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(54) **REFRIGERANT VOLUME MEASUREMENT SYSTEM AND REFRIGERANT-USING SYSTEM**

(57) A refrigerant amount measurement system (4) includes a connecting portion (400), a reservoir (460), a measurer (401), and a storage (472). The connecting portion (400) is connected to a first refrigerant circuit of a first refrigeration cycle apparatus (100A). The reservoir (460) reserves a refrigerant (R) in the first refrigerant circuit via the connecting portion (400), and returns the reserved refrigerant (R) to the first refrigerant circuit via the connecting portion (400). The measurer (401) measures an amount of the refrigerant (R) in the reservoir (460). A storage (472) stores a measurement result measured by the measurer (401).

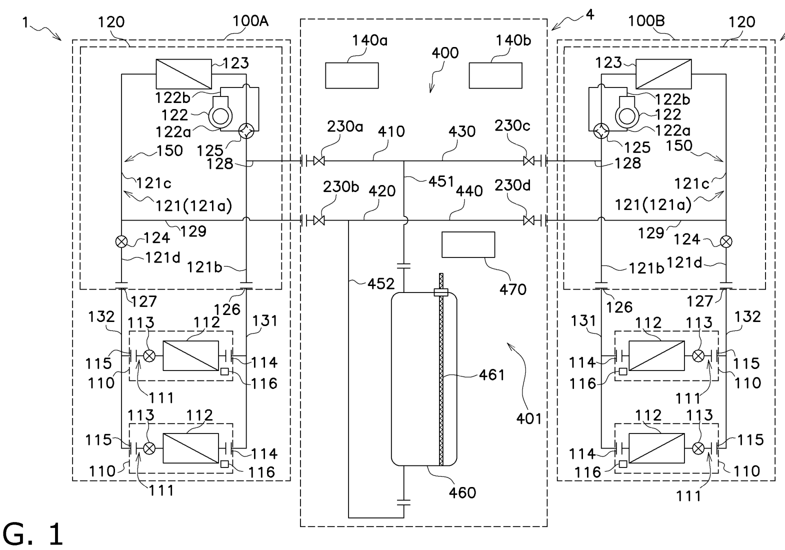

FIG. 1

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Description

TECHNICAL FIELD

[0001] A refrigerant amount measurement system and a refrigerant use system.

BACKGROUND ART

[0002] In order to repair a refrigeration cycle apparatus such as an air conditioner, in some cases, a refrigerant is charged on the basis of a difference between an initial charge amount of the refrigerant in the refrigeration cycle apparatus and an amount of the refrigerant recovered at the time of repair.

[0003] Patent Literature 1 (JP 2010-190545 A) discloses a refrigeration apparatus capable of detecting a shortage state of the refrigerant by a receiver tank internally connected to a refrigerant circuit. The refrigeration apparatus disclosed in Patent Literature 1 displays a shortage of a refrigerant amount based on a detection value of the refrigerant detected by a liquid level detector of the receiver tank incorporated in the apparatus.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] The refrigeration apparatus disclosed in Patent Literature 1 detects a shortage state of the refrigerant by the receiver tank internally connected to the refrigerant circuit. The refrigerant also flows into the receiver tank incorporated in the apparatus during a normal operation (such as air conditioning operation). Therefore, the refrigeration apparatus disclosed in Patent Literature 1 requires a refrigerant amount corresponding to the volume of the receiver tank in addition to a refrigerant amount corresponding to the existing refrigerant circuit. The refrigeration apparatus disclosed in Patent Literature 1 causes a pressure loss of the refrigerant when the refrigerant passes through the receiver tank.

[0005] The present disclosure proposes a refrigerant amount measurement system that is externally connected to a refrigerant circuit of a refrigeration cycle apparatus, does not generate an additional refrigerant amount or a pressure loss, and clarifies a refrigerant leakage amount from a start of use to disposal of the refrigeration cycle apparatus.

<Solution to Problem>

[0006] A refrigerant amount measurement system according to a first aspect includes a connecting portion, a reservoir, a measurer, and a storage. The connecting portion is connected to a first refrigerant circuit of a first refrigeration cycle apparatus. The reservoir reserves a refrigerant in the first refrigerant circuit via the connecting portion, and returns the reserved refrigerant to the first refrigerant circuit via the connecting portion. The measurer measures an amount of the refrigerant in the reservoir. The storage stores a measurement result measured by the measurer.

[0007] This refrigerant amount measurement system reserves the refrigerant in the first refrigerant circuit in the reservoir externally connected to the first refrigerant circuit. The refrigerant amount measurement system measures the amount of the refrigerant in the reservoir and stores the measurement result. The refrigerant amount measurement system returns the reserved refrigerant to the first refrigerant circuit from the reservoir externally connected to the first refrigerant circuit. Therefore, the refrigerant amount measurement system can clarify a leakage amount of the refrigerant in the first refrigerant circuit without generating an additional refrigerant amount or a pressure loss.

[0008] A refrigerant amount measurement system according to a second aspect is the refrigerant amount measurement system according to the first aspect, in which the connecting portion includes a first pipe and a second pipe. Each of the first pipe and the second pipe is provided with an on-off valve.

[0009] The connecting portion of this refrigerant amount measurement system includes the first pipe and the second pipe. Therefore, this refrigerant amount measurement system can be connected to the first refrigerant circuit by the first pipe and the second pipe separately for each state of the refrigerant. Each of the first pipe and the second pipe is provided with an on-off valve. Therefore, this refrigerant amount measurement system can allow or interrupt communication between the first pipe and the second pipe.

[0010] A refrigerant amount measurement system according to a third aspect is the refrigerant amount measurement system according to the second aspect and further includes a control unit. The control unit performs a first refrigerant amount measurement operation. The first refrigerant amount measurement operation is an operation of controlling the first refrigeration cycle apparatus and the on-off valve to transfer the refrigerant from the first refrigerant circuit to the reservoir, cause the measurer to measure the amount of the refrigerant, and return the refrigerant from the reservoir to the first refrigerant circuit.

[0011] The control unit of this refrigerant amount measurement system performs the first refrigerant amount measurement operation. Therefore, the refrigerant amount measurement system can reduce the time and effort required for the work of clarifying the leakage amount of the refrigerant in the first refrigerant circuit.

[0012] A refrigerant amount measurement system according to a fourth aspect is the refrigerant amount measurement system according to the third aspect, in which the connecting portion is also connected to a second refrigerant circuit of a second refrigeration cycle apparatus. The control unit further includes a third pipe and a fourth pipe each provided with the on-off valve. The connecting portion is connected to the first refrigerant circuit by the first pipe and the second pipe, and is connected to the second refrigerant circuit by the third pipe and the fourth pipe.

[0013] The connecting portion of this refrigerant amount measurement system is also connected to the second refrigerant circuit of the second refrigeration cycle apparatus. Therefore, this refrigerant amount measurement system can also clarify a leakage amount of the refrigerant in the second refrigerant circuit. The connecting portion of this refrigerant amount measurement system includes the third pipe and the fourth pipe. Therefore, this refrigerant amount measurement system can be connected to the second refrigerant circuit by the third pipe and the fourth pipe separately for each state of the refrigerant. Each of the third pipe and the fourth pipe is provided with an on-off valve. Therefore, this refrigerant amount measurement system can allow or interrupt communication between the third pipe and the fourth pipe.

[0014] A refrigerant amount measurement system according to a fifth aspect is the refrigerant amount measurement system according to the fourth aspect, in which the control unit further performs a second refrigerant amount measurement operation. The second refrigerant amount measurement operation is an operation of controlling the second refrigeration cycle apparatus and the on-off valve to transfer the refrigerant from the second refrigerant circuit to the reservoir, cause the measurer to measure the amount of the refrigerant, and return the refrigerant from the reservoir to the second refrigerant circuit.

[0015] The control unit of this refrigerant amount measurement system further performs the second refrigerant amount measurement operation. Therefore, the refrigerant amount measurement system can also reduce the time and effort required for the work of clarifying the leakage amount of the refrigerant in the second refrigerant circuit.

[0016] A refrigerant amount measurement system according to a sixth aspect is the refrigerant amount measurement system according to the fifth aspect, in which the control unit performs the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times.

[0017] The control unit of this refrigerant amount measurement system performs the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times. Therefore, this refrigerant amount measurement system can separately clarify the leakage amount of the refrigerant in the first refrigerant circuit and the leakage amount of the refrigerant in the second refrigerant circuit

[0018] A refrigerant amount measurement system according to a seventh aspect is the refrigerant amount measurement system according to the fifth or sixth aspect, in which the control unit performs the first refrigerant amount measurement operation in a time zone in which a normal operation of the first refrigeration cycle apparatus is stopped. The control unit performs the second refrigerant amount measurement operation in a time zone in which a normal operation of the second refrigeration cycle apparatus is stopped.

[0019] The control unit of this refrigerant amount measurement system performs the first refrigerant amount measurement operation in a time zone in which the normal operation of the first refrigeration cycle apparatus is stopped. Therefore, this refrigerant amount measurement system is not affected by the normal operation of the first refrigeration cycle apparatus, and can further clarify the leakage amount of the refrigerant in the first refrigerant circuit. The control unit performs the second refrigerant amount measurement operation in a time zone in which the normal operation of the second refrigeration cycle apparatus is stopped. Therefore, this refrigerant amount measurement system is not affected by the normal operation of the second refrigeration cycle apparatus, and can further clarify the leakage amount of the refrigerant in the second refrigerant circuit.

[0020] A refrigerant amount measurement system according to an eighth aspect is the refrigerant amount measurement system according to any of the fifth to seventh aspects, in which the control unit performs a first reserving operation and a second reserving operation. The first reserving operation is an operation of transferring the refrigerant from the first refrigerant circuit to the reservoir when the refrigerant leaks from the first refrigerant circuit. The second reserving operation is an operation of transferring the refrigerant from the second refrigerant circuit to the reservoir when the refrigerant leaks from the second refrigerant circuit.

[0021] The control unit of this refrigerant amount measurement system performs the first reserving operation. Therefore, when the refrigerant in the first refrigerant circuit leaks, this refrigerant amount measurement system can reserve the refrigerant in the first refrigerant circuit in the reservoir to suppress release of the refrigerant to the atmosphere. In addition, the control unit of this refrigerant amount measurement system performs the second reserving operation. Therefore, when the refrigerant in the second refrigerant circuit leaks, this refrigerant amount measurement system can reserve the refrigerant in the second refrigerant circuit in the reservoir to suppress release of the refrigerant into the atmosphere.

[0022] A refrigerant amount measurement system according to a ninth aspect is the refrigerant amount measurement system according to any of the first to eighth aspects, in which the measurer includes an electrode rod.

[0023] The measurer of this refrigerant amount measurement system includes the electrode rod. Therefore, this refrigerant amount measurement system can further clarify the leakage amount of the refrigerant by using the electrode rod.

[0024] A refrigerant amount measurement system according to a tenth aspect is the refrigerant amount measurement system according to any of the ninth aspect, in which the measurer further includes a cylindrical member surrounding the electrode rod.

[0025] The measurer of this refrigerant amount measurement system further includes the cylindrical member surrounding the electrode rod. Therefore, this refrigerant amount measurement system can further clarify the leakage amount of the refrigerant by using the cylindrical member.

[0026] A refrigerant amount measurement system according to an eleventh aspect is the refrigerant amount measurement system according to one of the first to tenth aspects, in which the measurer measures the amount of the refrigerant by at least one method of a radio wave method, an ultrasonic method, a float method, a pressure method, a differential pressure method, and an electrostatic capacitance method.

[0027] In this refrigerant amount measurement system, the measurer measures the amount of the refrigerant by at least one method of the radio wave method, the ultrasonic method, the float method, the pressure method, the differential pressure method, and the electrostatic capacitance method. Therefore, this refrigerant amount measurement system can further clarify the leakage amount of the refrigerant on the basis of various methods.

[0028] A refrigerant use system according to a twelfth aspect includes the refrigerant amount measurement system according to one of the first to eleventh aspects, and a refrigeration cycle apparatus.

[0029] This refrigerant use system includes the refrigerant amount measurement system and the refrigeration cycle apparatus. Therefore, this refrigerant use system can clarify the leakage amount of the refrigerant of the refrigeration cycle apparatus included in this refrigerant use system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a schematic configuration diagram showing a refrigerant use system 1.

FIG. 2 is a control block diagram of a control unit 140.

FIG. 3 is a control block diagram of a calculation device 470.

FIG. 4 is a schematic configuration diagram showing a flow of a refrigerant R in a first half operation of an operation of transferring the refrigerant R to a reservoir 460.

FIG. 5 is a schematic configuration diagram showing a flow of the refrigerant R in a second half operation of the operation of transferring the refrigerant R to the reservoir 460.

FIG. 6 is a schematic configuration diagram showing the reservoir 460 in which the refrigerant R is reserved and an electrode rod 461.

FIG. 7 is a diagram showing a relationship between an electrostatic capacitance C and a liquid level height h in accordance with a temperature.

FIG. 8 is a schematic configuration diagram showing a flow of the refrigerant R in an operation of returning the refrigerant R to a refrigerant circulation path 150.

FIG. 9 is a schematic configuration diagram showing the flow of the refrigerant R in the operation of returning the refrigerant R to the refrigerant circulation path 150.

FIG. 10 is a schematic configuration diagram showing a flow of the refrigerant R in a first half operation of a first reserving operation.

FIG. 11 is a schematic configuration diagram showing a flow of the refrigerant R in a second half operation of the first reserving operation.

FIG. 12A is a schematic configuration diagram showing the reservoir 460, the electrode rod 461, and a cylindrical member 462.

FIG. 12B is a sectional view showing a cross section A in FIG. 12A.

DESCRIPTION OF EMBODIMENTS

<First embodiment>

(1) Overall configuration

[0031] Description is made to a refrigerant use system 1 according to a first embodiment of the present disclosure. FIG. 1 is a schematic configuration diagram showing the refrigerant use system 1.

[0032] The refrigerant use system 1 includes a first refrigeration cycle apparatus 100A, a second refrigeration cycle apparatus 100B, and a refrigerant amount measurement system 4. The refrigerant amount measurement system 4 measures an amount of a refrigerant R of the first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B. The first refrigeration cycle apparatus 100A communicates with the refrigerant amount measurement system 4 through a first pipe 410 and a second pipe 420. The second refrigeration cycle apparatus 100B communicates with the refrigerant amount measurement system 4 through a third pipe 430 and a fourth pipe 440.

[0033] The first refrigeration cycle apparatus 100A is electrically connected to a control unit 140a of the refrigerant amount measurement system 4. The second refrigeration cycle apparatus 100B is electrically connected to a control unit 140b of the refrigerant amount measurement system 4.

[0034] FIG. 1 shows a state where the refrigerant amount measurement system 4 is attached to the first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B. Note that the number of refrigeration cycle apparatuses 100 included in the refrigerant use system 1 is not limited to two, and for example, the number of refrigeration cycle apparatuses 100 may be one or three or more.

[0035] The first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B have similar devices and have similar functions. Therefore, in the following description common to the first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B, the description will be made as the refrigeration cycle apparatus 100. In the description in which requiring distinction between the first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B, "A" or "B" is added to reference signs of devices constituting the first refrigeration cycle apparatus 100A and the second refrigeration cycle apparatus 100B for distinction.

[0036] The control unit 140a and the control unit 140b have similar devices and have similar functions. Therefore, in the following description common to the control unit 140a and the control unit 140b, the description will be made as the control unit 140. In the description in which requiring distinction between the control unit 140a and the control unit 140b, "a" or "b" is added to reference signs of devices constituting the control unit 140a and the control unit 140b for distinction.

[0037] Note that, in the following description, the same reference signs are given to the same or corresponding configurations in the individual embodiments and modifications, and a description thereof is appropriately omitted.

(2) Detailed configuration

(2-1) Refrigeration cycle apparatus

[0038] The refrigeration cycle apparatus 100 is an air conditioner that cools and heats an air conditioning target space (not shown) by using a vapor compression refrigeration cycle. The refrigeration cycle apparatus 100 includes an indoor unit 110, an outdoor unit 120, a gas-side connection pipe 131, and a liquid-side connection pipe 132. The refrigeration cycle apparatus 100 is a multi-type air conditioner for a building and includes two indoor units 110. The number of the indoor units 110 included in the refrigeration cycle apparatus 100 is not limited to two, and for example, the number of the indoor units 110 may be one or three or more.

