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(54) **REFRIGERATION CYCLE DEVICE**

KÄLTEKREISLAUFVORRICHTUNG

DISPOSITIF À CYCLE DE RÉFRIGÉRATION

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Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus including a relay unit.

Background Art

[0002] There has heretofore been a technique for identifying an abnormality in a device mounted in a refrigeration cycle apparatus (see, for example, Patent Literature 1).

[0003] According to Patent Literature 1, in a case in which an indoor unit expansion valve is a device to be subjected to an abnormality judgment, a comparison between operating states is made by comparing a current opening degree and a current degree of superheating of the indoor unit expansion valve with a past opening degree and a past degree of superheating of the indoor unit expansion valve under equal load conditions, for example, during cooling operation. That is the opening degree of the indoor unit expansion valve is an operating point of the device, and the degree of superheating is a quantity of state of the device. Since it has been previously verified that the indoor unit expansion valve operates in a predetermined control range, the indoor unit expansion valve is subjected to an abnormality judgment based on the opening degree of the indoor unit expansion valve and the magnitude of the degree of superheating associated therewith.

[0004] Moreover, Patent Literature 2 and Patent Literature 5 disclose a refrigeration cycle apparatus according to the preamble of claim 1.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2016-084969
Patent Literature 2: JP2016508590
Patent Literature 3: WO2017033240
Patent Literature 4: EP3470291
Patent Literature 5: JP 6628911
Patent Literature 6: WO2016/174767

Summary of Invention

Technical Problem

[0006] There has hithereto been a refrigeration cycle apparatus including an outdoor unit, a plurality of indoor units, and a relay unit having a plurality of high-pressure valves and a plurality of low-pressure valves. In the case of occurrence of an open-lock abnormality (i.e. an abnormality of a high-pressure or low-pressure valve remaining open and becoming unable to be closed) in such a refrigeration cycle apparatus, it has been difficult to identify such an abnormality with the technique of Patent Literature 1.

[0007] The present invention was made to solve such a problem as that mentioned above, and has as an object to provide a refrigeration cycle apparatus capable of, when including a relay unit having a plurality of high-pressure valves and a plurality of low-pressure valves, identifying an open-lock abnormality in the high-pressure valves or the low-pressure valves.

Solution to Problem

[0008] A refrigeration cycle apparatus according to claim 1 is provided. The refrigeration cycle apparatus includes an outdoor unit including a compressor and an outdoor heat exchanger, a plurality of indoor units each including an indoor heat exchanger and an expansion device, a relay unit intervening between the outdoor unit and each of the plurality of indoor units and serving to cause refrigerant from the outdoor unit to branch off into each of the indoor units, a refrigerant circuit in which the compressor, the outdoor heat exchanger, the expansion device and the indoor heat exchanger are connected by refrigerant pipes and through which refrigerant circulates, and a controller configured to control the plurality of indoor units. The relay unit includes a plurality of high-pressure valves each provided in a corresponding one of a plurality of high-pressure pipes connecting a high-pressure side of the outdoor unit and each of the indoor units and a plurality of low-pressure valves each provided in a corresponding one of a plurality of low-pressure pipes connecting a low-pressure side of the outdoor unit and each of the indoor units. The controller is configured to, when an operation state of at least one of the indoor units is changed from a first state to a second state, judge, based on a degree of supercooling of an outlet of the outdoor heat exchanger or the indoor heat exchanger that functions as a condenser or based on a degree of superheating of a suction side of the compressor, whether an abnormality is present in the plurality of high-pressure valves or the plurality of low-pressure valves.

Advantageous Effects of Invention

[0009] The refrigeration cycle apparatus is configured to, when an operation state of at least one of the indoor units is changed from a first state to a second state, judge, based on a degree of supercooling of an outlet of the outdoor heat exchanger or the indoor heat exchanger that functions as a condenser or based on a degree of superheating of a suction side of the compressor, whether an abnormality is present in the plurality of high-pressure valves or the plurality of low-pressure valves. This makes it possible to, when including a relay unit having a plurality of high-pressure valves and a plurality of low-pressure valves, identify an open-lock abnormality in the high-pressure valves or the low-pressure valves.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a diagram showing a configuration of a refrigeration cycle apparatus according to Embodiment 1.

[Fig. 2] Fig. 2 is a diagram showing a refrigerant circuit state where two indoor units of the refrigeration cycle apparatus according to Embodiment 1 are both in cooling operation.

[Fig. 3] Fig. 3 is a diagram showing a refrigerant circuit state where one of the two indoor units of the refrigeration cycle apparatus according to Embodiment 1 is in cooling operation and the other of the two indoor units is under suspension.

[Fig. 4] Fig. 4 is a diagram showing a refrigerant circuit state where one of high-pressure valves of the refrigeration cycle apparatus according to Embodiment 1 is in a state of open-lock abnormality and the two indoor units are both in cooling operation.

[Fig. 5] Fig. 5 is a diagram showing a refrigerant circuit state where one of the high-pressure valves of the refrigeration cycle apparatus according to Embodiment 1 is in a state of open-lock abnormality, one of the two indoor units is in cooling operation, and the other of the two indoor units is under suspension.

[Fig. 6] Fig. 6 is a pressure-enthalpy diagram of refrigerant flowing through a bypass in the refrigeration cycle apparatus according to Embodiment 1.

[Fig. 7] Fig. 7 is a pressure-enthalpy diagram of refrigerant not flowing through a bypass in the refrigeration cycle apparatus according to Embodiment 1.

[Fig. 8] Fig. 8 is a flow chart showing a flow of control of the refrigeration cycle apparatus according to Embodiment 1 during an abnormality sensing mode.

[Fig. 9] Fig. 9 is a flow chart showing a flow of control of a modification of the refrigeration cycle apparatus according to Embodiment 1 during an abnormality sensing mode.

[Fig. 10] Fig. 10 is a diagram showing a refrigerant circuit state where two indoor units of a refrigeration cycle apparatus according to Embodiment 2 are both in heating operation.

[Fig. 11] Fig. 11 is a diagram showing a refrigerant circuit state where one of the two indoor units of the refrigeration cycle apparatus according to Embodiment 2 is in heating operation and the other of the two indoor units is under suspension.

[Fig. 12] Fig. 12 is a diagram showing a refrigerant circuit state where one of low-pressure valves of the refrigeration cycle apparatus according to Embodiment 2 is in a state of open-lock abnormality and the two indoor units are both in heating operation.

[Fig. 13] Fig. 13 is a diagram showing a refrigerant circuit state where one of the low-pressure valves of the refrigeration cycle apparatus according to Embodiment 2 is in a state of open-lock abnormality, one of the two indoor units is in heating operation, and the other of the two indoor units is under suspension.

[Fig. 14] Fig. 14 is a flow chart showing a flow of control of the refrigeration cycle apparatus according to Embodiment 2 during the abnormality sensing mode.

[Fig. 15] Fig. 15 is a flow chart showing a flow of control of a modification of the refrigeration cycle apparatus according to Embodiment 2 during an abnormality sensing mode.

[Fig. 16] Fig. 16 is a diagram showing a configuration of a refrigeration cycle apparatus according to Embodiment 3.

[Fig. 17] Fig. 17 is a diagram showing a refrigerant circuit state where two indoor units of the refrigeration cycle apparatus according to Embodiment 3 are both in cooling operation.

[Fig. 18] Fig. 18 is a diagram showing a refrigerant circuit state where one of the two indoor units of the refrigeration cycle apparatus according to Embodiment 3 is in cooling operation and the other of the two indoor units is under suspension.

[Fig. 19] Fig. 19 is a diagram showing a refrigerant circuit state where one of high-pressure valves of the refrigeration cycle apparatus according to Embodiment 3 is in a state of open-lock abnormality and the two indoor units are both in cooling operation.

[Fig. 20] Fig. 20 is a diagram showing a refrigerant circuit state where one of the high-pressure valves of the refrigeration cycle apparatus according to Embodiment 3 is in a state of open-lock abnormality, one of the two indoor units is in cooling operation, and the other of the two indoor units is under suspension.

[Fig. 21] Fig. 21 is a diagram showing a refrigerant circuit state where two indoor units of a refrigeration cycle apparatus according to Embodiment 4 are both in heating operation.

[Fig. 22] Fig. 22 is a diagram showing a refrigerant circuit state where one of the two indoor units of the refrigeration cycle apparatus according to Embodiment 4 is in heating operation and the other of the two indoor units is under suspension.

[Fig. 23] Fig. 23 is a diagram showing a refrigerant circuit state where one of low-pressure valves of the refrigeration cycle apparatus according to Embodiment 4 is in a state of open-lock abnormality and the two indoor units are both in heating operation.

[Fig. 24] Fig. 24 is a diagram showing a refrigerant circuit state where one of the low-pressure valves of the refrigeration cycle apparatus according to Embodiment 4 is in a state of open-lock abnormality, one of the two indoor units is in heating operation, and the other of the two indoor units is under suspension.

Description of Embodiments

[0011] The following describes embodiments of the present disclosure with reference to the drawings. It should be noted that the present disclosure is not limited by the embodiments to be described below. Further, relationships in size between one component and another in the following drawings may be different from actual ones.

Embodiment 1

[0012] Fig. 1 is a diagram showing a configuration of a refrigeration cycle apparatus 100 according to Embodiment 1.

[0013] Embodiment 1 takes, as an example of the refrigeration cycle apparatus 100, an air-conditioning apparatus, configured to carry out cooling operation and heating operation, in which, as shown in Fig. 1, two indoor units 20a and 20b are connected via a relay unit 40 to one outdoor unit 10. It should be noted that although Fig. 1 shows a configuration in which the refrigeration cycle apparatus 100 includes the two indoor units 20a and 20b, the refrigeration cycle apparatus 100 needs only include more than one indoor unit.

[0014] The refrigeration cycle apparatus 100 includes the outdoor unit 10, the two indoor units 20a and 20b, and the relay unit 40. Moreover, refrigerant having flowed out of the outdoor unit 10 is caused by the relay unit 40 to branch off into the two indoor units 20a and 20b, and flows into each of the indoor units 20a and 20b. Then, the refrigerant having flowed out of each of the indoor units 20a and 20b returns to the outdoor unit 10 via the relay unit 40 again.

[0015] The outdoor unit 10 includes a compressor 11, an outdoor heat exchanger 12, a flow switching device 13, a refrigerant connecting pipes 18 and 19, check valves 14 to 17, temperature sensors 53, 54a, and 54b, and a pressure sensor 61.

[0016] The indoor unit 20a includes an expansion device 21a and an indoor heat exchanger 22a. Similarly, the indoor unit 20b includes an expansion device 21b and an indoor heat exchanger 22b.

[0017] The relay unit 40 includes high-pressure pipes 46a and 46b, low-pressure pipes 47a and 47b, high-pressure valves 41a and 41b, low-pressure valves 42a and 42b, valves 43 and 44, and a reservoir 45.

[0018] The refrigeration cycle apparatus 100 includes a refrigerant circuit 1 in which the compressor 11, the flow switching device 13, the outdoor heat exchanger 12, the reservoir 45, the expansion devices 21a and 21b, and the indoor heat exchangers 22a and 22b are connected by refrigerant pipes and through which refrigerant circulates.

[0019] Further, the refrigeration cycle apparatus 100 includes a controller 30, a notifying unit 36, and an operation mode switching unit 37, and the notifying unit 36 and the operation mode switching unit 37 are each connected to the controller 30. It should be noted that the notifying unit 36 and the operation mode switching unit 37 may be provided in the controller 30 as part of the controller 30.

[0020] The compressor 11 is a fluid machine configured to suction low-temperature and low-pressure gas refrigerant, compress the low-temperature and low-pressure gas refrigerant into high-temperature and high-pressure gas refrigerant, and discharge the high-temperature and high-pressure gas refrigerant. While the compressor 11 is in operation, refrigerant circulates through the refrigerant circuit 1. The compressor 11 is for example an inverter-driven compressor with adjustable operating frequency. Further, operation of the compressor 11 is controlled by the controller 30.

