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(54) AIR CONDITIONING SYSTEM

(57) Provided is an air conditioning system (100), including an outdoor unit (200), an indoor unit (300), a refrigerant recycling apparatus (400) and a controller (600). The outdoor unit (200) includes an outdoor refrigerant leakage detection device (218). The indoor unit (300) includes an indoor refrigerant leakage detection device (304). The refrigerant recycling apparatus (400) is located between the outdoor unit (200) and the indoor unit (300), and is configured to recycle and store refrigerant in the air conditioning system (100) when refrigerant leakage occurs in one of the outdoor unit (200) and the indoor unit (300). The controller (600) is coupled to the outdoor refrigerant leakage detection device (218) and the indoor refrigerant leakage detection device (304), and is configured to: determine whether refrigerant leakage occurs in the indoor unit (300) and the outdoor unit (200); if it is determined that refrigerant leakage occurs in the indoor unit (300), control the air conditioning system (100) to run a first refrigerant recycling mode; and if it is determined that refrigerant leakage occurs in the outdoor unit (200), control the air conditioning system (100) to run a second refrigerant recycling mode.

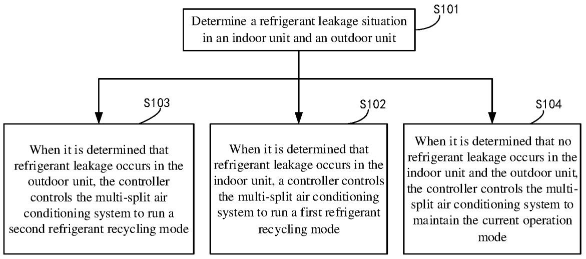

FIG. 14

Processed by Luminess, 75001 PARIS (FR)

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese Patent Application No. 202210847980.3 filed on July 19, 2022 and to Chinese Patent Application No. 202210851580.X filed on July 19, 2022, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of home appliance technologies, and in particular, to an air conditioning system.

BACKGROUND

[0003] With the development of the economy and society, air conditioners are more and more widely used. Moreover, when air conditions are required in a plurality of small regions in the same region, in consideration of energy saving, a multi-split air conditioning system including an outdoor unit and a plurality of indoor units is generally adopted to achieve control over multi-region room temperatures.

SUMMARY

[0004] In one aspect, an air conditioning system is provided. The air conditioning system includes an outdoor unit, one or more indoor units, a refrigerant recycling apparatus, and a controller. The outdoor unit includes an outdoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the outdoor unit. The indoor unit includes an indoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the indoor unit. The refrigerant recycling apparatus is located between the outdoor unit and the indoor unit and configured to recycle and store refrigerant in the air conditioning system when refrigerant leakage occurs in one of the outdoor unit and the indoor unit. The controller is coupled to the outdoor refrigerant leakage detection device and the indoor refrigerant leakage detection device and is configured to: acquire a detection result of the indoor refrigerant leakage detection device; determine, according to the detection result of the indoor refrigerant leakage detection device, whether refrigerant leakage occurs in the indoor unit; if yes, control the air conditioning system to run a first refrigerant recycling mode, and if not, control the air conditioning system to maintain the current operation mode; acquire a detection result of the outdoor refrigerant leakage detection device; determine, according to the detection result of the outdoor refrigerant leakage detection device, whether refrigerant leakage occurs in the outdoor unit; if yes, control the air conditioning system to run a second refrigerant recycling mode; and if not, control the air conditioning system to maintain the current operation mode. In the first refrigerant recycling mode, the refrigerant in a pipeline of the indoor unit flows into a compressor of the outdoor unit and then is recycled into the refrigerant recycling apparatus through the outdoor unit. In the second refrigerant recycling mode, the refrigerant in a pipeline of the outdoor unit flows into the compressor and then is recycled into the refrigerant recycling apparatus through the indoor unit.

[0005] In another aspect, an air conditioning system is provided. The air conditioning system includes an outdoor unit, one or more indoor units, a refrigerant recycling apparatus, and a controller. The outdoor unit includes an outdoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the outdoor unit. The indoor unit includes an indoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the indoor unit. The refrigerant recycling apparatus is located between the outdoor unit and the indoor unit and configured to recycle and store refrigerant in the air conditioning system when refrigerant leakage occurs in one of the outdoor unit and the indoor unit. The controller is coupled to the outdoor refrigerant leakage detection device and the indoor refrigerant leakage detection device and is configured to: acquire a detection result of the indoor refrigerant leakage detection device; determine, according to the detection result of the indoor refrigerant leakage detection device, whether refrigerant leakage occurs in the indoor unit; if yes, control the air conditioning system to run a first refrigerant recycling mode, and if not, control the air conditioning system to maintain the current operation mode; acquire a detection result of the outdoor refrigerant leakage detection device; determine, according to the detection result of the outdoor refrigerant leakage detection device, whether refrigerant leakage occurs in the outdoor unit; if yes, control the air conditioning system to run a second refrigerant recycling mode; and if not, control the air conditioning system to maintain the current operation mode; and when one of the first refrigerant recycling mode and the second refrigerant recycling mode is completed, control the air conditioning system to run a refrigerant release mode if receiving a control signal instructing the air conditioning system to operate in one of a refrigeration mode and a heating mode. In the first refrigerant recycling mode, the refrigerant in a pipeline of the indoor unit flows into a compressor of the outdoor unit and then is recycled into the refrigerant recycling apparatus through the outdoor unit. In the second refrigerant recycling mode, the refrigerant in a pipeline of the outdoor unit flows into the compressor and then is recycled into the refrigerant recycling apparatus through the indoor unit. In the refrigerant release mode, the refrigerant recycled in the refrigerant recycling apparatus is released into a pipeline in the air conditioning system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] In order to describe technical solutions in the present disclosure more clearly, the accompanying drawings to be used in some embodiments of the present disclosure will be introduced briefly below. However, the accompanying drawings to be described below are merely accompanying drawings of some embodiments of the present disclosure, and those of ordinary skill in the art can obtain other drawings according to these drawings. In addition, the accompanying drawings in the following description may be regarded as schematic diagrams, and are not limitations on actual sizes of products, actual processes of methods, and actual timings of signals as referred to in the embodiments of the present disclosure.

FIG. 1 is a structural diagram of an air conditioning system according to some embodiments;
FIG. 2 is a block diagram of an air conditioning system according to some embodiments;
FIG. 3 is a schematic diagram of a refrigerant circulation (a refrigeration mode) of an air conditioning system according to some embodiments;
FIG. 4 is another schematic diagram of a refrigerant circulation (a heating mode) of an air conditioning system according to some embodiments;
FIG. 5 is a schematic diagram of a refrigerant circulation (a first refrigerant recycling mode) of yet another air conditioning system according to some embodiments;
FIG. 6 is yet another schematic diagram of a refrigerant circulation (a second refrigerant recycling mode) of an air conditioning system according to some embodiments;
FIG. 7 is a structural diagram of another air conditioning system according to some embodiments;
FIG. 8 is yet another schematic diagram of a refrigerant circulation (a refrigeration mode) of an air conditioning system according to some embodiments;
FIG. 9 is yet another schematic diagram of a refrigerant circulation (a heating mode) of an air conditioning system according to some embodiments;
FIG. 10 is yet another schematic diagram of a refrigerant circulation (a first refrigerant recycling mode) of an air conditioning system according to some embodiments;
FIG. 11 is yet another schematic diagram of a refrigerant circulation (a second refrigerant recycling mode) of an air conditioning system according to some embodiments;
FIG. 12 is yet another schematic diagram of a refrigerant circulation (a refrigerant release mode under a refrigeration condition) of an air conditioning system according to some embodiments;
FIG. 13 is yet another schematic diagram of a refrigerant circulation (a refrigerant release mode under a heating condition) of an air conditioning system according to some embodiments;
FIG. 14 is a flowchart of controlling an air conditioning system according to some embodiments;
FIG. 15 is another flowchart of controlling an air conditioning system according to some embodiments;
FIG. 16 is yet another flowchart of controlling an air conditioning system according to some embodiments;
FIG. 17 is yet another flowchart of controlling an air conditioning system according to some embodiments;
FIG. 18 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 19 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 20 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 21 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 22 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 23 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 24 is a structural diagram of yet another air conditioning system according to some embodiments;
FIG. 25 is yet another flowchart of controlling an air conditioning system according to some embodiments;
FIG. 26 is yet another flowchart of controlling an air conditioning system according to some embodiments; and
FIG. 27 is a structural diagram of the hardware of a controller according to some embodiments.

DETAILED DESCRIPTION

[0007] Technical solutions in some embodiments of the present disclosure will be described clearly and completely with reference to the accompanying drawings below. Apparently, the described embodiments are merely some but not all embodiments of the present disclosure. All other embodiments obtained by those of ordinary skill in the art based on the embodiments provided in the present disclosure shall be included in the protection scope of the present disclosure.

[0008] Unless the context requires otherwise, throughout the specification and the claims, the term "comprise" and other forms thereof such as the third-person singular form "comprises" and the present participle form "comprising" are construed as open and inclusive meaning, i.e., "including, but not limited to". In the description of the specification, the terms such as "one embodiment", "some embodiments", "exemplary embodiments", "example", "specific example", and "some examples" are intended to indicate that specific features, structures, materials or characteristics related to the embodiment(s) or example(s) are included in at least one embodiment or example of the present disclosure. Schematic representations of the above terms do not necessarily refer to the same embodiment(s) or example(s). In addition, the specific features, structures, materials, or characteristics may be included in any one or more embodiments or examples in any suitable manner.

[0009] Hereinafter, the terms such as "first" and "second" are used for descriptive purposes only, and are not to be construed as indicating or implying the relative importance or implicitly indicating the number of indicated technical features. Thus, a feature defined with "first" or "second" may explicitly or implicitly include one or more of the features. In the description of the embodiments of the present disclosure, "a plurality of" means two or more unless otherwise specified.

[0010] In the description of some embodiments, the terms such as "coupled" and "connected" and derivatives thereof may be used. The term "connected" should be understood in a broad sense. For example, "connected" may be a fixed connection, a detachable connection, or an integrated connection; or a direct connection or an indirect connection through an intermediary. The term "coupled" may indicate that two or more components are in direct physical or electrical contact. The term "coupled" or "communicatively coupled" may also mean that two or more components are not in direct contact with each other, but still cooperate or interact with each other. The embodiments disclosed herein are not necessarily limited to the content herein.

[0011] The phrase "at least one of A, B, and C" has the same meaning as the phrase "at least one of A, B, or C", both including the following combinations of A, B, and C: only A, only B, only C, a combination of A and B, a combination of A and C, a combination of B and C, and a combination of A, B and C.

[0012] The phrase "A and/or B" includes the following three combinations: only A, only B, and a combination of A and B.

[0013] The use of the phrase "applicable to" or "configured to" herein means an open and inclusive expression, which does not exclude devices that are applicable to or configured to perform additional tasks or steps.

[0014] The term such as "substantially," "about,", or "approximately" as used herein includes a stated value and an average value within an acceptable range of deviation of a particular value. The acceptable range of deviation is determined by those of ordinary skill in the art in view of measurement in question and an error associated with a particular amount of measurement (i.e., limitations of a measurement system).

[0015] The term such as "parallel," "perpendicular," or "equal" as used herein includes a stated condition and a condition similar to the stated condition. A range of the similar condition is within an acceptable deviation range, and the acceptable deviation range is determined by those of ordinary skill in the art, considering measurement in question and errors associated with a particular amount of measurement (i.e., limitations of a measurement system). For example, the term "parallel" includes absolute parallelism and approximate parallelism, and an acceptable range of deviation of the approximate parallelism may be a deviation within 5°. The term "perpendicular" includes absolute perpendicularity and approximate perpendicularity, and an acceptable range of deviation of the approximate perpendicularity may also be a deviation within 5°. The term "equal" includes absolute equality and approximate equality, and an acceptable range of deviation of the approximate equality may be a difference between two equals being less than or equal to 5% of one of the two equals.

[0016] In the related art, during use of an air conditioning system, there is a need to use a heat transfer tube on a heat exchanger (such as a copper tube or an aluminum tube) to transfer heat. However, the heat transfer tube may be corroded due to long-time exposure to an outdoor environment, which may cause the problem of refrigerant leakage.

[0017] In order to prevent a risk caused by refrigerant leakage, a pair of electronic expansion valves is generally added to an inlet and an outlet of an indoor unit of the air conditioning system to prevent refrigerant from leaking into the indoor environment. However, the refrigerant is recycled at a low rate, and the refrigerant not recycled may be discharged into the outdoor environment, causing a problem of environmental pollution.

[0018] To solve the above problems, some embodiments of the present disclosure provide an air conditioning system. A refrigerant recycling apparatus is arranged between an outdoor unit and an indoor unit of the air conditioning system. When the refrigerant leaks, a flowing direction of the refrigerant in the air conditioning system is controlled by controlling the closed and open states of a first solenoid valve, a second solenoid valve, and a third solenoid valve in the refrigerant recycling apparatus in combination with operation modes that the outdoor unit and the indoor unit are to enter, to introduce the refrigerant in the air conditioning system into a liquid storage tank of the refrigerant recycling apparatus, which increases a recycling rate of the refrigerant, thereby preventing the problem of environmental pollution caused by discharge of the refrigerant into the outdoor environment and improving environmental protection of the air conditioning system.

[0019] It is to be noted that some embodiments of the present disclosure are mainly described based on an example in which the air conditioning system is a multi-split air conditioning system. However, this cannot be understood as a limitation on the present disclosure.

[0020] As shown in FIG. 1, a multi-split air conditioning system 100 includes an outdoor unit 200, an indoor unit 300, and a refrigerant recycling apparatus 400. The indoor unit 300 may include a plurality of indoor units connected in parallel. For example, the indoor unit 300 includes a first indoor unit 300A and a second indoor unit 300B.

[Outdoor unit]

[0021] The outdoor unit 200 includes a compressor 201, a four-way valve 202 (such as a four-way reversing valve), an outdoor heat exchanger 203, and an outdoor expansion valve 204 connected in sequence.

[0022] In some embodiments, the outdoor heat exchanger 203 is located between the compressor 201 and the refrigerant recycling apparatus 400. The outdoor heat exchanger 203 has a first end and a second end, which are an end A1 and an end A2 respectively. For example, the end A1 of the outdoor heat exchanger 203 is connected to the compressor 201 through the four-way valve 202, and the end A2 of the outdoor heat exchanger 203 is connected to the refrigerant recycling apparatus 400. The outdoor heat exchanger 203 is configured to allow heat exchange between the refrigerant flowing in a heat transfer tube of the outdoor heat exchanger 203 and outdoor air.

[0023] The outdoor expansion valve 204 is located between the outdoor heat exchanger 203 and the refrigerant recycling apparatus 400. The outdoor expansion valve 204 is connected to the end A2 of the outdoor heat exchanger 203 through a pipeline.

[0024] The compressor 201 is arranged between the indoor unit 300 and the outdoor heat exchanger 203. The compressor 201 has an intake port B1 and an exhaust port B2. The compressor 201 is configured to provide power for refrigerant circulation. Taking refrigeration circulation as an example, the compressor 201 delivers compressed refrigerant through the four-way valve 202 to the outdoor heat exchanger 203.

[0025] For example, the compressor 201 is a -capacity-variable compressor with inverter-based rotational speed control.

[0026] In some embodiments, as shown in FIG. 1, the four-way valve 202 has four ports, which are a port D, a port C, a port S, and a port E respectively. The port D of the four-way valve 202 is connected to the exhaust port B2 of the compressor 201, the port C of the four-way valve 202 is connected to the end A1 of the outdoor heat exchanger 203, the port S of the four-way valve 202 is connected to the intake port B1 of the compressor 201, and the port E of the four-way valve 202 is connected to the indoor heat exchanger 301 in the indoor unit 300. The four-way valve 202 enables the multi-split air conditioning system 100 to switch between operation modes (such as a refrigeration mode and a heating mode) by changing the flowing direction of the refrigerant in the pipeline of the system.

[0027] In some embodiments, the outdoor unit 200 further includes an outdoor fan 215. The outdoor fan 215 is configured to generate airflow flowing through the outside of the outdoor heat exchanger 203 to facilitate heat exchange between the refrigerant flowing in the heat transfer tube of the outdoor heat exchanger 203 and the outdoor air.

[0028] In some embodiments, the outdoor unit 200 further includes an outdoor fan motor 216. The outdoor fan motor 216 is coupled to the outdoor fan 215 to drive the outdoor fan 215 to rotate or change a rotational speed of the outdoor fan 215.

[0029] In some embodiments, the outdoor unit 200 further includes a gas-liquid separator 205, an oil separator 206, an oil return capillary 207, and an outdoor check valve 208.

[0030] As shown in FIG. 1, the oil separator 206 has a first end, a second end, and a third end, which are an end F1, an end F2, and an end F3 respectively. For example, the end F1 of the oil separator 206 is connected to the exhaust port B of the compressor 201 through a pipeline, the end F2 of the oil separator 206 is connected to the outdoor check valve 208 through a pipeline, and the end F3 of the oil separator 206 is connected to the gas-liquid separator 205 through a pipeline.

[0031] The outdoor check valve 208 is located between the oil separator 206 and the four-way valve 202 and is connected to the end F2 of the oil separator 206 and the port D of the four-way valve 202 through pipelines, so that the end F2 of the oil separator 206 is in one-way communication with the port D of the four-way valve 202.

[0032] The gas-liquid separator 205 has a first port G1 and a second port G2. The first port G1 of the gas-liquid separator 205 is connected to the end F3 of the oil separator 206 and the port S of the four-way valve 202 respectively through pipelines. The second port G2 of gas-liquid separator 205 is connected to the intake port B1 of the compressor 201 through a pipeline.

[0033] In some embodiments, as shown in FIG. 2, the outdoor unit 200 further includes an outdoor refrigerant leakage detection device 218. The outdoor refrigerant leakage detection device 218 is configured to detect whether refrigerant leakage occurs in the outdoor unit 200.

[0034] In some embodiments, as shown in FIG. 1, the outdoor unit 200 further includes a first outdoor pressure sensor 209 and a second outdoor pressure sensor 210. The first outdoor pressure sensor 209 is arranged at the port G1 of the gas-liquid separator 205 and is configured to detect a pressure value of the refrigerant entering the compressor 201 from the gas-liquid separator 205. The second outdoor pressure sensor 210 is arranged on a pipeline connected between the outdoor check valve 208 and the four-way valve 202, and is configured to detect a pressure value of the refrigerant discharged from the compressor 201. For example, the first outdoor pressure sensor 209 is a low-pressure sensor, and the second outdoor pressure sensor 210 is a high-pressure sensor.

[0035] In some embodiments, as shown in FIG. 2, the outdoor unit 200 further includes a high-pressure switch 217 configured to monitor pressure of a pipeline in the multi-split air conditioning system 100 and send information indicating an abnormality when the pressure of the pipeline of the multi-split air conditioning system 100 is abnormal, so as to shut down the multi-split air conditioning system 100, thereby ensuring normal operation of the multi-split air conditioning system 100.

[0036] It is to be noted that the multi-split air conditioning system further includes a controller 600, and the controller 600 is coupled to the high-pressure switch 217 and the outdoor refrigerant leakage detection device 218.

[0037] The controller 600 includes a processor 601. The processor 601 may include a central processing unit (CPU), a microprocessor, and an application specific integrated circuit (ASIC), and may be configured to perform corresponding operations described in the controller 600 when the processor 601 executes a program stored in a non-transitory computer-readable medium coupled to the controller 600. The non-transitory computer-readable medium may include a magnetic storage device (e.g., a hard disk, a floppy disk, or a magnetic tape), a smart card, or a flash memory device (e.g., an erasable programmable read-only memory (EPROM), a card, a stick, or a keyboard drive).

[Indoor unit]

[0038] The indoor unit 300 includes an indoor heat exchanger 301, an indoor expansion valve 302, and an indoor fan 303. The indoor heat exchanger 301 is connected to the four-way valve 202 of the outdoor unit 200 through a first pipeline. For example, the first pipeline is (14)→(15)→(16)→(17)→(18) as shown in FIG. 1.

[0039] In some embodiments, as shown in FIG. 2, the indoor unit 300 further includes an indoor refrigerant leakage detection device 304. The indoor refrigerant leakage detection device 304 is configured to detect whether the refrigerant in the corresponding indoor unit leaks. For example, the indoor refrigerant leakage detection device 304 may be an indoor refrigerant leakage detection sensor.

[0040] In some embodiments, the indoor unit 300 further includes an indoor liquid pipe temperature sensor 305 and an indoor return air temperature sensor 306. The indoor liquid pipe temperature sensor 305 is configured to detect a refrigerant temperature of a pipeline in the indoor unit. The indoor return air temperature sensor 306 is configured to detect a return air temperature of the indoor unit.

[0041] As shown in FIG. 1, the first indoor unit 300A includes a first indoor heat exchanger 301A, a first indoor expansion valve 302A, and a first indoor refrigerant leakage detection device.

[0042] In some embodiments, the first indoor unit 300A further includes a first indoor liquid pipe temperature sensor, a first indoor return air temperature sensor, and a first indoor fan 303A.

[0043] As shown in FIG. 1, the second indoor unit 300B includes a second indoor heat exchanger 301B, a second indoor expansion valve 302B, and a second indoor refrigerant leakage detection device.

[0044] In some embodiments, the second indoor unit 300B further includes a second indoor liquid pipe temperature sensor, a second indoor return air temperature sensor, and a second indoor fan 303B.

[0045] The functions and settings of various components in the indoor unit 300 are described below by taking the first indoor unit 300A as an example.

[0046] In some embodiments, the first indoor heat exchanger 301A is configured to enable heat exchange between the refrigerant flowing in the heat transfer tube of the first indoor heat exchanger 301A and indoor air.

[0047] In some embodiments, the first indoor expansion valve 302A is arranged between the first indoor heat exchanger 301A and the refrigerant recycling apparatus 400, and is configured to enable the refrigerant flowing through the first indoor expansion valve 302A to be expanded and decompressed, and adjust a supply of the refrigerant in the pipeline.