[0039] Although details will be described later, the indoor unit 110 includes an indoor refrigerant flow path 111, and the outdoor unit 120 has an outdoor refrigerant flow path 121. The indoor refrigerant flow path 111, the outdoor refrigerant flow path 121, the gas-side connection pipe 131, and the liquid-side connection pipe 132 form a refrigerant circulation path 150. The refrigerant circulation path 150 of the first refrigeration cycle apparatus 100A is an example of a first refrigerant circuit. The refrigerant circulation path 150 of the second refrigeration cycle apparatus 100B is an example of a second refrigerant circuit. The refrigerant R is charged in the refrigerant circulation path 150. The refrigerant R charged into the refrigerant circulation path 150 is not limited, but is, for example, a fluorocarbon-based refrigerant R such as R32 and R410A having lower flammability (A2L). For example, the refrigerant R may have flammability or toxicity. Note that the refrigeration cycle apparatus 100 is not limited to the air conditioner, and may be, for example, a refrigerator, a freezer, a water heater, a floor heating apparatus, or the like.

(2-1-1) Indoor unit

[0040] The indoor unit 110 is installed in the air conditioning target space. The indoor unit 110 includes the indoor refrigerant flow path 111 and a detector 116.

[0041] The indoor refrigerant flow path 111 constitutes a part of the refrigerant circulation path 150. The indoor refrigerant flow path 111 is formed by connecting an indoor heat exchanger 112 and an indoor expansion mechanism 113 via a refrigerant pipe.

[0042] The indoor heat exchanger 112 exchanges heat between the refrigerant R flowing inside the indoor heat exchanger 112 and air in the air conditioning target space. The indoor heat exchanger 112 functions as an evaporator of the refrigerant R during a cooling operation, and functions as a radiator of the refrigerant R during a heating operation. One end of the indoor heat exchanger 112 is connected to a gas-side connecting portion 114 via a refrigerant pipe. The other end of the indoor heat exchanger 112 is connected to the indoor expansion mechanism 113 via a refrigerant pipe.

[0043] The indoor expansion mechanism 113 adjusts a pressure and a flow rate of the refrigerant R flowing through the refrigerant circulation path 150. The indoor expansion mechanism 113 is an electronic expansion valve whose opening degree is adjusted by an actuator (not shown). The indoor expansion mechanism 113 is connected to the indoor heat exchanger 112 and a liquid-side connecting portion 115 via a refrigerant pipe. An opening degree of the indoor expansion mechanism 113 is controlled by the control unit 140.

[0044] The gas-side connecting portion 114 is one end of the indoor refrigerant flow path 111. The gas-side connecting portion 114 is connected to the gas-side connection pipe 131.

[0045] The liquid-side connecting portion 115 is the other end of the indoor refrigerant flow path 111. The liquid-side connecting portion 115 is connected to the liquid-side connection pipe 132.

[0046] The detector 116 detects leakage of the refrigerant R from the refrigerant circulation path 150. The detector 116 is installed inside a casing (not shown) of the indoor unit 110. The detector 116 is not limited in terms of mode as long as a leakage of the refrigerant R from the refrigerant circulation path 150 is detected, and may be alternatively a sensor that detects the refrigerant R, or may detect a leakage of the refrigerant R through a sudden change in an air temperature inside the casing of the indoor unit 110 or a temperature of the pipe. After the detector 116 detects a leakage of the refrigerant R, the detector 116 transmits a signal indicating the leakage of the refrigerant R to the control unit 140.

(2-1-2) Outdoor unit

[0047] The outdoor unit 120 is disposed outside the air conditioning target space. The outdoor unit 120 is installed, for example, on a rooftop of a building where the refrigeration cycle apparatus 100 is installed or adjacent to the building. The outdoor unit 120 includes the outdoor refrigerant flow path 121, a gas-side branch pipe 128, and a liquid-side branch pipe 129.

[0048] The outdoor refrigerant flow path 121 constitutes a part of the refrigerant circulation path 150. The outdoor refrigerant flow path 121 is formed by connecting a first compressor 122, an outdoor heat exchanger 123, an outdoor expansion mechanism 124, a flow path switching mechanism 125, a gas-side connecting portion 126, and a liquid-side connecting portion 127 via a refrigerant pipe 121a. The refrigerant pipe 121a includes a first refrigerant pipe 121b, a second refrigerant pipe 121c, and a third refrigerant pipe 121d.

[0049] The first compressor 122 suctions the low-pressure refrigerant R in the refrigeration cycle from a suction pipe 122a, compresses the refrigerant R by a compression mechanism (not shown), and discharges the compressed refrigerant R to a discharge pipe 122b. The operation of the first compressor 122 is controlled by the control unit 140.

[0050] The outdoor heat exchanger 123 exchanges heat between the refrigerant R flowing inside the outdoor heat exchanger 123 and air (heat source air) at an installation location of the outdoor unit 120. The outdoor heat exchanger 123 functions as a radiator of the refrigerant R during the cooling operation, and functions as an evaporator of the refrigerant R during the heating operation. One end of the outdoor heat exchanger 123 is connected to the flow path switching mechanism 125 via a refrigerant pipe. The other end of the outdoor heat exchanger 123 is connected to the outdoor expansion mechanism 124 via a refrigerant pipe.

[0051] The outdoor expansion mechanism 124 adjusts the pressure and the flow rate of the refrigerant R flowing through the refrigerant circulation path 150. The outdoor expansion mechanism 124 is an electronic expansion valve whose opening degree is adjusted by an actuator (not shown). An opening degree of the indoor expansion mechanism 113 is controlled by the control unit 140. The outdoor expansion mechanism 124 is connected to the outdoor heat exchanger 123 and the liquid-side connecting portion 127 via a refrigerant pipe.

[0052] The flow path switching mechanism 125 changes a state of the refrigerant circulation path 150 between a first state and a second state by switching a flow direction of the refrigerant R. When the refrigerant circulation path 150 is in the first state, the outdoor heat exchanger 123 functions as a radiator of the refrigerant R, and the indoor heat exchanger 112 functions as an evaporator of the refrigerant R. When the refrigerant circulation path 150 is in the second state, the outdoor heat exchanger 123 functions as an evaporator of the refrigerant R, and the indoor heat exchanger 112 functions as a radiator of the refrigerant R. The flow path switching mechanism 125 is controlled by the control unit 140. In the present embodiment, the flow path switching mechanism 125 is a four-way switching valve. However, the flow path switching mechanism 125 is not limited to the four-way switching valve. For example, the flow path switching mechanism 125 may be configured by combining a plurality of electromagnetic valves and refrigerant pipes so that the flow direction of the refrigerant R can be switched as described below.

[0053] During the cooling operation, the flow path switching mechanism 125 sets a state of the refrigerant circulation path 150 to the first state. In other words, during the cooling operation, the flow path switching mechanism 125 causes the suction pipe 122a to communicate with the gas-side connecting portion 126, and causes the discharge pipe 122b to communicate with the outdoor heat exchanger 123 (see a broken line in the flow path switching mechanism 125 in FIG. 1). During the heating operation, the flow path switching mechanism 125 sets a state of the refrigerant circulation path 150 to the second state. In other words, during the heating operation, the flow path switching mechanism 125 causes the suction pipe 122a to communicate with the outdoor heat exchanger 123, and causes the discharge pipe 122b to communicate with the gas-side connecting portion 126 (see a solid line in the flow path switching mechanism 125 in FIG. 1).

[0054] The gas-side connecting portion 126 is one end of the outdoor refrigerant flow path 121. The gas-side connection pipe 131 is connected to the gas-side connecting portion 126.

[0055] The liquid-side connecting portion 127 is the other end of the outdoor refrigerant flow path 121. The liquid-side connection pipe 132 is connected to the liquid-side connecting portion 127.

[0056] The first refrigerant pipe 121b connects the flow path switching mechanism 125 and the gas-side connecting portion 126.

[0057] The second refrigerant pipe 121c connects the outdoor heat exchanger 123 and the outdoor expansion mechanism 124.

[0058] The third refrigerant pipe 121d connects the outdoor expansion mechanism 124 and the liquid-side connecting portion 127.

[0059] The gas-side branch pipe 128 is a pipe that causes the first refrigerant pipe 121b and the refrigerant amount measurement system 4 to communicate with each other. In the present embodiment, one end of the gas-side branch pipe 128 is connected to the first refrigerant pipe 121b. The other end of the gas-side branch pipe 128 communicates with the first pipe 410 or the third pipe 430.

[0060] The liquid-side branch pipe 129 is a pipe that causes the second refrigerant pipe 121c and the refrigerant amount measurement system 4 to communicate with each other. In the present embodiment, one end of the liquid-side branch pipe 129 is connected to the second refrigerant pipe 121c. The other end of the liquid-side branch pipe 129 communicates with the second pipe 420 or the fourth pipe 440.

(2-1-3) Gas-side connection pipe and liquid-side connection pipe

[0061] The gas-side connection pipe 131 and the liquid-side connection pipe 132 connect the indoor refrigerant flow path 111 and the outdoor refrigerant flow path 121.

[0062] The gas-side connection pipe 131 is connected to the gas-side connecting portion 114 of the indoor refrigerant flow path 111 and the gas-side connecting portion 126 of the outdoor refrigerant flow path 121.

[0063] The indoor refrigerant flow path 111 is connected to the liquid-side connecting portion 115 of the indoor refrigerant flow path 111 and the liquid-side connecting portion 127 of the outdoor refrigerant flow path 121.

(2-2) Refrigerant amount measurement system

[0064] The refrigerant amount measurement system 4 is a system that reserves the refrigerant R of the refrigeration cycle apparatus 100, measures the amount of the refrigerant R, and returns the refrigerant R to the refrigeration cycle apparatus 100. The refrigerant amount measurement system 4 includes an on-off valve 230, the first pipe 410, the second pipe 420, the third pipe 430, the fourth pipe 440, a gas-side pipe 451, a liquid-side pipe 452, a reservoir 460, an electrode rod 461, a calculation device 470, and the control unit 140. The on-off valve 230, the first pipe 410, the second pipe 420, the third pipe 430, and the fourth pipe 440 constitute a connecting portion 400. The electrode rod 461 and a measurement calculator 471 constitute the measurer 401.

[0065] The refrigerant amount measurement system 4 is externally connected to the first refrigeration cycle apparatus 100A by the first pipe 410 and the second pipe 420. The refrigerant amount measurement system 4 is externally connected to the second refrigeration cycle apparatus 100B by the third pipe 430 and the fourth pipe 440. The number of the refrigeration cycle apparatuses 100 to which the refrigerant amount measurement system 4 is connected is not limited to two, and for example, the number of the refrigeration cycle apparatuses 100 may be one or three or more.

(2-2-1) Reservoir

[0066] The reservoir 460 is a cylindrical container that reserves the refrigerant R in the refrigerant circulation path 150 by a refrigerant amount measurement operation described later. The reservoir 460 is connected to the refrigeration cycle apparatus 100 by the first pipe 410, the second pipe 420, the third pipe 430, and the fourth pipe 440 via the gas-side pipe 451 and the liquid-side pipe 452. The reservoir 460 is not limited to a cylindrical container, and may be alternatively a container having another shape capable of reserving the refrigerant R.

(2-2-2) Gas-side pipe and liquid-side pipe

[0067] The gas-side pipe 451 is a pipe for causing the first pipe 410 and the third pipe 430 to communicate with the reservoir 460. One end of the gas-side pipe 451 is connected to the reservoir 460. The other end of the gas-side pipe 451 is connected to the gas-side branch pipe 128 via the first pipe 410 or the third pipe 430.

[0068] The liquid-side pipe 452 is a pipe for causing the second pipe 420 and the fourth pipe 440 to communicate with the reservoir 460. One end of the liquid-side pipe 452 is connected to the reservoir 460. The other end of the liquid-side pipe 452 is connected to the liquid-side branch pipe 129 via the second pipe 420 or the fourth pipe 440.

(2-2-3) Connecting portion

[0069] The connecting portion 400 causes the refrigerant circulation path 150 of the refrigeration cycle apparatus 100 and the reservoir 460 to communicate with each other. The connecting portion 400 includes the on-off valve 230, the first pipe 410, the second pipe 420, the third pipe 430, and the fourth pipe 440.

(2-2-3-1) First pipe

[0070] The first pipe 410 is a pipe that causes a gas-side branch pipe 128A of the first refrigeration cycle apparatus 100A and the gas-side pipe 451 to communicate with each other. One end of the first pipe 410 is connected to the gas-side branch pipe 128A of the first refrigeration cycle apparatus 100A. The other end of the first pipe 410 is connected to the gas-side pipe 451.

(2-2-3-2) Second pipe

[0071] The second pipe 420 is a pipe that causes a liquid-side branch pipe 129A of the first refrigeration cycle apparatus 100A and the liquid-side pipe 452 to communicate with each other. One end of the second pipe 420 is connected to the liquid-side branch pipe 129A of the first refrigeration cycle apparatus 100A. The other end of the second pipe 420 is connected to the liquid-side pipe 452.

(2-2-3-3) Third pipe

[0072] The third pipe 430 is a pipe that causes a gas-side branch pipe 128B of the second refrigeration cycle apparatus 100B and the gas-side pipe 451 to communicate with each other. One end of the third pipe 430 is connected to the gas-side branch pipe 128B of the second refrigeration cycle apparatus 100B. The other end of the third pipe 430 is connected to the gas-side pipe 451.

(2-2-3-4) Fourth pipe

[0073] The fourth pipe 440 is a pipe that causes a liquid-side branch pipe 129B of the second refrigeration cycle apparatus 100B and the liquid-side pipe 452 to communicate with each other. One end of the fourth pipe 440 is connected to the liquid-side branch pipe 129B of the second refrigeration cycle apparatus 100B. The other end of the fourth pipe 440 is connected to the liquid-side pipe 452.

(2-2-3-5) On-off valve

[0074] The on-off valve 230 is provided in the first pipe 410, the second pipe 420, the third pipe 430, and the fourth pipe 440. The on-off valve 230 included in the refrigerant amount measurement system 4 includes an on-off valve 230a, an on-off valve 230b, an on-off valve 230c, and an on-off valve 230d.

(2-2-3-5-1) On-off valve 230a

[0075] The on-off valve 230a is provided in the first pipe 410. The on-off valve 230a allows or interrupts communication of the first pipe 410. The on-off valve 230a is an electromagnetic on-off valve, and is controlled to opened and closed by the control unit 140a.

(2-2-3-5-2) On-off valve 230b

[0076] The on-off valve 230b is provided in the second pipe 420. The on-off valve 230b allows or interrupts communication of the second pipe 420. The on-off valve 230b is an electromagnetic on-off valve, and is controlled to opened and closed by the control unit 140a.

(2-2-3-5-3) On-off valve 230c

[0077] The on-off valve 230c is provided in the third pipe 430. The on-off valve 230c allows or interrupts communication of the third pipe 430. The on-off valve 230c is an electromagnetic on-off valve, and is controlled to opened and closed by the control unit 140b.

(2-2-3-5-4) On-off valve 230d

[0078] The on-off valve 230d is provided in the fourth pipe 440. The on-off valve 230d allows or interrupts communication of the fourth pipe 440. The on-off valve 230d is an electromagnetic on-off valve, and is controlled to opened and closed by the control unit 140b.

(2-2-4) Electrode rod

[0079] The electrode rod 461 is a device for measuring the amount of the refrigerant R in the reservoir 460. The electrode rod 461 is electrically connected to the measurement calculator 471. The electrode rod 461 is controlled by the control unit 140 via the measurement calculator 471. The electrode rod 461 is provided so as not to change a positional relationship between the electrode rod 461 and the reservoir 460. The detailed operation of the electrode rod 461 will be described later.

(2-2-5) Control unit

[0080] The control unit 140 controls operation of each unit constituting the refrigeration cycle apparatus 100 and the refrigerant amount measurement system 4. The control unit 140 is electrically connected to the indoor expansion mechanism 113, the detector 116, the first compressor 122, the outdoor expansion mechanism 124, the flow path switching mechanism 125, the on-off valve 230, and the calculation device 470 so as to be able to exchange control signals and information.

[0081] FIG. 2 is a control block diagram of the control unit 140. In the present embodiment, the control unit 140 is installed outside the refrigeration cycle apparatus 100. The control unit 140 may be provided in a casing of the outdoor unit 120 or in a server away from the refrigeration cycle apparatus 100.

[0082] The control unit 140 controls operations of each unit constituting the refrigeration cycle apparatus 100 and the refrigerant amount measurement system 4 to execute an air conditioning operation and a refrigerant amount measurement operation. The air conditioning operation includes the cooling operation and the heating operation. The refrigerant amount measurement operation includes a first refrigerant amount measurement operation and a second refrigerant amount measurement operation. The refrigerant amount measurement operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 to the reservoir 460, causing the measurer 401 to measure the amount of the refrigerant R, and returning the refrigerant R from the reservoir 460 to the refrigerant circulation path 150.

[0083] The first refrigeration cycle apparatus 100A is connected to the control unit 140a. The second refrigeration cycle apparatus 100B is connected to the control unit 140b. The control unit 140a and the control unit 140b are mutually electrically connected. Since the control unit 140a and the control unit 140b cooperate with each other to execute the air conditioning operation and the refrigerant amount measurement operation, hereinafter, the control unit 140a and the control unit 140b are collectively referred to as the control unit 140.

