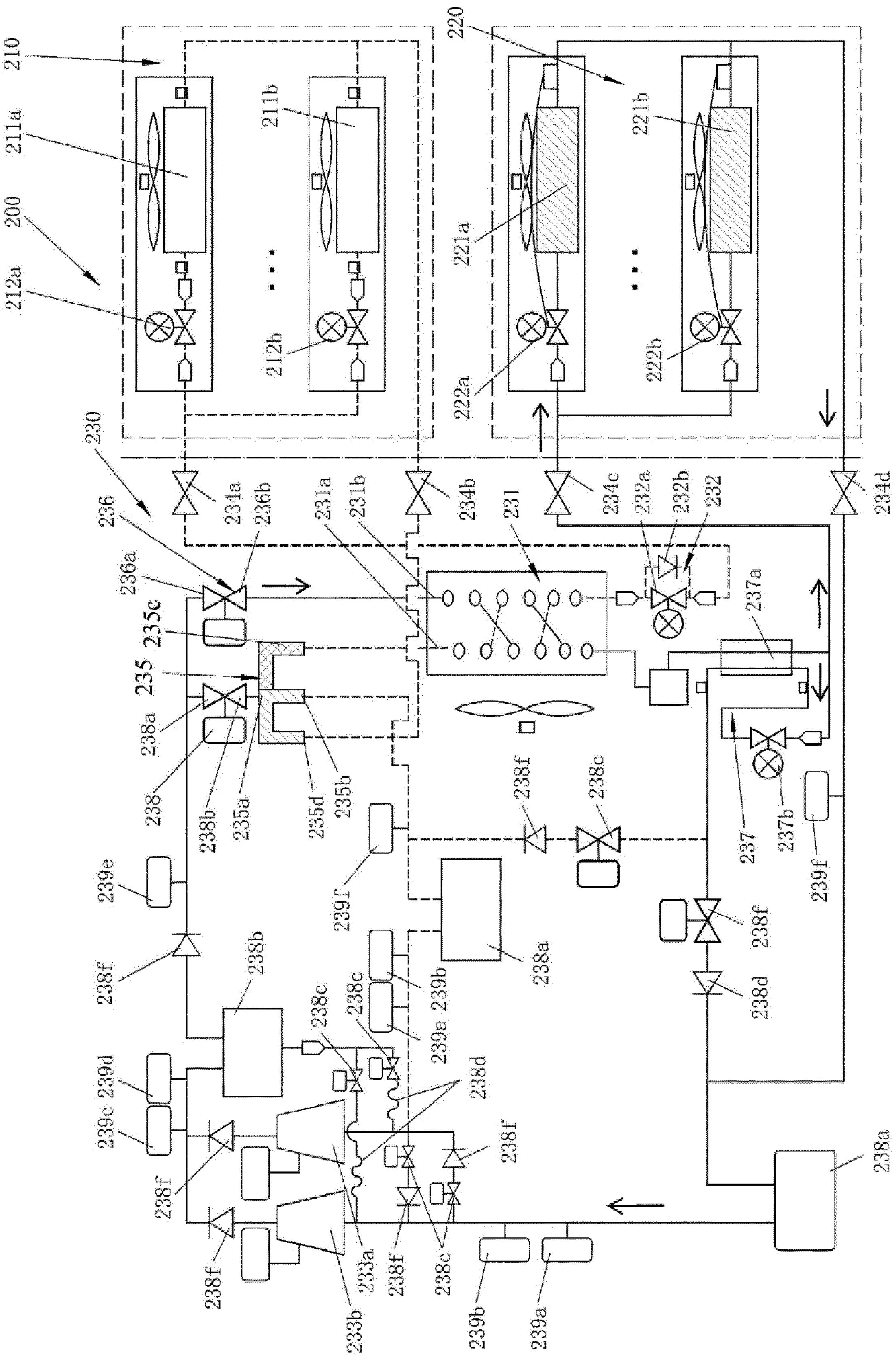
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Figure 9