[0048] For example, the first indoor unit 300A may include a plurality of first indoor expansion valves 302A (e.g., an electronic expansion valve). If an opening of the first indoor expansion valve 302A decreases, the flow-path resistance of the refrigerant passing through the first indoor expansion valve 302A increases. If the opening of the first indoor expansion valve 302A increases, the flow-path resistance of the refrigerant passing through the first indoor expansion valve 302A decreases. In this way, even if the states of other components in a loop do not change, when the opening of the first indoor expansion valve 302A changes, a flow rate of the refrigerant flowing to the first indoor heat exchanger 301A or flowing out of the first indoor heat exchanger 301A may also change.

[0049] It is to be noted that the number of the indoor expansion valve 302 and the number of the outdoor expansion valve 204 shown in FIG. 1 are merely examples, which are not limited in the present disclosure.

[0050] In some embodiments, the first indoor fan 303A generates airflow flowing through the outside of the first indoor heat exchanger 301A to facilitate the heat exchange between the refrigerant flowing in the heat transfer tube of the first indoor heat exchanger 301A and the indoor air.

[0051] In some embodiments, the indoor unit 300 further includes an indoor fan motor 307. The indoor fan motor 307 is coupled to the indoor fan 303 to drive the indoor fan or change a rotational speed of the indoor fan. As shown in FIG. 1, the first indoor unit 300A further includes a first indoor fan motor 307A, and the second indoor unit 300B further includes a second indoor fan motor 307B.

[0052] In some embodiments, referring to FIG. 2, the indoor unit 300 further includes one or more decompressors 308. The decompressor 308 is configured to reduce the pressure of the refrigerant in the pipeline. The decompressor 308 depressurizes a high-pressure refrigerant from the condenser, and delivers the depressurized refrigerant to the evaporator.

[0053] In some embodiments, the indoor unit 300 further includes a humidity sensor 309. The humidity sensor 309 is configured to detect relative humidity of the indoor air.

[0054] In some embodiments, the indoor unit 300 further includes a dew point meter 310. The dew point meter 310 is configured to detect an ambient dew point temperature near the indoor heat exchanger 301.

[0055] In some embodiments, the indoor unit 300 further includes a display 311. The display 311 is configured to display a control panel of the multi-split air conditioning system 100. For example, the display 311 may display an indoor temperature or the current operation mode of the indoor unit. A user may output a control instruction to the multi-split air conditioning system 100 by operating the control panel of the display 311.

[0056] In some embodiments, the display 311 may further include at least one of a pressure sensor 3111 and a temperature sensor 3112, and the display 311 may receive a user's instruction according to a user's operation, such as key pressing, gesture recognition, or voice recognition, and transmit the user instruction to the multi-split air conditioning system 100 to achieve a human-computer interaction function. For example, the display 311 may be a liquid crystal display, an organic light-emitting diode (OLED) display, or the like. It is to be noted that in some embodiments, the indoor unit 300 of the multi-split air conditioning system 100 may further include more indoor units, which are not described in detail herein again.

[0057] It is to be noted that the indoor heat exchanger 301, the indoor expansion valve 302, the indoor fan 303, the indoor refrigerant leakage detection device 304, the indoor liquid pipe temperature sensor 305, the indoor return air temperature sensor 306, the indoor fan motor 307, the decompressor 308, the humidity sensor 309, the dew point meter 310, and the display 311 are coupled to the controller 600.

[Refrigerant recycling apparatus]

[0058] As shown in FIG. 1, the refrigerant recycling apparatus 400 includes a first solenoid valve 401, a second solenoid valve 402, a third solenoid valve 403, and a liquid storage tank 404.

[0059] The liquid storage tank 404 has a first opening 4041 and a second opening 4042. The first opening 4041 of the liquid storage tank 404 is connected to the outdoor expansion valve 204 through the first solenoid valve 401. The second opening 4042 of the liquid storage tank 404 is connected to the indoor expansion valve 302 through the second solenoid valve 402. The liquid storage tank 404 is configured to store the refrigerant recycled by the multi-split air conditioning system 100 in a refrigerant recycling mode (i.e., a first refrigerant recycling mode and a second refrigerant recycling mode).

[0060] For example, the first solenoid valve 401 has a first end and a second end, which are an end H1 and an end H2 respectively. The end H1 of the first solenoid valve 401 is connected to the outdoor expansion valve 204 through a pipeline. The end H2 of the first solenoid valve 401 is connected to the first opening 4041 of the liquid storage tank 404.

[0061] The second solenoid valve 402 has a first end and a second end, which are an end I1 and an end I2 respectively. The end I1 of the second solenoid valve 402 is connected to the second opening 4042 of the liquid storage tank 404. The end I2 of the second solenoid valve 402 is connected to the indoor expansion valve 302 in each indoor unit through a pipeline.

[0062] The third solenoid valve 403 has a first end and a second end, which are an end J1 and an end J2 respectively. The end J1 of the third solenoid valve 403 is communicated with a pipeline between the outdoor expansion valve 204 and the first solenoid valve 401. The end J2 of the third solenoid valve 403 is communicated with a pipeline between the indoor expansion valve 302 in each indoor unit and the second solenoid valve 402. Therefore, the controller 600 controls a flowing direction of the refrigerant in the multi-split air conditioning system 100 by opening or closing the first solenoid valve 401, the second solenoid valve 402, and the third solenoid valve 403.

[0063] In some embodiments, the refrigerant recycling apparatus 400 further includes a fourth solenoid valve 405. The fourth solenoid valve 405 is arranged on a pipeline (i.e., a first pipeline) between the four-way valve 202 and the indoor heat exchanger 301.

[0064] The fourth solenoid valve 405 has a first end and a second end, which are an end K1 and an end K2 respectively. The end K1 of the fourth solenoid valve 405 is connected to the four-way valve 202 through a pipeline. The end K2 of the fourth solenoid valve 405 is connected to the indoor heat exchanger 301 in each indoor unit through a pipeline.

[0065] It is to be noted that the fourth solenoid valve 405 is configured to control whether the refrigerant can flow in the first pipeline connecting the indoor unit 300 and the four-way valve 202 of the outdoor unit 200.

[0066] In some embodiments, the above multi-split air conditioning system 100 has one or more of the following modes: a refrigeration mode, a heating mode, a first refrigerant recycling mode, and a second refrigerant recycling mode. When the multi-split air conditioning system 100 is in any one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, and the second refrigerant recycling mode, the fourth solenoid valve 405 is in the open state. Therefore, it is ensured that the refrigerant can circulate in the first pipeline. The above modes are respectively described below.

1. Refrigeration mode

[0067] When the multi-split air conditioning system 100 is in the refrigeration mode, the outdoor heat exchanger 203 operates as a condenser, the indoor heat exchanger operates as an evaporator, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, and the third solenoid valve 403 is in the open state.

[0068] A refrigerant circulation of the multi-split air conditioning system 100 in the refrigeration mode is described based on an example in which the first indoor unit 300A and the second indoor unit 300B are respectively indoor units requiring refrigeration. As shown in FIG. 3, for the four-way valve 202, the port D is connected to the port C, and the port E is connected to the port S. The first solenoid valve 401 and the second solenoid valve 402 are closed, the third solenoid valve 403 and the fourth solenoid valve 405 are opened, and the expansion valves (including the indoor expansion valve 302 and the outdoor expansion valve 204) are opened.

[0069] A loop of the refrigerant flowing through the first indoor unit 300A in the indoor unit 300 is: (1)→(2)→(3)→(4)→(5)→(6)→(7)→(8)→(9)→(10)→(12)→(14)→(15)→(16)→(17)→ (18)→(19)→(1).

[0070] A loop of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 is: (1)→(2)→(3)→(4)→(5)→(6)→(7)→(8)→(9)→(11)→(13)→(14)→(15)→(16)→(17) →(18)→(19)→(1).

[0071] It is to be noted that (14)-(15)-(16)-(17) is merely an example. (14)-(15)-(16)-(17) shown in some embodiments of the present disclosure may be replaced with one pipeline or a plurality of pipelines. For example, it is replaced with a pipeline (16), i.e., only the fourth solenoid valve 405 is on the pipeline.

[0072] In the refrigeration mode, a high-temperature high-pressure gaseous refrigerant discharged from the compressor 201 first flows to the outdoor heat exchanger 203, and then to the indoor heat exchanger 301. For example, the high-temperature high-pressure gaseous refrigerant discharged from the compressor 201 enters the oil separator 206, and the refrigerant entering the oil separator 206 is divided into two parts. One part enters the first port G1 of the gas-liquid separator 205 through the oil return capillary 207. The high-temperature high-pressure gaseous refrigerant from the oil separator 206, as the other part, enters the outdoor heat exchanger 203 through the outdoor check valve 208 and the four-way valve 202. The high-temperature high-pressure gaseous refrigerant is condensed into a medium-temperature high-pressure liquid refrigerant in the outdoor heat exchanger 203.

[0073] The medium-temperature high-pressure liquid refrigerant obtained by condensation by the outdoor heat exchanger 203 sequentially passes through the outdoor expansion valve 204 and the third solenoid valve 403 and is then divided into two parts. One part flows into the first indoor expansion valve 302A of the first indoor unit 300A to form a low-temperature low-pressure liquid refrigerant, and then the low-temperature low-pressure liquid refrigerant flows into the first indoor heat exchanger 301A and is evaporated into a low-temperature low-pressure gaseous refrigerant by the first indoor heat exchanger 301A. The other part flows into the second indoor expansion valve 302B of the second indoor unit 300B to form a low-temperature low-pressure liquid refrigerant, and then the low-temperature low-pressure liquid refrigerant flows into the second indoor heat exchanger 301B and is evaporated into a low-temperature low-pressure gaseous refrigerant by the second indoor heat exchanger 301B.

[0074] The low-temperature low-pressure gaseous refrigerant evaporated by the first indoor heat exchanger 301A and the second indoor heat exchanger 301B merges, passes through the fourth solenoid valve 405 into the four-way valve 202, and then returns to the compressor 201. For example, the low-temperature low-pressure gaseous refrigerant enters the gas-liquid separator 205. The low-temperature low-pressure gaseous refrigerant flowing out of the gas-liquid separator 205 enters the intake port B1 of the compressor 201. The low-temperature low-pressure gaseous refrigerant is compressed into a high-temperature high-pressure gaseous refrigerant by the compressor 201 and is then discharged from the exhaust port B2 of the compressor 201. So far, refrigeration of the multi-split air conditioning system 100 has been completed.

2. Heating mode

[0075] When the multi-split air conditioning system 100 is in the heating mode, the outdoor heat exchanger 203 operates as an evaporator, the indoor heat exchanger 301 operates as a condenser, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, and the third solenoid valve 403 is in the open state.

[0076] A refrigerant circulation of the heating mode of the multi-split air conditioning system 100 is described based on an example in which the first indoor unit 300A and the second indoor unit 300B are respectively indoor units requiring heating.

[0077] As shown in FIG. 4, for the four-way valve 202, the port S is connected to the port C, and the port E is connected to the port D. The first solenoid valve 401 and the second solenoid valve 402 are closed, the third solenoid valve 403 and the fourth solenoid valve 405 are opened, and the expansion valves (including the indoor expansion valve 302 and the outdoor expansion valve 204) are opened.

[0078] A loop of the refrigerant flowing through the first indoor unit 300A in the indoor unit 300 is: (1)→(2)→(18)→(17)→(16)→(15)→(14)→(12)→(10)→(9)→(8)→(7)→(6)→(5)→(4)→ (3)→(19)→(1).

[0079] A loop of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 is:

(1)→(2)→(18)→(17)→(16)→(15)→(14)→(13)→(11)→(-9)→(8)→(7)→(6)→(5)→ (4)→(3)→(19)→(1).

[0080] Compared with the refrigeration mode, in the heating mode, the high-temperature high-pressure gaseous refrigerant from the oil separator 206 first flows to the indoor heat exchanger 301, and is condensed into a medium-temperature high-pressure liquid refrigerant in the indoor heat exchanger 301. Then, the medium-temperature high-pressure liquid refrigerant enters the outdoor heat exchanger 203, is evaporated into a low-temperature low-pressure gaseous refrigerant through the outdoor heat exchanger 203, and finally returns to the compressor 201.

[0081] For example, the high-temperature high-pressure liquid refrigerant from the oil separator 206 sequentially passes through the outdoor check valve 208, the four-way valve 202, and the fourth solenoid valve 405, and then enters the first indoor heat exchanger 301A of the first indoor unit 300A and the second indoor heat exchanger 301B of the second indoor unit 300B respectively.

[0082] The first indoor heat exchanger 301A and the second indoor heat exchanger 301B respectively condense the entered high-temperature high-pressure gaseous refrigerant into a medium-temperature high-pressure liquid refrigerant. The medium-temperature high-pressure liquid refrigerant obtained by condensation passes through the first indoor expansion valve 302A and the second indoor expansion valve 302B respectively and then merges.

[0083] The merging refrigerant sequentially passes through the third solenoid valve 403 and the outdoor expansion valve 204 and then becomes a low-temperature low-pressure liquid refrigerant. The low-temperature low-pressure liquid refrigerant is evaporated into a low-temperature low-pressure gaseous refrigerant through the outdoor heat exchanger 203, which then returns to the compressor 201. So far, the operation of the heating mode of the multi-split air conditioning system 100 has been completed.

3. First refrigerant recycling mode

[0084] When the multi-split air conditioning system 100 is in the first refrigerant recycling mode, the outdoor heat exchanger 203 operates as a condenser, the indoor heat exchanger 301 operates as an evaporator, the first solenoid valve 401 is in the open state, the second solenoid valve 402 is in the closed state, and the third solenoid valve 403 is in the closed state.

[0085] In some embodiments, when it is detected that refrigerant leakage occurs in the indoor unit, if the multi-split air conditioning system 100 is in the heating mode, the multi-split air conditioning system 100 is controlled to switch to the refrigeration mode for operation, and if the multi-split air conditioning system 100 is in the refrigeration mode, the current mode is continued for operation. Moreover, the first solenoid valve 401 is controlled to be in the open state, the second solenoid valve 402 is controlled to be in the closed state, and the third solenoid valve 403 is controlled to be in the closed state.

[0086] An operation cycle of the multi-split air conditioning system 100 in the first refrigerant recycling mode is described based on an example in which the refrigerant in the first indoor unit 300A leaks and the refrigerant in the second indoor unit 300B does not leak.

[0087] As shown in FIG. 5, for the four-way valve 202, the port D is connected to the port C, and the port E is connected to the port S. The first indoor expansion valve 302A is closed, the second solenoid valve 402 and the third solenoid valve 403 are closed, the first solenoid valve 401 and the fourth solenoid valve 405 are opened, and the expansion valves (including the second indoor expansion valve 302B and the outdoor expansion valve 204) are opened.

[0088] A flowing direction of the refrigerant flowing through the outdoor unit 200 is: (1)→(2)→(3)→(4)→(5)→(6)→(20).

[0089] A flowing direction of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 is: (8)→(9)→(11)→(13)→(14)→(15)→(16)→(17)→(18)→(-19)→(1)→(2)→(3)→(4)→(5)→(6)→(20).

[0090] It is to be noted that the refrigerant in a pipeline (8) and a pipeline (9) can flow to the compressor 201 through the second indoor unit 300B (i.e., the indoor unit without refrigerant leakage), and be discharged by the compressor 201 or recycled to the refrigerant recycling apparatus 400.

[0091] In the first refrigerant recycling mode, a refrigerant path from the outdoor unit 200 to the indoor unit 300 is disconnected. When the refrigerant discharged from the compressor 201 flows through the refrigerant recycling apparatus 400, the refrigerant is recycled by the refrigerant recycling apparatus 400 and stored in the liquid storage tank 404, and the remaining refrigerant in the pipeline leading to the indoor unit 300 flows through the second indoor unit 300B and returns to the compressor 201.

[0092] For example, the refrigerant discharged from the compressor 201 is condensed into a medium-temperature high-pressure liquid refrigerant by the outdoor heat exchanger 203, sequentially passes through the outdoor expansion valve 204, the first solenoid valve 401, and the first opening 4041 of the liquid storage tank 404, and is stored in the liquid storage tank 404.

[0093] After the medium -temperature high-pressure liquid refrigerant in the pipeline (8) and the pipeline (9) flows into the second indoor expansion valve of the second indoor unit 300B and becomes low-temperature low-pressure liquid refrigerant, the low-temperature low-pressure liquid refrigerant flows into the second indoor heat exchanger 301B, and is evaporated into low-temperature low-pressure gaseous refrigerant through the second indoor heat exchanger 301B.

[0094] The low-temperature low-pressure gaseous refrigerant enters the four-way valve 202 through the fourth solenoid valve 405, and then returns to the compressor 201. So far, the operation of the first refrigerant recycling mode of the multi-split air conditioning system 100 has been completed.

[0095] In some embodiments, during the operation of the first refrigerant recycling mode, the indoor expansion valve corresponding to the indoor unit with refrigerant leakage is closed, and the indoor expansion valve corresponding to the indoor unit without refrigerant leakage is opened maximally.

[0096] For example, when the refrigerant in the first indoor unit 300A leaks and the refrigerant in the second indoor unit 300B does not leak, the first indoor expansion valve 302A is closed, and the second indoor expansion valve 302B is opened maximally.

4. Second refrigerant recycling mode

[0097] When the multi-split air conditioning system 100 is in the second refrigerant recycling mode, the outdoor heat exchanger 203 operates as an evaporator, the indoor heat exchanger 301 operates as a condenser, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the open state, and the third solenoid valve 403 is in the closed state.

[0098] In some embodiments, when it is detected that refrigerant leakage occurs in the outdoor unit 200, if the multi-split air conditioning system 100 is in the heating mode, the current mode is continued for operation, and if the multi-split air conditioning system 100 is in the refrigeration mode, the multi-split air conditioning system 100 is controlled to switch to the heating mode for operation. Moreover, the first solenoid valve 401 is controlled to be in the closed state, the second solenoid valve 402 is controlled to be in the open state, and the third solenoid valve 403 is controlled to be in the closed state.

[0099] An operation cycle of the multi-split air conditioning system 100 in the second refrigerant recycling mode is described below. As shown in FIG. 6, for the four-way valve 202, the port S is connected to the port C, and the port E is connected to the port D. The first solenoid valve 401 and the third solenoid valve 403 are closed, the second solenoid valve 402 and the fourth solenoid valve 405 are opened, and the expansion valves (including the indoor expansion valve 302 and the outdoor expansion valve 204) are opened.

[0100] A flowing direction of the refrigerant flowing through the first indoor unit 300A in the indoor unit 300 is:

(1)→(2)→(18)→(17)→(16)→(15)→(14)→(12)→(10)→(9)→(21).

[0101] A flowing direction of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 is:

(1)→(2)→(18)→(17)→(16)→(15)→(14)→(13)→(11)→(9)→(21).

[0102] A flowing direction of the refrigerant in the outdoor unit 200 is: (3)-(19)-(1).

[0103] In the second refrigerant recycling mode, a refrigerant path from the indoor unit 300 to the outdoor unit 200 is disconnected. The refrigerant discharged from the compressor 201 passes through the indoor unit 300 and is recycled by the refrigerant recycling apparatus 400 and stored in the liquid storage tank 404. The remaining refrigerant in the pipeline leading to the outdoor unit 200 returns to the compressor 201.

[0104] For example, the refrigerant discharged from the compressor 201 is condensed into a medium-temperature high-pressure liquid refrigerant by the first indoor heat exchanger 301A and the second indoor heat exchanger 301B, and merges after passing through the first indoor expansion valve 302A and the second indoor expansion valve 302B, and the merging medium-temperature high-pressure liquid refrigerant passes through the second solenoid valve 402 and the second opening 4042 of the liquid storage tank 404 and is then stored in the liquid storage tank 404.

[0105] The refrigerant in the outdoor unit 200 is evaporated into a low-temperature low-pressure gaseous refrigerant through the outdoor heat exchanger 203, and then returns to the compressor 201. So far, the operation of the second refrigerant recycling mode of the multi-split air conditioning system 100 has been completed.

[0106] Based on the above four different operation modes, the multi-split air conditioning system 100 may provide modes corresponding to different scenarios. For example, when refrigeration is required, the controller 600 switches the operation mode of the multi-split air conditioning system 100 to the refrigeration mode to reduce an indoor ambient temperature. When heating is required, the controller 600 switches the operation mode of the multi-split air conditioning system 100 to the heating mode to increase the indoor ambient temperature. When the refrigerant leaking in the indoor unit is required to be recycled, the controller 600 switches the multi-split air conditioning system 100 to the first refrigerant recycling mode, and the refrigerant leaking in the indoor unit is recycled through the refrigerant recycling apparatus 400. When the refrigerant leaking in the outdoor unit 200 is required to be recycled, the controller 600 switches the multi-split air conditioning system 100 to the second refrigerant recycling mode, and the refrigerant leaking in the outdoor unit 200 is recycled through the refrigerant recycling apparatus 400.

[0107] In some embodiments, the refrigerant recycling apparatus 400 further includes a fifth solenoid valve 406, and the fifth solenoid valve 406 is arranged between the fourth solenoid valve 405 and the indoor heat exchanger 301 in each indoor unit. The fifth solenoid valve 406 has a first end and a second end, which are an end L1 and an end L2 respectively.

[0108] For example, the end L1 of the fifth solenoid valve 406 is connected to the end K2 of the fourth solenoid valve 405 through a pipeline, and the end L2 of the fifth solenoid valve 406 is connected to the indoor heat exchanger 301 in each indoor unit through a pipeline. When the multi-split air conditioning system is in one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, and the second refrigerant recycling mode, the fifth solenoid valve 406 is in the open state.

[0109] It is to be noted that the fifth solenoid valve 406 is also configured to control whether the refrigerant can flow in the first pipeline connecting the indoor unit 300 and the four-way valve 202 of the outdoor unit 200.

[0110] In some embodiments, when the multi-split air conditioning system 100 enters a normal refrigeration or heating mode again after the refrigerant leakage is resolved, the refrigerant recycling apparatus 400 releases the recycled refrigerant from the liquid storage tank 404 into the first pipeline of the multi-split air conditioning system 100, to realize rational utilization of the recycled refrigerant, reduce consumption of refrigerant resources, and improve environmental protection of the multi-split air conditioning system 100.