[0084] Control of the refrigeration cycle apparatus 100 during the cooling operation and the heating operation will be described. Details of the refrigerant amount measurement operation will be described later.

(Cooling operation)

[0085] When execution of the cooling operation is instructed to the refrigeration cycle apparatus 100, the control unit 140 controls the flow path switching mechanism 125 to be in a state indicated by the broken line in FIG. 1 to set a state of the refrigerant circulation path 150 to the above-described first state, and operates the first compressor 122.

[0086] When the first compressor 122 is operated, a low-pressure gas refrigerant in the refrigeration cycle is compressed into a high-pressure gas refrigerant in the refrigeration cycle. The high-pressure gas refrigerant is sent to the outdoor heat exchanger 123 via the flow path switching mechanism 125, and exchanges heat with the heat source air to be condensed into a high-pressure liquid refrigerant. The high-pressure liquid refrigerant is sent to the indoor unit 110 via the indoor expansion mechanism 113 that is fully opened and the liquid-side connection pipe 132. The refrigerant R in a gas-liquid two-phase state sent to the indoor unit 110 is decompressed to a pressure close to a suction pressure of the first compressor 122 in the indoor expansion mechanism 113 having a reduced opening degree, becomes the refrigerant R in the gas-liquid two-phase state, and is sent to the indoor heat exchanger 112. The refrigerant R in the gas-liquid two-phase state exchanges heat with air in the air conditioning target space in the indoor heat exchanger 112 and evaporates to become a low-pressure gas refrigerant. The low-pressure gas refrigerant is sent to the outdoor unit 120 via the gas-side connection pipe 131, and sucked again into the first compressor 122 via the flow path switching mechanism 125. A temperature of air supplied to the indoor heat exchanger 112 decreases by heat exchange with the refrigerant R flowing through the indoor heat exchanger 112. The air cooled by the indoor heat exchanger 112 is blown out into the air conditioning target space.

(Heating operation)

[0087] When execution of the heating operation is instructed to the refrigeration cycle apparatus 100, the control unit 140 controls the flow path switching mechanism 125 to be in a state indicated by the solid line in FIG. 1 to set a state of the refrigerant circulation path 150 to the above-described second state, and operates the first compressor 122.

[0088] When the first compressor 122 is operated, a low-pressure gas refrigerant in the refrigeration cycle is compressed into a high-pressure gas refrigerant in the refrigeration cycle. The high-pressure gas refrigerant is sent to the indoor unit 110 via the flow path switching mechanism 125 and the gas-side connection pipe 131. The refrigerant R sent to the indoor unit 110 is sent to the indoor heat exchanger 112, and exchanges heat with air in the air conditioning target space to be condensed into a high-pressure liquid refrigerant. The temperature of air supplied to the indoor heat exchanger 112 rises by heat exchange with the refrigerant R flowing through the indoor heat exchanger 112. The air heated by the indoor heat exchanger 112 is blown out into the air conditioning target space. The high-pressure liquid refrigerant flowing out of the indoor heat exchanger 112 is sent to the outdoor unit 120 via the indoor expansion mechanism 113 that is fully opened and the liquid-side connection pipe 132. The refrigerant R sent to the outdoor unit 120 is decompressed to a pressure close to a suction pressure of the first compressor 122 in the outdoor expansion mechanism 124 having a reduced opening degree, and becomes the refrigerant R in a gas-liquid two-phase state and is sent to the outdoor heat exchanger 123. The refrigerant R in the gas-liquid two-phase state exchanges heat with the heat source air in the outdoor heat exchanger 123 and evaporates to become a low-pressure gas refrigerant. The low-pressure gas refrigerant is sucked into the first compressor 122 again via the flow path switching mechanism 125.

[0089] The control unit 140 is implemented by a computer. The control unit 140 includes a control calculation device and a storage device (both not shown). The control calculation device may be a processor such as a CPU or a GPU. The control calculation device reads a program stored in the storage device and executes predetermined image processing or calculation processing in accordance with the program. The control calculation device can write a calculation result to the storage device and read information stored in the storage device in accordance with the program. The storage device can be used as a database. Specific functions implemented by the control unit 140 will be described later.

[0090] Note that the configuration of the control unit 140 described here is merely an example, and the function of the control unit 140 described below may be implemented by software, hardware, or a combination of software and hardware.

(2-2-6) Calculation device

[0091] The calculation device 470 is a device that performs calculation related to measurement of the amount of the refrigerant R in the reservoir 460, and records and stores a measurement result in the storage 472. FIG. 3 is a control block diagram of the calculation device 470. The calculation device 470 includes the measurement calculator 471 and the storage 472. The calculation device 470 is electrically connected to the electrode rod 461 and the control unit 140. The calculation device 470 is controlled by the control unit 140.

[0092] The calculation device 470 may be provided near the place where the reservoir 460 is provided, in a building where the refrigeration cycle apparatus 100 or the reservoir 460 is provided, in a server away from the refrigeration cycle apparatus 100, or the like. The measurement calculator 471 and the storage 472 may be provided at different locations.

[0093] The calculation device 470 is implemented by a computer. The calculation device 470 includes a control calculation device and a storage device (both not shown). The control calculation device may be a processor such as a CPU or a GPU. The control calculation device reads a program stored in the storage device and executes predetermined image processing or calculation processing in accordance with the program. The control calculation device can write a calculation result to the storage device and read information stored in the storage device in accordance with the program. The storage device can be used as a database.

[0094] Note that the configuration of the calculation device 470 described here is merely an example, and the function of the calculation device 470 described below may be implemented by software, hardware, or a combination of software and hardware.

(2-2-6-1) Measurement calculator

[0095] The measurement calculator 471 performs calculation related to measurement of the amount of the refrigerant R in the reservoir 460 and records the measurement result in the storage 472. The measurement calculator 471 is electrically connected to the electrode rod 461 and the control unit 140. The measurement calculator 471 is controlled by the control unit 140. The detailed operation of the measurement calculator 471 will be described later.

(2-2-6-2) Storage

[0096] The storage 472 is a storage device that stores the measurement result of the amount of the refrigerant R in the reservoir 460. The storage 472 is electrically connected to the measurement calculator 471 and the control unit 140. The storage 472 is controlled by the control unit 140.

(3) Operation

[0097] The refrigerant amount measurement operation executed by the control unit 140 of the refrigerant amount measurement system 4 will be described.

(3-1) Refrigerant amount measurement operation

[0098] The refrigerant amount measurement operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 to the reservoir 460, causing the measurer 401 to measure the amount of the refrigerant R, and returning the refrigerant R from the reservoir 460 to the refrigerant circulation path 150. The refrigerant amount measurement operation is performed to measure a refrigerant charge amount in the refrigeration cycle apparatus at each time point from a start of use to disposal of the refrigeration cycle apparatus, and clarify a leakage amount of the refrigerant R from the refrigerant charge amount at the start of use, a refrigerant charge amount after the start of use, a refrigerant charge amount immediately before the disposal, and a difference between the refrigerant charge amount at the start of use and the refrigerant charge amount at each time point. The refrigerant amount measurement operation includes the first refrigerant amount measurement operation and the second refrigerant amount measurement operation.

(3-1-1) First refrigerant amount measurement operation

[0099] The first refrigerant amount measurement operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 of the first refrigeration cycle apparatus 100A to the reservoir 460, causing the measurer 401 to measure the amount of the refrigerant R, and returning the refrigerant R from the reservoir 460 to the refrigerant circulation path 150 of the first refrigeration cycle apparatus 100A. The first refrigerant amount measurement operation will be described separately for an operation of transferring the refrigerant R to the reservoir 460, an operation of causing the measurer 401 to measure the amount of the refrigerant R, and an operation of returning the refrigerant R to the refrigerant circulation path 150.

(3-1-1-1) Operation of transferring refrigerant to reservoir

(First half operation)

[0100] A first half operation of the operation of transferring the refrigerant R to the reservoir 460 is an operation of mainly reserving a liquid refrigerant in the refrigerant R in the refrigerant circulation path 150. FIG. 4 is a schematic configuration diagram showing a flow of the refrigerant R in the first half operation of the operation of transferring the refrigerant R to the reservoir 460.

[0101] In the first half operation of the operation of transferring the refrigerant R to the reservoir 460, the control unit 140a sets an indoor expansion mechanism 113A to an open state for all indoor units 110A. For an outdoor unit 120A, the control unit 140a sets an outdoor expansion mechanism 124A of the first refrigeration cycle apparatus 100A to a closed state, sets a flow path switching mechanism 125A to the first state, and operates the first compressor 122 (On). Furthermore, the control unit 140a sets the on-off valve 230b to the open state and sets the on-off valves 230 other than the on-off valve 230b to the closed state in the refrigerant amount measurement system 4. Specifically, the control unit 140a sets the on-off valve 230a, the on-off valve 230c, and the on-off valve 230d to the closed state.

[0102] The first half operation of the operation of transferring the refrigerant R to the reservoir 460 is executed, and thus, the refrigerant R in an indoor refrigerant flow path 111A is sucked by a first compressor 122A of the outdoor unit 120A as indicated by an arrow in FIG. 4. The refrigerant R sucked into the first compressor 122A is discharged from the first compressor 122A, and then passes through the flow path switching mechanism 125A and an outdoor heat exchanger 123A. The refrigerant R having passed through the outdoor heat exchanger 123A is sent to the outdoor expansion mechanism 124A, but flows into the liquid-side branch pipe 129A since the outdoor expansion mechanism 124A is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129A passes through the second pipe 420 and the liquid-side pipe 452 and flows into the reservoir 460. Since the on-off valve 230 other than the on-off valve 230b of the refrigerant amount measurement system 4 is in the closed state, the refrigerant R having flowed in is reserved in the reservoir 460.

[0103] The control unit 140a executes the first half operation of the operation of transferring the refrigerant R to the reservoir 460 for a predetermined time T 1 set in advance, and then, ends the first half operation of the operation of transferring the refrigerant R to the reservoir 460 and starts the second half operation of the operation of transferring the refrigerant R to the reservoir 460. The predetermined time T1 is set to a length that allows the liquid refrigerant inside the refrigerant circulation path 150A to be reserved into the reservoir 460.

(Second half operation)

[0104] The second half operation of the operation of transferring the refrigerant R to the reservoir 460 is an operation for reserving mainly the gas refrigerant in the reservoir 460, the gas refrigerant remaining in the outdoor refrigerant flow path 121 without being reserved in the reservoir 460 by the execution of the first half operation of the operation of transferring the refrigerant R to the reservoir 460. FIG. 5 is a schematic configuration diagram showing a flow of the refrigerant R in the second half operation of the operation of transferring the refrigerant R to the reservoir 460.

[0105] In the second half operation of the operation of transferring the refrigerant R to the reservoir 460, the control unit 140a sets the on-off valve 230a to the open state for the reservoir 460. In the other devices, the state of the first half operation of the operation of transferring the refrigerant R to the reservoir 460 is maintained.

[0106] The second half operation of the operation of transferring the refrigerant R to the reservoir 460 is executed, and thus, the gas refrigerant in the refrigerant R reserved in the reservoir 460 flows into the first pipe 410 through the on-off valve 230a as indicated by an arrow in FIG. 5. The refrigerant R having flowed into the first pipe 410 is sent to the outdoor refrigerant flow path 121A, passes through the flow path switching mechanism 125A, and is sucked by the first compressor 122A. The refrigerant R sucked into the first compressor 122A is discharged from the first compressor 122A, and passes through the outdoor heat exchanger 123A. The refrigerant R having passed through the outdoor heat exchanger 123A is sent to the outdoor expansion mechanism 124A, but flows into the liquid-side branch pipe 129A since the outdoor expansion mechanism 124A is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129A passes through the second pipe 420 and returns to the reservoir 460.

[0107] The control unit 140a executes the second half operation of the operation of transferring the refrigerant R to the reservoir 460 for a predetermined time T2 set in advance, and then, ends the second half operation of the operation of transferring the refrigerant R to the reservoir 460. For example, the predetermined time T2 is set to a length that allows the reservoir 460 to recover the refrigerant R remaining in the refrigerant circulation path 150A after execution of the first half operation of the operation of transferring the refrigerant R to the reservoir 460.

(3-1-1-2) Operation of causing measurer 401 to measure amount of refrigerant

[0108] The operation of causing the measurer 401 to measure the amount of the refrigerant R is an operation of causing the measurer 401 to measure the amount of the refrigerant R reserved in the reservoir 460. The control unit 140a causes the measurer 401 to measure the amount of the refrigerant R when a predetermined time T3 set in advance has elapsed from the time when the second half operation of the operation of transferring the refrigerant R to the reservoir 460 ends.

(Principle of measurement)

[0109] FIG. 6 is a schematic configuration diagram showing the reservoir 460 in which the refrigerant R is reserved and the electrode rod 461. An electrostatic capacitance C is determined by a distance X between the electrode rod 461 and the reservoir 460, dielectric constants ε of air and the refrigerant R, and an electrode area S.

[0110] The positional relationship between the electrode rod 461 and the reservoir 460 does not change. Therefore, the distance X between the electrode rod 461 and the reservoir 460 is a fixed value.

[0111] When the temperature is constant, the dielectric constants ε of the air and the refrigerant R are also fixed values. For example, when the temperature is 0 degrees, the dielectric constant ε of the air is 1.00059. When the temperature is 25 degrees and the refrigerant R is R32, the dielectric constant ε is 14.27. When the temperature is 25 degrees and the refrigerant R is R410A, the dielectric constant ε is 7.88.

[0112] Therefore, the electrostatic capacitance C varies depending on the electrode area S. A width d of the cylindrical reservoir 460 has a fixed value. Therefore, the electrode area S is proportional to a liquid level height h of the refrigerant R.

[0113] FIG. 7 is a diagram showing a relationship between an electrostatic capacitance C and a liquid level height h of the refrigerant R in accordance with the temperature. The dielectric constant ε of the refrigerant R decreases at a high temperature and increases at a low temperature.

[0114] Therefore, by measuring the electrostatic capacitance C and the temperature of the refrigerant R and using other eigenvalues, the liquid level height h of the refrigerant R can be calculated, and the refrigerant amount can be calculated.

(Operation of measurement)

[0115] In the storage 472, the distance X, the width d, the dielectric constants ε of the air and the refrigerant R associated with the temperature, and the like are recorded in advance.

[0116] The operation of causing the measurer 401 to measure the amount of the refrigerant R is executed, and thus, the control unit 140a causes the electrode rod 461 to measure the electrostatic capacitance C in the reservoir 460 via the measurement calculator 471. The control unit 140a causes a thermometer (not shown) to measure the temperature of the refrigerant R. The measurement calculator 471 compares the measured temperature of the refrigerant R with the dielectric constants ε of the air and the refrigerant R associated with the temperature recorded in the storage 472 to obtain the dielectric constants ε of the air and the refrigerant R. The measurement calculator 471 obtains the liquid level height h of the refrigerant R and the amount of the refrigerant R from the measured electrostatic capacitance C, the distance X and the width d recorded in the storage 472, and the obtained dielectric constants ε of the air and the refrigerant R. The measurement calculator 471 records the obtained amount of the refrigerant R in the storage 472. The measurement calculator 471 may transmit the obtained amount of the refrigerant R to the control unit 140a.

[0117] The measurement calculator 471 may calculate the dielectric constant ε of the air as one regardless of a change in temperature.

[0118] The refrigerant amount measurement system 4 measures the amount of the refrigerant R on the basis of the temperature of the refrigerant R measured by the thermometer. Therefore, the refrigerant amount measurement system 4 can accurately obtain the amount of the refrigerant R even when the temperature changes.

[0119] The measurement calculator 471 may perform calculation processing of obtaining a difference between the measured refrigerant amount and the refrigerant charge amount at the start of use. In this case, the storage 472 records in advance the refrigerant charge amount at the start of use. The measurement calculator 471 performs calculation processing on the basis of the refrigerant charge amount at the start of use stored in the storage 472 and the measured refrigerant amount. As a result, the refrigerant amount measurement system 4 can reduce a burden of work of clarifying the leakage amount of the refrigerant R.

[0120] The measurement calculator 471 may determine whether the refrigerant R has leaked on the basis of the refrigerant charge amount at the start of use, the refrigerant charge amount after the start of use, the refrigerant charge amount immediately before disposal, and the difference between the measured refrigerant amount and the refrigerant charge amount at the start of use. In this case, the storage 472 records in advance at least one of the refrigerant charge amount at the start of use, the refrigerant charge amount after the start of use, or the refrigerant charge amount immediately before disposal. The measurement calculator 471 determines whether the refrigerant R has leaked from at least one of the refrigerant charge amounts at the start of use, the refrigerant charge amount after the start of use, and the refrigerant charge amount immediately before discarding stored in the storage 472, or the difference between the measured refrigerant amount and the refrigerant charge amount at the start of use. As a result, the refrigerant amount measurement system 4 can reduce a burden of work of clarifying the leakage amount of the refrigerant R.