[0021] The outdoor heat exchanger 12 exchanges heat between refrigerant and outdoor air, and functions as a condenser or an evaporator. A fan (not illustrated) may be provided near the outdoor heat exchanger 12, and in that case, the amount of heat that is exchanged with outdoor air can be changed by changing the rotation speed of the fan and thereby changing the volume of air.

[0022] The flow switching device 13 is for example a four-way valve, and enables switching between cooling operation and heating operation to be done by switching the direction of flow of refrigerant. Switching of the flow switching device 13 is controlled by the controller 30. It should be noted that as the flow switching device 13, a combination of a two-way valve and a three-way valve or other devices may be used instead of the four-way valve.

[0023] The check valve 14 permits unidirectional flow of refrigerant, is provided in a refrigerant pipe between the outdoor heat exchanger 12 and the relay unit 40, and causes refrigerant discharged from the compressor 11 to flow through the relay unit 40 during cooling operation. The check valve 15 permits unidirectional flow of refrigerant, is provided in the refrigerant connecting pipe 18, and causes refrigerant discharged from the compressor 11 to flow through the relay unit 40 during heating operation. The check valve 16 permits unidirectional flow of refrigerant, is provided in the refrigerant connecting pipe 19, and causes refrigerant having returned from the relay unit 40 to flow to a suction side of the compressor 11 during heating operation. The check valve 17 permits unidirectional flow of refrigerant, is provided in a refrigerant pipe between the flow switching device 13 and the relay unit 40, and causes refrigerant having returned from the relay unit 40 to flow to the suction side of the compressor 11 during cooling operation. These check valves 14 to 17 are indispensable for always supplying high-pressure refrigerant to the reservoir 45 even when the flow switching device 13 has switched.

[0024] The refrigerant connecting pipe 18 connects a refrigerant pipe between the flow switching device 13 and the check valve 17 and a refrigerant pipe between the check valve 14 and the relay unit 40 in the outdoor unit 10. The refrigerant connecting pipe 19 connects a refrigerant pipe between the check valve 17 and the relay unit 40 and a refrigerant pipe between the outdoor heat exchanger 12 and the check valve 14 in the outdoor unit 10.

[0025] The temperature sensor 53 is provided between the outdoor heat exchanger 12 and the reservoir 45, senses the temperature of an outlet side of the outdoor heat exchanger 12 while the outdoor heat exchanger 12 is functioning as a condenser during cooling operation, and outputs a sensing signal to the controller 30. Further, the temperature sensor 54a is provided between the expansion device 21a and the indoor heat exchanger 22a, senses the temperature of an outlet side of the indoor heat exchanger 22a while the indoor heat exchanger 22a is functioning as a condenser during heating operation, and outputs a sensing signal to the controller 30. Similarly, the temperature sensor 54b is provided between the expansion device 21b and the indoor heat exchanger 22b, senses the temperature of an outlet side of the indoor heat exchanger 22b while the indoor heat exchanger 22b is functioning as a condenser during heating operation, and outputs a sensing signal to the controller 30. The temperature sensors 53, 54a, and 54b are for example thermistors whose values of resistance change with temperature.

[0026] The pressure sensor 61 is provided at a discharge side of the compressor 11, senses the pressure of the discharge side of the compressor 11, and outputs a sensing signal to the controller 30. The pressure sensor 61 for example receives the pressure of refrigerant, hydraulically senses the pressure with a pressure sensitive element, converts the pressure into an electrical signal corresponding to the pressure, and outputs the electrical signal. Instead of the pressure sensor 61, a two-phase temperature sensor (not illustrated) configured to sense the temperature of two-phase refrigerant flowing through the outdoor heat exchanger 12 and output a sensing signal to the controller 30 may be provided at an intermediate position in a pipe forming the outdoor heat exchanger 12.

[0027] The expansion devices 21a and 21b cause refrigerant to adiabatically expand. Although the expansion devices 21a and 21b are for example electronic expansion valves or temperature expansion valves, they may be capillary tubes or other devices. The opening degrees of the expansion devices 21a and 21b are controlled by the controller 30 so that the degrees of superheating of outlet sides of the indoor heat exchangers 22a and 22b come close to target values.

[0028] The indoor heat exchangers 22a and 22b cause heat exchange to be performed between refrigerant and indoor air and function as condensers or evaporators. Fans (not illustrated) may be provided near the indoor heat exchangers 22a and 22b, and in that case, the amounts of heat that are exchanged with indoor air can be changed by changing the rotation speeds of the fans and thereby changing the volumes of air.

[0029] The high-pressure valve 41a is constituted, for example, by a two-way valve or other devices, is provided in the high-pressure pipe 46a between the reservoir 45 and the indoor unit 20a, and permits or blocks the flow of refrigerant from the relay unit 40 to the indoor unit 20a. The high-pressure valve 41b is constituted, for example, by a two-way valve or other devices, is provided in the high-pressure pipe 46b between the reservoir 45 and the indoor unit 20b, and permits or blocks the flow of refrigerant from the relay unit 40 to the indoor unit 20b. The high-pressure valves 41a and 41b are in an open state during supply of high-pressure refrigerant to the indoor units 20a and 20b, for example, during heating operation, and are in a closed state under suspension or during cooling operation.

[0030] The low-pressure valve 42a is constituted, for example, by a two-way valve or other devices, is provided in the low-pressure pipe 47a between the outdoor unit 10 and the indoor unit 20a, and permits or blocks the flow of refrigerant from the relay unit 40 to the outdoor unit 10. The low-pressure valve 42b is constituted, for example, by a two-way valve or other devices, is provided in the low-pressure pipe 47b between the outdoor unit 10 and the indoor unit 20b, and permits or blocks the flow of refrigerant from the relay unit 40 to the outdoor unit 10. The low-pressure valves 42a and 42b are in an open state during supply of low-pressure refrigerant to the indoor units 20a and 20b, for example, during cooling operation, and are in a closed state under suspension or during heating operation.

[0031] The reservoir 45 is an element device for achieving cooling and heating simultaneous operation, and holds liquid refrigerant. This reservoir 45, combined with the high-pressure valves 41a and 41b and the low-pressure valves 42a and 42b, makes it possible to supply refrigerant to the indoor units 20a and 20b in proper condition.

[0032] The valves 43 and 44 are element devices needed to achieve cooling and heating simultaneous operation, and may have adjustable opening degrees or may simply open and close without adjustable opening degrees. In a case in which the outdoor heat exchanger 12 functions as a condenser, the valves 43 and 44 are controlled so that the valve 43 is in an open state and the valve 44 is in a closed state, and in a case in which the outdoor heat exchanger 12 functions as an evaporator, the valves 43 and 44 are controlled so that the valve 43 is in a closed state and the valve 44 is in an open state.

[0033] The controller 30 is constituted, for example, by dedicated hardware or a CPU (also referred to as "central processing unit", "central processing apparatus", "processing apparatus", "arithmetic apparatus", "microprocessor", and "processor") configured to execute a program stored in the after-mentioned storage unit 31.

[0034] In a case in which the controller 30 is dedicated hardware, the controller 30 falls in the category of, for example, a single circuit, a complex circuit, an ASIC (application specific integrated circuit), an FPGA (Field Programmable Gate Array), or a combination thereof. Functional units that the controller 30 implements may each be implemented via separate pieces of hardware, or the functional units may all be implemented via one piece of hardware.

[0035] In a case in which the controller 30 is a CPU, functions that the controller 30 executes are implemented via software, firmware, or a combination of software and firmware. Software and firmware are described as programs and stored in the storage unit 31. The CPU implements each of the functions of the controller 30 by executing a program stored in the storage unit 31.

[0036] It should be noted that some of the functions of the controller 30 may be implemented via dedicated hardware and others may be implemented via software or firmware.

[0037] The controller 30 controls overall operation of the refrigeration cycle apparatus 100 by controlling the compressor 11, the expansion devices 21a and 21b, or other devices based on sensing signals from the various sensors provided in the refrigeration cycle apparatus 100, operating signals from an operating unit (not illustrated), or other signals. Further, the controller 30 makes an abnormality judgment on the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b. It should be noted that the controller 30 may be provided inside the outdoor unit 10 or the indoor units 20a and 20b or may be provided outside the outdoor unit 10 or the indoor units 20a and 20b.

[0038] The controller 30 includes the storage unit 31, an extraction unit 32, a computing unit 33, a comparing unit 34, and a judging unit 35 as functional blocks configured to make an abnormality judgement. The term "abnormality judgement" here means judging whether an abnormality is present in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b in the refrigeration cycle apparatus 100.

[0039] The storage unit 31 stores various types of information, and includes, for example, a rewritable nonvolatile semiconductor memory such as a flash memory, an EPROM, and an EEPROM. In addition to that, the storage unit 31 may include a non-rewritable nonvolatile semiconductor memory such as a ROM or a rewritable volatile semiconductor memory such as a RAM. The storage unit 31 stores temperature and pressure data sensed separately by each of the various sensors. It should be noted that these temperature and pressure data are regularly acquired during operation of the refrigeration cycle apparatus 100.

[0040] The extraction unit 32 extracts, from among the data stored in the storage unit 31, data needed for an abnormality judgment. Note here that an abnormality judgment involves the use of data extracted while the compressor 11 is operating. A reason for this is that while the compressor 11 is not operating, a proper judgment cannot be made as to whether an abnormality is present in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b.

[0041] The computing unit 33 carries out a necessary computation based on data extracted by the extraction unit 32.

[0042] The comparing unit 34 makes a comparison between a value obtained by a computation carried out by the computing unit 33 and a threshold set in advance or a comparison between values obtained by computations carried out by the computing unit 33.

[0043] The judging unit 35 makes, based on a result of a comparison made by the comparing unit 34, a judgment as to whether an abnormality is present in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b.

[0044] The notifying unit 36 provides notification of various types of information such as the occurrence of an abnormality upon command from the controller 30. The notifying unit 36 includes at least either display means for providing visual notification of information or audio output means for providing auditory notification of information.

[0045] The operation mode switching unit 37 accepts, from a user, an operation of switching from one operation mode to another. When an operation of switching from one operation mode to another is done with the operation mode switching unit 37, a signal is outputted from the operation mode switching unit 37 to the controller 30, and the controller 30 switches from one operation mode to another based on the signal. The controller 30 has at least a normal operation mode and an abnormality sensing mode as operation modes.

<Normal Operation>

[0046] Next, a normal operation of the refrigeration cycle apparatus 100 is described by taking cooling operation as an example. It should be noted that during cooling operation, the flow switching device 13 is switched so that the discharge side of the compressor 11 becomes connected to the outdoor heat exchanger 12.

[0047] Fig. 2 is a diagram showing a refrigerant circuit state where the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 1 are both in cooling operation.

[0048] First, a normal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in cooling operation is described with reference to Fig. 2.

[0049] High-temperature and high-pressure gas refrigerant discharged from the compressor 11 passes through the flow switching device 13, flows into the outdoor heat exchanger 12, exchanges heat with outdoor air through the outdoor heat exchanger 12, and condenses into high-pressure liquid refrigerant. After that, the high-pressure liquid refrigerant passes through the check valve 14, flows out of the outdoor unit 10, and flows into the relay unit 40. After having flowed into the relay unit 40, the high-pressure liquid refrigerant passes through the reservoir 45 and the valve 43 and braches into flows of refrigerant that then flow out of the relay unit 40 and flow separately into each of the indoor units 20a and 20b.

After having flowed into the indoor units 20a and 20b, the liquid refrigerant is caused by the expansion devices 21a and 21b to adiabatically expand into low-temperature and low-pressure two-phase refrigerant. After that, the low-temperature and low-pressure two-phase refrigerant flows into the indoor heat exchangers 22a and 22b, exchanges heat with indoor air through the indoor heat exchangers 22a and 22b, and evaporates into low-temperature and low-pressure gas refrigerant. After that, the low-temperature and low-pressure gas refrigerant flows out of the indoor units 20a and 20b and flows into the relay unit 40. After having flowed into the relay unit 40, the flows of low-temperature and low-pressure gas refrigerant pass through the low-pressure valves 42a and 42b and merge into a flow of low-temperature and low-pressure gas refrigerant that then flows out of the relay unit 40. After having flowed out of the relay unit 40, the low-temperature and low-pressure gas refrigerant flows into the outdoor unit 10, passes through the check valve 17 and the flow switching device 13, and is suctioned into the compressor 11.