[0111] As shown in FIG. 7, the refrigerant recycling apparatus 400 further includes a first expansion valve 411. The liquid storage tank 404 further has a third opening 4043. The third opening 4043 of the liquid storage tank 404 is communicated with the first pipeline through the first expansion valve 411. For example, the third opening 4043 of the liquid storage tank 404 is arranged at the bottom of the liquid storage tank 404, which can improve refrigerant release efficiency.

[0112] In some embodiments, the above multi-split air conditioning system 100 has at least one or more of the following modes: a refrigeration mode, a heating mode, a first refrigerant recycling mode, a second refrigerant recycling mode, and a refrigerant release mode. As shown in FIG. 8 to FIG. 11, when the multi-split air conditioning system 100 is in one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, and the second refrigerant recycling mode, the first expansion valve 411 is in the closed state, and a flowing direction of the refrigerant is the same as the flowing direction of the refrigerant in the multi-split air conditioning system 100 not including the first expansion valve 411. Details are not described herein again.

[0113] A circulation process of the refrigerant in the refrigerant release mode is described below. It is to be noted that in the refrigerant release mode, the fourth solenoid valve and the fifth solenoid valve are in the open state, and the first expansion valve 411 is opened, to release the refrigerant in the liquid storage tank 404.

5. Refrigerant release mode

[0114] When the multi-split air conditioning system 100 is in the refrigerant release mode, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the open state, the third solenoid valve 403 is in the open state, the first expansion valve 411 is in the open state, one of the outdoor heat exchanger 203 and the indoor heat exchanger 301 operates as an evaporator, and the other operates as a condenser.

[0115] For example, there are two following application scenarios.

[0116] In the first scenario, when the multi-split air conditioning system 100 is in the refrigeration mode and the recycled refrigerant is required to be released, the outdoor heat exchanger 203 operates as a condenser, the indoor heat exchanger 301 operates as an evaporator, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, the third solenoid valve 403 is in the open state, and the first expansion valve 411 is in the open state.

[0117] In the second scenario, when the multi-split air conditioning system 100 is in the heating mode and the refrigerant recycled by the refrigerant recycling apparatus 400 is required to be released, the outdoor heat exchanger 203 operates as an evaporator, the indoor heat exchanger 301 operates as a condenser, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, the third solenoid valve 403 is in the open state, and the first expansion valve 411 is in the open state.

[0118] In the first scenario, a refrigerant circulation of the multi-split air conditioning system 100 in the refrigerant release mode is described based on an example in which the first indoor unit 300A and the second indoor unit 300B are indoor units requiring refrigeration.

[0119] As shown in FIG. 12, for the four-way valve 202, the port D is connected to the port C, and the port E is connected to the port S. The first solenoid valve 401 and the second solenoid valve 402 are closed, the third solenoid valve 403, the fourth solenoid valve 405, the fifth solenoid valve are opened, the first expansion valve 411 are opened, and the expansion valves (including the indoor expansion valve 302 and the outdoor expansion valve 204) are opened.

[0120] A loop of the refrigerant flowing through the first indoor unit 300A in the indoor unit 300 is: (1)→(2)→(3)→(4)→(5)→(6)→(7)→(8)→(9)→(10)→(12)→(14)→(15)→(16)→(17)→ (18)→(19)→(1).

[0121] A loop of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 is: (1)→(2)→(3)→(4)→(5)→(6)→(7)→(8)→(9)→(11)→(13)→(14)→(15)→(16)→(17) →(18)→(19)→(1).

[0122] Branches of the refrigerant flowing through the outdoor unit are: (15)→(16)→(17)→ (18)→(19)→(1)→(2)→(3)→(4) and (22)→(17)→(18)→(19)→(1)→(2)→(3)→(4).

[0123] For example, in the refrigeration mode, the liquid refrigerant stored in the liquid storage tank 404 flows out of the third opening 4043 (see FIG. 7) and is throttled through the first expansion valve 411 to form a low-temperature low-pressure refrigerant. The low-temperature low-pressure refrigerant merges with the low-temperature low-pressure gaseous refrigerant flowing out of each indoor unit, enters the four-way valve 202 through the fourth solenoid valve 405, and then enters the compressor 201. So far, the release of the refrigerant in the liquid storage tank 404 when the multi-split air conditioning system is in the refrigerant mode has been completed.

[0124] In the second scenario, a refrigerant circulation of the multi-split air conditioning system 100 in the refrigerant release mode is described based on an example in which the first indoor unit 300A and the second indoor unit 300B are indoor units requiring heating.

[0125] As shown in FIG. 13, for the four-way valve 202, the port S is connected to the port C, and the port E is connected to the port D. The first solenoid valve 401 and the second solenoid valve 402 are closed, the first expansion valve 411 is opened, the third solenoid valve 403, the fourth solenoid valve 405, and the fifth solenoid valve 406 are opened, and the expansion valves (including the indoor expansion valve 302 and the outdoor expansion valve 204) are opened.

[0126] Loops of the refrigerant flowing through the first indoor unit 300A in the indoor unit 300 are: (1)→(2)→(18)→(17)→(16)→(15)→(14)→(12)→(10)→(9)→(8)→(7)→(6)→(5)→(4) →(3)→(19)→(1) and (22)→(15)→(14)→(12)→(10)→(9)→(8)→(7)→(6)→(5)→(4)→(3)→(19) →(1).

[0127] Loops of the refrigerant flowing through the second indoor unit 300B in the indoor unit 300 are: (1)→(2)→(18)→(17)→(16)→(15)→(14)→(13)→(11)→(9)→(8)→(7)→(6)→(5) →(4)→(3)→(19)→(1) and (22)→(15)→(14)→(13)→(11)→(9)→(8)→(7)→(6)→(5)→(4)→(3) →(19)→(1).

[0128] For example, in the heating mode, the liquid refrigerant stored in the liquid storage tank 404 flows out of the third opening 4043 and is throttled through the first expansion valve 411 to form a low-temperature low-pressure refrigerant. The low-temperature low-pressure refrigerant merges with the high-temperature high-pressure gaseous refrigerant sequentially passing through the four-way valve 202 and the fourth solenoid valve 405, and then enters the first indoor heat exchanger 301A of the first indoor unit 300A and the second indoor heat exchanger 301B of the second indoor unit 300B respectively. So far, the release of the refrigerant in the liquid storage tank 404 when the multi-split air conditioning system is in the heating mode has been completed.

[0129] It is to be noted that the above two scenarios are merely exemplary. In some embodiments, the flowing direction of the refrigerant in the refrigerant release mode may alternatively be adjusted based on other application scenarios. For example, the refrigeration mode and the heating mode in the first scenario and the second scenario above are changed to other modes (such as a dehumidification mode and a drying mode).

[0130] In some embodiments, when the refrigerant is detected in the refrigerant recycling apparatus 400, the refrigerant release mode is enabled to completely release the refrigerant in the refrigerant recycling apparatus 400, and then other modes (such as the refrigeration mode, the heating mode, the dehumidification mode, and the drying mode) are run.

[0131] Based on the refrigerant release mode, when the refrigerant recycled in the refrigerant recycling apparatus 400 is required to be utilized, the operation mode of the multi-split air conditioning system 100 may be switched to the refrigerant release mode, and the recycled refrigerant is released to the first pipeline, to allow the multi-split air conditioning system 100 to use the recycled refrigerant during the operation in the refrigeration mode or the heating mode.

[0132] In some embodiments, as shown in FIG. 2, the multi-split air conditioning system 100 further includes a power supply device 500 that supplies power to respective components, such as a battery 501 and a power management chip 502. The battery 501 may be coupled to the controller 600 through the power management chip 502, to implement a power management function of the multi-split air conditioning system 100 through the power supply device 500.

[0133] In some embodiments, the controller 600 is coupled to the indoor refrigerant leakage detection device 304. The controller 600 is configured to acquire a detection result of the indoor refrigerant leakage detection device 304. The detection result of the indoor refrigerant leakage detection device 304 is used to indicate whether refrigerant leakage occurs in the indoor unit where the indoor refrigerant leakage detection device 304 is located.

[0134] The controller 600 determines, according to the detection result of the indoor refrigerant leakage detection device 304, whether refrigerant leakage occurs in one indoor unit of the indoor unit 300.

[0135] If refrigerant leakage occurs in one indoor unit of the indoor unit 300, the controller 600 controls the multi-split air conditioning system 100 to switch to the first refrigerant recycling mode, and recycles the refrigerant in the indoor unit 300 into the refrigerant recycling apparatus 400.

[0136] In some embodiments, the controller 600 is further configured to, when the multi-split air conditioning system 100 runs the first refrigerant recycling mode, close the indoor expansion valve in the indoor unit where refrigerant leakage occurs, to prevent continuous entry of the refrigerant into the indoor unit where refrigerant leakage occurs. In this way, leakage of the refrigerant in the indoor unit where refrigerant leakage occurs into the indoor environment is prevented, thereby ensuring the reliability of the multi-split air conditioning system 100.

[0137] In some embodiments, when the multi-split air conditioning system 100 runs the first refrigerant recycling mode, the indoor expansion valve of the indoor unit of the indoor unit 300 where refrigerant leakage does not occur is adjusted to a maximum opening, so that the refrigerant in the pipeline communicated with the indoor expansion valve of the indoor unit where refrigerant leakage occurs passes through the indoor unit 300 and the outdoor unit 200 more quickly and is finally recycled to the refrigerant recycling apparatus 400, thereby increasing a recycling speed of the refrigerant leakage of the indoor unit and ensuring refrigerant recycling efficiency of the multi-split air conditioning system 100.

[0138] In some embodiments, the controller 600 is coupled to the outdoor refrigerant leakage detection device 218 of the outdoor unit 200. The controller 600 is further configured to acquire a detection result of the outdoor refrigerant leakage detection device 218. The detection result of the outdoor refrigerant leakage detection device 218 is used to indicate whether refrigerant leakage occurs in the outdoor unit 200.

[0139] The controller 600 determines, according to the detection result of the outdoor refrigerant leakage detection device 218, whether refrigerant leakage occurs in the outdoor unit 200. If the detection result of the outdoor refrigerant leakage detection device 218 indicates that refrigerant leakage occurs in the outdoor unit 200, the controller 600 controls the multi-split air conditioning system 100 to switch to the second refrigerant recycling mode. Therefore, the refrigerant leaking from the outdoor unit 200 is recycled into the refrigerant recycling apparatus 400.

[0140] In some embodiments, when the multi-split air conditioning system 100 runs the second refrigerant recycling mode, the controller 600 controls the outdoor expansion valve 204 at a preset opening value. For example, the preset opening value is a maximum opening value. In this way, the refrigerant in the pipeline communicated with the outdoor expansion valve 204 can be recycled from the outdoor unit 200 and the indoor unit 300 to the refrigerant recycling apparatus 400 more quickly, thereby increasing a recycling speed of the refrigerant leaking from the outdoor unit 200 and ensuring refrigerant recycling efficiency of the multi-split air conditioning system 100.

[0141] In this way, when the controller 600 detects that refrigerant leakage occurs in the indoor unit or the outdoor unit 200, the refrigerant is recycled through the refrigerant recycling apparatus 400. Leakage of the refrigerant in the indoor unit into the indoor environment can be prevented, and the reliability of the multi-split air conditioning system 100 can be improved. Meanwhile, an amount of the refrigerant leaking from the outdoor unit 200 and discharged into the outdoor environment can be reduced, and the environmental protection of the multi-split air conditioning system 100 can be improved.

[0142] **In** some embodiments, the controller 600 is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if a refrigerant recycling stop condition is met, control the fourth solenoid valve 405 to be closed.

[0143] The refrigerant recycling stop condition includes one or more of the following: a duration during which the multi-split air conditioning system 100 runs one of the first refrigerant recycling mode and the second refrigerant recycling mode reaches a preset duration, and the pressure of the refrigerant entering the compressor 201 is within a preset pressure range.

[0144] It is to be noted that the above preset pressure range may be determined according to an atmospheric pressure of the outdoor environment.

[0145] For example, the pressure of the refrigerant in the compressor 201 is detected by a first outdoor pressure sensor 209 arranged at the intake port B1 of the compressor 201 as shown in FIG. 1.

[0146] **In** this way, by setting the refrigerant recycling stop condition, a time to end the refrigerant recycling can be determined, so that the multi-split air conditioning system 100 can recycle the refrigerant when the refrigerant exists in the pipeline, thereby preventing anomaly of or damage to the multi-split air conditioning system 100 caused by still running of the first refrigerant recycling mode or the second refrigerant recycling mode when no refrigerant exists in the pipeline of the multi-split air conditioning system 100, improving the reliability of the multi-split air conditioning system 100, and helping to prolong the service life of the multi-split air conditioning system 100.

[0147] **In** some embodiments, the controller 600 is further configured to, when the multi-split air conditioning system 100 is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the fifth solenoid valve 406 to be closed.

[0148] **In** this way, after completion of recycling of the refrigerant, the controller 600 can guarantee respective independence of the refrigerant recycling apparatus 400, the outdoor unit 200, and the indoor unit 300 by closing the first solenoid valve 401, the second solenoid valve 402, the third solenoid valve 403, the fourth solenoid valve 405, and the fifth solenoid valve 406. Therefore, the pipelines connecting the refrigerant recycling apparatus 400, the indoor unit 300, and the outdoor unit 200 are disconnected so that the refrigerant recycling apparatus 400 is not affected during replacement of the indoor unit or the outdoor unit 200 where refrigerant leakage occurs, and leakage of the refrigerant recycled to the refrigerant recycling apparatus 400 is prevented.

[0149] In some embodiments, referring to FIG. 1, the refrigerant recycling apparatus 400 further includes a first shut-off valve 407, a second shut-off valve 408, a third shut-off valve 409, and a fourth shut-off valve 410.

[0150] The first shut-off valve 407 is arranged on a pipeline between the four-way valve 202 and the fourth solenoid valve 405. For example, a first end of the first shut-off valve 407 is connected to the four-way valve 202 through a pipeline, and a second end of the first shut-off valve 407 is connected to the end K1 of the fourth solenoid valve 405 through a pipeline.

[0151] The second shut-off valve 408 is arranged on a pipeline between the fourth solenoid valve 405 and the indoor heat exchanger 301. For example, a first end of the second shut-off valve 408 is connected to the end L2 of the fourth solenoid valve 405 through a pipeline, and a second end of the second shut-off valve 408 is connected to the indoor heat exchanger 301 in each indoor unit through a pipeline.

[0152] It is to be noted that when the multi-split air conditioning system 100 includes the fifth solenoid valve 406, the second shut-off valve 408 is arranged on a pipeline between the fifth solenoid valve 406 and the indoor heat exchanger 301.

[0153] The third shut-off valve 409 is arranged on a pipeline between the outdoor expansion valve 204 and the first solenoid valve 401. For example, a first end of the third shut-off valve 409 is connected to the outdoor expansion valve 204 through a pipeline, and a second end of the third shut-off valve 409 is connected to the end H1 of the first solenoid valve 401 through a pipeline.

[0154] The fourth shut-off valve 410 is arranged on a pipeline between the second solenoid valve 402 and the indoor heat exchanger 301. For example, a first end of the fourth shut-off valve 410 is connected to the end I2 of the second solenoid valve 402 through a pipeline, and a second end of the fourth shut-off valve 410 is connected to the indoor expansion valve 302 in each indoor unit through a pipeline.

[0155] For example, when the multi-split air conditioning system 100 operates in any one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode, the first shut-off valve 407, the second shut-off valve 408, the third shut-off valve 409, and the fourth shut-off valve 410 are open. After the operation of the first refrigerant recycling mode or the second refrigerant recycling mode is completed, the first shut-off valve 407, the second shut-off valve 408, the third shut-off valve 409, and the fourth shut-off valve 410 are closed, to further prevent the flow of the refrigerant in the pipelines where the above shut-off valves are located.

[0156] In some embodiments, the outdoor unit 200 further includes a fifth shut-off valve 211 and a sixth shut-off valve 212.

[0157] The fifth shut-off valve 211 is arranged on a pipeline between the four-way valve 202 and the first shut-off valve 407. For example, a first end of the fifth shut-off valve 211 is connected to the four-way valve 202 through a pipeline, and a second end of the fifth shut-off valve 211 is connected to the first end of the first shut-off valve 407 through a pipeline.

[0158] The sixth shut-off valve 212 is arranged on a pipeline between the outdoor expansion valve 204 and the third shut-off valve 409. For example, a first end of the sixth shut-off valve 212 is connected to the outdoor expansion valve 204 through a pipeline, and a second end of the sixth shut-off valve 212 is connected to the first end of the third shut-off valve 409 through a pipeline.

[0159] For example, when the multi-split air conditioning system 100 operates in any one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode, the fifth shut-off valve 211 and the sixth shut-off valve 212 are open. After the operation of the first refrigerant recycling mode or the second refrigerant recycling mode is completed, the fifth shut-off valve 211 and the sixth shut-off valve 212 are closed, to better prevent the flow of the refrigerant in the pipelines where the above shut-off valves are located.

[0160] It is to be noted that the number of shut-off valves arranged in the multi-split air conditioning system 100 may be determined according to a requirement. For example, in some embodiments, as shown in FIG. 24, the indoor unit further includes a seventh shut-off valve 312 and an eighth shut-off valve 313. The seventh shut-off valve 312 and the eighth shut-off valve 313 are arranged at two ends of the indoor unit 300 respectively. That is, one of the seventh shut-off valve 312 and the eighth shut-off valve 313 is arranged at one end of the indoor unit 300 communicated with the four-way valve 202, and the other of the seventh shut-off valve 312 and the eighth shut-off valve 313 is arranged at an end of the indoor unit 300 and the refrigerant recycling apparatus 400. For example, the eighth shut-off valve 313 is arranged on a pipeline (14), and the seventh shut-off valve 312 is arranged on a pipeline (9).

[0161] In some embodiments, as shown in FIG. 1, the outdoor unit 200 further includes a sixth solenoid valve 213 and a seventh solenoid valve 214. The sixth solenoid valve 213 and the seventh solenoid valve 214 are arranged on a pipeline connecting the outdoor unit 200 and the refrigerant recycling apparatus 400.

[0162] For example, the sixth solenoid valve 213 is arranged on a pipeline between the four-way valve 202 and the fifth shut-off valve 211. The sixth solenoid valve 213 has a first end and a second end, which are an end M1 and an end M2 respectively. The end M1 of the sixth solenoid valve 213 is connected to the four-way valve 202 through a pipeline, and the end M2 of the sixth solenoid valve 213 is connected to the first end of the fifth shut-off valve 211 through a pipeline.

[0163] The seventh solenoid valve 214 is arranged on a pipeline between the outdoor expansion valve 204 and the sixth shut-off valve 212. The seventh solenoid valve 214 has a first end and a second end, which are an end N1 and an end N2 respectively. The end N1 of the seventh solenoid valve 214 is connected to the outdoor expansion valve 204 through a pipeline, and the end N2 of the seventh solenoid valve 214 is connected to the first end of the sixth shut-off valve 212 through a pipeline.

[0164] When the multi-split air conditioning system 100 operates in any one of the refrigeration mode, the heating mode, the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode, the sixth solenoid valve 213 and the seventh solenoid valve 214 are opened.

[0165] After completion of recycling of the refrigerant, by controlling the sixth solenoid valve 213 and the seventh solenoid valve 214 to be closed, pipelines between the outdoor unit 200, the refrigerant recycling apparatus 400, and the indoor unit 300 are disconnected, so that replacement of components of the outdoor unit 200 is not affected by the refrigerant recycling apparatus 400 and the indoor unit 300, improving convenience of mounting or replacement of the outdoor unit 200.

[0166] A method for controlling the multi-split air conditioning system 100 is described below. Referring to FIG. 14, the method for controlling the multi-split air conditioning system 100 includes step S101 to step S104.

[0167] In step S101, a refrigerant leakage situation in an indoor unit 300 and an outdoor unit 200 is determined.

[0168] In step S102, when it is determined that refrigerant leakage occurs in the indoor unit, a controller 600 controls the multi-split air conditioning system 100 to run a first refrigerant recycling mode.

[0169] In step S103, when it is determined that refrigerant leakage occurs in the outdoor unit 200, the controller 600 controls the multi-split air conditioning system 100 to run a second refrigerant recycling mode.

[0170] In step S104, when it is determined that no refrigerant leakage occurs in the indoor unit 300 and the outdoor unit 200, the controller 600 controls the multi-split air conditioning system 100 to maintain the current operation mode.

[0171] It is to be noted that the current operation mode may be a refrigeration mode, a heating mode, a dehumidification mode, or the like.

[0172] A method for controlling the multi-split air conditioning system 100 in the first refrigerant recycling mode is described below. As shown in FIG. 15, the method for controlling the multi-split air conditioning system 100 includes step S201 to step S206.

[0173] In step S201, the controller 600, according to the detection result of the indoor refrigerant leakage detection device 304, the indoor unit where refrigerant leakage occurs. The indoor unit where refrigerant leakage occurs may send early warning information. The early warning information is used to indicate that refrigerant leakage occurs in the indoor unit. For example, the early warning information may be voice, text, light, or the like.

[0174] In step S202, it is determined whether the multi-split air conditioning system 100 is in a refrigeration mode. If not, step S203 is performed. If yes, step S204 is performed.

[0175] In step S203, the multi-split air conditioning system 100 is switched to the refrigeration mode, and then step S204 is performed.

[0176] In step S204, the controller 600 controls the indoor expansion valve 302 corresponding to the indoor unit where refrigerant leakage occurs to be closed, the first solenoid valve 401 to be opened, and the second solenoid valve 402 and the third solenoid valve 403 to be closed.

[0177] In step S205, when a refrigerant recycling stop condition is met, the controller 600 controls the fourth solenoid valve 405 to be closed and sends a first replacement information. The first replacement information is used to prompt the user to replace the indoor unit where refrigerant leakage occurs.

[0178] In step S206, the controller 600 controls the multi-split air conditioning system 100 to stop operating.

[0179] A method for controlling the multi-split air conditioning system 100 in the second refrigerant recycling mode is described below. As shown in FIG. 16, the method for controlling the multi-split air conditioning system 100 includes step S301 to step S306.