[0121] Furthermore, when determining that the refrigerant R has leaked, the measurement calculator 471 may perform calculation processing of obtaining the leakage amount of the refrigerant R on the basis of the refrigerant charge amount at the start of use, the refrigerant charge amount after the start of use, the refrigerant charge amount immediately before disposal, or the difference between the measured refrigerant amount and the refrigerant charge amount at the start of use. As a result, the refrigerant amount measurement system 4 can reduce a burden of work of clarifying the leakage amount of the refrigerant R.

(3-1-1-3) Operation of returning refrigerant to refrigerant circulation path 150

[0122] The operation of returning the refrigerant R to the refrigerant circulation path 150 is an operation of charging the refrigerant R reserved in the reservoir 460 into the refrigerant circulation path 150. In the following description, a case where the refrigerant R is returned to the first refrigeration cycle apparatus 100A will be described as an example. FIG. 8 is a schematic configuration diagram showing the flow of the refrigerant R in the operation of returning the refrigerant R to the refrigerant circulation path 150.

[0123] In the operation of returning the refrigerant R to the refrigerant circulation path 150, for the outdoor unit 120A, the control unit 140a sets the outdoor expansion mechanism 124A of the first refrigeration cycle apparatus 100A to the open state, sets the flow path switching mechanism 125A to the first state, and operates the first compressor 122A (On). In addition, the control unit 140a sets the on-off valve 230a to the open state and sets the on-off valve 230b, the on-off valve 230c, and the on-off valve 230d to the closed state.

[0124] The operation of returning the refrigerant R to the refrigerant circulation path 150, and thus, the suction pressure of the first compressor 122A of the outdoor unit 120A acts on the inside of the reservoir 460 via the flow path switching mechanism 125, the gas-side branch pipe 128A, and the first pipe 410 as indicated by an arrow in FIG. 8. Due to the suction pressure acting inside the reservoir 460, the refrigerant R inside the reservoir 460 flows into the first pipe 410 and is charged in the refrigerant circulation path 150 via the gas-side branch pipe 128A.

[0125] The operation of returning the refrigerant R to the refrigerant circulation path 150 is executed for a predetermined time T4 set in advance, and then, the control unit 140a ends the operation of returning the refrigerant R to the refrigerant circulation path 150. The predetermined time T4 is set to, for example, a length that allows the refrigerant R reserved in the reservoir 460 to be charged in the refrigerant circulation path 150.

(3-1-2) Second refrigerant amount measurement operation

[0126] The second refrigerant amount measurement operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 of the second refrigeration cycle apparatus 100B to the reservoir 460, causing the measurer 401 to measure the amount of the refrigerant R, and returning the refrigerant R from the reservoir 460 to the refrigerant circulation path 150 of the second refrigeration cycle apparatus 100B. The second refrigerant amount measurement operation is similar to the first refrigerant amount measurement operation. Therefore, the second refrigerant amount measurement operation will be briefly described.

(3-1-2-1) Operation of transferring refrigerant to reservoir

(First half operation)

[0127] In the first half operation of the operation of transferring the refrigerant R to the reservoir 460, the control unit 140b sets an indoor expansion mechanism 113B to the open state for all indoor units 110B. For an outdoor unit 120B, the control unit 140b sets an outdoor expansion mechanism 124B of the second refrigeration cycle apparatus 100B to the closed state, sets a flow path switching mechanism 125B to the first state, and operates the first compressor 122 (On). Furthermore, the control unit 140b sets the on-off valve 230d to the open state and sets the on-off valves 230 other than the on-off valve 230d to the closed state. Specifically, the control unit 140b sets the on-off valve 230a, the on-off valve 230b, and the on-off valve 230c to the closed state.

[0128] The first half operation of the operation of transferring the refrigerant R to the reservoir 460 is executed, and thus, the refrigerant R in an indoor refrigerant flow path 111B is sucked by a first compressor 122B of the outdoor unit 120B. The refrigerant R sucked into the first compressor 122B is discharged from the first compressor 122B, and then passes through the flow path switching mechanism 125B and an outdoor heat exchanger 123B. The refrigerant R having passed through the outdoor heat exchanger 123B is sent to the outdoor expansion mechanism 124B, but flows into the liquid-side branch pipe 129B since the outdoor expansion mechanism 124B is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129B passes through the fourth pipe 440 and the liquid-side pipe 452 and flows into the reservoir 460. Since the on-off valve 230 other than the on-off valve 230d of the refrigerant amount measurement system 4 is in the closed state, the refrigerant R having flowed in is reserved in the reservoir 460.

[0129] The control unit 140d executes the first half operation of the operation of transferring the refrigerant R to the reservoir 460 for the predetermined time T1 set in advance, and then, ends the first half operation of the operation of transferring the refrigerant R to the reservoir 460 and starts the second half operation of the operation of transferring the refrigerant R to the reservoir 460. The predetermined time T1 is set to a length that allows the liquid refrigerant inside the refrigerant circulation path 150B to be reserved into the reservoir 460.

(Second half operation)

[0130] In the second half operation of the operation of transferring the refrigerant R to the reservoir 460, the control unit 140d sets the on-off valve 230c to the open state. In the other devices, the state of the first half operation of the operation of transferring the refrigerant R to the reservoir 460 is maintained.

[0131] The second half operation of the operation of transferring the refrigerant R to the reservoir 460 is executed, and thus, the gas refrigerant in the refrigerant R reserved in the reservoir 460 flows into the third pipe 430 through the on-off valve 230c. The refrigerant R having flowed into the third pipe 430 is sent to the outdoor refrigerant flow path 121B, passes through the flow path switching mechanism 125B, and is sucked by the first compressor 122B. The refrigerant R sucked into the first compressor 122B is discharged from the first compressor 122B, and passes through the outdoor heat exchanger 123B. The refrigerant R having passed through the outdoor heat exchanger 123B is sent to the outdoor expansion mechanism 124B, but flows into the liquid-side branch pipe 129B since the outdoor expansion mechanism 124B is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129B passes through the fourth pipe 440 and returns to the reservoir 460.

[0132] The control unit 140b executes the second half operation of the operation of transferring the refrigerant R to the reservoir 460 for the predetermined time T2 set in advance, and then, ends the second half operation of the operation of transferring the refrigerant R to the reservoir 460. For example, the predetermined time T2 is set to a length that allows the reservoir 460 to recover the refrigerant R remaining in the refrigerant circulation path 150B after execution of the second half operation of the operation of transferring the refrigerant to the reservoir 460.

(3-1-2-2) Operation of causing measurer 401 to measure amount of refrigerant

[0133] The operation of causing the measurer 401 to measure the amount of refrigerant in the second refrigerant amount measurement operation is similar to the operation of causing the measurer 401 to measure the amount of refrigerant in the first refrigerant amount measurement operation.

(3-1-2-3) Operation of returning refrigerant to refrigerant circulation path 150

[0134] In the operation of returning the refrigerant R to the refrigerant circulation path 150, for the outdoor unit 120B, the control unit 140b sets the outdoor expansion mechanism 124B of the second refrigeration cycle apparatus 100B to the open state, sets the flow path switching mechanism 125B to the first state, and operates the first compressor 122B (On). In addition, the control unit 140b sets the on-off valve 230c to the open state and sets the on-off valve 230a, the on-off valve 230b, and the on-off valve 230d to the closed state.

[0135] The operation of returning the refrigerant R to the refrigerant circulation path 150, and thus, the suction pressure of the first compressor 122B of the outdoor unit 120B acts on the inside of the reservoir 460 via the flow path switching mechanism 125, the gas-side branch pipe 128B, and the third pipe 430. Due to the suction pressure acting inside the reservoir 460, the refrigerant R inside the reservoir 460 flows into the third pipe 430 and is charged in the refrigerant circulation path 150 via the gas-side branch pipe 128B.

[0136] The operation of returning the refrigerant R to the refrigerant circulation path 150 is executed for the predetermined time T4 set in advance, and then, the control unit 140b ends the operation of returning the refrigerant R to the refrigerant circulation path 150. The predetermined time T4 is set to, for example, a length that allows the refrigerant R reserved in the reservoir 460 to be charged in the refrigerant circulation path 150.

(4) Characteristics

[0137] (4-1)

The refrigerant amount measurement system 4 includes the connecting portion 400, the reservoir 460, the measurer 401, and the storage 472. The connecting portion 400 is connected to the first refrigerant circuit of the first refrigeration cycle apparatus 100A. The reservoir 460 reserves the refrigerant R in the first refrigerant circuit via the connecting portion 400, and returns the reserved refrigerant R to the first refrigerant circuit via the connecting portion 400. The measurer 401 measures the amount of the refrigerant R in the reservoir 460. The storage 472 stores the measurement result measured by the measurer 401.

[0138] The refrigeration apparatus disclosed in Patent Literature 1 detects a shortage state of the refrigerant by the receiver tank internally connected to the refrigerant circuit. The refrigerant also flows into the receiver tank incorporated in the apparatus during a normal operation (such as air conditioning operation). Therefore, the refrigeration apparatus of Patent Literature 1 requires a refrigerant amount corresponding to the volume of the receiver tank in addition to a refrigerant amount corresponding to the existing refrigerant circuit. The refrigeration apparatus disclosed in Patent Literature 1 causes a pressure loss of the refrigerant when the refrigerant passes through the receiver tank.

[0139] This refrigerant amount measurement system 4 reserves the refrigerant R in the first refrigerant circuit in the reservoir 460 externally connected to the first refrigerant circuit. The refrigerant amount measurement system 4 measures the amount of the refrigerant R and stores the measurement result. The refrigerant amount measurement system 4 returns the reserved refrigerant R to the first refrigerant circuit from the reservoir 460 externally connected to the first refrigerant circuit. Since the reservoir 460 is externally connected, the refrigerant R in the first refrigerant circuit does not flow into the reservoir 460 when the first refrigeration cycle apparatus 100A is operated normally. Therefore, the refrigerant amount measurement system can clarify a charge amount and a leakage amount of the refrigerant in the first refrigerant circuit without generating an additional refrigerant amount or a pressure loss.

[0140] In the refrigeration apparatus in Patent Literature 1, a liquid level detector measures a difference in liquid level height. The user of the refrigeration apparatus can know the difference in liquid level height between the time points when the liquid level detector is used, and can know the shortage of the refrigerant (leakage of the refrigerant). However, it is difficult for the user of the refrigeration apparatus to know the charge amount (initial charge amount, charge amount at arbitrary time point, and the like). Therefore, the user of the refrigeration apparatus cannot know details of circumstances relating to charging and leakage in association with the charge amount and the time point.

[0141] This refrigerant amount measurement system 4 can measure the charge amount at an arbitrary time point. The user of this refrigerant amount measurement system 4 can know not only whether the refrigerant R has leaked, but also an arbitrary time point and a charge amount in association with each other. The user of this refrigerant amount measurement system 4 can know details of circumstances relating to charging and leakage. Therefore, the refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit.

[0142] When the measurement result of the charge amount is manually recorded, the time and effort of the work increases, and there is a possibility of leakage of the measurement result due to human error or omission of the measurement result due to aged deterioration of a recording medium. This refrigerant amount measurement system 4 stores the measurement result measured by the measurer 401 in the storage 472. The user of this refrigerant amount measurement system 4 can know the measurement result of the charge amount without omission, and can reduce the time and effort of work for storing the measurement result. Therefore, the refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit, and can reduce the time and effort of work for storing the measurement result.

[0143] (4-2)

In the refrigerant amount measurement system 4, the connecting portion 400 includes the first pipe 410 and the second pipe 420. Each of the first pipe 410 and the second pipe 420 is provided with the on-off valve 230.

[0144] The connecting portion 400 of this refrigerant amount measurement system 4 includes the first pipe 410 and the second pipe 420. Therefore, this refrigerant amount measurement system 4 can be connected to the first refrigerant circuit by the first pipe 410 and the second pipe 420 separately for each state of the refrigerant R. Each of the first pipe 410 and the second pipe 420 is provided with the on-off valve 230. Therefore, this refrigerant amount measurement system 4 can allow or interrupt communication between the first pipe 410 and the second pipe 420.

[0145] (4-3)

The refrigerant amount measurement system 4 further includes the control unit 140. The control unit 140 performs the first refrigerant amount measurement operation. The first refrigerant amount measurement operation is an operation of controlling the first refrigeration cycle apparatus 100A and the on-off valve 230 to transfer the refrigerant R from the first refrigerant circuit to the reservoir 460, cause the measurer 401 to measure the amount of the refrigerant R, and return the refrigerant R from the reservoir 460 to the first refrigerant circuit.

[0146] The control unit 140 of this refrigerant amount measurement system 4 performs the first refrigerant amount measurement operation. Therefore, the refrigerant amount measurement system 4 can reduce the time and effort required for the work of clarifying the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit.

[0147] This refrigerant amount measurement system 4 can automatically measure the charge amount by the control unit 140. This refrigerant amount measurement system 4 stores the automatically measured charge amount in the storage 472. The user of this refrigerant amount measurement system 4 can know the charge amount automatically measured at a past time point by the storage 472. Therefore, the user of this refrigerant amount measurement system 4 can know circumstances relating to charging and leakage in more detail in association with the charge amount and the past time point. Therefore, the refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit.

[0148] (4-4)

In the refrigerant amount measurement system 4, the connecting portion 400 is also connected to the second refrigerant circuit of the second refrigeration cycle apparatus 100B. The control unit 140 further includes the third pipe 430 and the fourth pipe 440 each provided with the on-off valve 230. The connecting portion 400 is connected to the first refrigerant circuit by the first pipe 410 and the second pipe 420, and is connected to the second refrigerant circuit by the third pipe 430 and the fourth pipe 440.

[0149] The connecting portion 400 of this refrigerant amount measurement system 4 is also connected to the second refrigerant circuit of the second refrigeration cycle apparatus 100B. Therefore, this refrigerant amount measurement system 4 can also clarify the charge amount and the leakage amount of the refrigerant R in the second refrigerant circuit. The connecting portion 400 of this refrigerant amount measurement system 4 includes the third pipe 430 and the fourth pipe 440. Therefore, this refrigerant amount measurement system 4 can be connected to the second refrigerant circuit by the third pipe 430 and the fourth pipe 440 separately for each state of the refrigerant R. Each of the third pipe 430 and the fourth pipe 440 is provided with the on-off valve 230. Therefore, this refrigerant amount measurement system 4 can allow or interrupt communication between the third pipe 430 and the fourth pipe 440.

[0150] (4-5)

In the refrigerant amount measurement system 4, the control unit 140 further performs the second refrigerant amount measurement operation. The second refrigerant amount measurement operation is an operation of controlling the second refrigeration cycle apparatus 100B and the on-off valve 230 to transfer the refrigerant R from the second refrigerant circuit to the reservoir 460, cause the measurer 401 to measure the amount of the refrigerant R, and return the refrigerant R from the reservoir 460 to the second refrigerant circuit.

[0151] The control unit 140 of this refrigerant amount measurement system 4 further performs the second refrigerant amount measurement operation. Therefore, the refrigerant amount measurement system 4 can also reduce the time and effort required for the work of clarifying the charge amount and the leakage amount of the refrigerant R in the second refrigerant circuit.

[0152] (4-6)

In the refrigerant amount measurement system 4, the measurer 401 includes the electrode rod 461.

[0153] The measurer 401 of this refrigerant amount measurement system 4 includes the electrode rod 461. Therefore, this refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R by using the electrode rod 461.

[0154] (4-7)

The refrigerant use system 1 includes the refrigerant amount measurement system 4 and the refrigeration cycle apparatus 100.

[0155] This refrigerant use system 1 includes the refrigerant amount measurement system 4 and the refrigeration cycle apparatus 100. Therefore, this refrigerant use system 1 can clarify the charge amount and the leakage amount of the refrigerant R of the refrigeration cycle apparatus 100 included in this refrigerant use system 1.

(5) Modifications

(5-1) Modification 1A

[0156] In the refrigerant amount measurement operation of the above embodiment, the refrigerant R is returned to the refrigerant circulation path 150 by the suction pressure. However, the operation of returning the refrigerant R to the refrigerant circulation path 150 is not limited to this operation. For example, an operation of returning the refrigerant R to the refrigerant circulation path 150 of the first refrigeration cycle apparatus 100A will be described. FIG. 9 is a schematic configuration diagram showing the flow of the refrigerant R in the operation of returning the refrigerant R to the refrigerant circulation path 150.