[0050] Fig. 3 is a diagram showing a refrigerant circuit state where one of the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 1 is in cooling operation and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 3, the indoor unit 20a is under suspension, and the indoor unit 20b is in cooling operation.

[0051] Next, a normal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in cooling operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 3.

[0052] When the indoor unit 20a is under suspension, the expansion device 21a of the indoor unit 20a thus suspended is in a closed state, and the low-pressure valve 42a, which is connected to the indoor unit 20a, is in a closed state. That is, all valves connected to an inlet side and the outlet side of the indoor heat exchanger 22a of the indoor unit 20a thus suspended are in a closed state, so that no refrigerant is supplied to the indoor heat exchanger 22a thus suspended.

<Abnormal Operation>

[0053] Next, an abnormal operation of the refrigeration cycle apparatus 100 is described by taking cooling operation as an example.

[0054] Fig. 4 is a diagram showing a refrigerant circuit state where one of the high-pressure valves 41a and 41b of the refrigeration cycle apparatus 100 according to Embodiment 1 is in a state of open-lock abnormality and the two indoor units 20a and 20b are both in cooling operation. In the refrigerant circuit state shown in Fig. 4, an open-lock abnormality is present in the high-pressure valve 41a. The term "open-lock abnormality" here refers to an abnormality of a valve remaining open and becoming unable to be closed.

[0055] First, an abnormal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in cooling operation is described with reference to Fig. 4.

[0056] As shown in Fig. 4, in a case in which an open-lock abnormality is present in the high-pressure valve 41a, high-pressure liquid refrigerant from the reservoir 45 flows in to a low-pressure side through the high-pressure valve 41a and the low-pressure valve 42a, with the result that the high-pressure liquid refrigerant flows through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0057] Fig. 5 is a diagram showing a refrigerant circuit state where one of the high-pressure valves 41a and 41b of the refrigeration cycle apparatus 100 according to Embodiment 1 is in a state of open-lock abnormality, one of the two indoor units 20a and 20b is in cooling operation, and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 5, an open-lock abnormality is present in the high-pressure valve 41a, the indoor unit 20a is under suspension, and the indoor unit 20b is in cooling operation.

[0058] Next, an abnormal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in cooling operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 5.

[0059] As shown in Fig. 5, since the indoor unit 20a is under suspension, all valves connected to the indoor heat exchanger 22a except the high-pressure valve 41a, which is in a state of open-lock abnormality, are in a closed state. That is, the expansion device 21a and the low-pressure valve 42a are in a closed state. Therefore, unlike in the case of the abnormal operation described with reference to Fig. 4, high-pressure liquid refrigerant does not flow through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0060] Depending on the presence or absence of such a bypass for refrigerant, there is a difference in value of at least either SC, which is the degree of supercooling of an outlet of the outdoor heat exchanger 12 that functions as a condenser, or SH_s, which is the degree of superheating of the suction side of the compressor 11. Accordingly, in Embodiment 1, these values are used to identify a valve with an open-lock abnormality. In the following, the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser is referred to as "degree of supercooling at condenser outlet", and the degree of superheating of the suction side of the compressor 11 is referred to as "degree of superheating at compressor suction".

[0061] Although not described in Embodiment 1, at the occurrence of refrigerant leakage, the amount of refrigerant in the refrigerant circuit 1 decreases, with the result that the degree of supercooling at condenser outlet SC decreases and the degree of superheating at compressor suction SH_s increases. This makes it possible to isolate a refrigerant leakage abnormality from an open-lock abnormality. Therefore, in sensing an open-lock abnormality, an action of isolating an open-lock abnormality from other abnormalities may be added. Examples of the action include checking for the absence of refrigerant leakage first before the start of the sensing.

[0062] Fig. 6 is a pressure-enthalpy diagram of refrigerant flowing through a bypass in the refrigeration cycle apparatus 100 according to Embodiment 1. Fig. 7 is a pressure-enthalpy diagram of refrigerant not flowing through a bypass in the refrigeration cycle apparatus 100 according to Embodiment 1. It should be noted that the pressure-enthalpy diagram shown in Fig. 6 represents the refrigerant circuit state shown in Fig. 4 and the pressure-enthalpy diagram shown in Fig. 7 represents the refrigerant circuit state shown in Fig. 5.

[0063] Next, the pressure-enthalpy diagram of refrigerant flowing through a bypass in the refrigeration cycle apparatus 100 according to Embodiment 1 and the pressure-enthalpy diagram of refrigerant not flowing through a bypass in the refrigeration cycle apparatus 100 according to Embodiment 1 are described with reference to Figs. 6 and 7, respectively.

[0064] In the refrigerant circuit state shown in Fig. 4, the presence of an open-lock abnormality in the high-pressure valve 41a causes the formation of a bypass for refrigerant, thus causing high-pressure refrigerant at the outlet side of the outdoor heat exchanger 12 to migrate to the low-pressure side and making it easy for the suction side of the compressor 11 to become wet. This results in decreases in the degree of supercooling at condenser outlet SC and the degree of superheating at compressor suction SH_s as shown in Fig. 6. At this point in time, no supercooled liquid is present at the outlet of the outdoor heat exchanger 12, and instead, liquid refrigerant is present at the suction side of the compressor 11. Further, in a case in which the degrees of superheating of the outlet sides of the indoor heat exchangers 22a and 22b are controlled, the suction side of the compressor 11 is in a state of gaining a degree of superheating, provided there is no bypass for refrigerant formed by the open-lock abnormality in the high-pressure valve 41a. However, since liquid refrigerant is present at the suction side of the compressor 11, it is found, as shown in Fig. 6, that refrigerant at the suction side of the compressor 11 is in a two-phase state or a saturated state.

[0065] In the refrigerant circuit state shown in Fig. 5, despite the presence of an open-lock abnormality in the high-pressure valve 41a, there is no bypass of refrigerant. Therefore, as shown in Fig. 7, high-pressure liquid refrigerant accumulates at the outlet of the outdoor heat exchanger 12, which is in a state of gaining a degree of supercooling. Further, since there is no bypass of refrigerant, the suction side of the compressor 11 too is in a state of gaining a degree of superheating as shown in Fig. 7.

[0066] As noted above, since, depending on the presence or absence of a bypass for refrigerant due to an open-lock abnormality, there are differences in value of the degree of supercooling of the outlet of the outdoor heat exchanger 12 and the degree of superheating of the suction side of the compressor 11, at least either of these values is checked. Doing so makes it possible to judge whether a bypass for refrigerant is present due to an open-lock abnormality.

[0067] Fig. 8 is a flow chart showing a flow of control of the refrigeration cycle apparatus 100 according to Embodiment 1 during the abnormality sensing mode.

[0068] In the abnormality sensing mode, a judgment is made as to whether an open-lock abnormality is present in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b. In Embodiment 1, a judgment is made as to whether an open-lock abnormality is present in the high-pressure valves 41a and 41b. When a predetermined period of time elapses during the normal operation mode or when an operation of switching from one operation mode to another is done with the operation mode switching unit 37, the controller 30 switches from the normal operation mode to the abnormality sensing mode and executes an abnormality judgment process shown in Fig. 8. The following describes the flow of control of the refrigeration cycle apparatus 100 according to Embodiment 1 during the abnormality sensing mode with reference to Fig. 8.

(Step S101)

[0069] The controller 30 brings all indoor units 20a and 20b under suspension. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the high-pressure valves 41a and 41b, the low-pressure valves 42a and 42b, and the valves 43 and 44 into a closed state.

(Step S102)

[0070] The controller 30 brings all indoor units 20a and 20b into cooling operation. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the low-pressure valves 42a and 42b, and the valve 43 into an open state.

(Step S103)

[0071] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 53 from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S104)

[0072] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than a threshold X set in advance. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold X (YES), the controller

30 proceeds to step S105. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold X (NO), the controller 30 proceeds to step S110. It should be noted that the threshold X is for example 4 and is a value that is set for higher operating efficiency.

(Step S105)

[0073] The controller 30 brings one indoor unit 20b under suspension. At this point in time, the controller 30 brings the expansion device 21b and the low-pressure valve 42b, which are connected to the indoor heat exchanger 22b, into a closed state.

(Step S106)

[0074] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 53 from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S107)

[0075] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than the threshold X. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold X (YES), the controller 30 proceeds to step S108. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold X (NO), the controller 30 proceeds to step S109.

(Step S108)

[0076] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the high-pressure valve 41a.

(Step S109)

[0077] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the high-pressure valve 41b.

(Step S110)

[0078] The controller 30 notifies through the notifying unit 36 that there is no abnormality in the high-pressure valve 41a or 41b. It should be noted that step S110 may be omitted.

[0079] Fig. 9 is a flow chart showing a flow of control of a modification of the refrigeration cycle apparatus 100 according to Embodiment 1 during an abnormality sensing mode. In the modification of Embodiment 1, a judgment is made as to whether an open-lock abnormality is present in the high-pressure valves 41a and 41b.

[0080] When a predetermined period of time elapses during the normal operation mode or when an operation of switching from one operation mode to another is done with the operation mode switching unit 37, the controller 30 switches from the normal operation mode to the abnormality sensing mode and executes an abnormality judgment process shown in Fig. 9. The following describes the flow of control of the refrigeration cycle apparatus 100 according to the modification of Embodiment 1 during the abnormality sensing mode with reference to Fig. 9.

(Step S201)

[0081] The controller 30 brings all indoor units 20a and 20b under suspension. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the high-pressure valves 41a and 41b, the low-pressure valves 42a and 42b, and the valves 43 and 44 into a closed state.

(Step S202)

[0082] The controller 30 brings one indoor unit 20a into cooling operation. At this point in time, the controller 30 brings the expansion device 21a and the low-pressure valve 42a, which are connected to the indoor heat exchanger 22a, and the valve 43 into an open state.

(Step S203)

[0083] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 53 from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S204)

[0084] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than a threshold X set in advance. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold X (YES), the controller 30 proceeds to step S205. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold X (NO), the controller 30 proceeds to step S207. It should be noted that the threshold X is for example 4 and is a value that is set for higher operating efficiency.

(Step S205)

[0085] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the high-pressure valve 41a.

(Step S206)

[0086] The controller 30 brings the indoor unit 20a under suspension out of operation. At this point in time, the controller 30 brings the expansion device 21a and the low-pressure valve 42a, which are connected to the indoor heat exchanger 22a, into a closed state.

(Step S207)

[0087] The controller 30 brings the other indoor unit 20b into cooling operation. At this point in time, the controller 30 brings the expansion device 21b and the low-pressure valve 42b, which are connected to the indoor heat exchanger 22b, into an open state.

(Step S208)

[0088] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 53 from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S209)

[0089] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than the threshold X. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold X (YES), the controller 30 proceeds to step S210. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold X (NO), the controller 30 proceeds to step S211.

(Step S210)

[0090] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the high-pressure valve 41b.

(Step S211)

[0091] The controller 30 notifies through the notifying unit 36 that there is no abnormality in the high-pressure valve 41a and 41b. It should be noted that step S211 may be omitted.

[0092] As noted above, the abnormality sensing mode of Embodiment 1 shown in Fig. 8 includes bringing all indoor units 20a and 20b into operation and then bringing them one by one under suspension, calculating the degree of supercooling at condenser outlet SC of each of the indoor units 20a and 20b, and judging whether the value is not lower than a value set in advance. On the other hand, the abnormality sensing mode of the modification of Embodiment 1 shown in Fig. 9 includes bringing the indoor units 20a and 20b one by one into operation, calculating the degree of supercooling at condenser outlet SC of each of the indoor units 20a and 20b, and judging whether the value is not lower than a value set in advance.