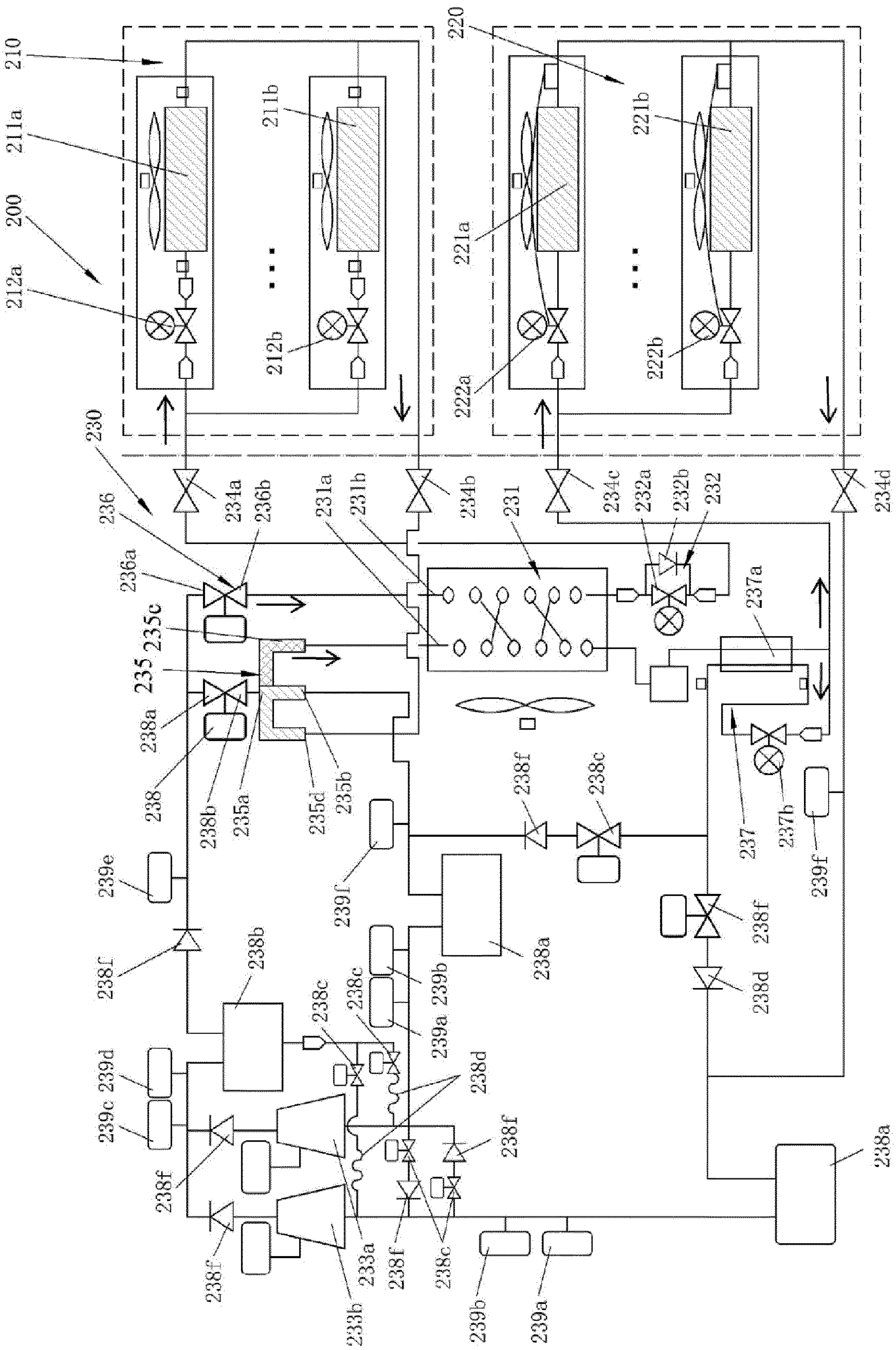
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Figure 10