[0157] In the operation of returning the refrigerant R to the refrigerant circulation path 150, for the outdoor unit 120A, the control unit 140a sets the outdoor expansion mechanism 124A of the first refrigeration cycle apparatus 100A to the open state, sets the flow path switching mechanism 125A to the second state, and operates the first compressor 122A (On). In addition, the control unit 140a sets the on-off valve 230a and the on-off valve 230b to the open state and sets the on-off valve 230c and the on-off valve 230d to the closed state.

[0158] The operation of returning the refrigerant R to the refrigerant circulation path 150, and thus, a discharge pressure of the first compressor 122A of the outdoor unit 120A acts on the inside of the reservoir 460 via the flow path switching mechanism 125, the gas-side branch pipe 128A, and the first pipe 410 as indicated by an arrow in FIG. 9. Due to the discharge pressure acting on the inside of the reservoir 460, the refrigerant R in the reservoir 460 bypasses a check valve 455, flows into the second pipe 420, and is charged in the refrigerant circulation path 150 via the liquid-side branch pipe 129.

[0159] The operation of returning the refrigerant R to the refrigerant circulation path 150 of the second refrigeration cycle apparatus 100B may be performed in a similar manner to the above.

(5-2) Modification 1B

[0160] The control unit 140 may perform the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times. The control unit 140a and the control unit 140b are electrically connected to each other and cooperate with each other, so that the control unit 140a and the control unit 140b can perform the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times.

[0161] The control unit 140 of the refrigerant amount measurement system 4 according to the present embodiment performs the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times. Therefore, this refrigerant amount measurement system 4 can separately clarify the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit and the charge amount and the leakage amount of the refrigerant R in the second refrigerant circuit.

(5-3) Modification 1C

[0162] The control unit 140 may perform the first refrigerant amount measurement operation in a time zone in which the normal operation of the first refrigeration cycle apparatus 100A is stopped. The control unit 140 may perform the second refrigerant amount measurement operation in a time zone in which the normal operation of the second refrigeration cycle apparatus 100B is stopped. Examples of the normal operation include the cooling operation, the heating operation, a hot water supply operation, a refrigerating operation, a freezing operation, and a floor heating operation.

[0163] The control unit 140 of the refrigerant amount measurement system 4 according to the present embodiment performs the first refrigerant amount measurement operation in a time zone in which the normal operation of the first refrigeration cycle apparatus 100A is stopped. Therefore, this refrigerant amount measurement system 4 is not affected by the normal operation of the first refrigeration cycle apparatus 100A, and can further clarify the charge amount and the leakage amount of the refrigerant R in the first refrigerant circuit. The control unit 140 performs the second refrigerant amount measurement operation in a time zone in which the normal operation of the second refrigeration cycle apparatus 100B is stopped. Therefore, this refrigerant amount measurement system 4 is not affected by the normal operation of the second refrigeration cycle apparatus 100B, and can further clarify the charge amount and the leakage amount of the refrigerant R in the second refrigerant circuit.

(5-4) Modification 1D

[0164] The on-off valve 230 according to the above embodiment is controlled by the control unit 140, and automatically allows or interrupts communication of the pipes. However, the on-off valve 230 may manually allow or interrupt communication of the pipes in addition to or instead of the above embodiment.

[0165] By manually allowing or interrupting the communication of the pipes by the on-off valve 230, the communication of the pipe can be allowed or interrupted even in a situation where the control by the control unit 140 is difficult.

<Second embodiment>

(1) Configuration

[0166] A refrigerant use system 1 according to a second embodiment of the present disclosure will be described focusing on differences from the refrigerant use system 1 according to the first embodiment.

[0167] The control unit 140 of the refrigerant use system 1 according to the second embodiment performs a reserving operation in addition to the operation executed by the control unit 140 of the refrigerant use system 1 according to the first embodiment.

(2) Operation

(2-1) Reserving operation

[0168] The reserving operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 to the reservoir 460 when the refrigerant R leaks from the refrigerant circulation path 150. The reserving operation is executed, for example, to prevent further leakage of the refrigerant R when the refrigerant R leaks from the refrigerant circulation path 150. The reserving operation includes a first reserving operation and a second reserving operation.

(2-1-1) First reserving operation

[0169] The first reserving operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 to the reservoir 460 when the refrigerant R leaks from the refrigerant circulation path 150 of the first refrigeration cycle apparatus 100A. The first reserving operation includes a first half operation and a second half operation.

(First half operation)

[0170] The first half operation of the first reserving operation is an operation of mainly reserving a liquid refrigerant in the refrigerant R in the refrigerant circulation path 150. FIG. 10 is a schematic configuration diagram showing a flow of the refrigerant R in the first half operation of the first reserving operation.

[0171] In the first half operation of the first reserving operation, the control unit 140a sets the indoor expansion mechanism 113A to the open state for all the indoor units 110A. For the outdoor unit 120A, the control unit 140a sets the outdoor expansion mechanism 124A of the first refrigeration cycle apparatus 100A to the closed state, sets the flow path switching mechanism 125A to the first state, and operates the first compressor 122 (On). Furthermore, the control unit 140a sets the on-off valve 230b to the open state and sets the on-off valves 230 other than the on-off valve 230b to the closed state in the refrigerant amount measurement system 4. Specifically, the control unit 140a sets the on-off valve 230a, the on-off valve 230c, and the on-off valve 230d to the closed state.

[0172] The first half operation of the first reserving operation is executed, and thus, the refrigerant R in an indoor refrigerant flow path 111A is sucked by the first compressor 122A of the outdoor unit 120A as indicated by an arrow in FIG. 10. The refrigerant R sucked into the first compressor 122A is discharged from the first compressor 122A, and then passes through the flow path switching mechanism 125A and the outdoor heat exchanger 123A. The refrigerant R having passed through the outdoor heat exchanger 123A is sent to the outdoor expansion mechanism 124A, but flows into the liquid-side branch pipe 129A since the outdoor expansion mechanism 124A is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129A passes through the second pipe 420 and the liquid-side pipe 452 and flows into the reservoir 460. Since the on-off valve 230 other than the on-off valve 230b of the refrigerant amount measurement system 4 is in the closed state, the refrigerant R having flowed in is reserved in the reservoir 460.

[0173] The control unit 140a executes the first half operation of the first reserving operation for a predetermined time T5 set in advance, and then, ends the first half operation of the first reserving operation and starts a second half operation of the first reserving operation. For example, the predetermined time T5 is set to a length that allows the liquid refrigerant inside the refrigerant circulation path 150A to be reserved into the reservoir 460.

(Second half operation)

[0174] The second half operation of the first reserving operation is an operation for reserving mainly the gas refrigerant in the reservoir 460, the gas refrigerant remaining in the outdoor refrigerant flow path 121without being reserved in the reservoir 460 by the execution of the first half operation of the first reserving operation. FIG. 11 is a schematic configuration diagram showing a flow of the refrigerant R in the second half operation of the first reserving operation.

[0175] In the second half operation of the first reserving operation, the control unit 140a sets the on-off valve 230a to the open state. In the other devices, the state of the first half operation of the first reserving operation is maintained.

[0176] The second half operation of the first reserving operation is executed, and thus, the gas refrigerant in the refrigerant R reserved in the reservoir 460 flows into the first pipe 410 through the on-off valve 230a as indicated by an arrow in FIG. 11. The refrigerant R having flowed into the first pipe 410 is sent to the outdoor refrigerant flow path 121A, passes through the flow path switching mechanism 125A, and is sucked by the first compressor 122A. The refrigerant R sucked into the first compressor 122A is discharged from the first compressor 122A, and passes through the outdoor heat exchanger 123A. The refrigerant R having passed through the outdoor heat exchanger 123A is sent to the outdoor expansion mechanism 124A, but flows into the liquid-side branch pipe 129A since the outdoor expansion mechanism 124A is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129A passes through the second pipe 420 and returns to the reservoir 460.

[0177] The control unit 140a executes the second half operation of the first reserving operation for a predetermined time T6 set in advance, and then, ends the second half operation of the first reserving operation. For example, the predetermined time T6 is set to a length that allows the reservoir 460 to recover the refrigerant R remaining in the refrigerant circulation path 150A after execution of the first half operation of the first reserving operation.

[0178] As described above, even when the refrigerant R leaks from the refrigerant circulation path 150A, since the refrigerant R inside the refrigerant circulation path 150A is reserved in the reservoir 460 by executing the first reserving operation by the control unit 140a, further leakage of the refrigerant R is prevented.

(2-1-2) Second reserving operation

[0179] The second reserving operation is an operation of transferring the refrigerant R from the refrigerant circulation path 150 to the reservoir 460 when the refrigerant R leaks from the refrigerant circulation path 150 of the second refrigeration cycle apparatus 100B. The second reserving operation is similar to the first reserving operation.

(First half operation)

[0180] In the first half operation of the second reserving operation, the control unit 140b sets the indoor expansion mechanism 113B to the open state for all the indoor units 110B. For the outdoor unit 120B, the control unit 140b sets the outdoor expansion mechanism 124B of the second refrigeration cycle apparatus 100B to the closed state, sets the flow path switching mechanism 125B to the first state, and operates the first compressor 122 (On). Furthermore, the control unit 140b sets the on-off valve 230d to the open state and sets the on-off valves 230 other than the on-off valve 230d to the closed state. Specifically, the control unit 140b sets the on-off valve 230a, the on-off valve 230b, and the on-off valve 230c to the closed state.

[0181] The first half operation of the second reserving operation is executed, and thus, the refrigerant R in the indoor refrigerant flow path 111B is sucked by the first compressor 122B of the outdoor unit 120B. The refrigerant R sucked into the first compressor 122B is discharged from the first compressor 122B, and then passes through the flow path switching mechanism 125B and the outdoor heat exchanger 123B. The refrigerant R having passed through the outdoor heat exchanger 123B is sent to the outdoor expansion mechanism 124B, but flows into the liquid-side branch pipe 129B since the outdoor expansion mechanism 124B is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129B passes through the fourth pipe 440 and the liquid-side pipe 452 and flows into the reservoir 460. Since the on-off valve 230 other than the on-off valve 230d of the refrigerant amount measurement system 4 is in the closed state, the refrigerant R having flowed in is reserved in the reservoir 460.

[0182] The control unit 140d executes the first half operation of the second reserving operation for a predetermined time T7 set in advance, and then, ends the first half operation of the second reserving operation and starts a second half operation of the second reserving operation. The predetermined time T7 is set to a length that allows the liquid refrigerant inside the refrigerant circulation path 150B to be reserved into the reservoir 460.

(Second half operation)

[0183] In the second half operation of the second reserving operation, the control unit 140d sets the on-off valve 230c to the open state. In the other devices, the state of the first half operation of the operation of transferring the refrigerant R to the reservoir 460 is maintained.

[0184] The second half operation of the second reserving operation is executed, and thus, the gas refrigerant in the refrigerant R reserved in the reservoir 460 flows into the third pipe 430 through the on-off valve 230c. The refrigerant R having flowed into the third pipe 430 is sent to the outdoor refrigerant flow path 121B, passes through the flow path switching mechanism 125B, and is sucked by the first compressor 122B. The refrigerant R sucked into the first compressor 122B is discharged from the first compressor 122B, and passes through the outdoor heat exchanger 123B. The refrigerant R having passed through the outdoor heat exchanger 123B is sent to the outdoor expansion mechanism 124B, but flows into the liquid-side branch pipe 129B since the outdoor expansion mechanism 124B is in the closed state. The refrigerant R having flowed into the liquid-side branch pipe 129B passes through the fourth pipe 440 and returns to the reservoir 460.

[0185] The control unit 140b executes the second half operation of the second reserving operation for a predetermined time T8 set in advance, and then, ends the second half operation of the second reserving operation. For example, the predetermined time T8 is set to a length that allows the reservoir 460 to recover the refrigerant remaining in the refrigerant circulation path 150B after execution of the second half operation of the second reserving operation.

[0186] As described above, even when the refrigerant R leaks from the refrigerant circulation path 150B, since the refrigerant R inside the refrigerant circulation path 150B is reserved in the reservoir 460 by executing the second reserving operation by the control unit 140b, further leakage of the refrigerant R is prevented.

(3) Characteristics

[0187] In the refrigerant amount measurement system 4, the control unit 140 performs the first reserving operation and the second reserving operation. The first reserving operation is an operation of transferring the refrigerant R from the first refrigerant circuit to the reservoir 460 when the refrigerant R leaks from the first refrigerant circuit. The second reserving operation is an operation of transferring the refrigerant R from the second refrigerant circuit to the reservoir 460 when the refrigerant R leaks from the second refrigerant circuit.

[0188] The control unit 140 of this refrigerant amount measurement system 4 performs the first reserving operation. Therefore, when the refrigerant R in the first refrigerant circuit leaks, this refrigerant amount measurement system 4 can reserve the refrigerant R in the first refrigerant circuit in the reservoir 460 to suppress release of the refrigerant R to the atmosphere. In addition, the control unit 140 of this refrigerant amount measurement system 4 performs the second reserving operation. Therefore, when the refrigerant R in the second refrigerant circuit leaks, this refrigerant amount measurement system 4 can reserve the refrigerant R in the second refrigerant circuit in the reservoir 460 to suppress release of the refrigerant R to the atmosphere.

<Third embodiment>

(1) Overall configuration

[0189] A refrigerant use system 1 according to a third embodiment of the present disclosure will be described focusing on differences from the refrigerant use system 1 according to the first embodiment.

[0190] The measurer 401 of the refrigerant use system 1 according to the third embodiment further includes a cylindrical member 462 in addition to constituent elements of the measurer 401 of the refrigerant use system 1 according to the first embodiment. The measurer 401 includes the measurement calculator 471, the electrode rod 461, and the cylindrical member 462.

(2) Detailed configuration

[0191] FIG. 12A is a schematic configuration diagram showing the reservoir 460, the electrode rod 461, and the cylindrical member 462. The cylindrical member 462 is a member surrounding the electrode rod 461. FIG. 12B is a sectional view showing a cross section A in FIG. 12A. Unlike the first embodiment, the measurement calculator 471 uses a distance X between the electrode rod 461 and the cylindrical member 462 in the measurement of the refrigerant amount.

[0192] The cylindrical member 462 enables the measurer 401 to accurately measure the refrigerant amount even when the positional relationship between the reservoir 460 and the electrode rod 461 changes or when the shape of a wall surface of the reservoir 460 changes. In addition, since the refrigerant amount can be measured with high accuracy regardless of the shape of the reservoir 460, the shape of the electrode rod 461, the position of the electrode rod 461, and the like, the refrigerant amount measurement system 4 can be easily designed and manufactured.

(3) Characteristics

[0193] In the refrigerant amount measurement system 4, the measurer 401 includes the cylindrical member 462 surrounding the electrode rod 461.

[0194] The measurer 401 of this refrigerant amount measurement system 4 includes the cylindrical member 462 surrounding the electrode rod 461. Therefore, this refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R by using the cylindrical member 462.

(4) Modifications

(4-1) Modification 1A

[0195] In the above embodiment, the measurer 401 measures the amount of the refrigerant R by an electrostatic capacitance method. However, the method of measuring the refrigerant amount by the measurer 401 is not limited to this method. The measurer 401 may measure the amount of the refrigerant R by at least any method of a radio wave method, an ultrasonic method, a float method, a pressure method, a differential pressure method, or an electrostatic capacitance method.

[0196] The radio wave method is a method of measuring the amount of the refrigerant by measuring time until a radio wave is reflected by the liquid surface of the refrigerant R and returned. The ultrasonic method is a method of measuring the amount of the refrigerant by measuring time until an ultrasonic wave is reflected by the liquid surface of the refrigerant R and returned. The float method is a method of measuring the amount of refrigerant by measuring the height of a float floating on the liquid level of the refrigerant R. The pressure method is a method of measuring the refrigerant amount by measuring a pressure value of a liquid bottom surface of the refrigerant R. The differential pressure method is a method of measuring the amount of refrigerant by measuring a differential pressure value between the liquid bottom surface and an upper surface of the reservoir 460.

[0197] In the refrigerant amount measurement system 4 according of the present embodiment, the measurer 401 measures the amount of the refrigerant R by at least any method of the radio wave method, the ultrasonic method, the float method, the pressure method, the differential pressure method, or the electrostatic capacitance method.

[0198] In this refrigerant amount measurement system 4, the measurer 401 measures the amount of the refrigerant R by at least any method of the radio wave method, the ultrasonic method, the float method, the pressure method, the differential pressure method, or the electrostatic capacitance method. Therefore, this refrigerant amount measurement system 4 can further clarify the charge amount and the leakage amount of the refrigerant R on the basis of various methods.

[0199] The embodiments of the present disclosure have been described above. It is understood that various changes to modes and details should be available without departing from the object and the scope of the present disclosure recited in the claims.