[0093] Note here that a comparison between the time required for processing in the abnormality sensing mode of Embodiment 1 and the time required for processing in the abnormality sensing mode of the modification of Embodiment 1 shows that the time required for processing in the abnormality sensing mode of the modification of Embodiment 1 is shorter. A reason for this is that in a case in which at the occurrence of an open-lock abnormality in the high-pressure valves 41a and 41b, a bypass for refrigerant comes into being out of nothingness as in the case of the abnormality sensing mode of the modification of Embodiment 1, high-pressure liquid refrigerant flows in to the low-pressure side without causing liquid refrigerant at the low-pressure side to migrate to a high-pressure side, with the result that a rapid change in state appears as a change in the degree of supercooling at condenser outlet SC.

[0094] Meanwhile, in a case in which at the occurrence of an open-lock abnormality in the high-pressure valves 41a and 41b, a bypass for refrigerant passes into nothingness out of being as in the case of the abnormality sensing mode of Embodiment 1, it is necessary to cause liquid refrigerant at the low-pressure side to migrate to the high-pressure side. Moreover, since this migration takes time, it is necessary, in the abnormality sensing mode of Embodiment 1, to prevent a misjudgment by taking a long time between a change in operating state and a judgment, that is, between step S105 and steps S106 and S107.

[0095] As a result, the abnormality sensing mode of the modification of Embodiment 1, in which high-pressure liquid refrigerant flows in to the low-pressure side without causing liquid refrigerant at the low-pressure side to migrate to the high-pressure side, requires a shorter time for processing than the abnormality sensing mode of Embodiment 1.

[0096] It should be noted that although Embodiment 1 describes a method for identifying an open-lock abnormality in the high-pressure valves 41a and 41b from a change in the degree of supercooling at condenser outlet SC, this is not intended to impose any limitation. It is also possible to identify an open-lock abnormality in the high-pressure valves 41a and 41b from a change in the degree of superheating of the suction side of the compressor 11. The degree of superheating of the suction side of the compressor 11 may be calculated by using, for example, a low-pressure pressure sensor (not illustrated) configured to sense the pressure of a low-pressure side of the refrigeration cycle apparatus 100 and a suction-side temperature sensor (not illustrated) configured to sense the temperature of the suction side of the compressor 11. Further, the low-pressure pressure sensor may be replaced by a two-phase temperature sensor (not illustrated) provided at an intermediate position in a pipe forming the indoor heat exchangers 22a and 22b and configured to sense the temperature of two-phase refrigerant flowing through the indoor heat exchangers 22a and 22b and output a sensing signal to the controller 30.

[0097] It should be noted that although Embodiment 1 and the modification thereof have described processing in the case of two indoor units 20a and 20b, this is not intended to impose any limitation and is also applicable to the case of three or more indoor units 20a and 20b. Further, although Embodiment 1 and the modification thereof describe a method for identifying an abnormality while bringing the indoor units 20a and 20b one by one under suspension or into operation, this is not intended to impose any limitation. In a case in which there are three or more indoor units 20a and 20b or other cases, groups each including a given number of indoor units are formed, and while the groups are each sequentially brought under suspension or into operation, a judgment is made as to whether any of the groups has a high-pressure valve 41a or 41b with an open-lock abnormality. Then, a group identified as having a high-pressure valve 41a or 41b with an open-lock abnormality is divided into a plurality of groups. Repeating this process makes it possible to more efficiently narrow down to a high-pressure valve 41a or 41b with an open-lock abnormality, making it possible to shorten the processing time.

[0098] As noted above, a refrigeration cycle apparatus 100 according to Embodiment 1 includes an outdoor unit 10 including a compressor 11 and an outdoor heat exchanger 12, a plurality of indoor units 20a and 20b each including an indoor heat exchanger 22a or 22b and an expansion device 21a or 21b. Further, the refrigeration cycle apparatus 100 includes a relay unit 40 intervening between the outdoor unit 10 and each of the plurality of indoor units 20a and 20b and serving to cause refrigerant from the outdoor unit 10 to branch off into each of the indoor units 20a and 20b. Further, the refrigeration cycle apparatus 100 includes a refrigerant circuit 1 in which the compressor 11, the outdoor heat exchanger 12, the expansion device 21a or 21b, and the indoor heat exchanger 22a or 22b are connected by refrigerant pipes and through which refrigerant circulates and a controller 30 configured to control the plurality of indoor units 20a and 20b. Further, the relay unit 40 includes a plurality of high-pressure valves 41a and 41b each provided in a corresponding one of a plurality of high-pressure pipes 46a and 46b connecting a high-pressure side of the outdoor unit 10 and each of the indoor units 20a and 20b and a plurality of low-pressure valves 42a and 42b each provided in a corresponding one of a plurality of low-pressure pipes 47a and 47b connecting a low-pressure side of the outdoor unit 10 and each of the indoor units 20a and 20b. Moreover, the controller 30 is configured to, when an operation state of at least one of the indoor units 20a and 20b is changed from a first state to a second state, judge, based on a degree of supercooling of an outlet of the outdoor heat exchanger 12 or the indoor heat exchanger 22a or 22b that functions as a condenser or based on a degree of superheating of a suction side of the compressor 11, whether an abnormality is present in the plurality of high-pressure valves 41a and 41b or the plurality of low-pressure valves 42a and 42b.

[0099] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, the high-pressure valves 41a and 41b and the low-pressure valves 42a and 42b connected to the indoor units 20a and 20b that are under suspension are controlled to be in a closed state, the first state is an operating state, and the second state is a suspended state.

[0100] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, the high-pressure valves 41a and 41b and the low-pressure valves 42a and 42b connected to the indoor units 20a and 20b that are under suspension are controlled to be in a closed state, the first state is a suspended state, and the second state is an operating state.

[0101] The refrigeration cycle apparatus 100 according to Embodiment 1 is configured to, when an operation state of at least one of the indoor units 20a and 20b is changed from a first state to a second state, judge, based on a degree of supercooling of an outlet of the outdoor heat exchanger 12 or the indoor heat exchanger 22a or 22b that functions as a condenser or based on a degree of superheating of a suction side of the compressor 11, whether an abnormality is present in the plurality of high-pressure valves 41a and 41b or the plurality of low-pressure valves 42a and 42b. This makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b.

[0102] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, in a case in which the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as a condenser and all of the high-pressure valves 41a and 41b are in a closed state, the first state is a state where one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is controlled to be in an open state and the second state is a state where one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is controlled to be in a closed state.

[0103] The refrigeration cycle apparatus 100 according to Embodiment 1 is configured to, when one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is changed from an open state to a closed state, judge, based on the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or based on the degree of superheating of the suction side of the compressor 11, whether an open-lock abnormality is present in the high-pressure valves 41a and 41b. This makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the high-pressure valves 41a and 41b.

[0104] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, in a case in which the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as a condenser and all of the high-pressure valves 41a and 41b are in a closed state, the first state is a state where one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is controlled to be in a closed state and the second state is a state where one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is controlled to be in an open state.

[0105] The refrigeration cycle apparatus 100 according to Embodiment 1 is configured to, when one of the low-pressure valves 42a and 42b connected to the at least one of the indoor units 20a and 20b is changed from a closed state to an open state, judge, based on the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or based on the degree of superheating of the suction side of the compressor 11, whether an open-lock abnormality is present in the high-pressure valves 41a and 41b. This makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the high-pressure valves 41a and 41b.

[0106] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as a condenser, and in a case in which the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser when all of the indoor units 20a and 20b are in an operating state or the degree of superheating of the suction side of the compressor 11 is less than a threshold X set in advance, the controller 30 is configured to, in a case in which when the operation state of at least one of the indoor units 20a and 20b is changed from an operating state that is the first state to a suspended state that is the second state, the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is less than the threshold X, judge that an abnormality is present in one of the high-pressure valves 41a and 41b connected to one of the indoor units 20a and 20b that is in an operating state and, in a case in which the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is not less than the threshold X, judge that an abnormality is present in one of the high-pressure valves 41a and 41b connected to one of the indoor units 20a and 20b that is in a suspended state.

[0107] Further, in the refrigeration cycle apparatus 100 according to Embodiment 1, the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as a condenser, and in a case in which all of the indoor units 20a and 20b are in a suspended state, the controller 30 is configured to, in a case in which when the operation state of at least one of the indoor units 20a and 20b is changed from a suspended state that is the first state to an operating state that is the second state, the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is less than a threshold X set in advance, judge that an abnormality is present in one of the high-pressure valves 41a and 41b connected to one of the indoor units 20a and 20b that is in an operating state and, in a case in which the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is not less than the threshold X, judge that no abnormality is present in one of the high-pressure valves 41a and 41b connected to one of the indoor units 20a and 20b that is in an operating state.

[0108] As noted above, the refrigeration cycle apparatus 100 according to Embodiment 1 makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the high-pressure valves 41a and 41b.

Embodiment 2.

[0109] The following describes Embodiment 2, but omits to describe features that overlap those of Embodiment 1 and assigns identical reference signs to components that are identical or equivalent to those of Embodiment 1.

[0110] Embodiment 2 is described by taking heating operation as an example, whereas Embodiment 1 has been described by taking cooling operation as an example.

<Normal Operation>

[0111] The following describes a normal operation of the refrigeration cycle apparatus 100 by taking heating operation as an example. It should be noted that during heating operation, the flow switching device 13 is switched so that the suction side of the compressor 11 becomes connected to the outdoor heat exchanger 12.

[0112] Fig. 10 is a diagram showing a refrigerant circuit state where the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 2 are both in heating operation.

[0113] First, a normal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in heating operation is described with reference to Fig. 10.

[0114] High-temperature and high-pressure gas refrigerant discharged from the compressor 11 passes through the flow switching device 13 and the check valve 15, flows out of the outdoor unit 10, and flows into the relay unit 40. After having flowed into the relay unit 40, the high-temperature and high-pressure gas refrigerant passes through the reservoir 45 and the high-pressure valves 41a and 41b and braches into flows of refrigerant that then flow out of the relay unit 40 and flow separately into each of the indoor units 20a and 20b. After having flowed into the indoor units 20a and 20b, the high-temperature and high-pressure gas refrigerant flows into the indoor heat exchangers 22a and 22b, exchanges heat with indoor air through the indoor heat exchangers 22a and 22b, and condenses into high-pressure liquid refrigerant. After that, the high-pressure liquid refrigerant is caused by the expansion devices 21a and 21b to adiabatically expand into low-temperature and low-pressure two-phase refrigerant that then flows out of the indoor units 20a and 20b and flows into the relay unit 40. After having flowed into the relay unit 40, the low-temperature and low-pressure two-phase refrigerant passes through the valve 44, flows out of the relay unit 40, and flows into the outdoor unit 10. After having flowed into the outdoor unit 10, the low-temperature and low-pressure two-phase refrigerant passes through the check valve 16, flows into the outdoor heat exchanger 12, exchanges heat with outdoor air through the outdoor heat exchanger 12, and evaporates into low-temperature and low-pressure gas refrigerant. After that, the low-temperature and low-pressure gas refrigerant passes through the flow switching device 13 and is suctioned into the compressor 11.

[0115] Fig. 11 is a diagram showing a refrigerant circuit state where one of the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 2 is in heating operation and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 11, the indoor unit 20a is under suspension, and the indoor unit 20b is in heating operation.

[0116] Next, a normal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in heating operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 11.

[0117] When the indoor unit 20a is under suspension, the expansion device 21a of the indoor unit 20a thus suspended is in a closed state, and the high-pressure valve 41a, which is connected to the indoor unit 20a, is in a closed state. That is, all valves connected to an inlet side and the outlet side of the indoor heat exchanger 22a of the indoor unit 20a thus suspended are in a closed state, so that no refrigerant is supplied to the indoor heat exchanger 22a thus suspended.

<Abnormal Operation>

[0118] Next, an abnormal operation of the refrigeration cycle apparatus 100 is described by taking heating operation as an example.

[0119] Fig. 12 is a diagram showing a refrigerant circuit state where one of the low-pressure valves 42a and 42b of the refrigeration cycle apparatus 100 according to Embodiment 2 is in a state of open-lock abnormality and the two indoor units 20a and 20b are both in heating operation. In the refrigerant circuit state shown in Fig. 12, an open-lock abnormality is present in the low-pressure valve 42a.