[0180] In step S301, the controller 600 determines, according to the detection result of the outdoor refrigerant leakage detection device 218, that refrigerant leakage occurs in the outdoor unit 200. The outdoor unit 200 may send early warning information. The early warning information is used to indicate that refrigerant leakage occurs in the outdoor unit. For example, the early warning information may be voice, text, light, or the like.

[0181] In step S302, it is determined whether the multi-split air conditioning system 100 is in a heating mode. If not, step S303 is performed. If yes, step S304 is performed.

[0182] In step S303, the multi-split air conditioning system 100 is switched to the heating mode, and then step S304 is performed.

[0183] In step S304, the controller 600 controls the first solenoid valve 401 to be closed, the second solenoid valve 402 to be opened, and the third solenoid valve 403 to be closed.

[0184] In step S305, when a refrigerant recycling stop condition is met, the controller 600 controls the fourth solenoid valve 405 to be closed and sends a second replacement information. The second replacement information is used to prompt the user to replace the outdoor unit 200.

[0185] For example, the refrigerant recycling stop condition includes one or more of the following: a duration during which the multi-split air conditioning system 100 runs one of the first refrigerant recycling mode and the second refrigerant recycling mode reaches a preset duration, and the pressure of the refrigerant entering the compressor is within a preset pressure range.

[0186] In step S306, the controller 600 controls the multi-split air conditioning system 100 to stop operating.

[0187] A method for controlling the multi-split air conditioning system 100 during refrigerant release is described below. As shown in FIG. 17, the method for controlling the multi-split air conditioning system 100 includes step S401 and step S402.

[0188] In step S401, when the first refrigerant recycling mode or the second refrigerant recycling mode is completed, if a control signal instructing the multi-split air conditioning system 100 to operate in the refrigeration mode is received, the controller 600 controls the multi-split air conditioning system 100 to run the first refrigerant release mode.

[0189] It is to be noted that, when the multi-split air conditioning system 100 is in the first refrigerant release mode, the outdoor heat exchanger 203 operates as a condenser, the indoor heat exchanger 301 operates as an evaporator, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, the third solenoid valve 403 is in the open state, and the first expansion valve 411 is in the open state.

[0190] In step S402, when the first refrigerant recycling mode or the second refrigerant recycling mode is completed, if a control signal instructing the multi-split air conditioning system 100 to operate in the heating mode is received, the controller 600 controls the multi-split air conditioning system 100 to run the second refrigerant release mode.

[0191] It is to be noted that, when the multi-split air conditioning system 100 is in the second refrigerant release mode, the outdoor heat exchanger 203 operates as an evaporator, the indoor heat exchanger 301 operates as a condenser, the first solenoid valve 401 is in the closed state, the second solenoid valve 402 is in the closed state, the third solenoid valve 403 is in the open state, and the first expansion valve 411 is in the open state.

[0192] As shown in FIG. 18 to FIG. 21, in some embodiments, the refrigerant recycling apparatus 400 further includes a second expansion valve 412. The liquid storage tank 404 further has a fourth opening 4044. For example, the fourth opening is located at the top of the liquid storage tank 404. The second expansion valve 412 has the following arrangement manners.

[0193] As shown in FIG. 18 and FIG. 20, a first end of the second expansion valve 412 is connected to the fourth opening 4044 of the liquid storage tank 404, a second end of the second expansion valve 412 is communicated with a second pipeline, and the second pipeline is a pipeline between the fourth solenoid valve 405 and the fifth solenoid valve 406. For example, the second pipeline is a pipeline (16) as shown in FIG. 3. For example, the first end of the second expansion valve 412 is connected to the second end of the fourth solenoid valve 405 through a pipeline, and the second end of the second expansion valve 412 is connected to the second end of the first solenoid valve 401 through a pipeline. It is to be noted that the arrangement manner is applicable to the first refrigerant recycling mode.

[0194] As shown in FIG. 19 and FIG. 21, the first end of the second expansion valve 412 is communicated with a third pipeline, the second end of the second expansion valve 412 is communicated with the second pipeline, and the third pipeline is a pipeline between the first solenoid valve 401 and the first opening 4041 of the liquid storage tank 404. For example, the first end of the second expansion valve 412 is connected to the second end of the fourth solenoid valve 405 through a pipeline, and the second end of the second expansion valve 412 is connected to the fourth opening 4044 of the liquid storage tank 404 through a pipeline. It is to be noted that the arrangement manner is applicable to both the first refrigerant recycling mode and the second refrigerant recycling mode.

[0195] In some embodiments, a plurality of second expansion valves 412 may be provided, and may be arranged in different manners respectively.

[0196] When the multi-split air conditioning system 100 operates in one of the refrigeration mode, the heating mode, and the refrigerant release mode, the second expansion valve 412 is in the closed state. When the multi-split air conditioning system 100 operates in one of the first refrigerant recycling mode and the second refrigerant recycling mode, the second expansion valve 412 is opened, and when the refrigerant recycling is completed, the second expansion valve 412 is closed.

[0197] In this way, during the refrigerant recycling, when the amount of refrigerant circulating in the multi-split air conditioning system 100 becomes less and less and the low pressure of the pipeline of the multi-split air conditioning system 100 becomes closer and closer to a preset pressure range (which generally refers to atmospheric pressure of an environment where the multi-split air conditioning system 100 is located), an exhaust temperature of the compressor 201 may become higher and higher, which may affect reliability of the compressor 201. The second expansion valve 412 is arranged between the first solenoid valve 401 and the fourth solenoid valve 405, or the second expansion valve 412 is arranged between the fourth solenoid valve 405 and the liquid storage tank 404. Therefore, during the refrigerant recycling, the second expansion valve 412 is opened to circulate part of the refrigerant to the compressor 201 to reduce the exhaust temperature of the compressor 201, thereby ensuring stability of the compressor 201 during the refrigerant recycling.

[0198] In addition, during the refrigerant recycling, the refrigerant entering the liquid storage tank 404 may be a two-phase (gaseous and liquid) refrigerant. Compared with the liquid refrigerant, since the average density of the two-phase refrigerant is small, the total mass of the refrigerant stored in the liquid storage tank 404 may be reduced, thereby affecting the refrigerant recycling effect. Therefore, during the refrigerant recycling, the second expansion valve 412 is opened, so that the gaseous refrigerant flows out through the second expansion valve 412, to improve the refrigerant recycling effect.

[0199] As shown in FIG. 22, in some embodiments, the refrigerant recycling apparatus 400 further includes a first subcooler 413. The first subcooler 413 has a first channel 416 and a second channel 417. The third opening 4043 of the liquid storage tank 404 is communicated with the first pipeline sequentially through the first expansion valve 411 and the first channel 416 of the first subcooler 413. The third solenoid valve 403 is connected to the outdoor expansion valve 204 through the second channel 417 of the first subcooler 413.

[0200] As shown in FIG. 22, in some embodiments, the refrigerant recycling apparatus 400 further includes a first temperature sensor 420. The controller 600 is coupled to the first temperature sensor 420. For example, the first temperature sensor 420 is arranged on a pipeline (22).

The first temperature sensor 420 is configured to detect a temperature value of the refrigerant flowing out of the first channel 416 of the first subcooler 413.

[0201] As shown in FIG. 23, in some embodiments, the refrigerant recycling apparatus 400 further includes a throttling device 414 and a second subcooler 415. The second subcooler 415 has a third channel 418 and a fourth channel 419. The third opening 4043 of the liquid storage tank 404 is communicated with the first pipeline sequentially through the throttling device 414 and the third channel 418 of the second subcooler 415. The third solenoid valve 403 is connected to the indoor expansion valve 302 through the fourth channel 419 of the second subcooler 415.

[0202] As shown in FIG. 23, in some embodiments, the refrigerant recycling apparatus 400 further includes a second temperature sensor 421. The controller 600 is coupled to the second temperature sensor 421. The second temperature sensor 421 is configured to detect a temperature value of the refrigerant flowing out of the third channel 418. For example, the second temperature sensor 421 may be arranged at a point C.

[0203] The functions and arrangements of the components of the refrigerant recycling apparatus 400 are described below.

[0204] In some embodiments, by arranging the first subcooler 413, the refrigerant recycled in the refrigerant recycling apparatus 400 flows through the first channel 416 of the first subcooler 413, and during the operation of the multi-split air conditioning system 100, the refrigerant flows through the second channel 417 of the first subcooler 413. The second channel 417 cools the refrigerant flowing therethrough to release corresponding heat. The first channel 416 uses the heat released by the second channel 417 to heat the recycled refrigerant flowing through the first channel 416, making the liquid refrigerant in the two-phase refrigerant be converted into the gaseous refrigerant during the recycling, reducing content of the liquid refrigerant in the two-phase refrigerant released by the refrigerant recycling apparatus, and increasing content of the gaseous refrigerant in the released refrigerant, to ensure use efficiency of the recycled refrigerant.

[0205] It is to be noted that, by arranging the first subcooler 413, when the multi-split air conditioning system 100 in the refrigeration mode releases the recycled refrigerant, the refrigerant recycling apparatus releases the recycled refrigerant to the compressor 201 of the outdoor unit 200, and the content of the liquid refrigerant in the refrigerant released by the refrigerant recycling apparatus is reduced, which may reduce liquid return of the compressor and prolong the service life of the compressor. Meanwhile, when the multi-split air conditioning system 100 in the heating mode releases the recycled refrigerant, the refrigerant recycling apparatus 400 releases the recycled refrigerant to the indoor heat exchanger of the indoor unit, and the content of the gaseous refrigerant in the released recycled refrigerant increases, which may increase an amount of the refrigerant recycled by the indoor heat exchanger and improve utilization of the recycled refrigerant.

[0206] In some embodiments, by arranging the first temperature sensor 420, the opening of the first expansion valve 411 can be controlled. For example, referring to FIG. 25, the method for controlling the multi-split air conditioning system 100 includes step S501 to step S505.

[0207] In step S501, when the multi-split air conditioning system 100 runs the refrigerant release mode, the controller 600 acquires a first temperature value detected by the first temperature sensor and a pressure value detected by a first outdoor pressure sensor 209.

[0208] In step S502, the controller 600 determines a second temperature value according to the pressure value detected by the first outdoor pressure sensor 209. The second temperature value is a saturation temperature value corresponding to the pressure value detected by the first outdoor pressure sensor 209.

[0209] In step S503, it is determined whether a difference between the first temperature value and the second temperature value is less than a first preset temperature value. If not, step S504 is performed. If yes, step S505 is performed.

[0210] In step S504, the controller 600 controls the first expansion valve 411 to increase the opening.

[0211] In step S505, the controller 600 controls the first expansion valve 411 to reduce the opening.

[0212] In this way, by comparing the first temperature value of the refrigerant flowing out of the first channel 416 of the first subcooler 413 and the second temperature value, a first temperature difference between the first temperature value and the second temperature value is obtained. The opening of the first expansion valve is controlled based on a relationship between the first temperature difference and a first preset temperature value, to ensure that the opening of the first expansion valve is within a reasonable range, thereby ensuring that the amount of the refrigerant released by the refrigerant recycling apparatus is within the reasonable range.

[0213] According to the multi-split air conditioning system 100 in some embodiments of the present disclosure, untimely handling of the refrigerant by the multi-split air conditioning system 100 due to an excessive amount of the refrigerant in the pipeline of the entire multi-split air conditioning system 100 caused by an excessive amount of the refrigerant released by the refrigerant recycling apparatus 400 is prevented. In addition, reduction of operating efficiency of the multi-split air conditioning system 100 (such as reduction of a refrigeration speed or a heating speed) due to an excessively small amount of the refrigerant in the pipeline of the entire multi-split air conditioning system 100 caused by an excessively small amount of the refrigerant released by the refrigerant recycling apparatus 400 is prevented.

[0214] Through the throttling device 414 and the second subcooler 415, the refrigerant recycled in the refrigerant recycling apparatus 400 is throttled through the throttling device 414 and flows through the third channel 418 of the second subcooler 415. During the operation of the multi-split air conditioning system 100, the refrigerant flows through the fourth channel 419 of the second subcooler 415. The fourth channel 419 cools the refrigerant flowing through the fourth channel 419 to release corresponding heat. The third channel 418 uses the heat released by the fourth channel 419 to heat the recycled refrigerant flowing through the third channel 418, making the liquid refrigerant in the two-phase refrigerant be converted into the gaseous refrigerant during the recycling, reducing content of the liquid refrigerant in the two-phase refrigerant released by the refrigerant recycling apparatus 400, and increasing content of the gaseous refrigerant in the released refrigerant, to ensure use efficiency of the recycled refrigerant.

[0215] In some embodiments, by arranging the second temperature sensor 421, the refrigerant release process of the refrigerant recycling apparatus 400 can be controlled. For example, as shown in FIG. 26, the method for controlling the multi-split air conditioning system 100 includes step S601 to step S605.

[0216] In step S601, when the multi-split air conditioning system 100 runs the refrigerant release mode, the controller 600 acquires a third temperature value detected by the second temperature sensor and the pressure value detected by the first outdoor pressure sensor 209.

[0217] In step S602, a second temperature value is determined according to the pressure value detected by the first outdoor pressure sensor. The second temperature value is a saturation temperature value corresponding to the pressure value detected by the first outdoor pressure sensor.

[0218] In step S603, it is determined whether a difference between the third temperature value and the second temperature value is less than a second preset temperature value. If not, step S604 is performed. If yes, step S605 is performed.

[0219] In step S604, the controller 600 controls the multi-split air conditioning system 100 to stop running the refrigerant release mode.

[0220] In step S605, the controller 600 controls the multi-split air conditioning system 100 to continue to run the refrigerant release mode.

[0221] It is to be noted that the first preset temperature value and the second preset temperature value are determined according to a refrigerant type and a compressor type, and the second preset temperature value is a smaller value.

[0222] In addition, the refrigerant released from the liquid storage tank 404 flows through three points A, B, and C in FIG. 23. In the three points, refrigerant temperatures at the points A and B are the same, and refrigerant temperatures at the points B and C may change due to the amount of the refrigerant in the liquid storage tank 404. For example, when the refrigerant exists in the liquid storage tank 404, the refrigerant temperatures at the two points B and C are roughly equal. When no refrigerant exists in the liquid storage tank 404, the refrigerant temperature at the point C is greater than the refrigerant temperature at the point B.

[0223] In this way, by comparing the third temperature value of the refrigerant flowing out of the third channel 418 of the second subcooler 415 and the second temperature value, a second temperature difference between the third temperature value and the second temperature value is obtained. The release process of the refrigerant recycling apparatus is reasonably controlled based on a relationship between the second temperature difference and the second preset temperature value, to ensure that the refrigerant recycling apparatus 400 can release the refrigerant when the refrigerant is sufficient. This prevents the multi-split air -conditioning system 100 from still running the refrigerant release mode when there is no refrigerant in the refrigerant recycling device, which would result in an abnormally low amount of refrigerant in the multi-split air conditioning system 100 and thus reduce the operation efficiency.

[0224] Some embodiments of the present disclosure further provide a structural diagram of hardware of a controller. As shown in FIG. 27, the controller 600 further includes a memory 602 and a communication interface 603 connected to the processor 601. The processor 601, the memory 602, and the communication interface 603 are connected through a bus 604.

[0225] The processor 601 has a data processing function, and the memory 602 is configured to store data. The memory 602 may be a random access memory (RAM). For example, the memory 602 includes computer program codes. The processor 601 is configured to execute the computer program codes stored in the memory 602, thereby implementing the control method provided in the embodiments of the present disclosure.

[0226] The communications interface 603 may be configured to communicate with another device or a communication network (for example, the Ethernet, a radio access network (RAN)), or a wireless local area network (WLAN). The communication interface 603 may be a module, a circuit, a transceiver, or any apparatus that can implement communication.

[0227] The bus 604 may be a peripheral component interconnect (PCI) bus, an extended industry standard architecture (EISA) bus, or the like. Information may be transmitted between the components through the bus 604. For ease of representation, only one bold line is used to represent the bus in FIG. 27, but this does not mean that there is only one bus or one type of bus.

[0228] Embodiments of the present disclosure further provide a computer-readable storage medium. The computer-readable storage medium includes computer-executable instructions. The computer-executable instructions, when executed by a computer, cause the computer to perform the method provided in the above embodiments.

[0229] Embodiments of the present disclosure further provide a computer program product. The computer program product may be directly loaded into a memory and include software codes. After the computer program product is loaded and executed by a computer, the method provided in the above embodiments can be implemented.

[0230] Those skilled in the art will understand that the scope of disclosure of the present disclosure is not limited to the above specific embodiments and some elements of the embodiments may be modified and substituted without departing from the spirits of the present disclosure. The scope of the present disclosure is limited by the appended claims.

Claims

1. An air conditioning system, comprising:

    an outdoor unit comprising an outdoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the outdoor unit;
    one or more indoor units each comprising an indoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the indoor unit;
    a refrigerant recycling apparatus located between the outdoor unit and the indoor unit and configured to recycle and store refrigerant in the air conditioning system when refrigerant leakage occurs in one of the outdoor unit and the indoor unit; and
    a controller coupled to the outdoor refrigerant leakage detection device and the indoor refrigerant leakage detection device respectively and configured to:

        acquire a detection result of the indoor refrigerant leakage detection device;
        determine, according to the detection result of the indoor refrigerant leakage detection device, whether refrigerant leakage occurs in the indoor unit;
        if yes, control the air conditioning system to run a first refrigerant recycling mode, and if not, control the air conditioning system to maintain a current operation mode; and
        acquire a detection result of the outdoor refrigerant leakage detection device;
        determine, according to the detection result of the outdoor refrigerant leakage detection device, whether refrigerant leakage occurs in the outdoor unit;
        if yes, control the air conditioning system to run a second refrigerant recycling mode; and if not, control the air conditioning system to maintain the current operation mode;

    wherein in the first refrigerant recycling mode, the refrigerant in a pipeline of the indoor unit flows into a compressor of the outdoor unit and then is recycled into the refrigerant recycling apparatus through the outdoor unit; and
    in the second refrigerant recycling mode, the refrigerant in a pipeline of the outdoor unit flows into the compressor and then is recycled into the refrigerant recycling apparatus through the indoor unit.

2. The air conditioning system according to claim 1, wherein the refrigerant recycling apparatus comprises a liquid storage tank configured to store the refrigerant recycled by the refrigerant recycling apparatus.

3. The air conditioning system according to claim 2, wherein

    the outdoor unit further comprises a four-way valve, an outdoor heat exchanger, and an outdoor expansion valve;
    the indoor unit further comprises an indoor heat exchanger and an indoor expansion valve, the indoor heat exchanger being connected to the four-way valve through a first pipeline, the first pipeline being a pipeline between the indoor heat exchanger and the four-way valve; and
    the refrigerant recycling apparatus further comprises:

        a first solenoid valve, wherein the liquid storage tank is connected to the outdoor expansion valve through the first solenoid valve;
        a second solenoid valve, wherein the liquid storage tank is connected to the indoor expansion valve through the second solenoid valve; and
        a third solenoid valve, a first end of the third solenoid valve being communicated with a pipeline between the outdoor expansion valve and the first solenoid valve, and a second end of the third solenoid valve being communicated with a pipeline between the indoor expansion valve and the second solenoid valve.

4. The air conditioning system according to claim 3, wherein

    when the air conditioning system is in the first refrigerant recycling mode, the outdoor heat exchanger operates as a condenser, the indoor heat exchanger operates as an evaporator, the first solenoid valve is in the open state, the second solenoid valve is in the closed state, and the third solenoid valve is in the closed state; and

when the air conditioning system is in the second refrigerant recycling mode, the outdoor heat exchanger operates as an evaporator, the indoor heat exchanger operates as a condenser, the first solenoid valve is in the closed state, the second solenoid valve is in the open state, and the third solenoid valve is in the closed state.

5. The air conditioning system according to claim 4, wherein the controller is further configured to:

when the air conditioning system runs the first refrigerant recycling mode, close the indoor expansion valve in the indoor unit where refrigerant leakage occurs; and

when the air conditioning system runs the second refrigerant recycling mode, control the outdoor expansion valve to be at a preset opening value.

6. The air conditioning system according to claim 5, wherein

the refrigerant recycling apparatus further comprises a fourth solenoid valve, the fourth solenoid valve being connected to the four-way valve and the indoor heat exchanger respectively; and

the fourth solenoid valve is in the open state when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode.

7. The air conditioning system according to claim 6, wherein the controller is further configured to:

in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if a refrigerant recycling stop condition is met, control the fourth solenoid valve to be closed;

wherein the refrigerant recycling stop condition comprises at least one of the following:

a duration during which the air conditioning system runs one of the first refrigerant recycling mode and the second refrigerant recycling mode reaches a preset duration; and

a pressure of the refrigerant entering the compressor is within a preset pressure range.

8. The air conditioning system according to claim 6, wherein

the refrigerant recycling apparatus further comprises a fifth solenoid valve, the fifth solenoid valve being connected to the fourth solenoid valve and the indoor heat exchanger in each indoor unit respectively; and

the fifth solenoid valve is in the open state when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode.

9. The air conditioning system according to claim 8, wherein the controller is further configured to:

when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if a refrigerant recycling stop condition is met, control the fifth solenoid valve to be closed;

wherein the refrigerant recycling stop condition comprises at least one of the following:

a duration during which the air conditioning system runs one of the first refrigerant recycling mode and the second refrigerant recycling mode reaches a preset duration; and

a pressure of the refrigerant entering the compressor is within a preset pressure range.

10. The air conditioning system according to claim 8, wherein

the refrigerant recycling apparatus further comprises a second expansion valve, the second expansion valve meeting one of the following:

the second expansion valve being communicated with the liquid storage tank and a second pipeline respectively, the second pipeline being a pipeline between the fourth solenoid valve and the fifth solenoid valve;

or, the second expansion valve being communicated with the second pipeline and a third pipeline respectively, the third pipeline being a pipeline between the first solenoid valve and the liquid storage tank;

wherein the second expansion valve is in the open state when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode.