REFERENCE SIGNS LIST

[0200]

1 Refrigerant use system
4 Refrigerant amount measurement system
100 Refrigeration cycle apparatus
100A First refrigeration cycle apparatus
100B Second refrigeration cycle apparatus
110 Indoor unit
111 Indoor refrigerant flow path
112 Indoor heat exchanger
113 Indoor expansion mechanism
114 Gas-side connecting portion
115 Liquid-side connecting portion
116 Detector
120 Outdoor unit
121 Outdoor refrigerant flow path
121b First refrigerant pipe
121c Second refrigerant pipe
121d Third refrigerant pipe
122 First compressor
123 Outdoor heat exchanger
124 Outdoor expansion mechanism
125 Flow path switching mechanism
126 Gas-side connecting portion
127 Liquid-side connecting portion
128 Gas-side branch pipe
129 Liquid-side branch pipe
131 Gas-side connection pipe
132 Liquid-side connection pipe
140(140a, 140b) Control unit
150 Refrigerant circulation path
230(230a, 230b, 230c, 230d) On-off valve
400 Connecting portion
401 Measurer
410 First pipe
420 Second pipe
430 Third pipe
440 Fourth pipe
451 Gas-side pipe
452 Liquid-side pipe
455 Check valve
460 Reservoir
461 Electrode rod
462 Cylindrical member
470 Calculation device
471 Measurement calculator
472 Storage

CITATION LIST

PATENT LITERATURE

[0201] Patent Literature 1: JP 2010-190545 A

Claims

1. A refrigerant amount measurement system (4) comprising:

   a connecting portion (400) connected to a first refrigerant circuit of a first refrigeration cycle apparatus (100A);
   a reservoir (460) that reserves a refrigerant (R) in the first refrigerant circuit via the connecting portion and returns the refrigerant reserved to the first refrigerant circuit via the connecting portion;
   a measurer (401) that measures an amount of the refrigerant in the reservoir; and
   a storage (472) that stores a measurement result measured by the measurer.

2. The refrigerant amount measurement system according to claim 1, wherein

   the connecting portion includes a first pipe (410) and a second pipe (420), and
   each of the first pipe and the second pipe is provided with an on-off valve (230).

3. The refrigerant amount measurement system ac-

cording to claim 2, further comprising a control unit (140) that performs a first refrigerant amount measurement operation of controlling the first refrigeration cycle apparatus and the on-off valve to transfer the refrigerant from the first refrigerant circuit to the reservoir, cause the measurer to measure the amount of the refrigerant, and return the refrigerant from the reservoir to the first refrigerant circuit.

4. The refrigerant amount measurement system according to claim 3, wherein

the connecting portion is also connected to a second refrigerant circuit of a second refrigeration cycle apparatus (100B),
the connecting portion further includes a third pipe (430) and a fourth pipe (440) each provided with an on-off valve, and
the connecting portion is connected to the first refrigerant circuit by the first pipe and the second pipe and is connected to the second refrigerant circuit by the third pipe and the fourth pipe.

5. The refrigerant amount measurement system according to claim 4, wherein the control unit performs a second refrigerant amount measurement operation of controlling the second refrigeration cycle apparatus and the on-off valve to transfer the refrigerant from the second refrigerant circuit to the reservoir, cause the measurer to measure the amount of the refrigerant, and return the refrigerant from the reservoir to the second refrigerant circuit.

6. The refrigerant amount measurement system according to claim 5, wherein the control unit performs the first refrigerant amount measurement operation and the second refrigerant amount measurement operation at different times.

7. The refrigerant amount measurement system according to claim 5 or 6, wherein

the control unit performs the first refrigerant amount measurement operation in a time zone in which a normal operation of the first refrigeration cycle apparatus is stopped, and
the control unit performs the second refrigerant amount measurement operation in a time zone in which a normal operation of the second refrigeration cycle apparatus is stopped.

8. The refrigerant amount measurement system according to any one of claims 5 to 7, wherein

the control unit performs a first reserving operation of transferring the refrigerant from the first refrigerant circuit to the reservoir when the refrigerant leaks from the first refrigerant circuit, and
the control unit performs a second reserving operation of transferring the refrigerant from the second refrigerant circuit to the reservoir when the refrigerant leaks from the second refrigerant circuit.

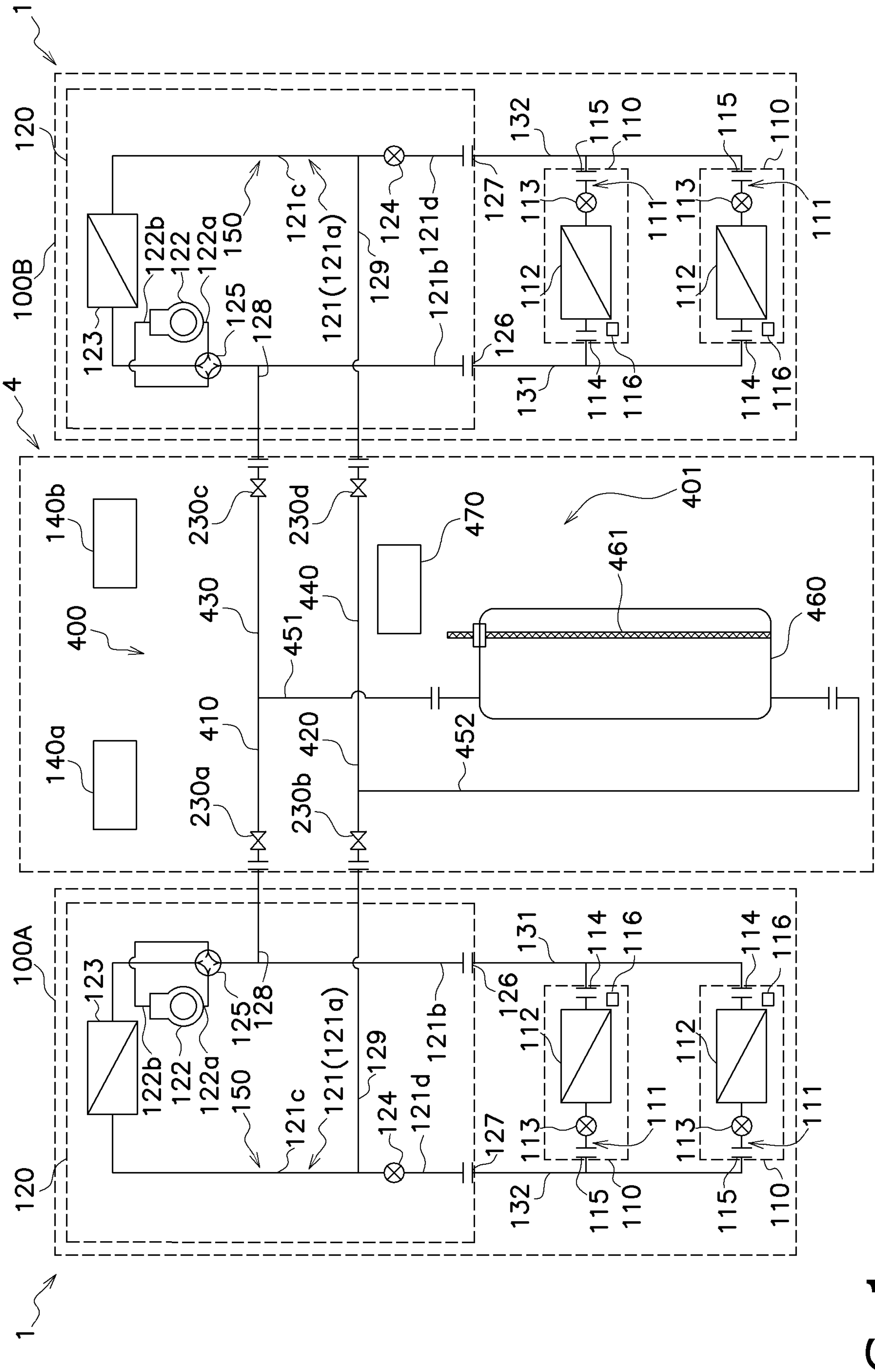
9. The refrigerant amount measurement system according to any one of claims 1 to 8, wherein the measurer includes an electrode rod (461).

10. The refrigerant amount measurement system according to claim 9, wherein the measurer further includes a cylindrical member (462) surrounding the electrode rod.

11. The refrigerant amount measurement system according to any one of claims 1 to 10, wherein the measurer measures the amount of the refrigerant by at least one method of a radio wave method, an ultrasonic method, a float method, a pressure method, a differential pressure method, and an electrostatic capacitance method.

12. A refrigerant use system (1) comprising:

a refrigeration cycle apparatus; and
the refrigerant amount measurement system according to any one of claims 1 to 11.


1
4
100A
100B
120
121(121a)
121b
121c
121d
122
122a
122b
123
124
125
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127
128
129
131
132
110
111
112
113
114
115
116
150
140a
140b
400
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410
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440
451
452
460
461
470
230a
230b
230c
230d

FIG. 1

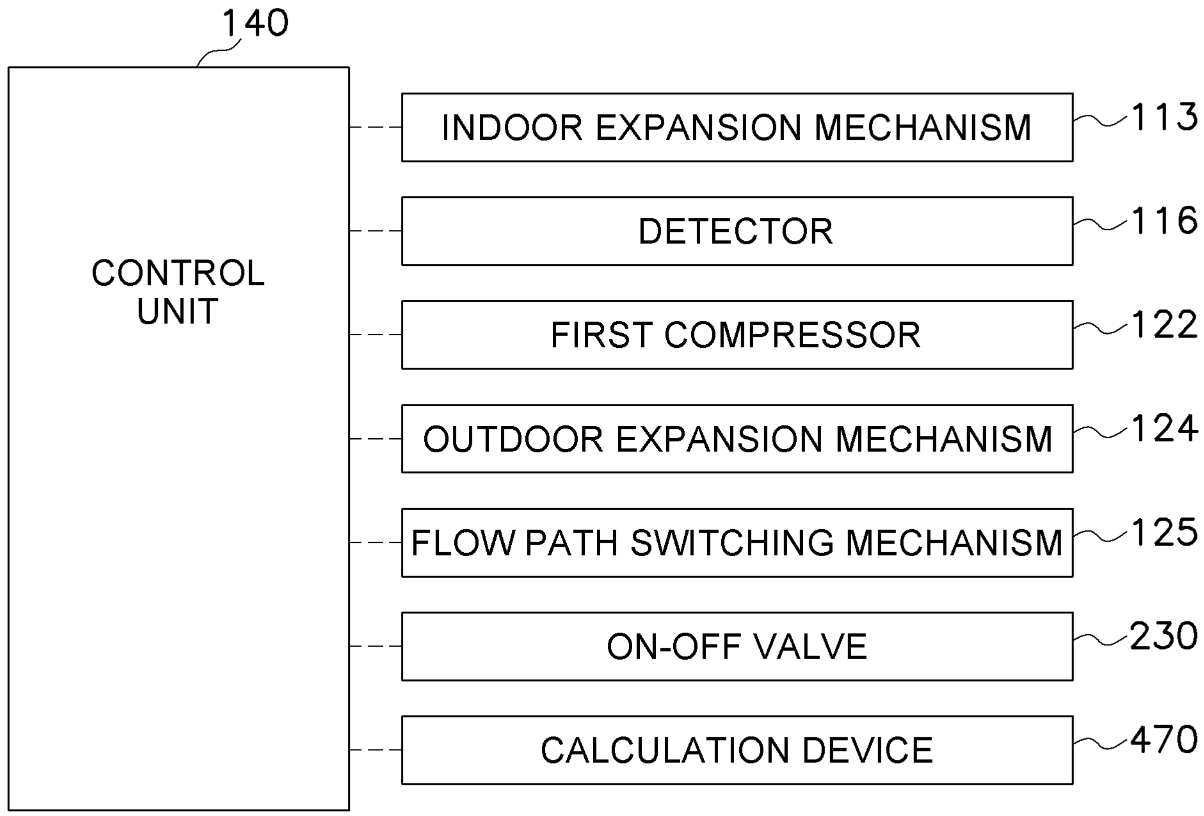

140
CONTROL UNIT
INDOOR EXPANSION MECHANISM
113
DETECTOR
116
FIRST COMPRESSOR
122
OUTDOOR EXPANSION MECHANISM
124
FLOW PATH SWITCHING MECHANISM
125
ON-OFF VALVE
230
CALCULATION DEVICE
470

FIG. 2

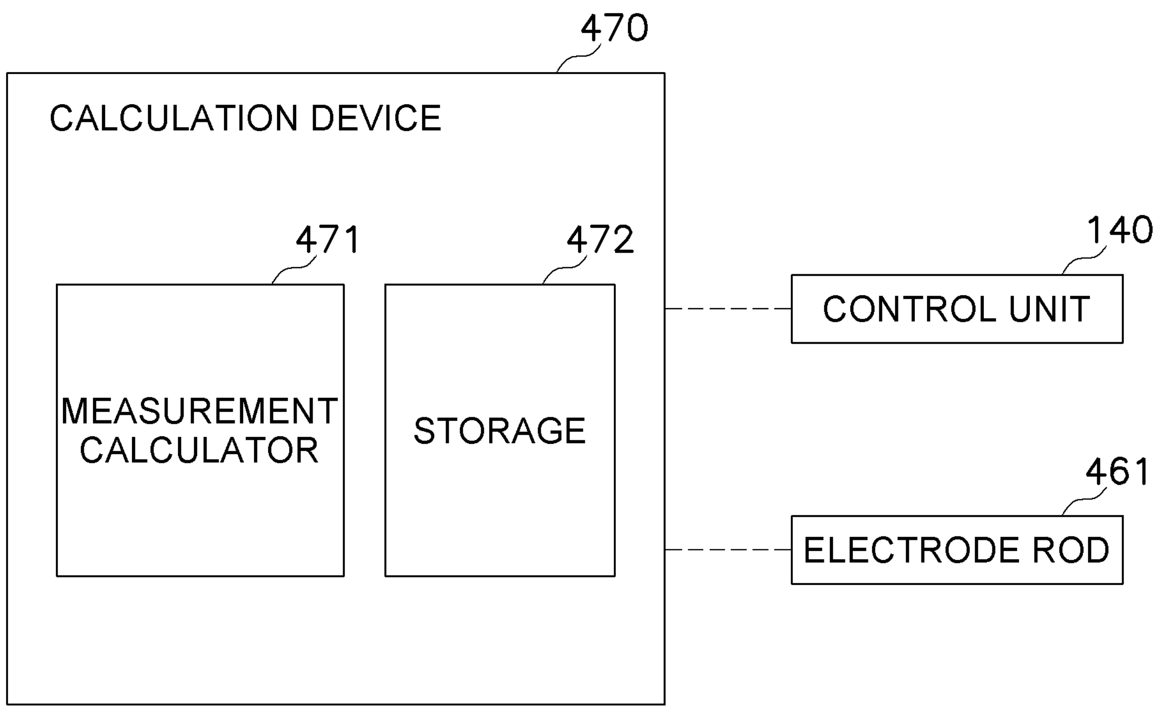

470
CALCULATION DEVICE
471
MEASUREMENT CALCULATOR
472
STORAGE
140
CONTROL UNIT
461
ELECTRODE ROD

FIG. 3

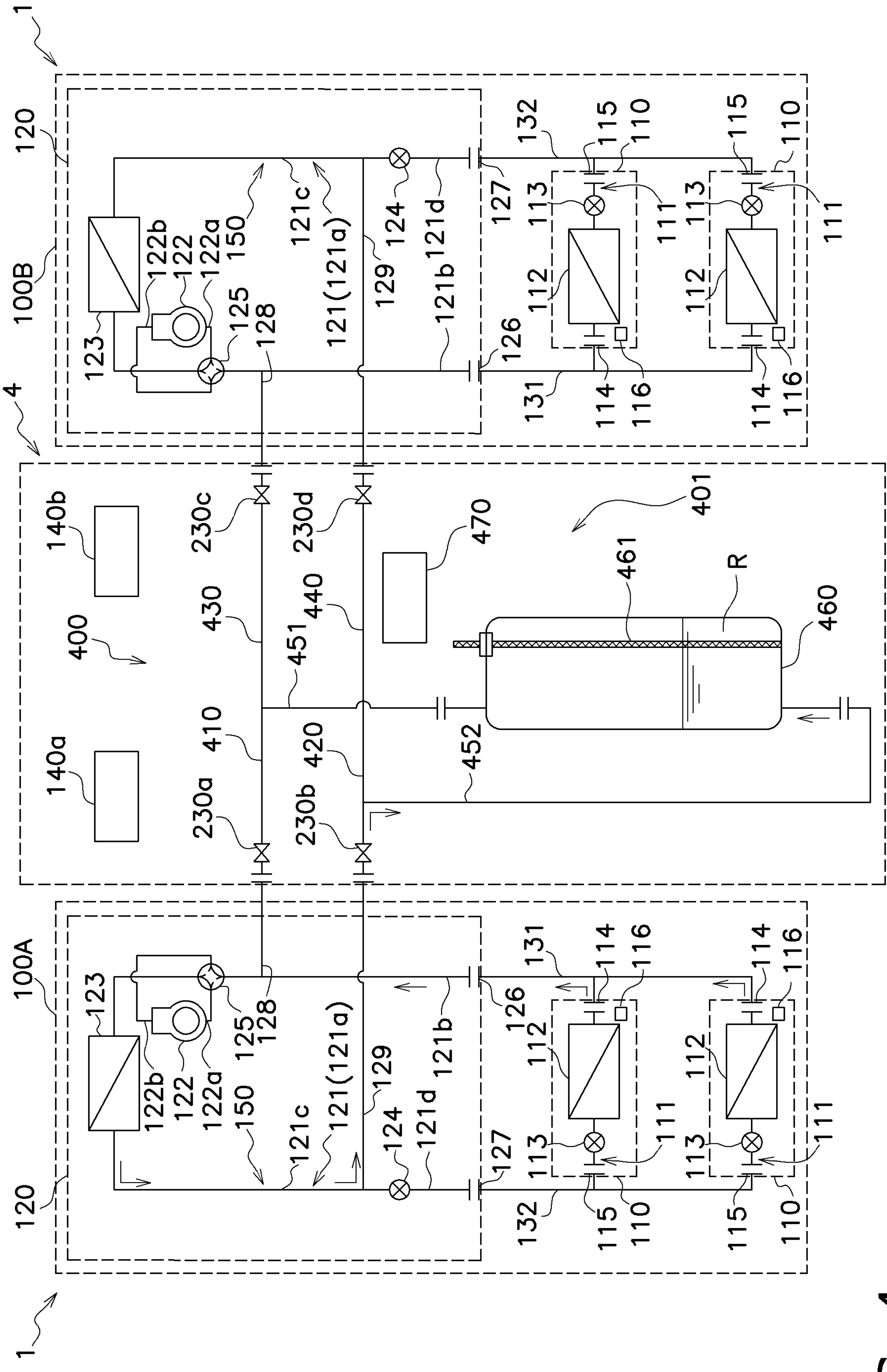

1
120
100B
4
123
122b
122
122a
125
128
150
121c
121(121a)
129
124
121d
121b
126
127
132
131
115
110
113
111
112
114
116
140a
140b
400
230a
230b
230c
230d
410
420
430
440
451
452
470
461
R
460
401
100A