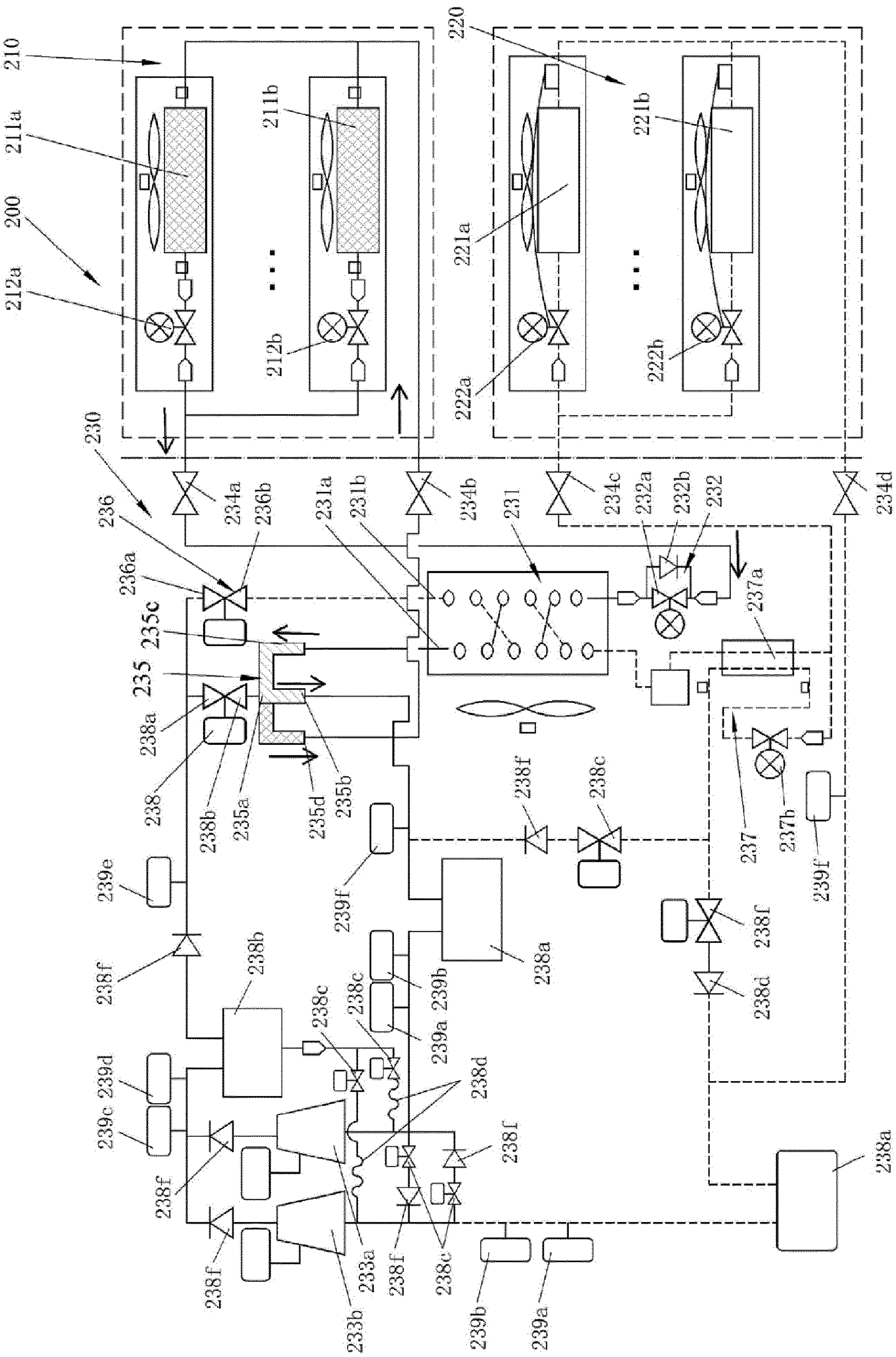
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Figure 11