11. The air conditioning system according to claim 7, wherein the second refrigerant recycling apparatus further comprises:

a first shut-off valve arranged on a pipeline between the four-way valve and the fourth solenoid valve;

a second shut-off valve arranged on a pipeline between the fourth solenoid valve and the indoor heat exchanger;
a third shut-off valve arranged on a pipeline between the outdoor expansion valve and the first solenoid valve; and
a fourth shut-off valve arranged on a pipeline between the second solenoid valve and the indoor heat exchanger;
wherein the first shut-off valve, the second shut-off valve, the third shut-off valve, and the fourth shut-off valve are opened when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode;
wherein the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the first shut-off valve, the second shut-off valve, the third shut-off valve, and the fourth shut-off valve to be closed.

12. The air conditioning system according to claim 11, wherein the outdoor unit further comprises:

a fifth shut-off valve arranged on a pipeline between the four-way valve and the first shut-off valve; and
a sixth shut-off valve arranged on a pipeline between the outdoor expansion valve and the third shut-off valve;
wherein the fifth shut-off valve and the sixth shut-off valve are opened when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode; and
wherein the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the fifth shut-off valve and the sixth shut-off valve to be closed.

13. The air conditioning system according to claim 12, wherein the outdoor unit further comprises:

a sixth solenoid valve arranged on a pipeline between the four-way valve and the fifth shut-off valve; and
a seventh solenoid valve arranged on a pipeline between the outdoor expansion valve and the sixth shut-off valve;
wherein the sixth solenoid valve and the seventh solenoid valve are opened when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode; and
wherein the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the sixth solenoid valve and the seventh solenoid valve to be closed.

14. An air conditioning system, comprising:

an outdoor unit comprising an outdoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the outdoor unit;
one or more indoor units each comprising an indoor refrigerant leakage detection device configured to detect whether refrigerant leakage occurs in the indoor unit;
a refrigerant recycling apparatus located between the outdoor unit and the indoor unit and configured to recycle and store refrigerant in the air conditioning system when refrigerant leakage occurs in one of the outdoor unit and the indoor unit; and
a controller coupled to the outdoor refrigerant leakage detection device and the indoor refrigerant leakage detection device and configured to:

acquire a detection result of the indoor refrigerant leakage detection device;
determine, according to the detection result of the indoor refrigerant leakage detection device, whether refrigerant leakage occurs in the indoor unit;
if yes, control the air conditioning system to run a first refrigerant recycling mode, and if not, control the air conditioning system to maintain a current operation mode;
acquire a detection result of the outdoor refrigerant leakage detection device;
determine, according to the detection result of the outdoor refrigerant leakage detection device, whether refrigerant leakage occurs in the outdoor unit;
if yes, control the air conditioning system to run a second refrigerant recycling mode;

and if not, control the air conditioning system to maintain the current operation mode; and
when one of the first refrigerant recycling mode and the second refrigerant recycling mode is completed, control the air conditioning system to run a refrigerant release mode if the controller receives a control signal instructing the air conditioning system to operate in one of a refrigera-

tion mode and a heating mode;
wherein, in the first refrigerant recycling mode, the refrigerant in a pipeline of the indoor unit enters a compressor of the outdoor unit and then is recycled into the refrigerant recycling apparatus through the outdoor unit;
in the second refrigerant recycling mode, the refrigerant in a pipeline of the outdoor unit enters the compressor and then is recycled into the refrigerant recycling apparatus through the indoor unit; and
in the refrigerant release mode, the refrigerant recycled in the refrigerant recycling apparatus is released into a pipeline in the air conditioning system.

15. The air conditioning system according to claim 14, wherein the refrigerant recycling apparatus comprises a liquid storage tank configured to store the refrigerant recycled by the refrigerant recycling apparatus.

16. The air conditioning system according to claim 15, wherein

the outdoor unit further comprises a four-way valve and an outdoor expansion valve;
the indoor unit comprises an indoor heat exchanger and an indoor expansion valve, the indoor heat exchanger being connected to the four-way valve; and
the refrigerant recycling apparatus further comprises:

a first solenoid valve, wherein the liquid storage tank is connected to the outdoor expansion valve through the first solenoid valve;
a second solenoid valve, wherein the liquid storage tank is connected to the indoor expansion valve through the second solenoid valve;
a third solenoid valve, a first end of the third solenoid valve being communicated with a pipeline between the first solenoid valve and the outdoor expansion valve, and a second end of the third solenoid valve being communicated with a pipeline between the second solenoid valve and the indoor expansion valve; and
a first expansion valve, wherein the liquid storage tank is communicated with a first pipeline through the first expansion valve, the first pipeline being a pipeline between the indoor heat exchanger and the four-way valve.

17. The air conditioning system according to claim 16, wherein

when the air conditioning system is in the first refrigerant recycling mode, the outdoor heat exchanger operates as a condenser, the indoor heat exchanger operates as an evaporator, the first solenoid valve is in the open state, the second solenoid valve is in the closed state, the third solenoid valve is in the closed state, and the first expansion valve is in the closed state;
when the air conditioning system is in the second refrigerant recycling mode, the outdoor heat exchanger operates as an evaporator, the indoor heat exchanger operates as a condenser, the first solenoid valve is in the closed state, the second solenoid valve is in the open state, the third solenoid valve is in the closed state, and the first expansion valve is in the closed state; and
when the air conditioning system is in the refrigerant release mode, the first solenoid valve is in the closed state, the second solenoid valve is in the closed state, the third solenoid valve is in the open state, the first expansion valve is in an open state, the refrigerant in the liquid storage tank is released into the first pipeline through the first expansion valve, one of the outdoor heat exchanger and the indoor heat exchanger operates as an evaporator, and the other operates as a condenser.

18. The air conditioning system according to claim 17, wherein
the refrigerant recycling apparatus further comprises a first subcooler, the first subcooler having a first channel and a second channel; the liquid storage tank is communicated with the first pipeline through the first expansion valve and the first channel; and the first end of the third solenoid valve is connected to the outdoor expansion valve through the second channel.

19. The air conditioning system according to claim 18, wherein

the refrigerant recycling apparatus further comprises a first temperature sensor, the first temperature sensor being configured to detect a temperature value of the refrigerant flowing out of the first channel of the first subcooler;
the outdoor unit further comprises a gas-liquid separator and a first outdoor pressure sensor, the first outdoor pressure sensor being configured to detect a pressure value of the refrigerant entering the compressor from the gas-liquid separator; and
the controller is further configured to:

when the air conditioning system runs the refrigerant release mode, acquire a first temperature value detected by the first temperature sensor and a pressure value detected by the first outdoor pressure sensor;
determine a second temperature value according to the pressure value detected by the first outdoor pressure sensor, the second temperature value being a saturation temperature value corresponding to the pressure value detected by the first outdoor pressure sensor;
determine whether a difference between the first temperature value and the second temperature value is less than a first preset temperature value; and
if yes, control the first expansion value to reduce an opening of the first expansion value; and if not, control the first expansion valve to increase the opening of the first expansion value.

20. The air conditioning system according to claim 19, wherein
the refrigerant recycling apparatus further comprises a throttling device and a second subcooler; the second subcooler has a third channel and a fourth channel; the liquid storage tank is communicated with the first pipeline through the throttling device and the third channel of the second subcooler; and the second end of the third solenoid valve is connected to the indoor expansion valve through the fourth channel of the second subcooler.

21. The air conditioning system according to claim 20, wherein

the refrigerant recycling apparatus further comprises a second temperature sensor, the second temperature sensor being configured to detect a temperature value of the refrigerant flowing out of the third channel of the second subcooler; and the controller is further configured to:

when the air conditioning system runs the refrigerant release mode, acquire a third temperature value detected by the second temperature sensor and the pressure value detected by the first outdoor pressure sensor;
determine the second temperature value according to the pressure value detected by the first outdoor pressure sensor;
determine whether a difference between the third temperature value and the second temperature value is less than a second preset temperature value; and
if yes, control the air conditioning system to continue to run the refrigerant release mode; and if not, control the air conditioning system to end the running of the refrigerant release mode.

22. The air conditioning system according to claim 17, wherein

the refrigerant recycling apparatus further comprises a fourth solenoid valve, the fourth solenoid valve being connected to the four-way valve and the indoor heat exchanger respectively; and
the fourth solenoid valve is in the open state when the air conditioning system is in one of the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode; and
when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if a refrigerant recycling stop condition is met, the controller controls the fourth solenoid valve to be closed;
wherein the refrigerant recycling stop condition comprises at least one of the following:

a duration during which the air conditioning system runs one of the first refrigerant recycling mode and the second refrigerant recycling mode reaches a preset duration; and
a pressure of the refrigerant entering the compressor is within a preset pressure range.

23. The air conditioning system according to claim 22, wherein

the refrigerant recycling apparatus further comprises a fifth solenoid valve, the fifth solenoid valve being connected to the fourth solenoid valve and the indoor heat exchanger respectively; and
the fifth solenoid valve is in the open state when the air conditioning system is in one of the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode; and
when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, the controller controls the fifth solenoid valve to be closed.

24. The air conditioning system according to claim 23, wherein
the refrigerant recycling apparatus further comprises a second expansion valve, the second expansion

valve meeting one of the following:

the second expansion valve being communicated with the liquid storage tank and a second pipeline respectively, the second pipeline being a pipeline between the fourth solenoid valve and the fifth solenoid valve;
or, the second expansion valve being communicated with the second pipeline and a third pipeline respectively, the third pipeline being a pipeline between the first solenoid valve and the liquid storage tank;
wherein when the air conditioning system is in the refrigerant release mode, the second expansion valve is closed; and
the second expansion valve being is in the open state when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode.

25. The air conditioning system according to claim 24, wherein the refrigerant recycling apparatus further comprises:

a first shut-off valve arranged on a pipeline between the four-way valve and the fourth solenoid valve;
a second shut-off valve arranged on a pipeline between the fifth solenoid valve and the indoor heat exchanger;
a third shut-off valve arranged on a pipeline between the outdoor expansion valve and the first solenoid valve;
a fourth shut-off valve arranged on a pipeline between the second solenoid valve and the indoor heat exchanger;
when the air conditioning system is in one of the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode, the first shut-off valve, the second shut-off valve, the third shut-off valve, and the fourth shut-off valve are opened; and
the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the first shut-off valve, the second shut-off valve, the third shut-off valve, and the fourth shut-off valve to be closed.

26. The air conditioning system according to claim 25, wherein the outdoor unit further comprises:

a fifth shut-off valve, the fifth shut-off valve being arranged on a pipeline between the four-way valve and the first shut-off valve; and
a sixth shut-off valve, the sixth shut-off valve being arranged on a pipeline between the outdoor expansion valve and the third shut-off valve;
wherein the fifth shut-off valve and the sixth shut-off valve are opened when the air conditioning system is in one of the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode; and
the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the fifth shut-off valve and the sixth shut-off valve to be closed.

27. The air conditioning system according to claim 26, wherein the outdoor unit further comprises:

a sixth solenoid valve, the sixth solenoid valve being arranged on a pipeline between the four-way valve and the fifth shut-off valve; and
a seventh solenoid valve, the seventh solenoid valve being arranged on a pipeline between the outdoor expansion valve and the sixth shut-off valve;
wherein the sixth solenoid valve and the seventh solenoid valve are opened when the air conditioning system is in one of the first refrigerant recycling mode, the second refrigerant recycling mode, and the refrigerant release mode; and
the controller is further configured to, when the air conditioning system is in one of the first refrigerant recycling mode and the second refrigerant recycling mode, if the refrigerant recycling stop condition is met, control the sixth solenoid valve and the seventh solenoid valve to be closed.

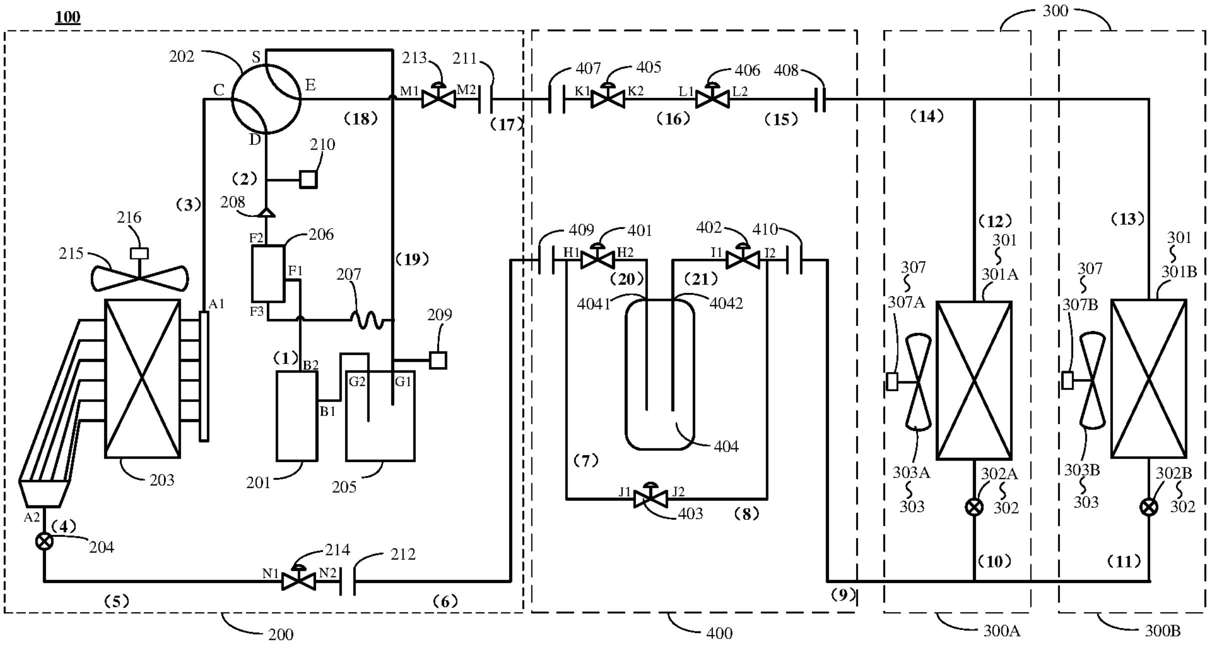
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FIG. 1

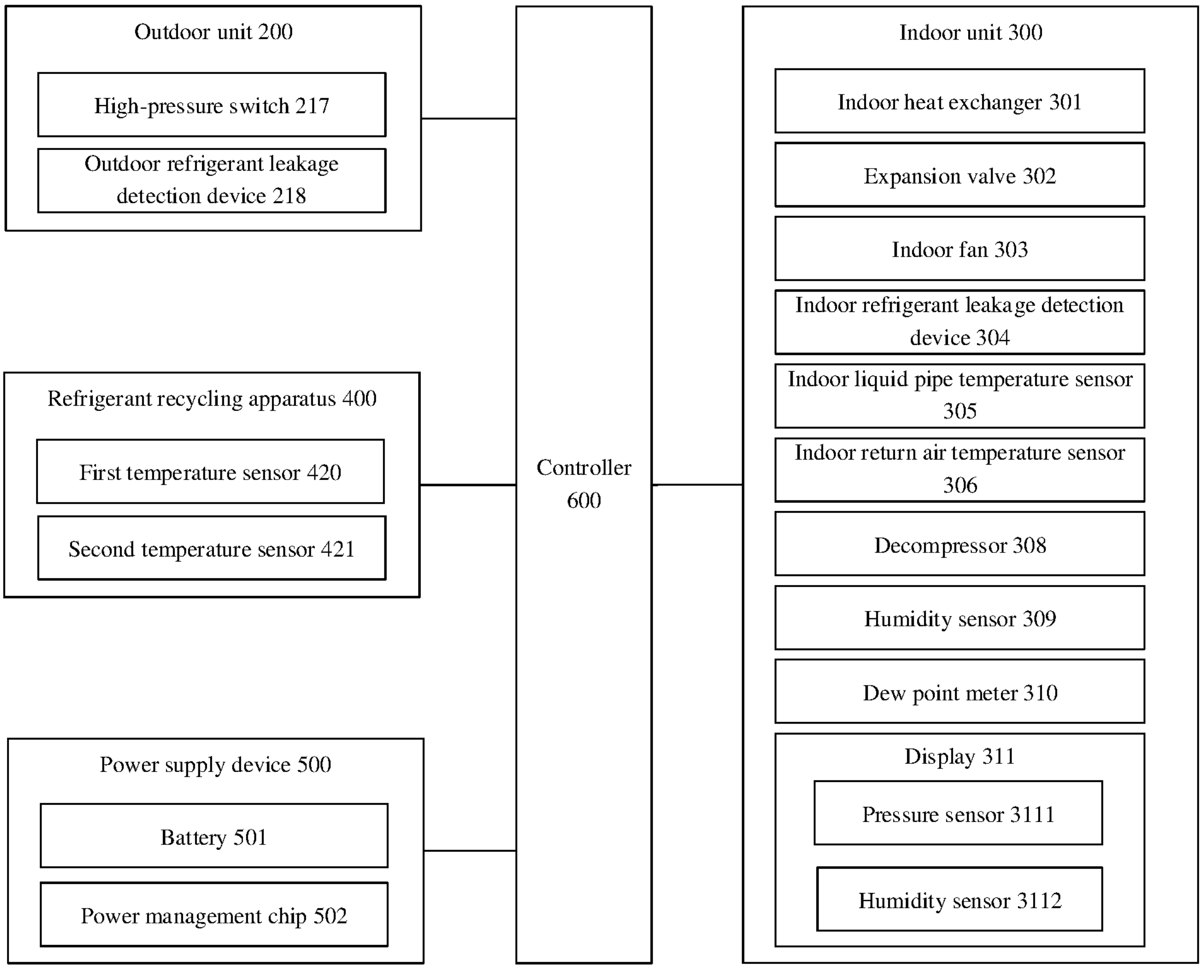
Outdoor unit 200
High-pressure switch 217
Outdoor refrigerant leakage detection device 218
Refrigerant recycling apparatus 400
First temperature sensor 420
Second temperature sensor 421
Power supply device 500
Battery 501
Power management chip 502
Controller 600
Indoor unit 300
Indoor heat exchanger 301
Expansion valve 302
Indoor fan 303
Indoor refrigerant leakage detection device 304
Indoor liquid pipe temperature sensor 305
Indoor return air temperature sensor 306
Decompressor 308
Humidity sensor 309
Dew point meter 310
Display 311
Pressure sensor 3111
Humidity sensor 3112

FIG. 2

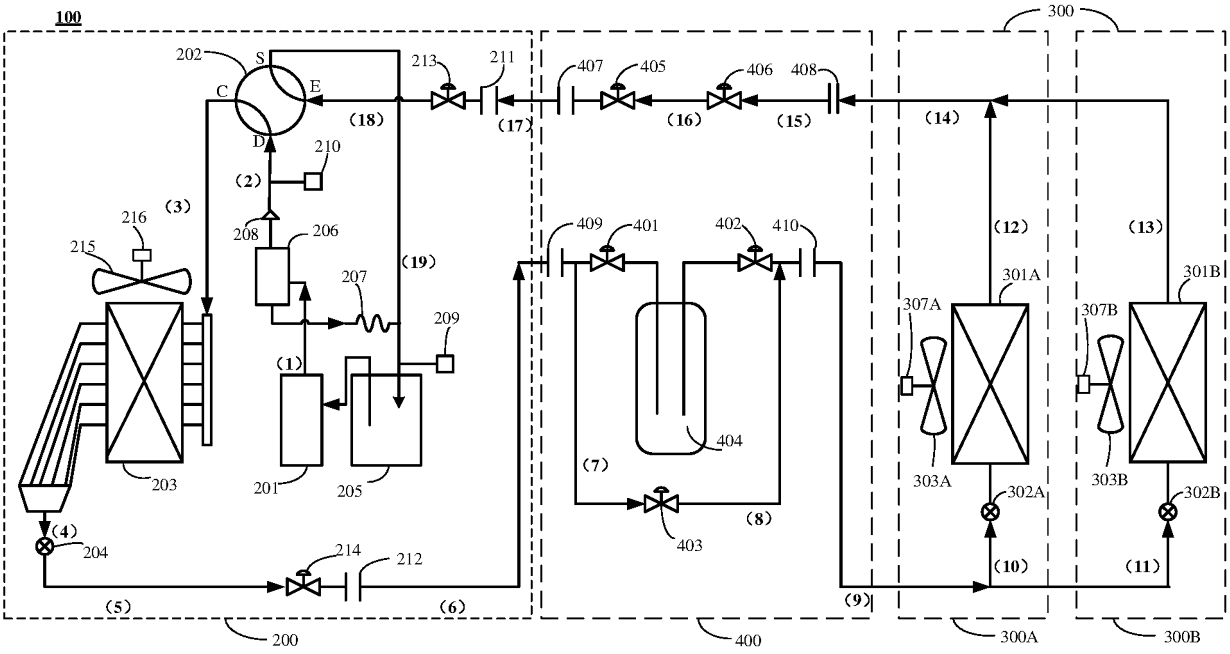
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FIG. 3

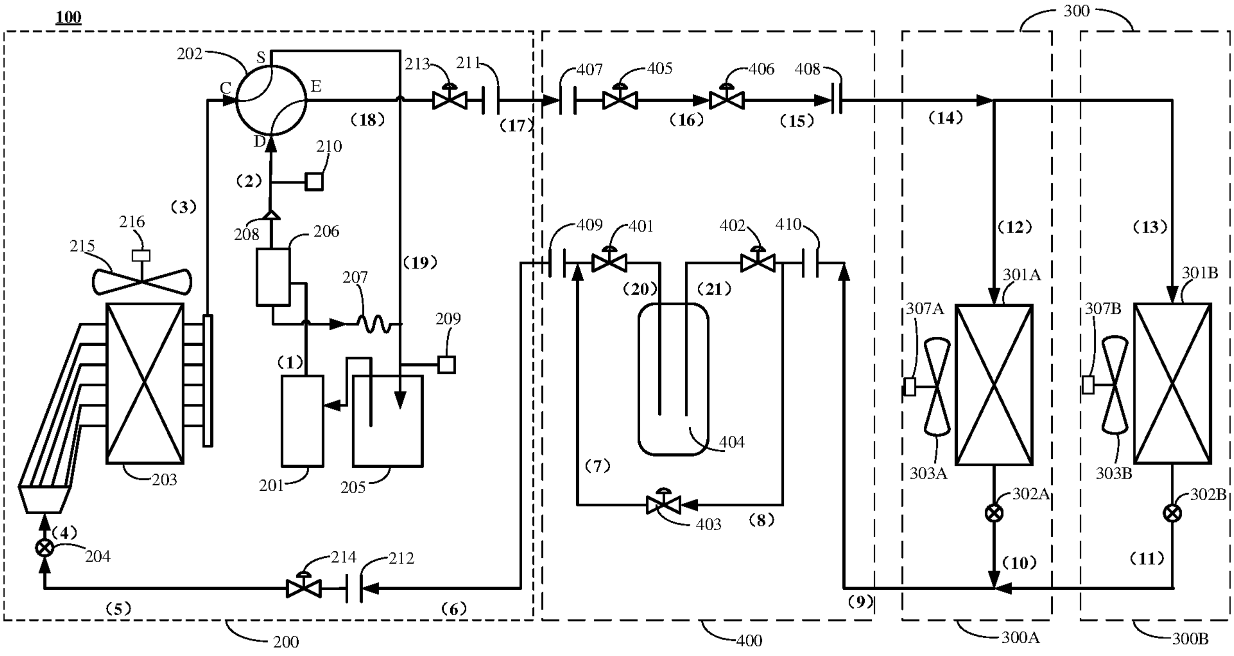
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FIG. 4