FIG. 4

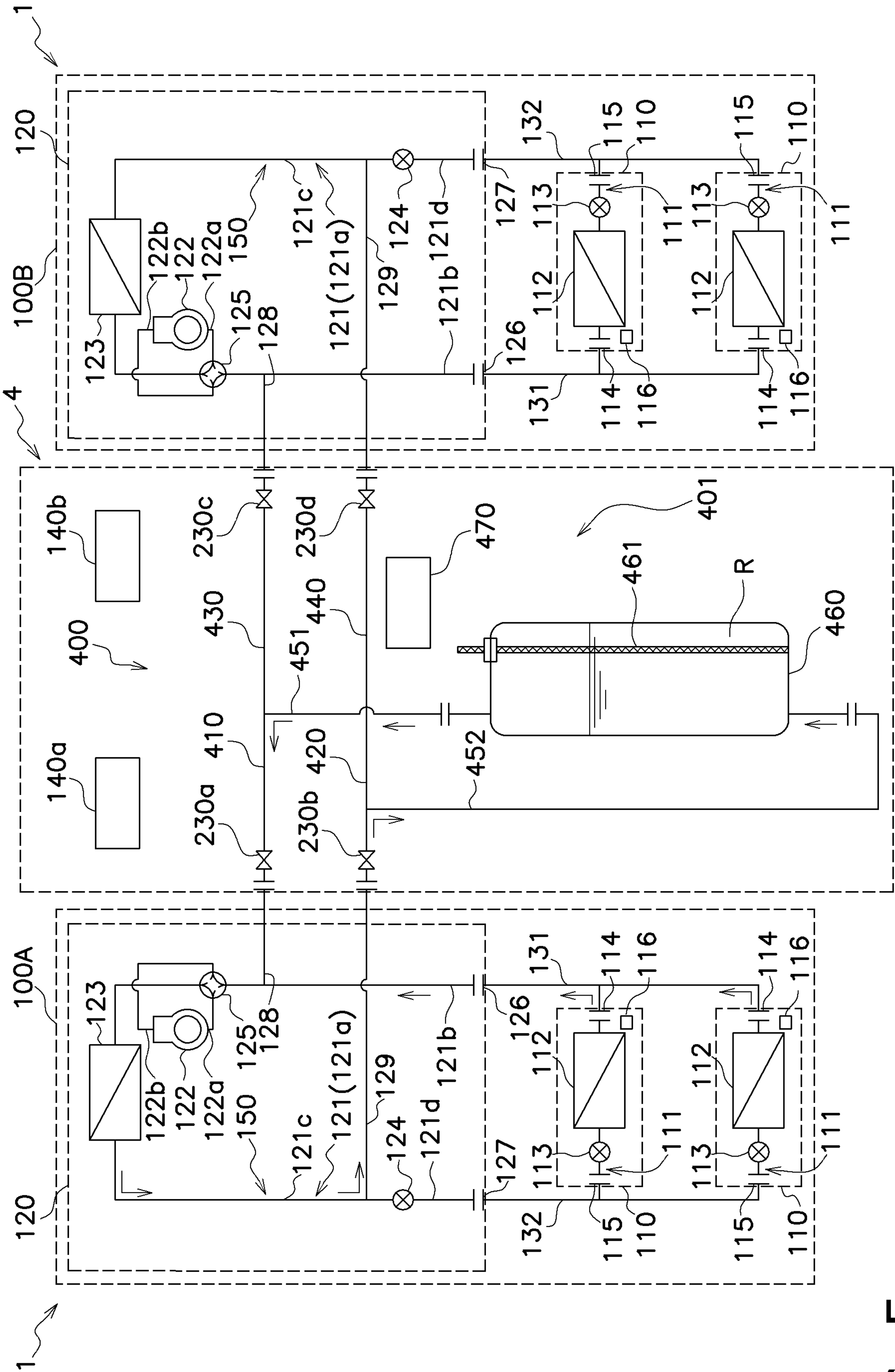

1
120
100B
123
122b
122
122a
125
128
150
121c
121(121a)
129
124
121d
121b
126
127
132
115
110
113
111
112
131
114
116
4
140b
140a
400
230c
230d
430
440
451
410
420
230a
230b
452
470
401
461
R
460
100A

FIG. 5

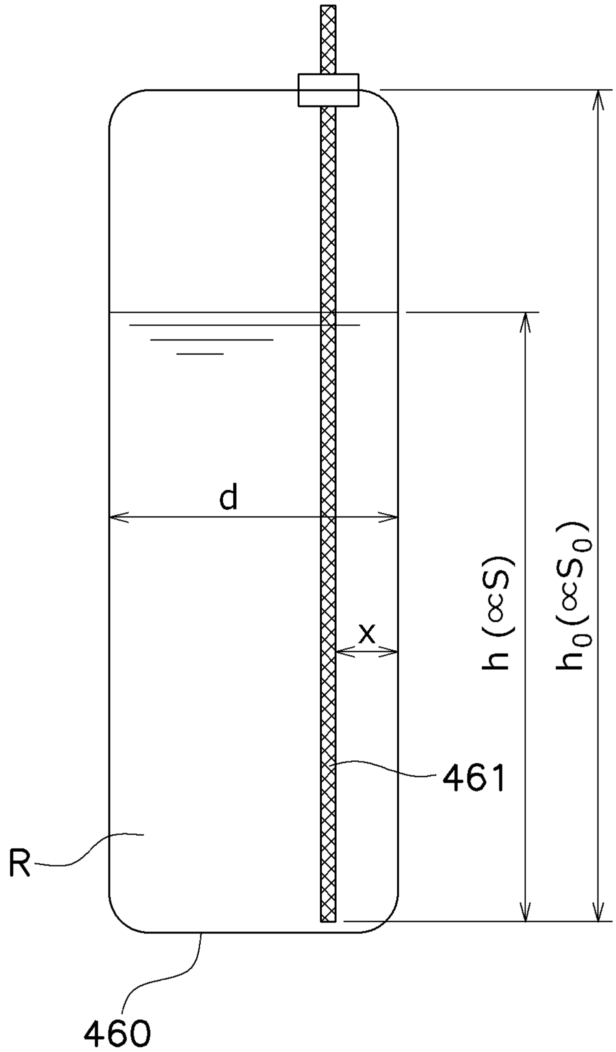


FIG. 6

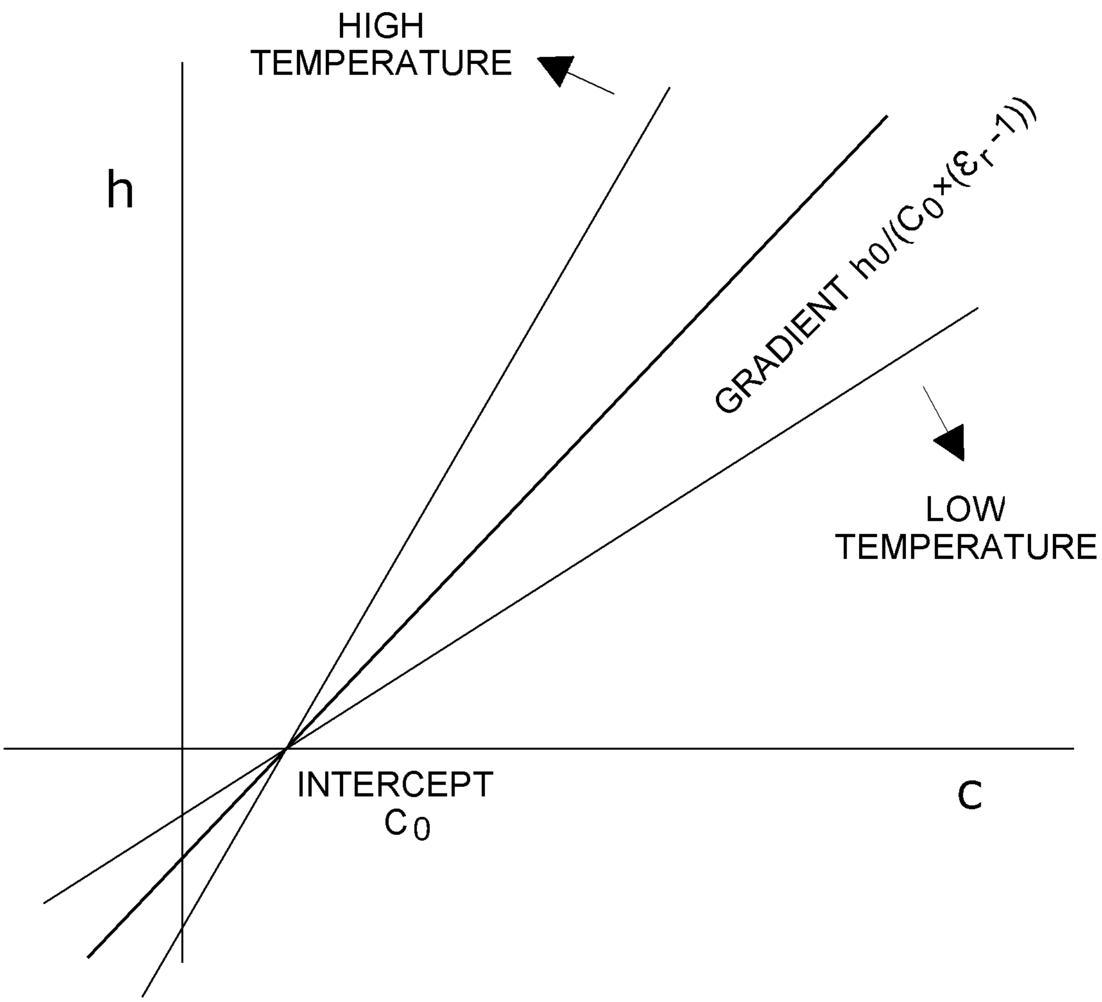
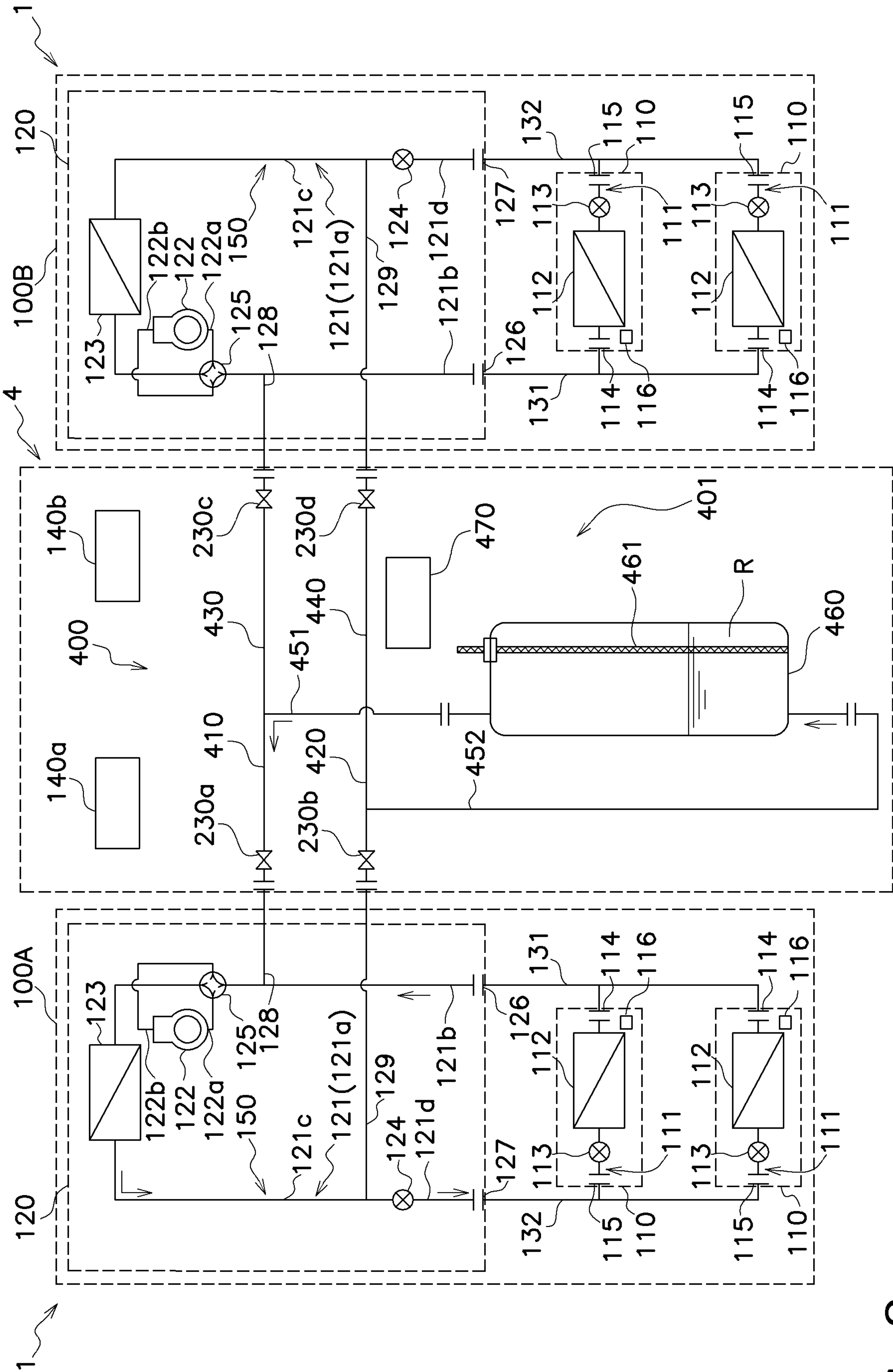