[0120] First, an abnormal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in heating operation is described with reference to Fig. 12.

[0121] As shown in Fig. 12, in a case in which an open-lock abnormality is present in the low-pressure valve 42a, high-pressure liquid refrigerant from the reservoir 45 flows in to a low-pressure side through the high-pressure valve 41a and the low-pressure valve 42a, with the result that the high-pressure liquid refrigerant flows through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0122] Fig. 13 is a diagram showing a refrigerant circuit state where one of the low-pressure valves 42a and 42b of the refrigeration cycle apparatus 100 according to Embodiment 2 is in a state of open-lock abnormality, one of the two indoor units 20a and 20b is in heating operation, and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 13, an open-lock abnormality is present in the low-pressure valve 42a, the indoor unit 20a is under suspension, and the indoor unit 20b is in heating operation.

[0123] Next, an abnormal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in heating operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 13.

[0124] As shown in Fig. 13, since the indoor unit 20a is under suspension, all valves connected to the indoor heat exchanger 22a except the low-pressure valve 42a, which is in a state of open-lock abnormality, are in a closed state. That is, the expansion device 21a and the high-pressure valve 41a are in a closed state. Therefore, unlike in the case of the abnormal operation described with reference to Fig. 12, high-pressure liquid refrigerant does not flow through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0125] Depending on the presence or absence of such a bypass for refrigerant, there is a difference in value of at least either SC, which is the degree of supercooling of an outlet of the indoor heat exchanger 22a or 22b that functions as a condenser, or SH_S, which is the degree of superheating of the suction side of the compressor 11. Accordingly, in Embodiment 2, these values are used to identify a valve with an open-lock abnormality. In the following, the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser is referred to as "degree of supercooling at condenser outlet", and the degree of superheating of the suction side of the compressor 11 is referred to as "degree of superheating at compressor suction".

[0126] Although not described in Embodiment 2, at the occurrence of refrigerant leakage, the amount of refrigerant in the refrigerant circuit 1 decreases, with the result that the degree of supercooling at condenser outlet SC decreases and the degree of superheating at compressor suction SH_s increases. This makes it possible to isolate a refrigerant leakage abnormality from an open-lock abnormality. Therefore, in sensing an open-lock abnormality, an action of isolating an open-lock abnormality from other abnormalities may be added. Examples of the action include checking for the absence of refrigerant leakage first before the start of the sensing.

[0127] A description of a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 2 is in a state of open-lock abnormality and a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 2 is in a normal state is omitted, as the pressure-enthalpy diagrams are identical in content to those shown in Figs. 6 and 7 described in Embodiment 1.

[0128] Fig. 14 is a flow chart showing a flow of control of the refrigeration cycle apparatus 100 according to Embodiment 2 during an abnormality sensing mode. In the abnormality sensing mode, a judgment is made as to whether an open-lock abnormality is present in the high-pressure valves 41a and 41b or the low-pressure valves 42a and 42b. In Embodiment 2, a judgment is made as to whether an open-lock abnormality is present in the low-pressure valves 42a and 42b. When a predetermined period of time elapses during the normal operation mode or when an operation of switching from one operation mode to another is done with the operation mode switching unit 37, the controller 30 switches from the normal operation mode to the abnormality sensing mode and executes an abnormality judgment process shown in Fig. 14. The following describes the flow of control of the refrigeration cycle apparatus 100 according to Embodiment 1 during the abnormality sensing mode with reference to Fig. 14.

(Step S301)

[0129] The controller 30 brings all indoor units 20a and 20b under suspension. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the high-pressure valves 41a and 41b, the low-pressure valves 42a and 42b, and the valves 43 and 44 into a closed state.

(Step S302)

[0130] The controller 30 brings all indoor units 20a and 20b into heating operation. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the high-pressure valves 41a and 41b, and the valve 44 into an open state.

(Step S303)

[0131] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 54a or 54b from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S304)

[0132] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than a threshold Y set in advance. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold Y (YES), the controller 30 proceeds to step S305. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold Y (NO), the controller 30 proceeds to step S310. It should be noted that the threshold Y is for example 4 and is a value that is set for higher operating efficiency.

(Step S305)

[0133] The controller 30 brings one indoor unit 20b under suspension. At this point in time, the controller 30 brings the expansion device 21b and the high-pressure valve 41b, which are connected to the indoor heat exchanger 22b, into a closed state.

(Step S306)

[0134] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 54a from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S307)

[0135] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than the threshold Y. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold Y (YES), the controller 30 proceeds to step S308. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold Y (NO), the controller 30 proceeds to step S309.

(Step S308)

[0136] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the low-pressure valve 42a.

(Step S309)

[0137] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the low-pressure valve 42b.

(Step S310)

[0138] The controller 30 notifies through the notifying unit 36 that there is no abnormality in the low-pressure valve 42a and 42b. It should be noted that step S310 may be omitted.

[0139] Fig. 15 is a flow chart showing a flow of control of a modification of the refrigeration cycle apparatus 100 according to Embodiment 2 during an abnormality sensing mode. In the modification of Embodiment 2, a judgment is made as to whether an open-lock abnormality is present in the low-pressure valves 42a and 42b.

[0140] When a predetermined period of time elapses during the normal operation mode or when an operation of switching from one operation mode to another is done with the operation mode switching unit 37, the controller 30 switches from the normal operation mode to the abnormality sensing mode and executes an abnormality judgment process shown in Fig. 15. The following describes the flow of control of the refrigeration cycle apparatus 100 according to the modification of Embodiment 2 during the abnormality sensing mode with reference to Fig. 15.

(Step S401)

[0141] The controller 30 brings all indoor units 20a and 20b under suspension. At this point in time, the controller 30 brings the expansion devices 21a and 21b, the high-pressure valves 41a and 41b, the low-pressure valves 42a and 42b, and the valves 43 and 44 into a closed state.

(Step S402)

[0142] The controller 30 brings one indoor unit 20a into heating operation. At this point in time, the controller 30 brings the expansion device 21a and the high-pressure valve 41a, which are connected to the indoor heat exchanger 22a, and the valve 44 into an open state.

(Step S403)

[0143] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 54a from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S404)

[0144] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than a threshold Y set in advance. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold Y (YES), the controller 30 proceeds to step S405. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold Y (NO), the controller 30 proceeds to step S407. It should be noted that the threshold Y is for example 4 and is a value that is set for higher operating efficiency.

(Step S405)

[0145] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the low-pressure valve 42a.

(Step S406)

[0146] The controller 30 brings the indoor unit 20a under suspension out of operation. At this point in time, the controller 30 brings the expansion device 21a and the high-pressure valve 41a, which are connected to the indoor heat exchanger 22a, into a closed state.

(Step S407)

[0147] The controller 30 brings the other indoor unit 20b into heating operation. At this point in time, the controller 30 brings the expansion device 21b and the high-pressure valve 41b, which are connected to the indoor heat exchanger 22b, into an open state.

(Step S408)

[0148] The controller 30 calculates the degree of supercooling at condenser outlet SC by subtracting a temperature sensed by the temperature sensor 54b from a saturated liquid temperature into which a pressure sensed by the pressure sensor 61 is converted.

(Step S409)

[0149] The controller 30 judges whether the degree of supercooling at condenser outlet SC is less than the threshold Y. In a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is less than the threshold Y (YES), the controller 30 proceeds to step S410. On the other hand, in a case in which the controller 30 judges that the degree of supercooling at condenser outlet SC is not less than the threshold Y (NO), the controller 30 proceeds to step S411.

(Step S410)

[0150] The controller 30 notifies through the notifying unit 36 that an open-lock abnormality is present in the low-pressure valve 42b.

(Step S411)

[0151] The controller 30 notifies through the notifying unit 36 that there is no abnormality in the low-pressure valve 42a and 42b. It should be noted that step S411 may be omitted.

[0152] As noted above, the abnormality sensing mode of Embodiment 2 shown in Fig. 14 includes bringing all indoor units 20a and 20b into operation and then bringing them one by one under suspension, calculating the degree of supercooling at condenser outlet SC of each of the indoor units 20a and 20b, and judging whether the value is not lower than a value set in advance. On the other hand, the abnormality sensing mode of the modification of Embodiment 2 shown in Fig. 15 includes bringing the indoor units 20a and 20b one by one into operation, calculating the degree of supercooling at condenser outlet SC of each of the indoor units 20a and 20b, and judging whether the value is not lower than a value set in advance.

[0153] Note here that a comparison between the time required for processing in the abnormality sensing mode of Embodiment 2 and the time required for processing in the abnormality sensing mode of the modification of Embodiment 2 shows that the time required for processing in the abnormality sensing mode of the modification of Embodiment 2 is shorter. A reason for this is that in a case in which at the occurrence of an open-lock abnormality in the low-pressure valves 42a and 42b, a bypass for refrigerant comes into being out of nothingness as in the case of the abnormality sensing mode of the modification of Embodiment 2, high-pressure liquid refrigerant flows in to the low-pressure side without causing liquid refrigerant at the low-pressure side to migrate to a high-pressure side, with the result that a rapid change in state appears as a change in the degree of supercooling at condenser outlet SC.

[0154] Meanwhile, in a case in which at the occurrence of an open-lock abnormality in the low-pressure valves 42a and 42b, a bypass for refrigerant passes into nothingness out of being as in the case of the abnormality sensing mode of Embodiment 2, it is necessary to cause liquid refrigerant at the low-pressure side to migrate to the high-pressure side. Moreover, since this migration takes time, it is necessary, in the abnormality sensing mode of Embodiment 2, to prevent a misjudgment by taking a long time between a change in operating state and a judgment, that is, between step S305 and steps S306 and S307.

[0155] As a result, the abnormality sensing mode of the modification of Embodiment 2, in which high-pressure liquid refrigerant flows in to the low-pressure side without causing liquid refrigerant at the low-pressure side to migrate to the high-pressure side, requires a shorter time for processing than the abnormality sensing mode of Embodiment 2.

[0156] It should be noted that although Embodiment 2 describes a method for identifying an open-lock abnormality in the low-pressure valves 42a and 42b from a change in the degree of supercooling at condenser outlet SC, this is not intended to impose any limitation. It is also possible to identify an open-lock abnormality in the low-pressure valves 42a and 42b from a change in the degree of superheating of the suction side of the compressor 11. The degree of superheating of the suction side of the compressor 11 may be calculated by using, for example, a low-pressure pressure sensor (not illustrated) configured to sense the pressure of a low-pressure side of the refrigeration cycle apparatus 100 and a suction-side temperature sensor (not illustrated) configured to sense the temperature of the suction side of the compressor 11. Further, the low-pressure pressure sensor may be replaced by a two-phase temperature sensor (not illustrated) provided at an intermediate position in a pipe forming the indoor heat exchangers 22a and 22b and configured to sense the temperature of two-phase refrigerant flowing through the indoor heat exchangers 22a and 22b and output a sensing signal to the controller 30.

[0157] It should be noted that although Embodiment 2 and the modification thereof have described processing in the case of two indoor units 20a and 20b, this is not intended to impose any limitation and is also applicable to the case of three or more indoor units 20a and 20b. Further, although Embodiment 2 and the modification thereof describe a method for identifying an abnormality while bringing the indoor units 20a and 20b one by one under suspension or into operation, this is not intended to impose any limitation. In a case in which there are three or more indoor units 20a and 20b or other cases, groups each including a given number of indoor units are formed, and while the groups are each sequentially brought under suspension or into operation, a judgment is made as to whether any of the groups has a low-pressure valve 42a or 42b with an open-lock abnormality. Then, a group identified as having a low-pressure valve 42a or 42b with an open-lock abnormality is divided into a plurality of groups. Repeating this process makes it possible to more efficiently narrow down to a low-pressure valve 42a or 42b with an open-lock abnormality, making it possible to shorten the processing time.

[0158] As noted above, in the refrigeration cycle apparatus 100 according to Embodiment 2, in a case in which the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as an evaporator and all of the high-pressure valves 41a and 41b are in a closed state, the first state is a state where one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is controlled to be in an open state and the second state is a state where one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is controlled to be in a closed state.