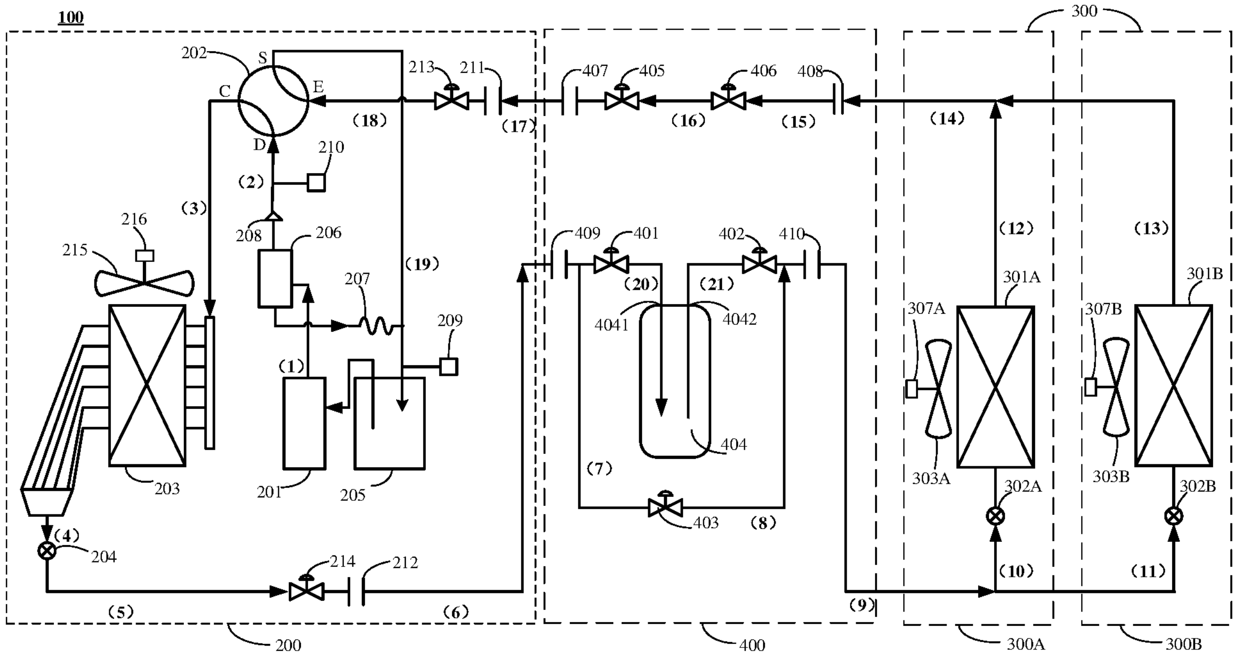
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FIG. 5

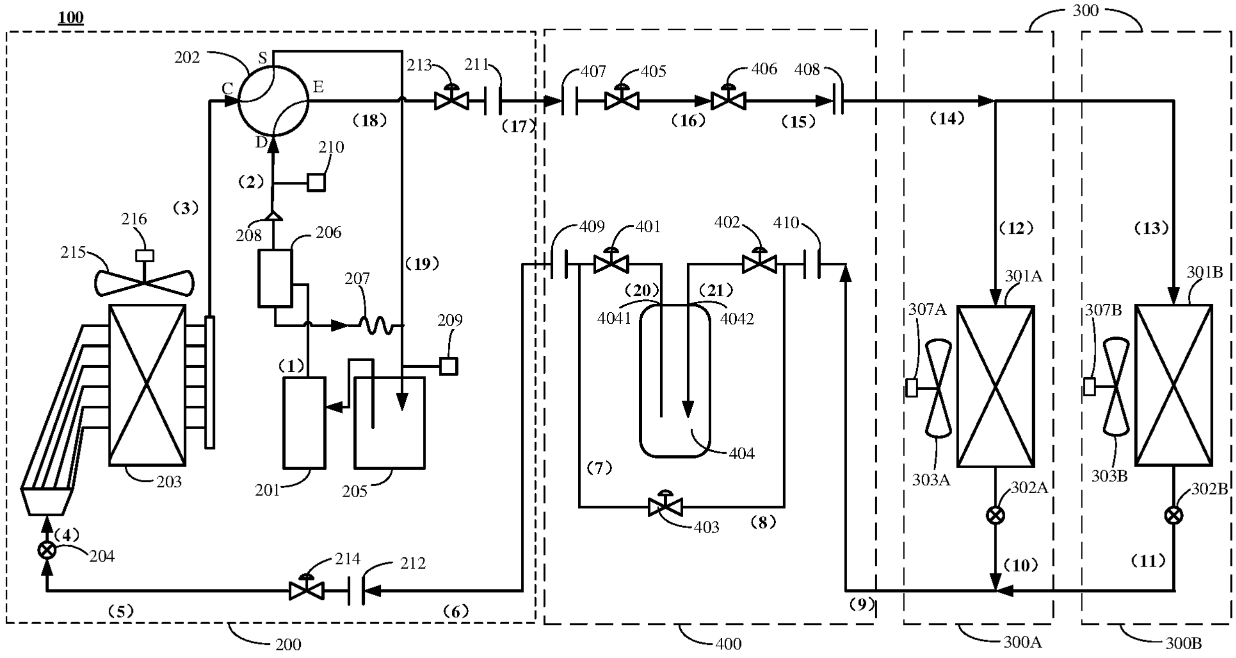
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FIG. 6

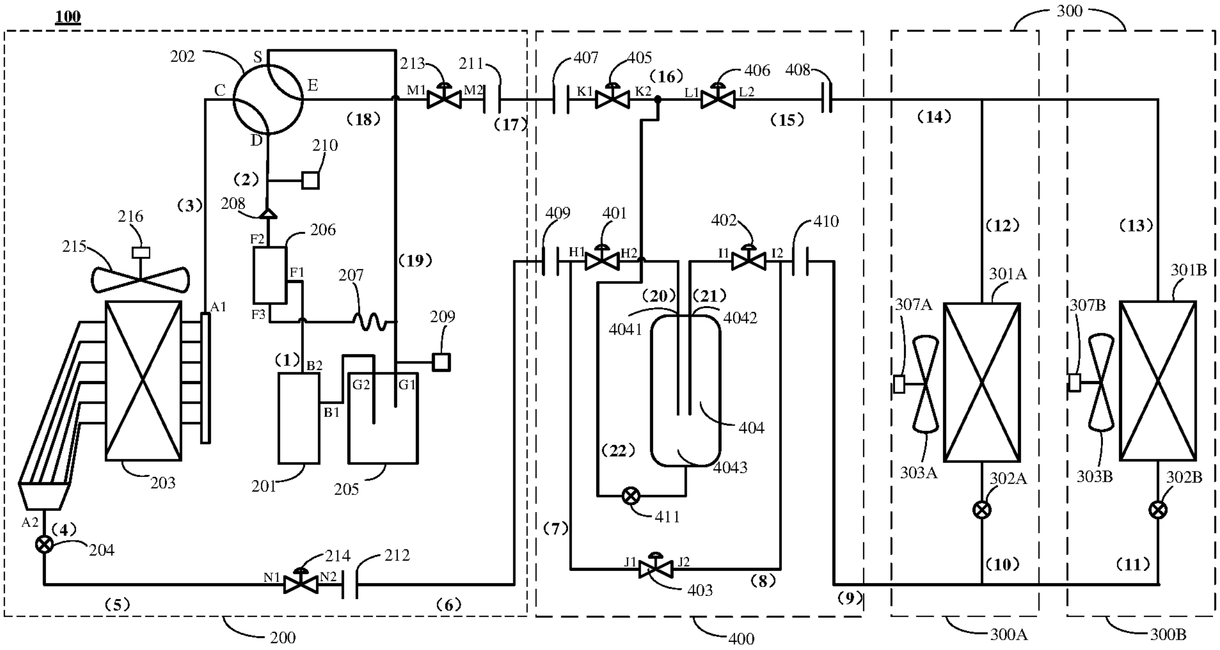
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FIG. 7

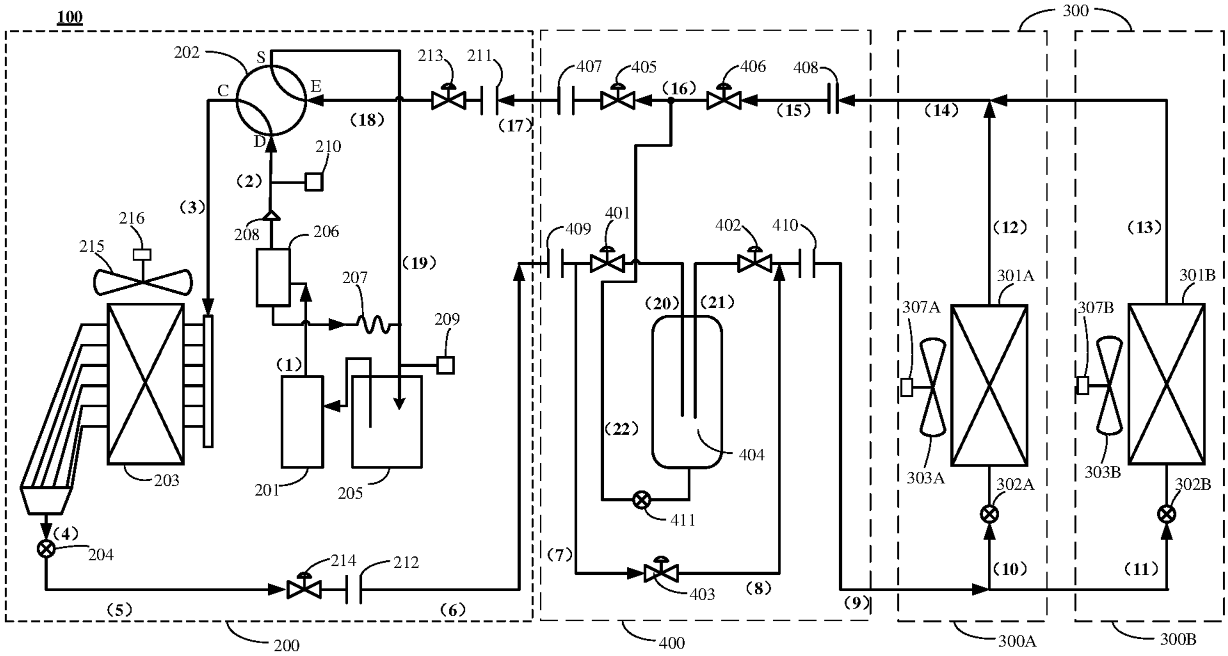
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FIG. 8

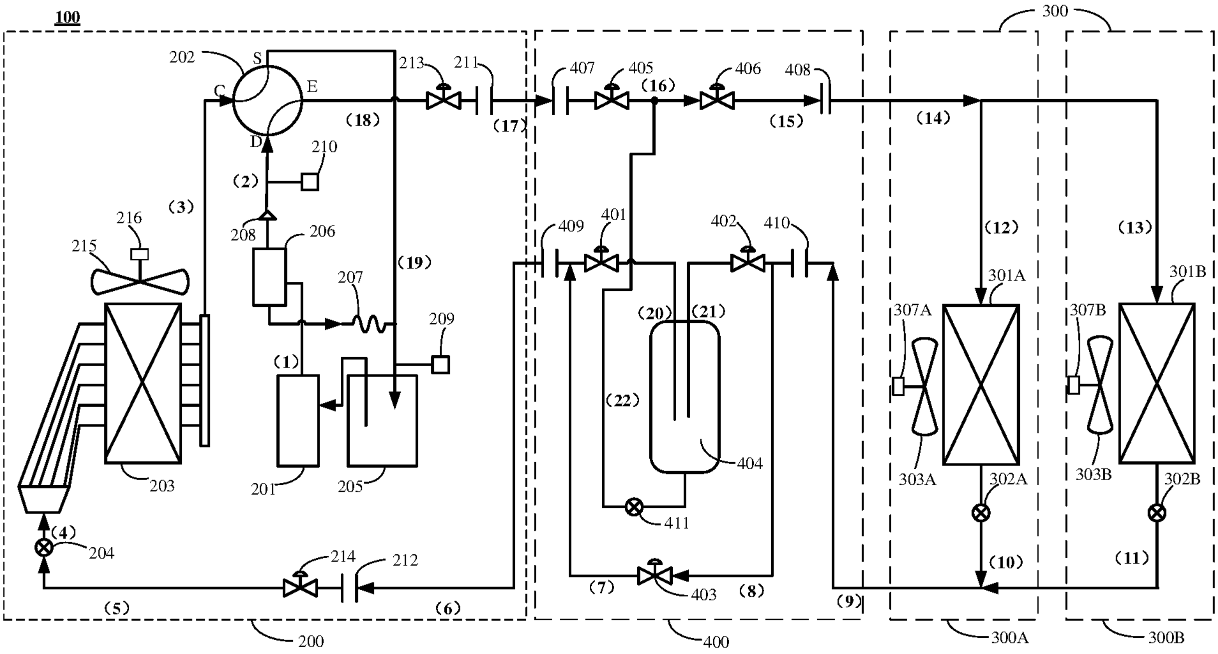
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FIG. 9

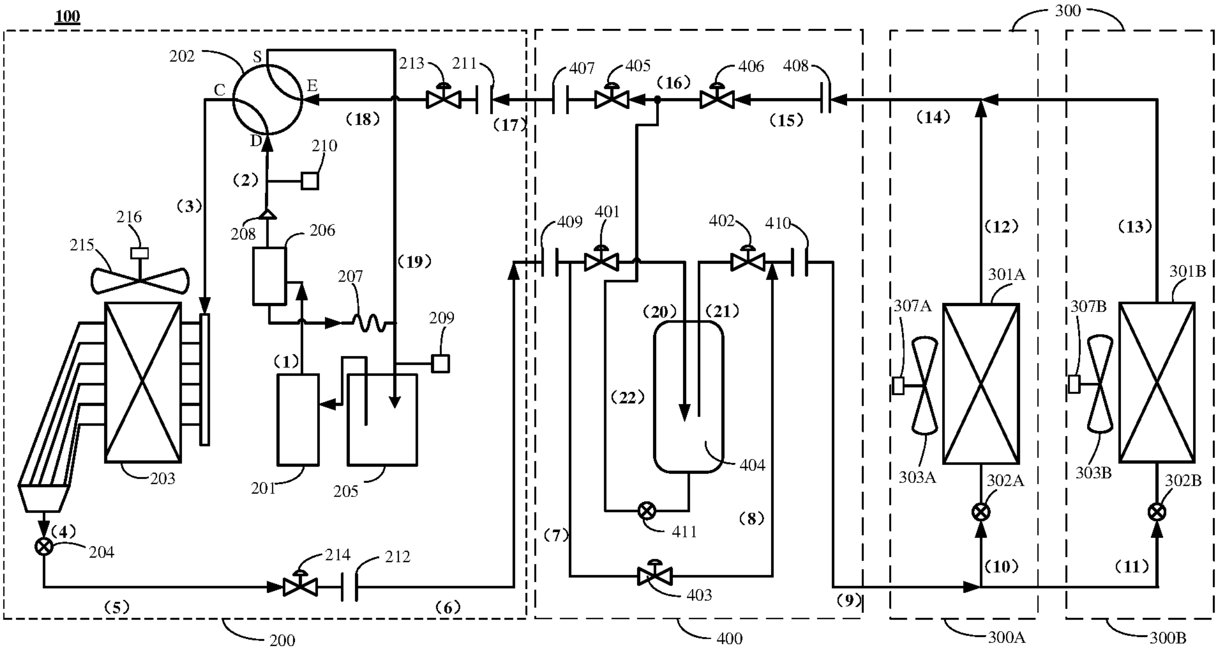
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FIG. 10

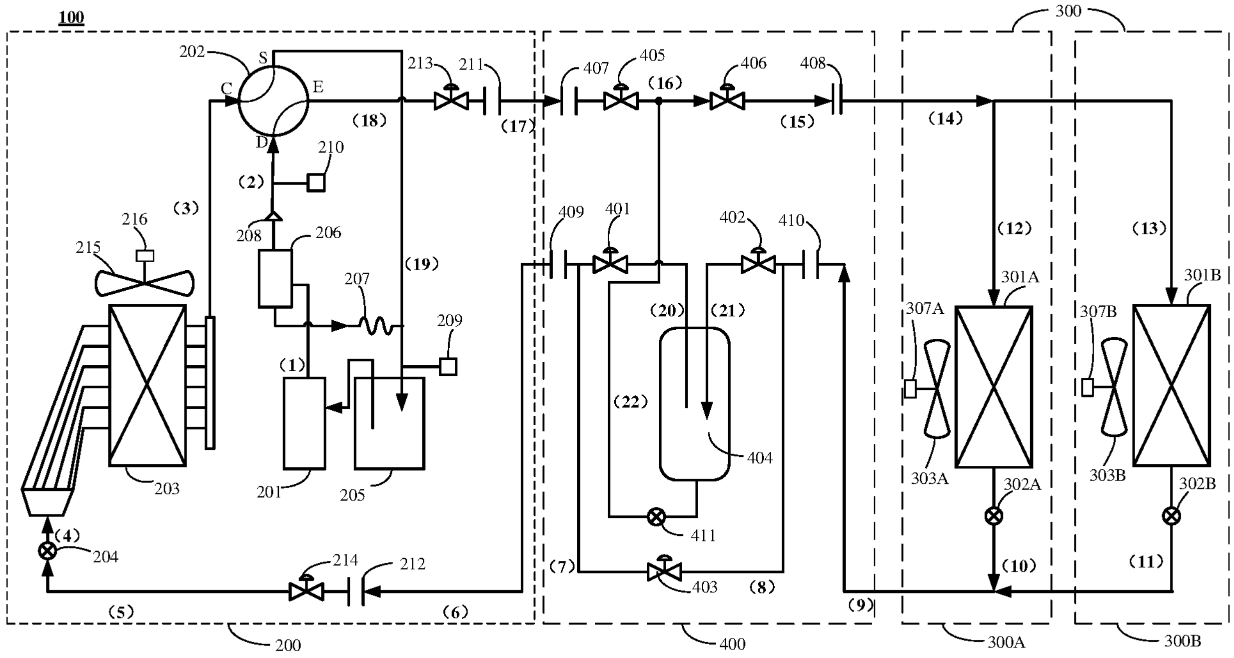
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FIG. 11

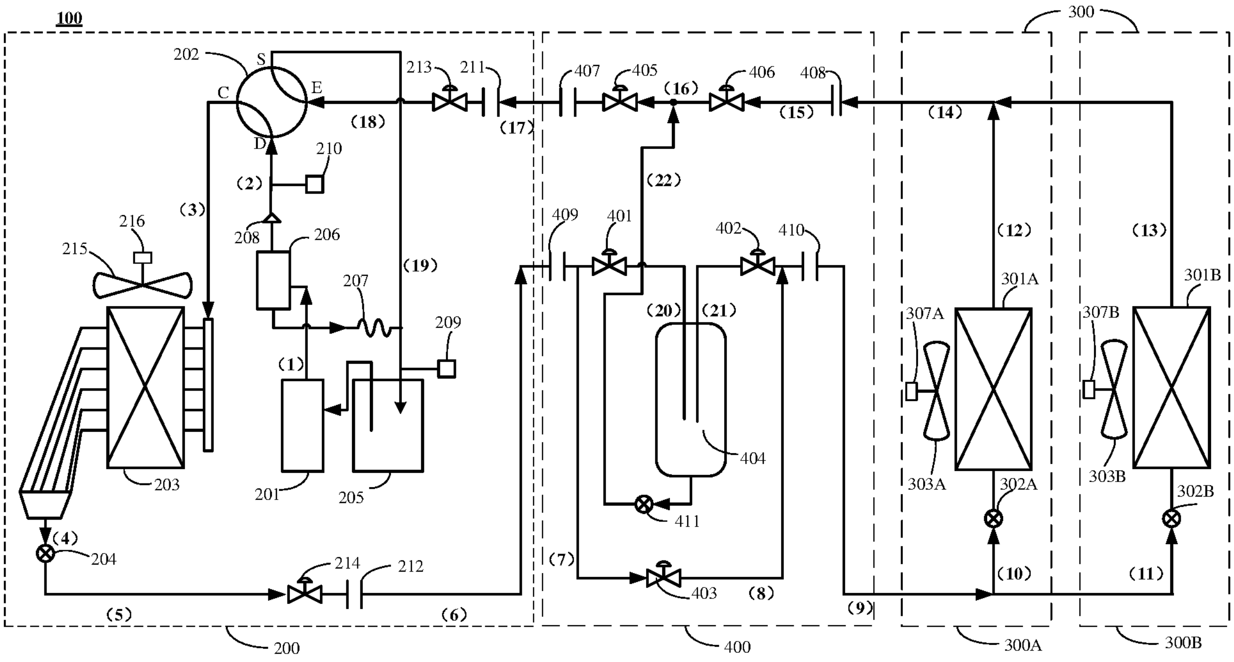
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FIG. 12