HIGH
TEMPERATURE
h
GRADIENT h0/(C0×(εr-1))
LOW
TEMPERATURE
INTERCEPT
C0
c

FIG. 7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122a
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128
150
121c
121(121a)
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121b
121d
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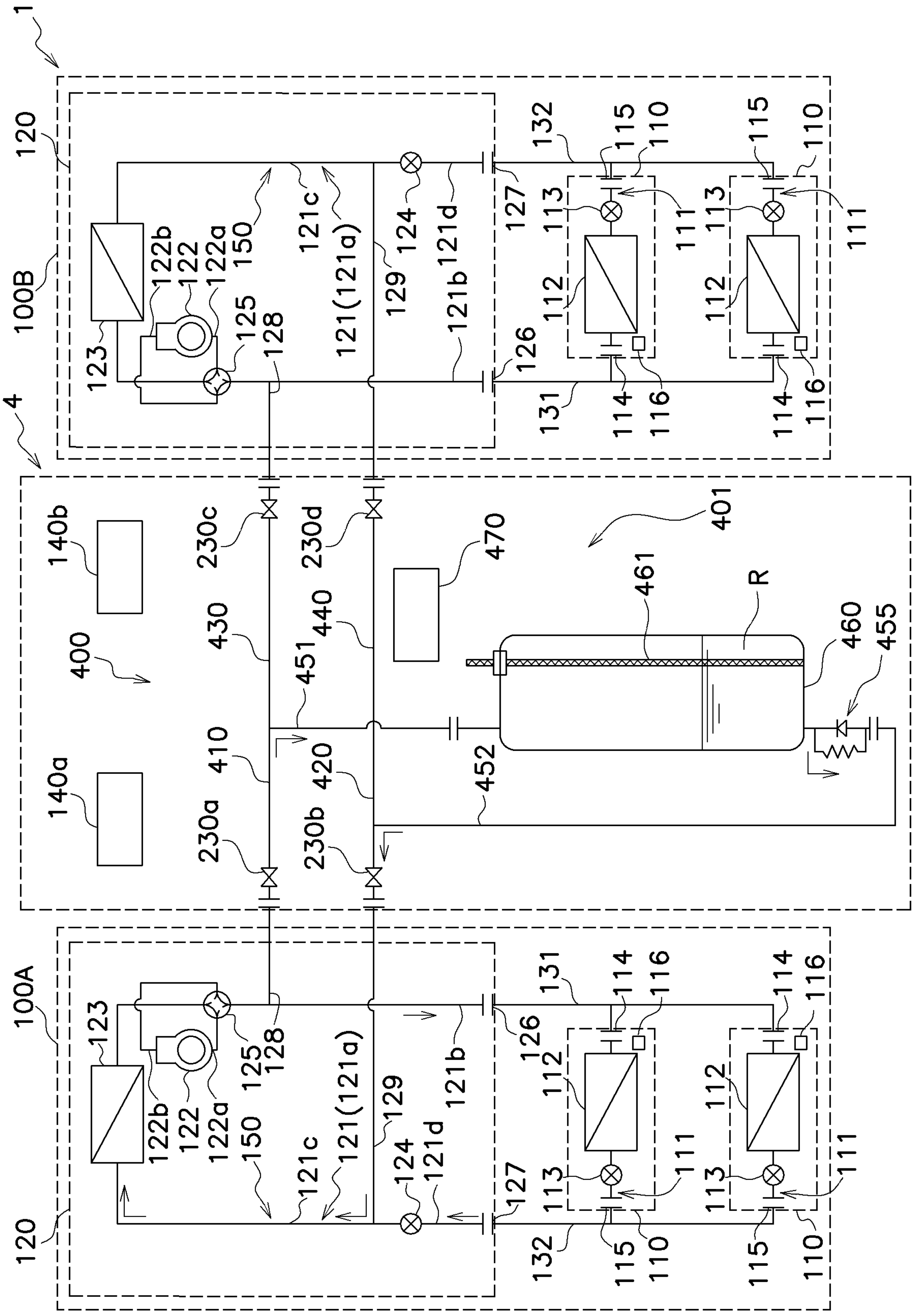
127
132
131
115
110
113
111
112
114
116
140b
140a
400
230c
230d
230a
230b
430
440
451
410
420
452
470
401
461
R
460
100A

FIG. 8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122b
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122a
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150
128
121c
121(121a)
129
124
121b
121d
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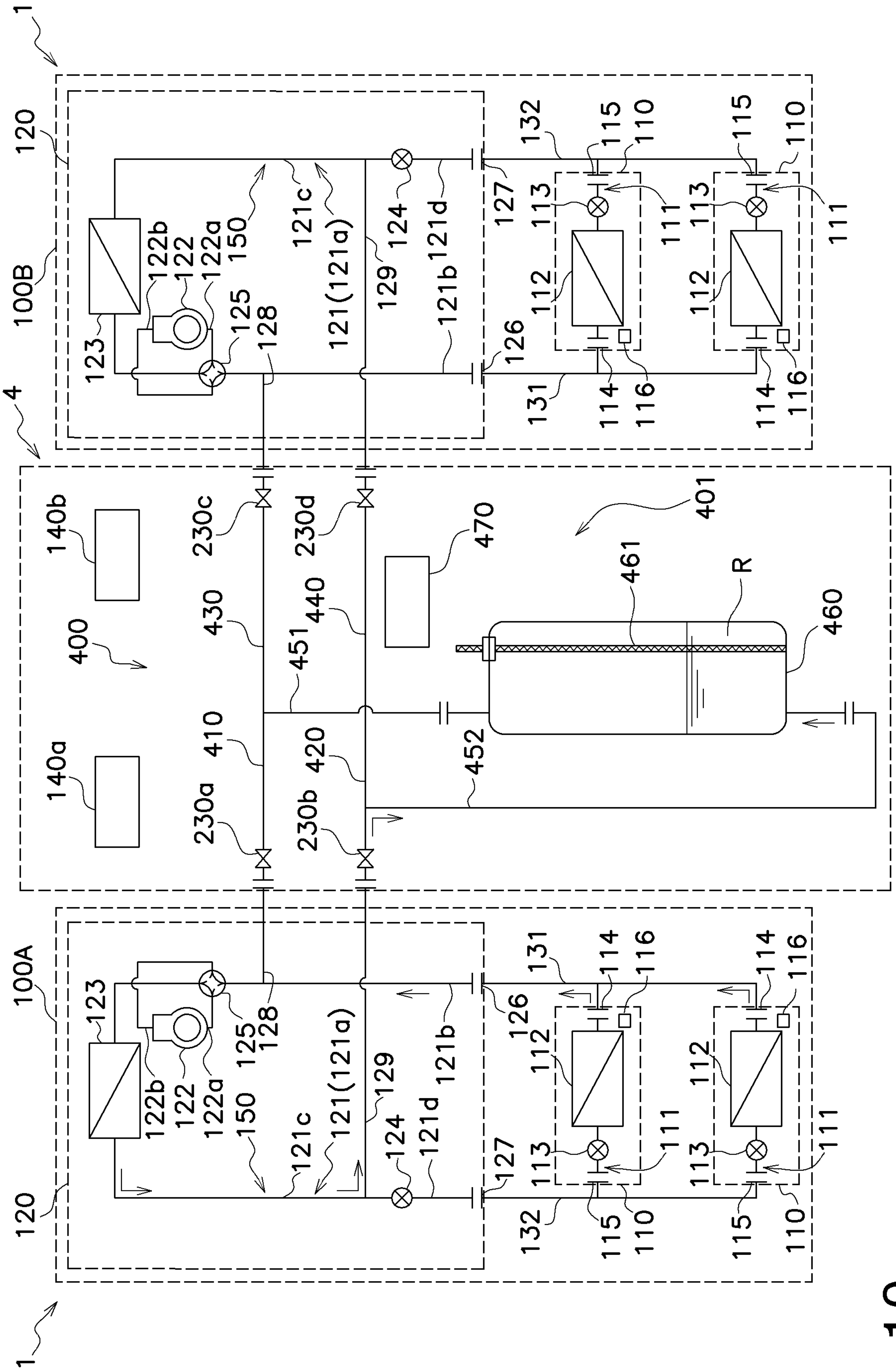
127
132
115
110
113
111
112
116
114
131
4
140b
140a
400
230c
230d
230a
230b
430
440
451
410
420
452
470
401
461
R
460
455
100A

FIG. 9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4
100A
100B
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121(121a)
121b
121c
121d
122
122a
122b
123
124
125
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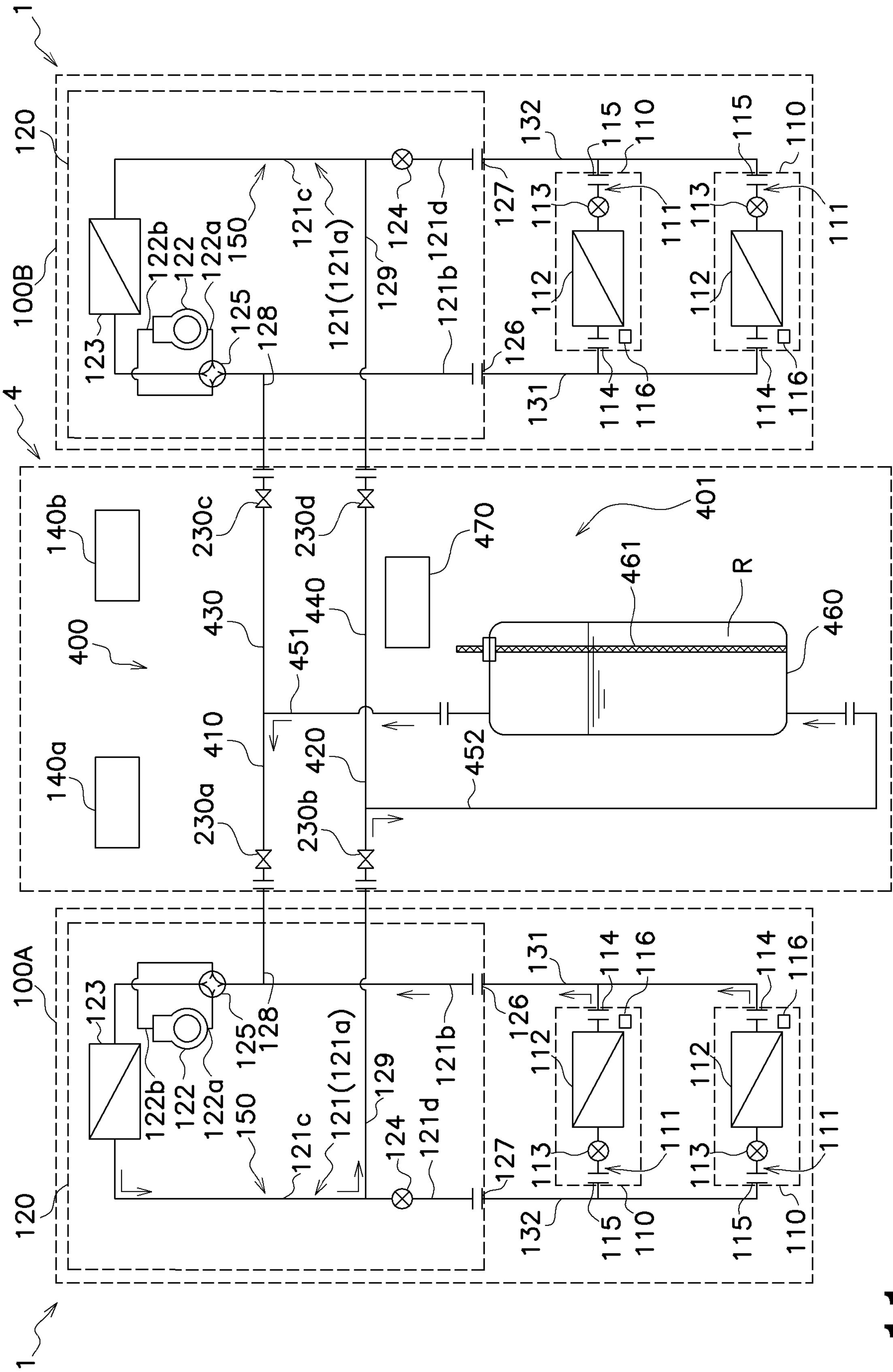
129
150
110
111
112
113
114
115
116
131
132
400
401
140a
140b
230a
230b
230c
230d
410
420
430
440
451
452
460
461
470
R

FIG. 10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4
100A
100B
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121(121a)
121b
121c
121d
122
122a
122b
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124
125
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150
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116
131
132
400
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230b
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452
460
461
470
R

FIG. 11

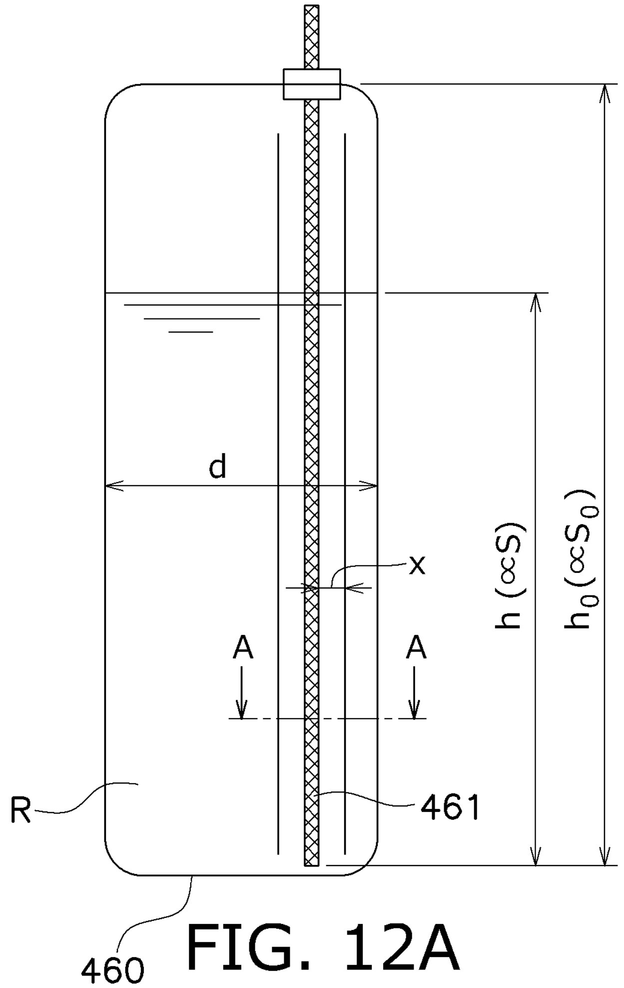

FIG. 12A

CROSS SECTION AA

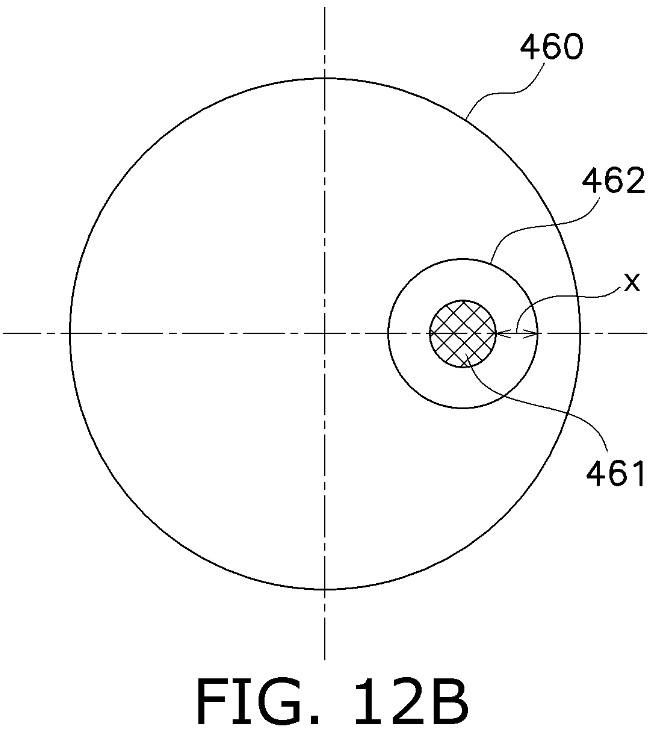

FIG. 12B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/023655

A. CLASSIFICATION OF SUBJECT MATTER

F25B 43/00(2006.01)i; ***F25B 45/00***(2006.01)i; ***F25B 1/00***(2006.01)i; ***F25B 49/02***(2006.01)i
FI: F25B49/02 520Z; F25B43/00 F; F25B45/00 D; F25B45/00 F; F25B1/00 397B; F25B1/00 391

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)

F25B43/00; F25B45/00; F25B1/00; F25B49/02

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2018-71955 A (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC) 10 May 2018 (2018-05-10) paragraphs [0048], [0068]-[0070], fig. 7	1-3
Y	paragraphs [0048], [0068]-[0070], fig. 7	2-5, 9-12
A	entire text, all drawings	6-8
Y	JP 7-218008 A (HITACHI LTD) 18 August 1995 (1995-08-18) paragraph [0030], fig. 5	9-12
X	WO 2017/037771 A1 (MITSUBISHI ELECTRIC CORP) 09 March 2017 (2017-03-09) paragraphs [0083], [0099], fig. 15	1
Y	paragraphs [0083], [0099], fig. 15	2-5, 9-12

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 September 2023	**12 September 2023**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/023655

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2018-71955 A	10 May 2018	(Family: none)	
JP 7-218008 A	18 August 1995	(Family: none)	
WO 2017/037771 A1	09 March 2017	US 2018/0231286 A1 paragraphs [0119], [0136], fig. 15 EP 3343133 A1 CN 107923680 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2010190545 A **[0003] [0201]**