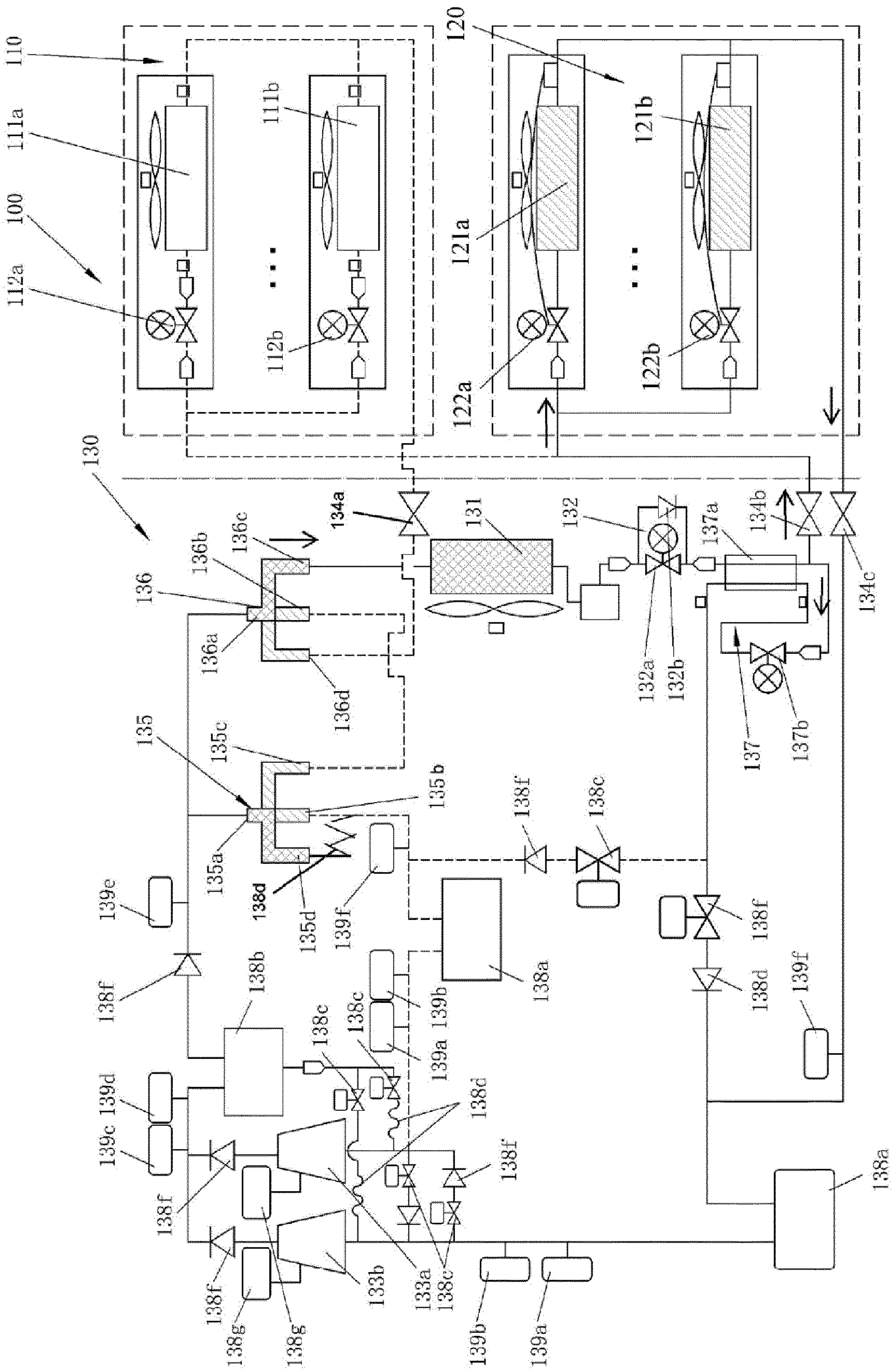
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Figure 12

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 1182

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 863 153 A1 (DAIKIN IND LTD [JP]; DAIKIN EUROPE NV [BE]) 22 April 2015 (2015-04-22)	1-3,5-7	INV. F25B5/02 F25B6/02 F25B13/00 F25B40/00 F25B41/26 F25B49/02
A	* paragraphs [0018] - [0079]; figures 1-5 *	4	
A	EP 2 236 957 A2 (HITACHI APPLIANCES INC [JP]) 6 October 2010 (2010-10-06) * paragraph [0022]; figure 1 *	4	
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TECHNICAL FIELDS SEARCHED (IPC)

F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	7 June 2022	Lepers, Joachim

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