[0159] The refrigeration cycle apparatus 100 according to Embodiment 2 is configured to, when one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is changed from an open state to a closed state, judge, based on the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or based on the degree of superheating of the suction side of the compressor 11, whether an open-lock abnormality is present in the low-pressure valves 42a and 42b. This makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the low-pressure valves 42a and 42b.

[0160] Further, in the refrigeration cycle apparatus 100 according to Embodiment 2, in a case in which the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as an evaporator and all of the high-pressure valves 41a and 41b are in a closed state, the first state is a state where one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is controlled to be in a closed state and the second state is a state where one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is controlled to be in an open state.

[0161] The refrigeration cycle apparatus 100 according to Embodiment 2 is configured to, when one of the high-pressure valves 41a and 41b connected to the at least one of the indoor units 20a and 20b is changed from a closed state to an open state, judge, based on the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or based on the degree of superheating of the suction side of the compressor 11, whether an open-lock abnormality is present in the low-pressure valves 42a and 42b. This makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the low-pressure valves 42a and 42b.

[0162] Further, in the refrigeration cycle apparatus 100 according to Embodiment 2, the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as an evaporator, and in a case in which the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser when all of the indoor units 20a and 20b are in an operating state or the degree of superheating of the suction side of the compressor 11 is less than a threshold Y set in advance, the controller 30 is configured to, in a case in which when the operation state of at least one of the indoor units 20a and 20b is changed from an operating state that is the first state to a suspended state that is the second state, the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is less than the threshold Y, judge that an abnormality is present in one of the low-pressure valves 42a and 42b connected to one of the indoor units 20a and 20b that is in an operating state and, in a case in which the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is not less than the threshold Y, judge that an abnormality is present in one of the low-pressure valves 42a and 42b connected to one of the indoor units 20a and 20b that is in a suspended state.

[0163] Further, in the refrigeration cycle apparatus 100 according to Embodiment 2, the refrigerant circuit 1 is configured such that the outdoor heat exchanger 12 serves as an evaporator, and in a case in which all of the indoor units 20a and 20b are in a suspended state, the controller 30 is configured to, in a case in which when the operation state of at least one of the indoor units 20a and 20b is changed from a suspended state that is the first state to an operating state that is the second state, the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is less than a threshold Y set in advance, judge that an abnormality is present in one of the low-pressure valves 42a and 42b connected to one of the indoor units 20a and 20b that is in an operating state and, in a case in which the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser or the degree of superheating of the suction side of the compressor 11 is not less than the threshold Y, judge that no abnormality is present in one of the low-pressure valves 42a and 42b connected to one of the indoor units 20a and 20b that is in an operating state.

[0164] As noted above, the refrigeration cycle apparatus 100 according to Embodiment 2 makes it possible to, when including a relay unit 40 having a plurality of high-pressure valves 41a and 41b and a plurality of low-pressure valves 42a and 42b, identify an open-lock abnormality in the low-pressure valves 42a and 42b.

Embodiment 3

[0165] The following describes Embodiment 3, but omits to describe features that overlap those of Embodiments 1 and 2 and assigns identical reference signs to components that are identical or equivalent to those of Embodiments 1 and 2.

[0166] Fig. 16 is a diagram showing a configuration of a refrigeration cycle apparatus 100 according to Embodiment 3.

[0167] Embodiment 3 takes, as an example of the refrigeration cycle apparatus 100, an air-conditioning apparatus, configured to carry out cooling operation and heating operation, in which, as shown in Fig. 16, two indoor units 20a and 20b are connected via a relay unit 40 to one outdoor unit 10. It should be noted that although Fig. 16 shows a configuration in which the refrigeration cycle apparatus 100 includes the two indoor units 20a and 20b, the refrigeration cycle apparatus 100 needs only include more than one indoor unit.

[0168] The refrigeration cycle apparatus 100 includes the outdoor unit 10, the two indoor units 20a and 20b, and the relay unit 40. Moreover, refrigerant having flowed out of the outdoor unit 10 is caused by the relay unit 40 to branch off into the two indoor units 20a and 20b, and flows into each of the indoor units 20a and 20b. Then, the refrigerant having flowed out of each of the indoor units 20a and 20b returns to the outdoor unit 10 via the relay unit 40 again.

[0169] The outdoor unit 10 includes a compressor 11, an outdoor heat exchanger 12, on-off valves 51 and 52, a temperature sensor 53, and a pressure sensor 61. Instead of the pressure sensor 61, a two-phase temperature sensor (not illustrated) configured to sense the temperature of two-phase refrigerant flowing through the outdoor heat exchanger 12 and output a sensing signal to the controller 30 may be provided at an intermediate position in a pipe forming the outdoor heat exchanger 12.

[0170] The indoor unit 20a includes an expansion device 21a, an indoor heat exchanger 22a, and a temperature sensor 54a. Similarly, the indoor unit 20b includes an expansion device 21b, an indoor heat exchanger 22b, and a temperature sensor 54b.

[0171] The relay unit 40 includes high-pressure pipes 46a and 46b, low-pressure pipes 47a and 47b, high-pressure valves 41a and 41b, and low-pressure valves 42a and 42b.

[0172] The refrigeration cycle apparatus 100 includes a refrigerant circuit 1 in which the compressor 11, the outdoor heat exchanger 12, the expansion devices 21a and 21b, and the indoor heat exchangers 22a and 22b are connected by refrigerant pipes and through which refrigerant circulates.

[0173] Further, the refrigeration cycle apparatus 100 includes a controller 30, a notifying unit 36, and an operation mode switching unit 37, and the notifying unit 36 and the operation mode switching unit 37 are each connected to the controller 30. It should be noted that the notifying unit 36 and the operation mode switching unit 37 may be provided in the controller 30 as part of the controller 30.

[0174] The on-off valves 51 and 52 are for example two-way valves, and enable switching between cooling operation and heating operation to be done by switching between an open state and a closed state. During cooling operation, the on-off valve 51 is in an open state, and the on-off valve 52 is in a closed state. During heating operation, the on-off valve 51 is in a closed state, and the on-off valve 52 is in an open state.

<Normal Operation>

[0175] The following describes a normal operation of the refrigeration cycle apparatus 100 by taking cooling operation as an example. During cooling operation, the on-off valve 51 is in an open state, and the on-off valve 52 is in a closed state.

[0176] Fig. 17 is a diagram showing a refrigerant circuit state where the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 3 are both in cooling operation.

[0177] First, a normal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in cooling operation is described with reference to Fig. 17.

[0178] High-temperature and high-pressure gas refrigerant discharged from the compressor 11 passes through the on-off valve 51, flows into the outdoor heat exchanger 12, exchanges heat with outdoor air through the outdoor heat exchanger 12, and condenses into high-pressure liquid refrigerant. After that, the high-pressure liquid refrigerant flows out of the outdoor unit 10, branches into flows of refrigerant that then flow separately into each of the indoor units 20a and 20b. After having flowed into the indoor units 20a and 20b, the liquid refrigerant is caused by the expansion devices 21a and 21b to adiabatically expand into low-temperature and low-pressure two-phase refrigerant. After that, the low-temperature and low-pressure two-phase refrigerant flows into the indoor heat exchangers 22a and 22b, exchanges heat with indoor air through the indoor heat exchangers 22a and 22b, and evaporates into low-temperature and low-pressure gas refrigerant. After that, the low-temperature and low-pressure gas refrigerant flows out of the indoor units 20a and 20b and flows into the relay unit 40. After having flowed into the relay unit 40, the flows of low-temperature and low-pressure gas refrigerant pass through the low-pressure valves 42a and 42b and merge into a flow of low-temperature and low-pressure gas refrigerant that then flows out of the relay unit 40. After having flowed out of the relay unit 40, the low-temperature and low-pressure gas refrigerant flows into the outdoor unit 10 and is suctioned into the compressor 11.

[0179] Fig. 18 is a diagram showing a refrigerant circuit state where one of the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 3 is in cooling operation and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 18, the indoor unit 20a is under suspension, and the indoor unit 20b is in cooling operation.

[0180] Next, a normal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in cooling operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 18.

[0181] When the indoor unit 20a is under suspension, the expansion device 21a of the indoor unit 20a thus suspended is in a closed state, and the low-pressure valve 42a, which is connected to the indoor unit 20a, is in a closed state. That is, all valves connected to an inlet side and the outlet side of the indoor heat exchanger 22a of the indoor unit 20a thus suspended are in a closed state, so that no refrigerant is supplied to the indoor heat exchanger 22a thus suspended.

<Abnormal Operation>

[0182] Next, an abnormal operation of the refrigeration cycle apparatus 100 is described by taking cooling operation as an example.

[0183] Fig. 19 is a diagram showing a refrigerant circuit state where one of the high-pressure valves 41a and 41b of the refrigeration cycle apparatus 100 according to Embodiment 3 is in a state of open-lock abnormality and the two indoor units 20a and 20b are both in cooling operation. In the refrigerant circuit state shown in Fig. 19, an open-lock abnormality is present in the high-pressure valve 41a.

[0184] First, an abnormal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in cooling operation is described with reference to Fig. 19.

[0185] As shown in Fig. 19, in a case in which an open-lock abnormality is present in the high-pressure valve 41a, high-pressure liquid refrigerant from the discharge side of the compressor 11 flows in to a low-pressure side through the high-pressure valve 41a and the low-pressure valve 42a, with the result that the high-pressure liquid refrigerant flows through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0186] Fig. 20 is a diagram showing a refrigerant circuit state where one of the high-pressure valves 41a and 41b of the refrigeration cycle apparatus 100 according to Embodiment 3 is in a state of open-lock abnormality, one of the two indoor units 20a and 20b is in cooling operation, and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 20, an open-lock abnormality is present in the high-pressure valve 41a, the indoor unit 20a is under suspension, and the indoor unit 20b is in cooling operation.

[0187] Next, an abnormal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in cooling operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 20.

[0188] As shown in Fig. 20, since the indoor unit 20a is under suspension, all valves connected to the indoor heat exchanger 22a except the high-pressure valve 41a, which is in a state of open-lock abnormality, are in a closed state. That is, the expansion device 21a and the low-pressure valve 42a are in a closed state. Therefore, unlike in the case of the abnormal operation described with reference to Fig. 19, high-pressure refrigerant does not flow through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0189] Depending on the presence or absence of such a bypass for refrigerant, there is a difference in value of at least either SC, which is the degree of supercooling of an outlet of the outdoor heat exchanger 12 that functions as a condenser, or SH_s, which is the degree of superheating of the suction side of the compressor 11. Accordingly, in Embodiment 3, these values are used to identify a valve with an open-lock abnormality. In the following, the degree of supercooling of the outlet of the outdoor heat exchanger 12 that functions as a condenser is referred to as "degree of supercooling at condenser outlet", and the degree of superheating of the suction side of the compressor 11 is referred to as "degree of superheating at compressor suction".

[0190] Although not described in Embodiment 3, at the occurrence of refrigerant leakage, the amount of refrigerant in the refrigerant circuit 1 decreases, with the result that the degree of supercooling at condenser outlet SC decreases and the degree of superheating at compressor suction SH_s increases. This makes it possible to isolate a refrigerant leakage abnormality from an open-lock abnormality. Therefore, in sensing an open-lock abnormality, an action of isolating an open-lock abnormality from other abnormalities may be added. Examples of the action include checking for the absence of refrigerant leakage first before the start of the sensing.

[0191] A description of a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 3 is in a state of open-lock abnormality and a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 3 is in a normal state is omitted, as the pressure-enthalpy diagrams are identical in content to those shown in Figs. 6 and 7 described in Embodiment 1. Further, a description of a flow of control of the refrigeration cycle apparatus 100 according to Embodiment 3 during the abnormality sensing mode is omitted, as the flow of control is identical in content to those shown in Figs. 8 and 9 described in Embodiment 1.