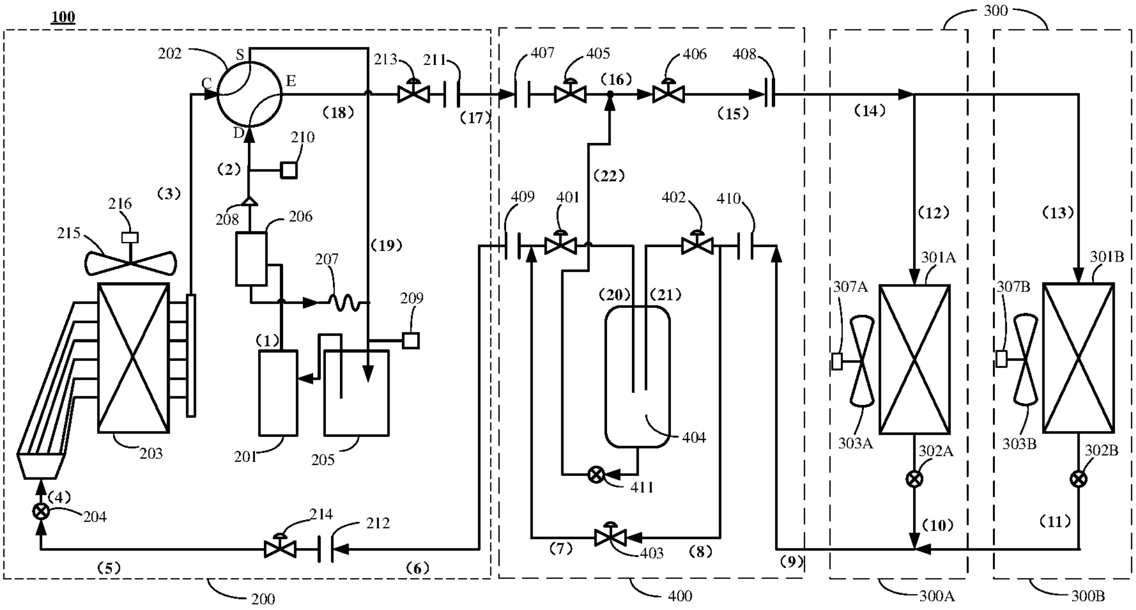
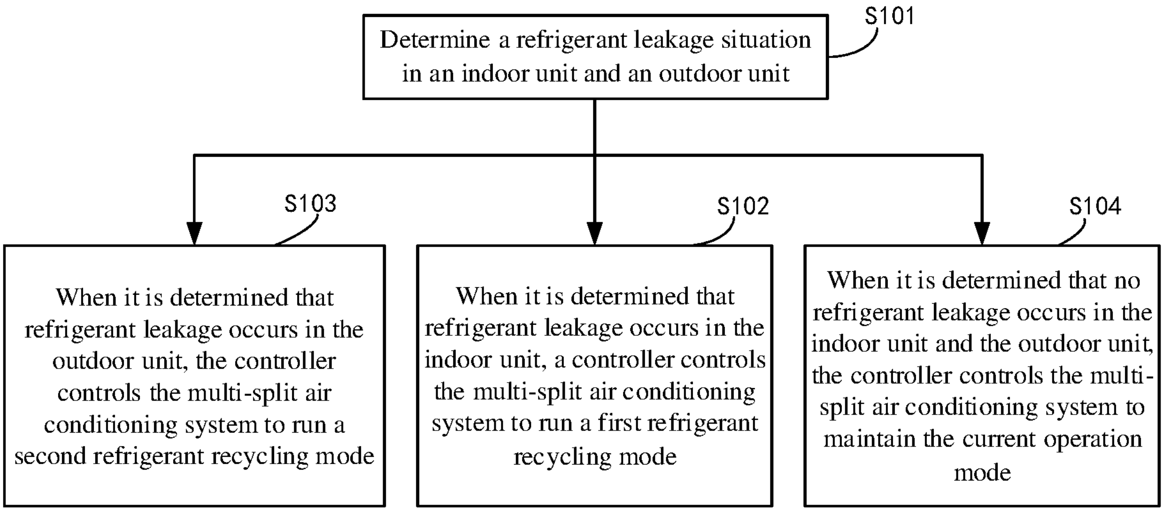


FIG. 13



Determine a refrigerant leakage situation in an indoor unit and an outdoor unit

When it is determined that refrigerant leakage occurs in the outdoor unit, the controller controls the multi-split air conditioning system to run a second refrigerant recycling mode

When it is determined that refrigerant leakage occurs in the indoor unit, a controller controls the multi-split air conditioning system to run a first refrigerant recycling mode

When it is determined that no refrigerant leakage occurs in the indoor unit and the outdoor unit, the controller controls the multi-split air conditioning system to maintain the current operation mode

FIG. 14

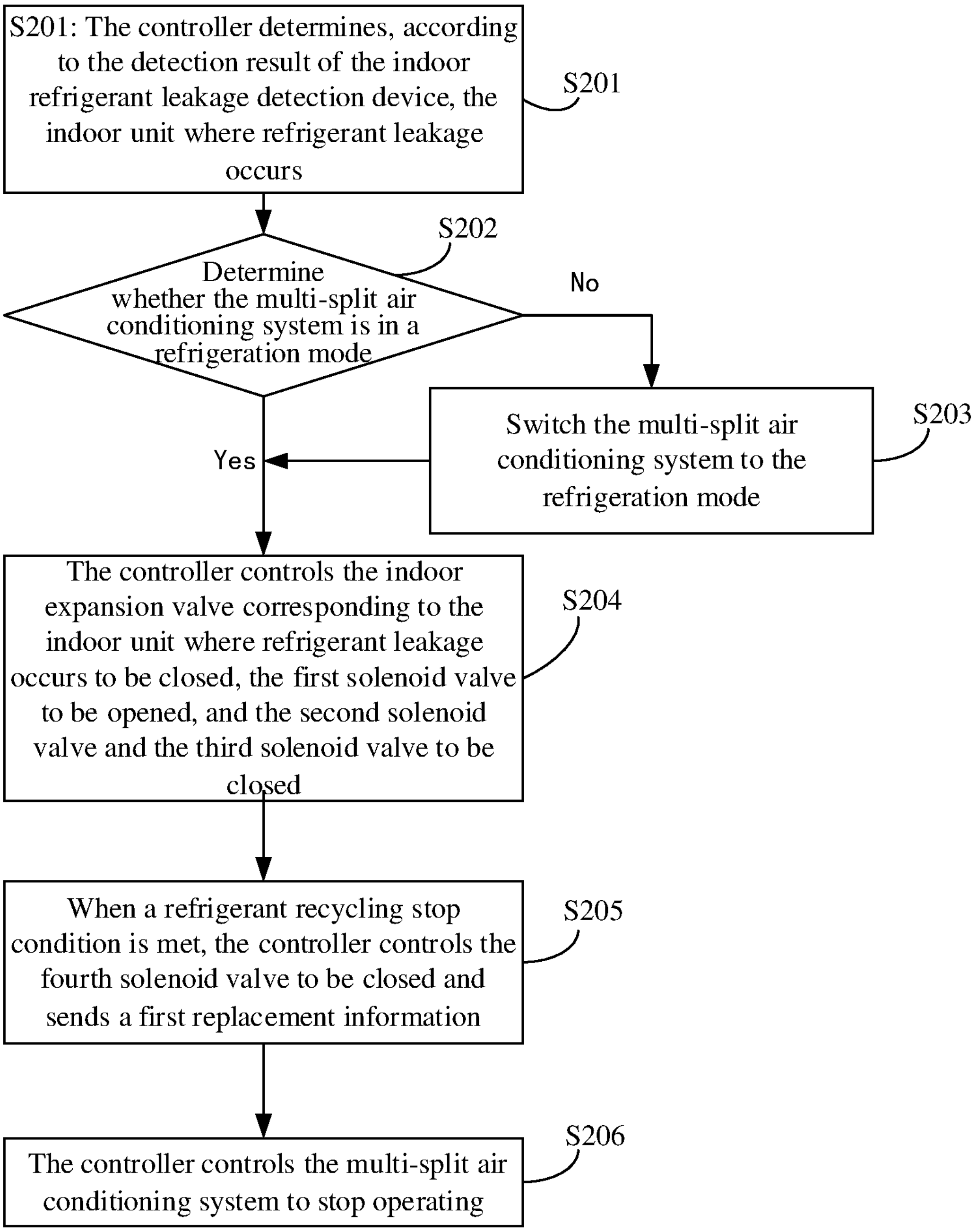

S201: The controller determines, according to the detection result of the indoor refrigerant leakage detection device, the indoor unit where refrigerant leakage occurs
S201
S202
Determine whether the multi-split air conditioning system is in a refrigeration mode
No
Switch the multi-split air conditioning system to the refrigeration mode
S203
Yes
The controller controls the indoor expansion valve corresponding to the indoor unit where refrigerant leakage occurs to be closed, the first solenoid valve to be opened, and the second solenoid valve and the third solenoid valve to be closed
S204
When a refrigerant recycling stop condition is met, the controller controls the fourth solenoid valve to be closed and sends a first replacement information
S205
The controller controls the multi-split air conditioning system to stop operating
S206

FIG. 15

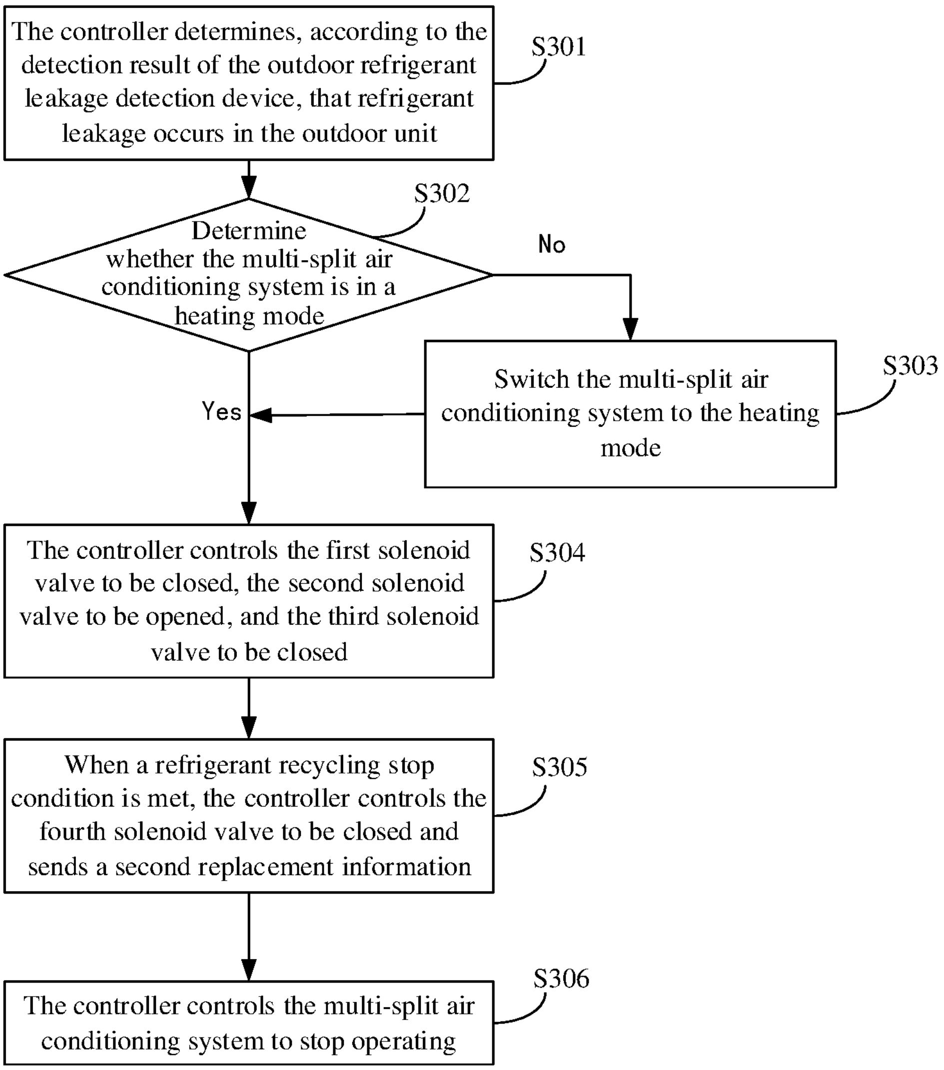

The controller determines, according to the detection result of the outdoor refrigerant leakage detection device, that refrigerant leakage occurs in the outdoor unit
S301
S302
Determine whether the multi-split air conditioning system is in a heating mode
No
Switch the multi-split air conditioning system to the heating mode
S303
Yes
The controller controls the first solenoid valve to be closed, the second solenoid valve to be opened, and the third solenoid valve to be closed
S304
When a refrigerant recycling stop condition is met, the controller controls the fourth solenoid valve to be closed and sends a second replacement information
S305
The controller controls the multi-split air conditioning system to stop operating
S306

FIG. 16

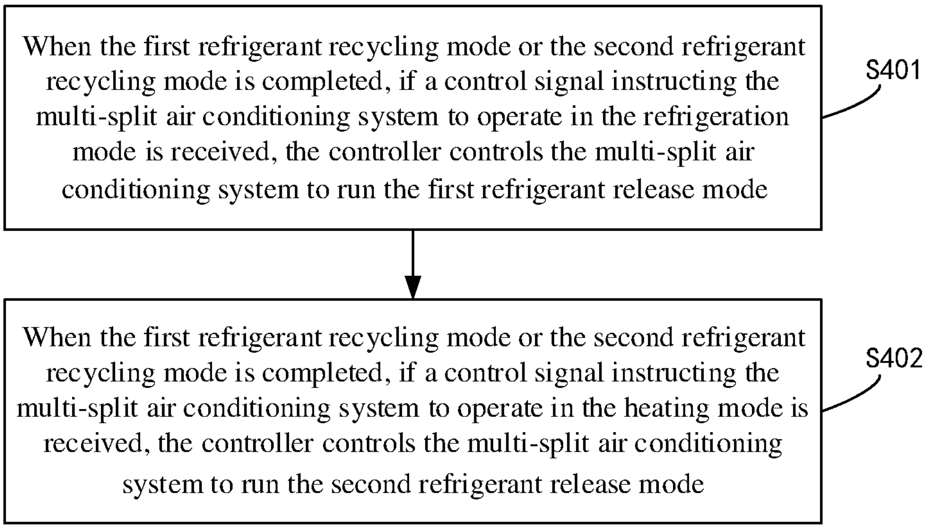

When the first refrigerant recycling mode or the second refrigerant recycling mode is completed, if a control signal instructing the multi-split air conditioning system to operate in the refrigeration mode is received, the controller controls the multi-split air conditioning system to run the first refrigerant release mode
S401
When the first refrigerant recycling mode or the second refrigerant recycling mode is completed, if a control signal instructing the multi-split air conditioning system to operate in the heating mode is received, the controller controls the multi-split air conditioning system to run the second refrigerant release mode
S402

FIG. 17

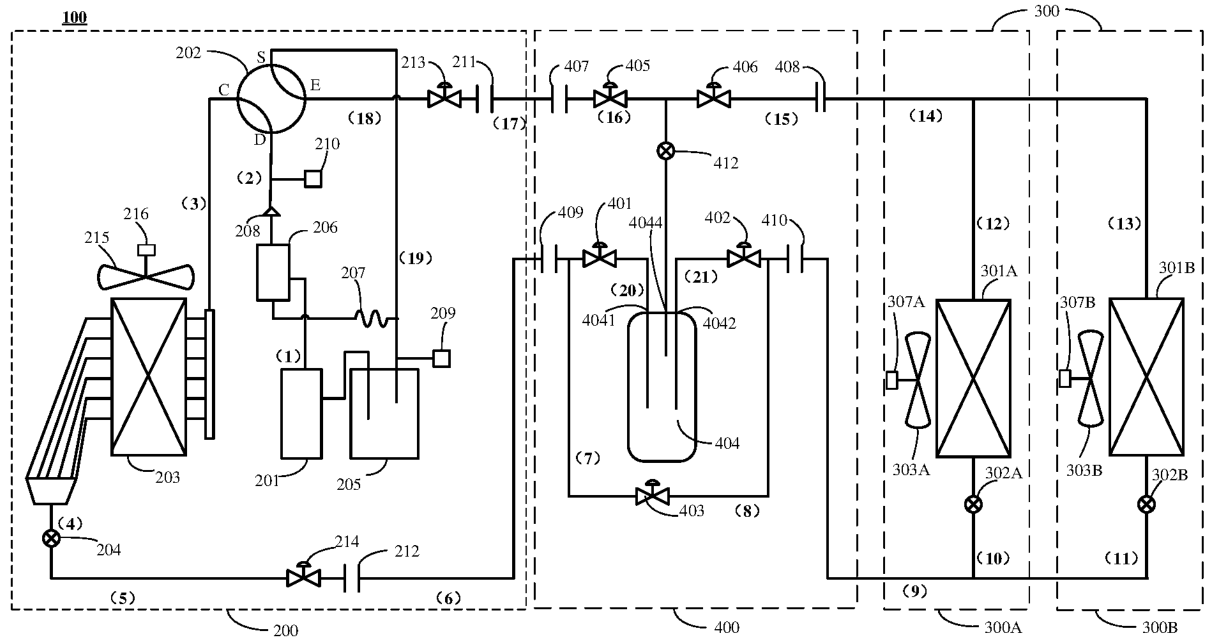

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FIG. 18

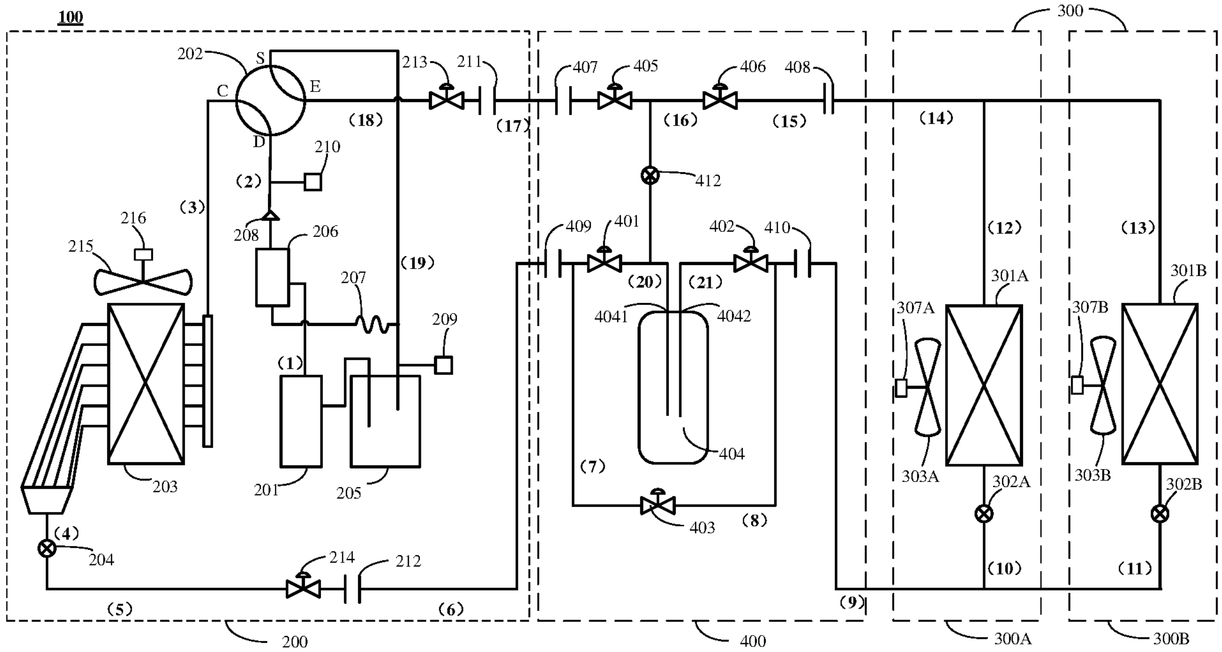
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FIG. 19

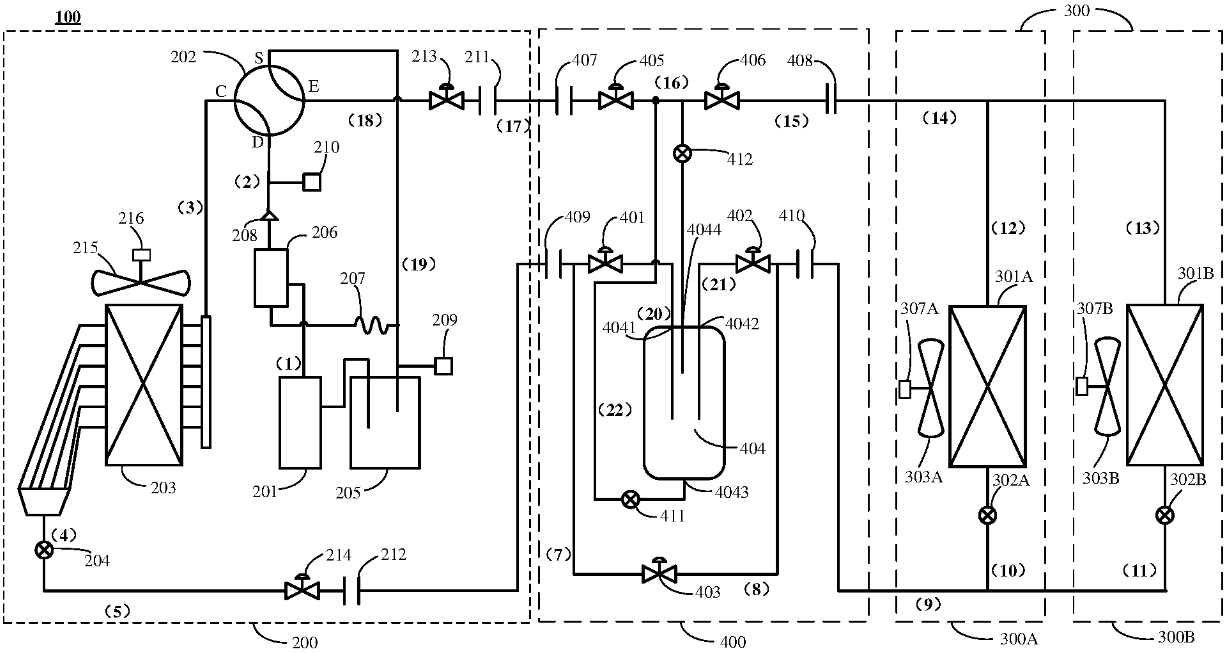
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FIG. 20

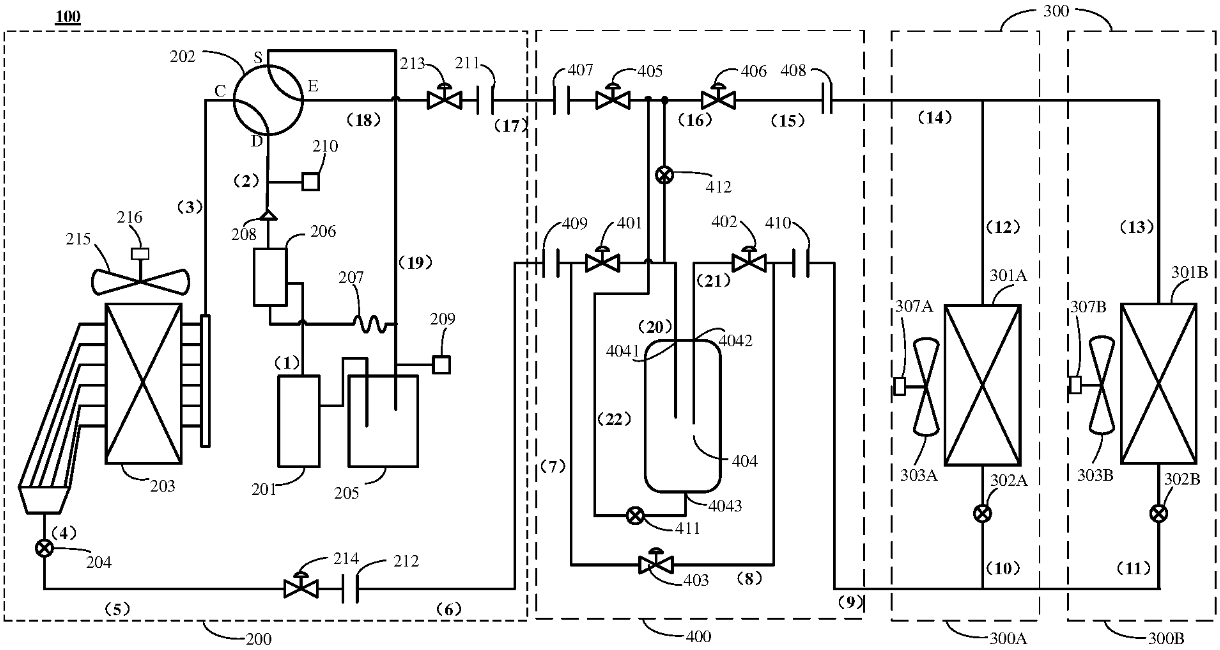
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FIG. 21

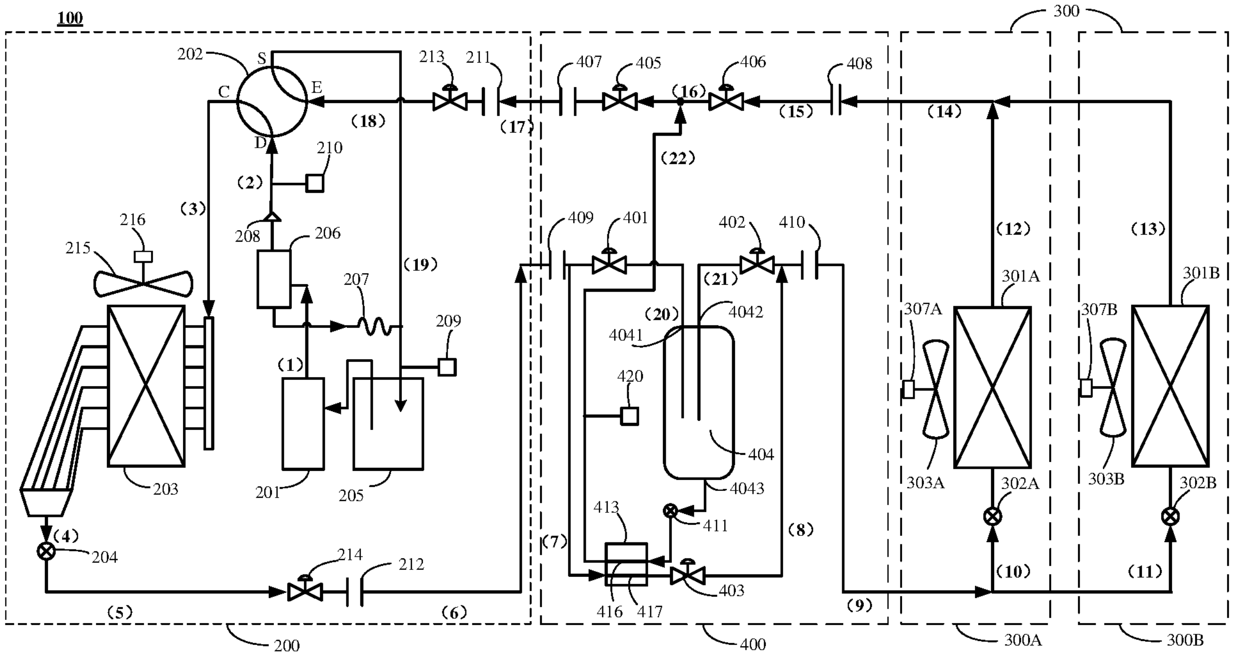
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FIG. 22

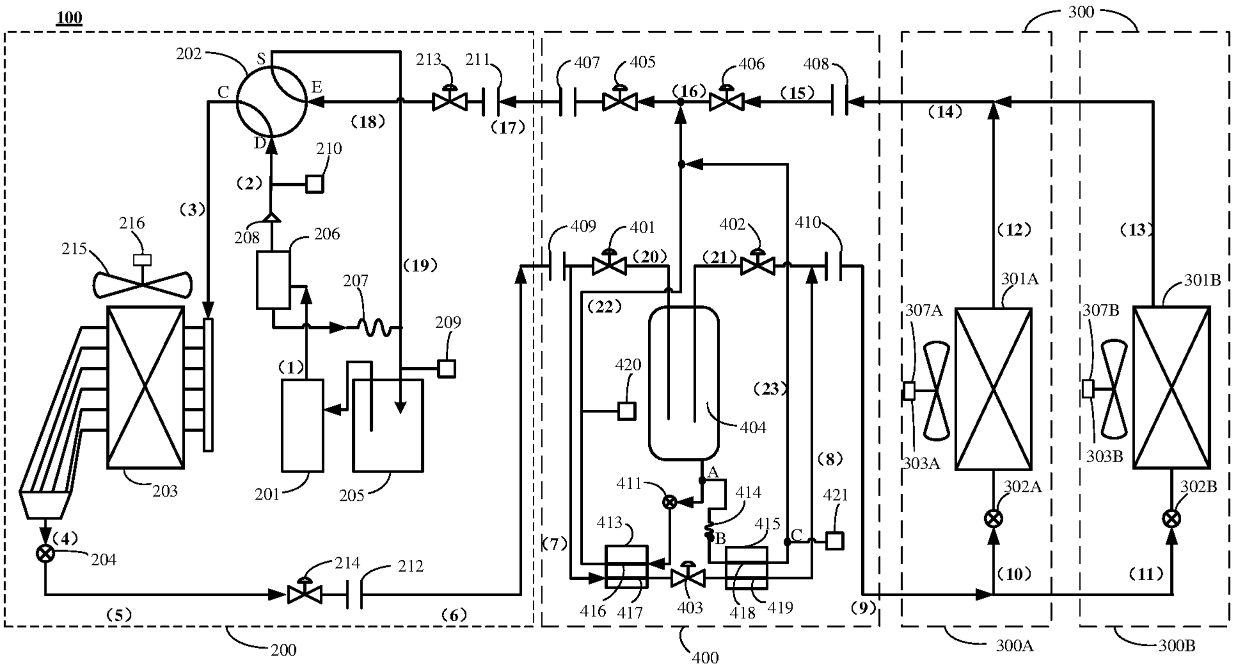
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FIG. 23

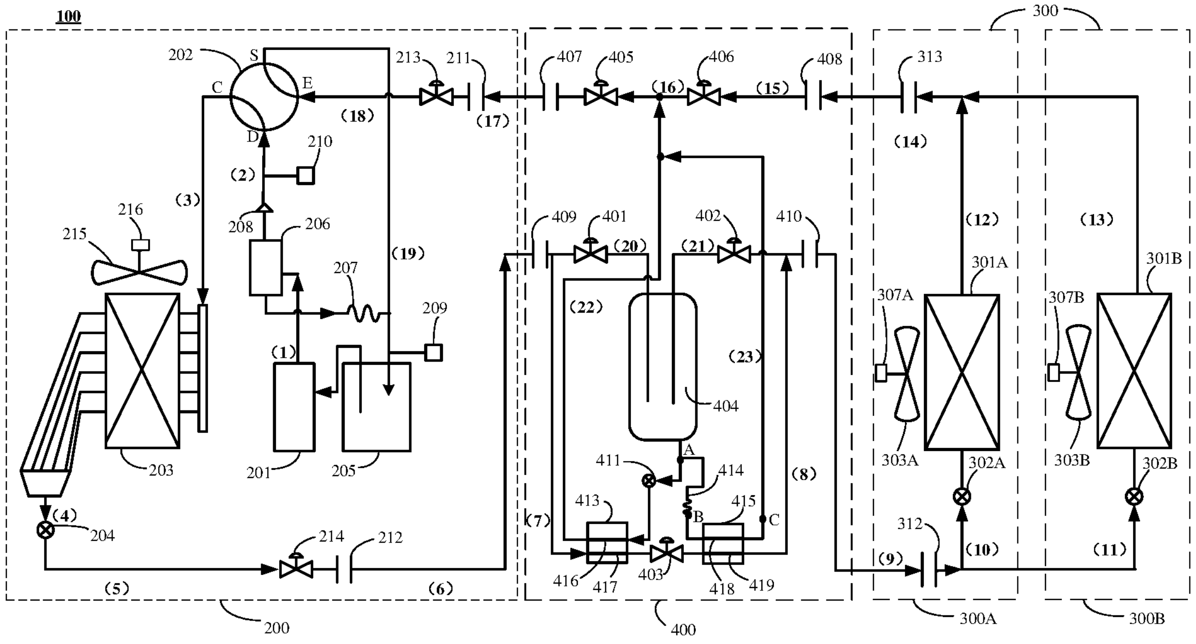
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FIG. 24

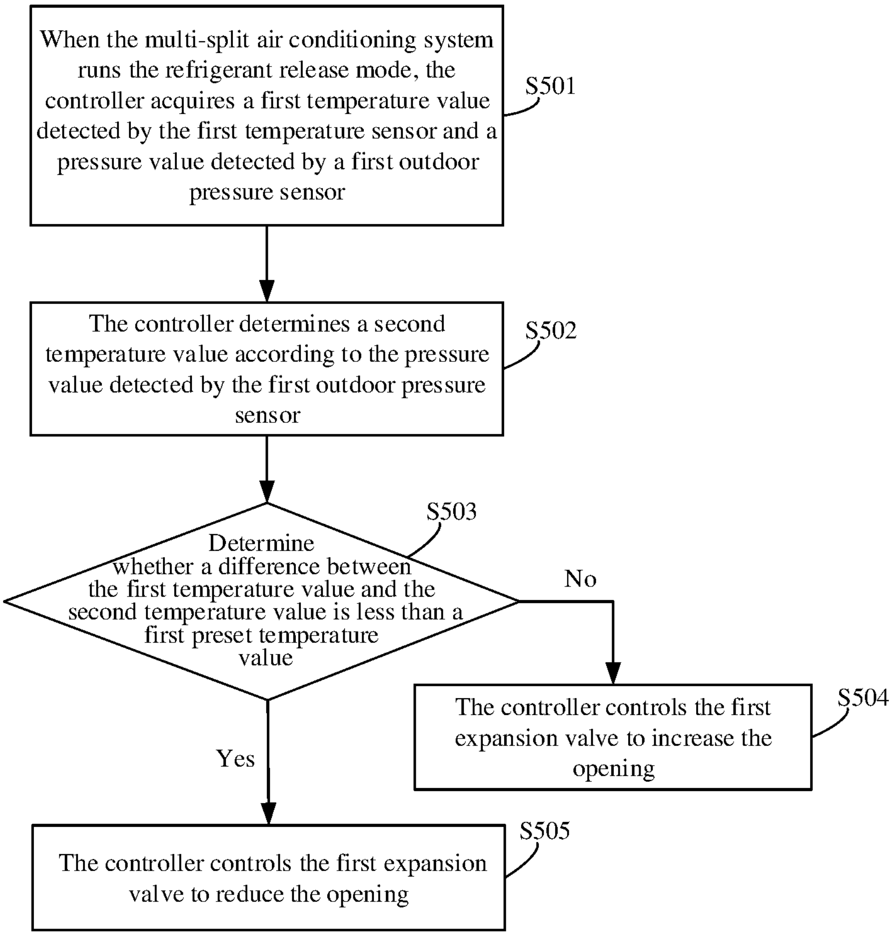
When the multi-split air conditioning system runs the refrigerant release mode, the controller acquires a first temperature value detected by the first temperature sensor and a pressure value detected by a first outdoor pressure sensor
S501
The controller determines a second temperature value according to the pressure value detected by the first outdoor pressure sensor
S502
S503
Determine whether a difference between the first temperature value and the second temperature value is less than a first preset temperature value
No
The controller controls the first expansion valve to increase the opening
S504
Yes
The controller controls the first expansion valve to reduce the opening
S505

FIG. 25

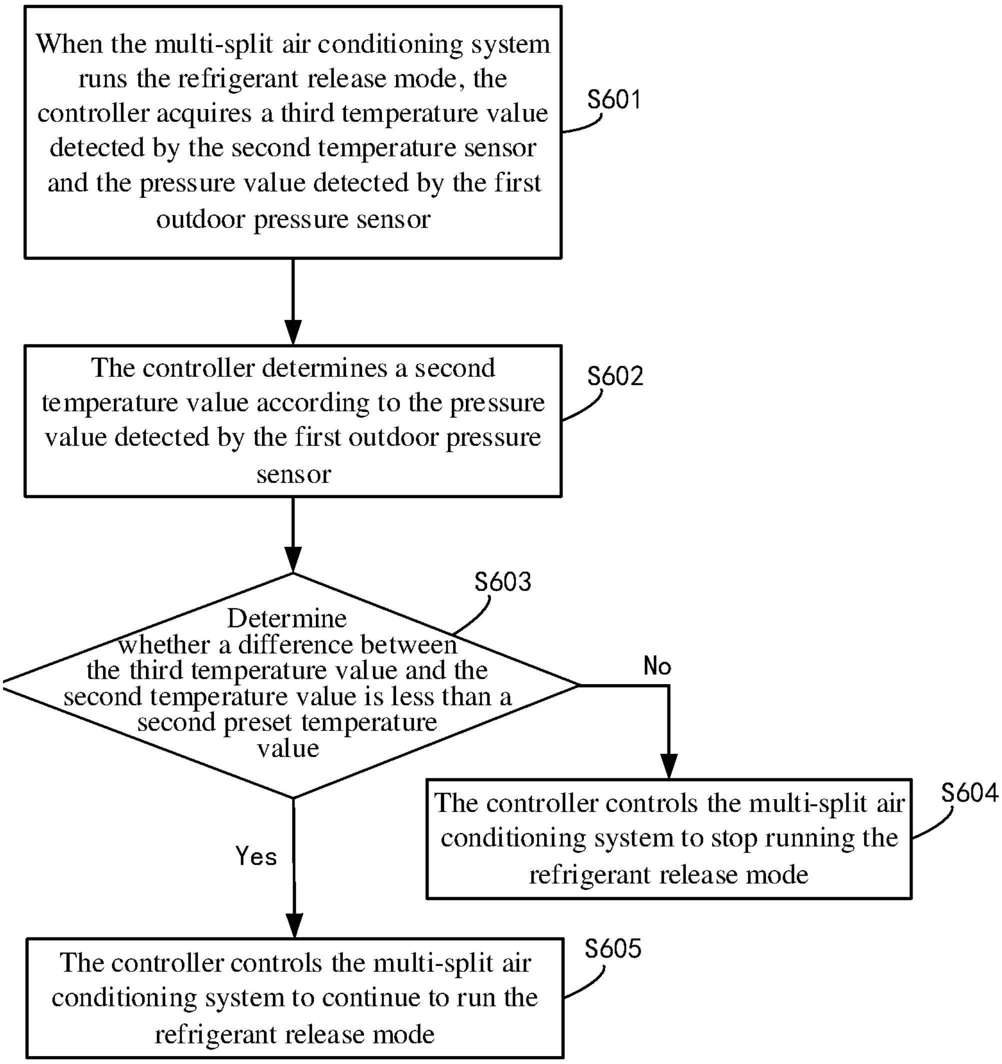
When the multi-split air conditioning system runs the refrigerant release mode, the controller acquires a third temperature value detected by the second temperature sensor and the pressure value detected by the first outdoor pressure sensor
S601
The controller determines a second temperature value according to the pressure value detected by the first outdoor pressure sensor
S602
Determine whether a difference between the third temperature value and the second temperature value is less than a second preset temperature value
S603
No
The controller controls the multi-split air conditioning system to stop running the refrigerant release mode
S604
Yes
The controller controls the multi-split air conditioning system to continue to run the refrigerant release mode
S605

FIG. 26

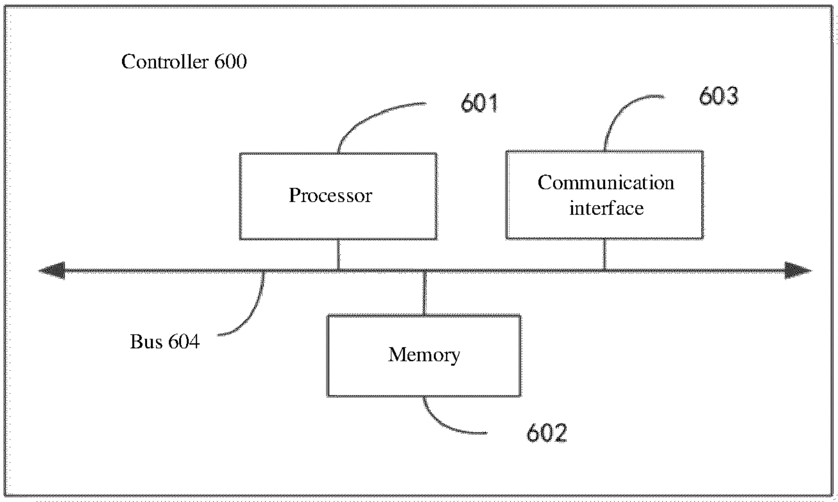
Controller 600
601
603
Processor
Communication interface
Bus 604
Memory
602

FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/078537

A. CLASSIFICATION OF SUBJECT MATTER

F24F11/36(2018.01)i;F24F11/61(2018.01)i;F24F11/65(2018.01)i;F24F11/84(2018.01)i;F24F11/64(2018.01)i;F24F1/10(2011.01)i;F24F1/16(2011.01)i;F25B41/20(2021.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F1，F24F11，F25B41

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

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

CNTXT, VEN, ENTXT, CNKI: 空调, 热泵, 冷媒, 制冷剂, 泄露, 泄漏, 室内, 室外, 内机, 外机, 回收, 收回, 收液, air 1w condition+, heat+ 1w pump+, leak+, refrigerant, agent, medium, recover+, indoor+, outdoor+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 115264620 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 01 November 2022 (2022-11-01) description, paragraphs [0077]-[0283], and figures 1-17	1-27
PX	CN 115264648 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 01 November 2022 (2022-11-01) description, paragraphs [0077]-[0266], and figures 1-17	1-27
PX	CN 115289553 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 04 November 2022 (2022-11-04) description, paragraphs [0070]-[0225], and figures 1-14	1-18, 22-27
PX	CN 115289605 A (QINGDAO HISENSE HITACHI AIR CONDITIONING SYSTEM CO., LTD.) 04 November 2022 (2022-11-04) description, paragraphs [0067]-[0225], and figures 1-11	1-18, 22-27
Y	CN 104566637 A (GUANGDONG MIDEA HVAC EQUIPMENT CO., LTD.) 29 April 2015 (2015-04-29) description, paragraphs [0068]-[0112], and figures 1-3	1-18, 22-27

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

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"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
04 May 2023

Date of mailing of the international search report
01 June 2023

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/CN)
China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/078537

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2015094574 A (DAIKIN INDUSTRIES, LTD.) 18 May 2015 (2015-05-18) description, paragraphs [0039]-[0126], and figures 1-17	1-18, 22-27
A	CN 109269011 A (AUX AIR CONDITIONER CO., LTD.) 25 January 2019 (2019-01-25) entire document	1-27
A	CN 103322641 A (GUANGDONG MEIZHI PRECISION MANUFACTURING CO., LTD.) 25 September 2013 (2013-09-25) entire document	1-27
A	JP 2015209979 A (DAIKIN INDUSTRIES, LTD.) 24 November 2015 (2015-11-24) entire document	1-27
A	JP H109692 A (HITACHI LTD. et al.) 16 January 1998 (1998-01-16) entire document	1-27

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/078537

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	115264620	A	01 November 2022	None			
CN	115264648	A	01 November 2022	None			
CN	115289553	A	04 November 2022	None			
CN	115289605	A	04 November 2022	None			
CN	104566637	A	29 April 2015	CN	104566637	B	03 April 2018
JP	2015094574	A	18 May 2015	None			
CN	109269011	A	25 January 2019	CN	109269011	B	21 September 2021
CN	103322641	A	25 September 2013	CN	103322641	B	01 June 2016
JP	2015209979	A	24 November 2015	JP	6361263	B2	25 July 2018
JP	H109692	A	16 January 1998	None			

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 202210847980 **[0001]**
- CN 202210851580X **[0001]**