[0192] It should be noted that although Embodiment 3 describes a method for identifying an open-lock abnormality in the high-pressure valves 41a and 41b from a change in the degree of supercooling at condenser outlet SC, this is not intended to impose any limitation. It is also possible to identify an open-lock abnormality in the high-pressure valves 41a and 41b from a change in the degree of superheating of the suction side of the compressor 11. The degree of superheating of the suction side of the compressor 11 may be calculated by using, for example, a low-pressure pressure sensor (not illustrated) configured to sense the pressure of a low-pressure side of the refrigeration cycle apparatus 100 and a suction-side temperature sensor (not illustrated) configured to sense the temperature of the suction side of the compressor 11. Further, the low-pressure pressure sensor may be replaced by a two-phase temperature sensor (not illustrated) provided at an intermediate position in a pipe forming the indoor heat exchangers 22a and 22b and configured to sense the temperature of two-phase refrigerant flowing through the indoor heat exchangers 22a and 22b and output a sensing signal to the controller 30.

Embodiment 4

[0193] The following describes Embodiment 4, but omits to describe features that overlap those of Embodiments 1 to 3 and assigns identical reference signs to components that are identical or equivalent to those of Embodiments 1 to 3.

[0194] Embodiment 4 is described by taking heating operation as an example, whereas Embodiment 3 has been described by taking cooling operation as an example.

<Normal Operation>

[0195] The following describes a normal operation of the refrigeration cycle apparatus 100 by taking heating operation as an example. During heating operation, the on-off valve 51 is in a closed state, and the on-off valve 52 is in an open state.

[0196] Fig. 21 is a diagram showing a refrigerant circuit state where the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 4 are both in heating operation.

[0197] First, a normal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in heating operation is described with reference to Fig. 21.

[0198] High-temperature and high-pressure gas refrigerant discharged from the compressor 11 flows out of the outdoor unit 10 and flows into the relay unit 40. After having flowed into the relay unit 40, the high-temperature and high-pressure gas refrigerant passes through the high-pressure valves 41a and 41b and braches into flows of refrigerant that then flow out of the relay unit 40 and flow separately into each of the indoor units 20a and 20b. After having flowed into the indoor units 20a and 20b, the high-temperature and high-pressure gas refrigerant flows into the indoor heat exchangers 22a and 22b, exchanges heat with indoor air through the indoor heat exchangers 22a and 22b, and condenses into high-pressure liquid refrigerant. After that, the high-pressure liquid refrigerant is caused by the expansion devices 21a and 21b to adiabatically expand into low-temperature and low-pressure two-phase refrigerant that then flows out of the indoor units 20a and 20b. After having flowed out of the indoor units 20a and 20b, the flows of low-temperature and low-pressure two-phase refrigerant merge into a flow of low-temperature and low-pressure two-phase refrigerant that then flows into the outdoor unit 10. After having flowed into the outdoor unit 10, the low-temperature and low-pressure two-phase refrigerant flows into the outdoor heat exchanger 12, exchanges heat with outdoor air through the outdoor heat exchanger 12, and evaporates into low-temperature and low-pressure gas refrigerant. After that, the low-temperature and low-pressure gas refrigerant passes through the on-off valve 52 and is suctioned into the compressor 11.

[0199] Fig. 22 is a diagram showing a refrigerant circuit state where one of the two indoor units 20a and 20b of the refrigeration cycle apparatus 100 according to Embodiment 4 is in heating operation and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 22, the indoor unit 20a is under suspension, and the indoor unit 20b is in heating operation.

[0200] Next, a normal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in heating operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 22.

[0201] When the indoor unit 20a is under suspension, the expansion device 21a of the indoor unit 20a thus suspended is in a closed state, and the high-pressure valve 41a, which is connected to the indoor unit 20a, is in a closed state. That is, all valves connected to an inlet side and the outlet side of the indoor heat exchanger 22a of the indoor unit 20a thus suspended are in a closed state, so that no refrigerant is supplied to the indoor heat exchanger 22a thus suspended.

<Abnormal Operation>

[0202] Next, an abnormal operation of the refrigeration cycle apparatus 100 is described by taking heating operation as an example.

[0203] Fig. 23 is a diagram showing a refrigerant circuit state where one of the low-pressure valves 42a and 42b of the refrigeration cycle apparatus 100 according to Embodiment 4 is in a state of open-lock abnormality and the two indoor units 20a and 20b are both in heating operation. In the refrigerant circuit state shown in Fig. 23, an open-lock abnormality is present in the low-pressure valve 42a.

[0204] First, an abnormal operation of the refrigeration cycle apparatus 100 during which the two indoor units 20a and 20b are both in heating operation is described with reference to Fig. 23.

[0205] As shown in Fig. 23, in a case in which an open-lock abnormality is present in the low-pressure valve 42a, high-pressure liquid refrigerant from the discharge side of the compressor 11 flows in to a low-pressure side through the high-pressure valve 41a and the low-pressure valve 42a, with the result that the high-pressure liquid refrigerant flows through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0206] Fig. 24 is a diagram showing a refrigerant circuit state where one of the low-pressure valves 42a and 42b of the refrigeration cycle apparatus 100 according to Embodiment 4 is in a state of open-lock abnormality, one of the two indoor units 20a and 20b is in heating operation, and the other of the two indoor units 20a and 20b is under suspension. In the refrigerant circuit state shown in Fig. 24, an open-lock abnormality is present in the low-pressure valve 42a, the indoor unit 20a is under suspension, and the indoor unit 20b is in heating operation.

[0207] Next, an abnormal operation of the refrigeration cycle apparatus 100 during which one of the two indoor units 20a and 20b is in heating operation and the other of the two indoor units 20a and 20b is under suspension is described with reference to Fig. 24.

[0208] As shown in Fig. 24, since the indoor unit 20a is under suspension, all valves connected to the indoor heat exchanger 22a except the low-pressure valve 42a, which is in a state of open-lock abnormality, are in a closed state. That is, the expansion device 21a and the high-pressure valve 41a are in a closed state. Therefore, unlike in the case of the abnormal operation described with reference to Fig. 23, high-pressure liquid refrigerant does not flow through a bypass to the low-pressure side without passing through the indoor unit 20a or 20b.

[0209] Depending on the presence or absence of such a bypass for refrigerant, there is a difference in value of at least either SC, which is the degree of supercooling of an outlet of the indoor heat exchanger 22a or 22b that functions as a condenser, or SH_s, which is the degree of superheating of the suction side of the compressor 11. Accordingly, in Embodiment 4, these values are used to identify a valve with an open-lock abnormality. In the following, the degree of supercooling of the outlet of the indoor heat exchanger 22a or 22b that functions as a condenser is referred to as "degree of supercooling at condenser outlet", and the degree of superheating of the suction side of the compressor 11 is referred to as "degree of superheating at compressor suction".

[0210] Although not described in Embodiment 4, at the occurrence of refrigerant leakage, the amount of refrigerant in the refrigerant circuit 1 decreases, with the result that the degree of supercooling at condenser outlet SC decreases and the degree of superheating at compressor suction SH_s increases. This makes it possible to isolate a refrigerant leakage abnormality from an open-lock abnormality. Therefore, in sensing an open-lock abnormality, an action of isolating an open-lock abnormality from other abnormalities may be added. Examples of the action include checking for the absence of refrigerant leakage first before the start of the sensing.

[0211] A description of a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 4 is in a state of open-lock abnormality and a pressure-enthalpy diagram representing the time when the refrigeration cycle apparatus 100 according to Embodiment 4 is in a normal state is omitted, as the pressure-enthalpy diagrams are identical in content to those shown in Figs. 6 and 7 described in Embodiment 1. Further, a description of a flow of control of the refrigeration cycle apparatus 100 according to Embodiment 4 during the abnormality sensing mode is omitted, as the flow of control is identical in content to those shown in Figs. 14 and 15 described in Embodiment 2.

[0212] It should be noted that without being bounded by the embodiments described above, various modifications of refrigeration cycle apparatuses 100 are possible. For example, although each of the embodiments described above has taken, as an example, a refrigeration cycle apparatus 100 capable of switching between executing heating operation and executing cooling operation, the refrigeration cycle apparatus 100 may be capable of executing only cooling operation or heating operation.

[0213] Further, although each of the embodiments described above has taken, as an example, a refrigeration cycle apparatus 100 including one outdoor unit 10, the refrigeration cycle apparatus 100 may include a plurality of the outdoor units 10.

[0214] Further, although the control during the abnormality sensing modes shown in Figs. 8 and 9 includes using the degree of supercooling at condenser outlet SC to judge whether an open-lock abnormality is present, this is not intended to impose any limitation. It is also possible to use the degree of superheating at compressor suction SH_s in addition to the degree of supercooling at condenser outlet SC to judge, from changes in the two parameters, whether an open-lock abnormality is present, or it is also possible to use only the degree of superheating at compressor suction SH_s to judge whether an open-lock abnormality is present.

[0215] Further, although each of the embodiments described above illustrates a case in which the indoor units are brought one by one under suspension or into operation, this is not intended to impose any limitation. When an outlet of a condenser is in a state of having gained a degree of supercooling, it is judged that there is no bypass for refrigerant, and when an outlet of a condenser is in a state of not having gained a degree of supercooling, it is judged that there is a bypass for refrigerant. Therefore, for example, if an outlet of a condenser has gained a degree of supercooling in a case in which a given number of indoor units have been brought into operation, it can be judged that high-pressure valves and low-pressure valves connected to the indoor units that are in operation at this point in time are normal. On the other hand, if an outlet of a condenser has not gained a degree of supercooling in a case in which a given number of indoor units have been brought into operation, it can be judged that a high-pressure valve or a low-pressure valves connected to at least one of the indoor units that are in operation at this point in time is abnormal.

[0216] With this utilized, for example, in a case in which there are a large number of indoor units, the indoor units are divided into a plurality of groups for efficient identification of a high-pressure valve or a low-pressure valve with an open-lock abnormality. Moreover, when there is a decrease in the degree of supercooling of an outlet of a condenser, it can be judged that a high-pressure valve or a low-pressure valve connected to a group of indoor units that are in operation is abnormal. Moreover, gradually reducing the number of indoor units that are in operation makes it possible to efficiently identify a high-pressure valve or a low-pressure valve with an open-lock abnormality.

Reference Signs List

[0217] 1: refrigerant circuit, 10: outdoor unit, 11: compressor, 12: outdoor heat exchanger, 13: flow switching device, 14 to 17: check valve, 18, 19: refrigerant connecting pipe, 20a, 20b: indoor unit, 21a, 21b: expansion device, 22a, 22b: indoor heat exchanger, 30: controller, 31: storage unit, 32: extraction unit, 33: computing unit, 34: comparing unit, 35: judging unit, 36: notifying unit, 37: operation mode switching unit, 40: relay unit, 41a, 41b: high-pressure valve, 42a, 42b: low-pressure valve, 43, 44: valve, 45: reservoir, 46a, 46b: high-pressure pipe, 47a, 47b: low-pressure pipe, 51, 52: on-off valve, 53, 54a, 54b: temperature sensor, 61: pressure sensor, 100: refrigeration cycle apparatus

Claims

1. A refrigeration cycle apparatus (100), comprising:

an outdoor unit (10) including a compressor (11) and an outdoor heat exchanger (12),
a plurality of indoor units (20a, 20b) each including an indoor heat exchanger (22a, 22b) and an expansion device (21a, 21b),
a relay unit (40) intervening between the outdoor unit (10) and each of the plurality of indoor units (20a, 20b) and serving to cause refrigerant from the outdoor unit (10) to branch off into each of the indoor units (20a, 20b),
a refrigerant circuit (1) in which the compressor (11), the outdoor heat exchanger (12), the expansion device (21a, 21b) and the indoor heat exchanger (22a, 22b) are connected by refrigerant pipes and through which refrigerant circulates, and
a controller (30) configured to control the plurality of indoor units (20a, 20b),
wherein
the relay unit (40) includes
a plurality of high-pressure valves (41a, 41b) each provided in a corresponding one of a plurality of high-pressure pipes (46a, 46b) connecting a high-pressure side of the outdoor unit (10) and each of the indoor units (20a, 20b), and
a plurality of low-pressure valves (42a, 42b) each provided in a corresponding one of a plurality of low-pressure pipes (47a, 47b) connecting a low-pressure side of the outdoor unit (10) and each of the indoor units (20a, 20b), **characterised in that**
the controller (30) is configured to, when an operation state of at least one of the indoor units (20a, 20b) is changed from a first state to a second state, judge, based on a degree of supercooling of an outlet of the outdoor heat exchanger (12) or the indoor heat exchanger (22a, 22b) that functions as a condenser or based on a degree of superheating of a suction side of the compressor (11), whether an abnormality is present in the plurality of high-pressure valves (41a, 41b) or the plurality of low-pressure valves (42a, 42b), wherein
the refrigerant circuit (1) is configured such that the outdoor heat exchanger (12) serves as a condenser, and
in a case in which the degree of supercooling of the outlet of the outdoor heat exchanger (12) that functions as a condenser when all of the indoor units (20a, 20b) are in an operating state or the degree of superheating of the suction side of the compressor (11) when all of the indoor units (20a, 20b) are in operating state is less than a threshold set in advance, the controller (30) is configured to, in a case in which when the operation state of at least one of the indoor units (20a, 20b) is changed from an operating state that is the first state to a suspended state that is the second state, the degree of supercooling of the outlet of the outdoor heat exchanger (12) that functions as a condenser or the degree of superheating of the suction side of the compressor (11) is less than the threshold, judge that an abnormality is present in one of the high-pressure valves (41a, 41b) connected to one of the indoor units (20a, 20b) that is in an operating state and, in a case in which the degree of supercooling of the outlet of the outdoor heat exchanger (12) that functions as a condenser or the degree of superheating of the suction side of the compressor (11) is not less than the threshold, judge that an abnormality is present in one of the high-pressure valves (41a, 41b) connected to one of the indoor units (20a, 20b) that is in a suspended state.

Patentansprüche

1. Kältekreislaufvorrichtung (100), umfassend:

eine Außeneinheit (10), die einen Kompressor (11) und einen Außenwärmetauscher (12) enthält,
eine Mehrzahl von Inneneinheiten (20a, 20b), die jeweils einen Innenwärmetauscher (22a, 22b) und eine Expansionseinrichtung (21a, 21b) enthalten,
eine Relaiseinheit (40), die zwischen der Außeneinheit (10) und jeder der Mehrzahl von Inneneinheiten (20a, 20b) interveniert bzw. geschaltet ist und dazu dient, zu bewirken, dass Kältemittel von der Außeneinheit (10) in jede der Inneneinheiten (20a, 20b) abzweigt,
einen Kältemittelkreislauf (1), in dem der Kompressor (11), der Außenwärmetauscher (12), die Expansionseinrichtung (21a, 21b) und der Innenwärmetauscher (22a, 22b) durch Kältemittelleitungen verbunden sind und durch den Käl-

temittel zirkuliert, und

eine Steuer- bzw. Regeleinrichtung (30), die konfiguriert ist, die Mehrzahl von Inneneinheiten (20a, 20b) zu steuern bzw. zu regeln,

wobei

die Relaiseinheit (40) enthält

eine Mehrzahl von Hochdruckventilen (41a, 41b), die jeweils in einer entsprechenden einer Mehrzahl von Hochdruckleitungen (46a, 46b) bereitgestellt sind, die eine Hochdruckseite der Außeneinheit (10) und jede der Inneneinheiten (20a, 20b) verbinden, und

eine Mehrzahl von Niederdruckventilen (42a, 42b), die jeweils in einer entsprechenden einer Mehrzahl von Niederdruckleitungen (47a, 47b) bereitgestellt sind, die eine Niederdruckseite der Außeneinheit (10) und jede der Inneneinheiten (20a, 20b) verbinden,

dadurch gekennzeichnet, dass die Steuer- bzw. Regeleinrichtung (30) konfiguriert ist, wenn ein Betriebszustand zumindest einer der Inneneinheiten (20a, 20b) von einem ersten Zustand in einen zweiten Zustand geändert, basierend auf einem Grad der Unterkühlung eines Auslasses des Außenwärmetauschers (12) oder des Innenwärmetauschers (22a, 22b), der als eine Kondensator fungiert, oder basierend auf einem Grad der Überhitzung einer Ansaugseite des Kompressors (11) zu beurteilen, ob an eine Anomalie bei der Mehrzahl von Hochdruckventilen (41a, 41b) oder der Mehrzahl von Niederdruckventilen (42a, 42b) vorliegt, wobei

der Kältemittelkreislauf (1) derart konfiguriert ist, dass der Außenwärmetauscher (12) als ein Kondensator dient, und

in einem Fall, in dem der Grad der Unterkühlung des Auslasses des Außenwärmetauschers (12), der als ein Kondensator fungiert, wenn alle der Inneneinheiten (20a, 20b) in einem Betriebszustand sind, zunimmt, oder der Grad der Überhitzung der Ansaugseite des Kompressors (11), wenn alle der Inneneinheiten (20a, 20b) in Betriebszustand sind, geringer ist als ein im Voraus festgelegter Schwellenwert, die Steuerungs- bzw. Regelungseinrichtung (30) konfiguriert ist, in einem Fall, in dem, wenn der Betriebszustand von zumindest einer der Inneneinheiten (20a, 20b) von einem Betriebszustand, der der erste Zustand ist, zu einem ausgesetzten Zustand geändert wird, der der zweite Zustand ist, der Grad der Unterkühlung des Auslasses des Außenwärmetauschers (12), der als ein Kondensator fungiert, oder der Grad der Überhitzung der Ansaugseite des Kompressors (11) geringer ist als der Schwellenwert, beurteilt, dass eine Anomalie bei einem der Hochdruckventile (41a, 41b), die mit einer der Inneneinheiten (20a, 20b) verbunden sind, die sich in einem Betriebszustand befindet, vorliegt, und in einem Fall, in dem der Grad der Unterkühlung des Auslasses des Außenwärmetauschers (12), der als ein Kondensator fungiert, oder der Grad der Überhitzung der Ansaugseite des Kompressors (11) nicht geringer ist als der Schwellenwert, beurteilt, dass eine Anomalie bei einem der Hochdruckventile (41a, 41b), die mit einer der Inneneinheiten (20a, 20b) verbunden sind, die sich in einem ausgesetzten Zustand befindet, vorliegt.

Revendications

1. Appareil à cycle de réfrigération (100), comprenant : une unité extérieure (10) incluant un compresseur (11) et un échangeur de chaleur extérieur (12),

une pluralité d'unités intérieures (20a, 20b) incluant chacune un échangeur de chaleur intérieur (22a, 22b) et un dispositif de détente (21a, 21b),

une unité relais (40) interposée entre l'unité extérieure (10) et chacune de la pluralité d'unités intérieures (20a, 20b) et servant à amener un réfrigérant provenant de l'unité extérieure (10) à se ramifier dans chacune des unités intérieures (20a, 20b),

un circuit de réfrigérant (1) dans lequel le compresseur (11), l'échangeur de chaleur extérieur (12), le dispositif de détente (21a, 21b) et l'échangeur de chaleur intérieur (22a, 22b) sont raccordés par

des conduits de réfrigérant et à travers lequel un réfrigérant circule, et un dispositif de commande (30) configuré pour commander la pluralité d'unités intérieures (20a, 20b),

dans lequel

l'unité relais (40) inclut

une pluralité de vannes haute pression (41a, 41b) ménagées chacune dans un conduit correspondant d'une pluralité de conduits haute pression (46a, 46b) raccordant un côté haute pression de l'unité extérieure (10) et chacune des unités intérieures (20a, 20b), et

une pluralité de vannes basse pression (42a, 42b) ménagées chacune dans un conduit correspondant d'une pluralité de conduits basse pression (47a, 47b) raccordant un côté haute pression de l'unité extérieure (10) et chacune des unités intérieures (20a, 20b), **caractérisé en ce que**

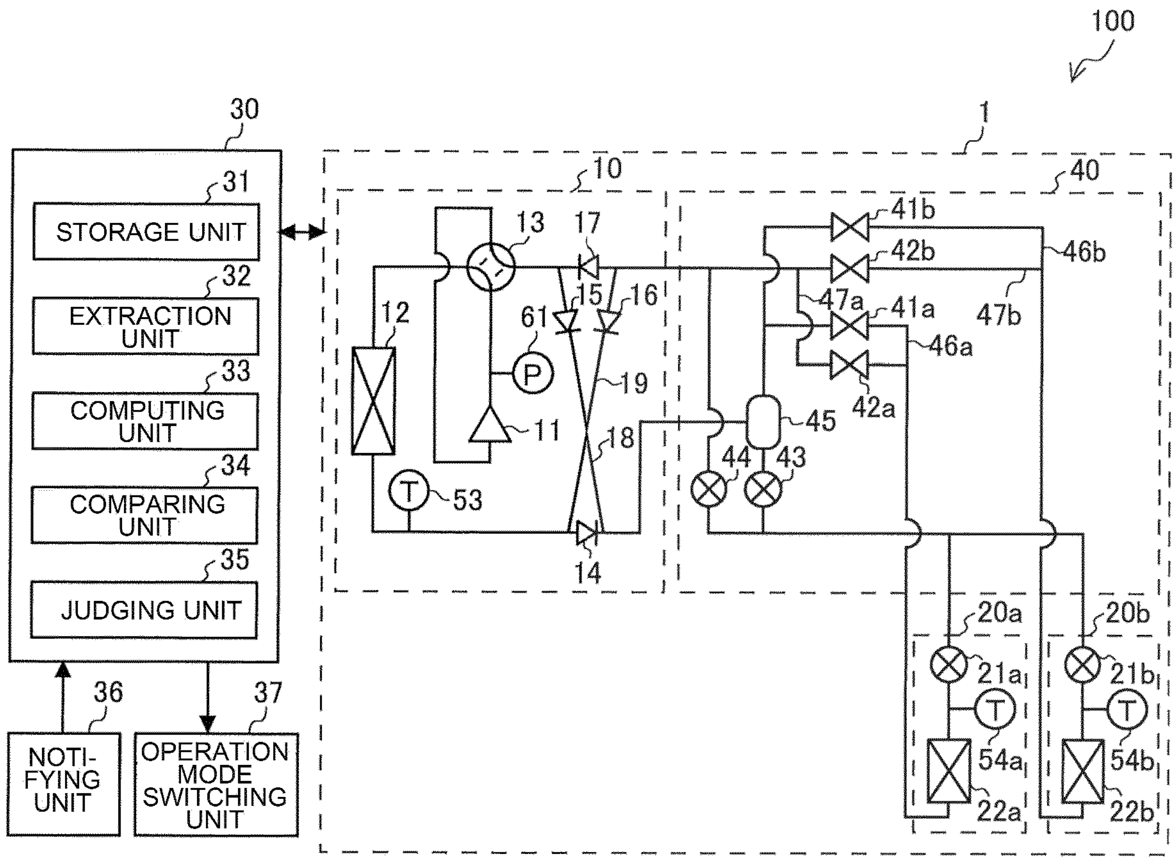
le dispositif de commande (30) est configuré pour, lorsqu'un état de fonctionnement d'au moins l'une des unités intérieures (20a, 20b) passe d'un premier état à un second état, juger, sur la base d'un degré de surfusion d'un orifice de sortie de l'échangeur de chaleur extérieur

(12) ou de l'échangeur de chaleur intérieur (22a, 22b) qui fonctionne comme un condenseur, ou sur la base d'un degré de surébullition d'un côté aspiration du compresseur (11), si une anomalie est présente dans la pluralité de vannes haute pression (41a, 41b) ou la pluralité de vannes basse pression (42a, 42b), dans lequel

le circuit de réfrigérant (1) est configuré de sorte que l'échangeur de chaleur extérieur (12) serve de condenseur, et

dans un cas dans lequel le degré de surfusion de l'orifice de sortie de l'échangeur de chaleur extérieur (12) qui fonctionne comme un condenseur lorsque toutes les unités intérieures (20a, 20b) sont dans un état de fonctionnement, ou le degré de surébullition du côté aspiration du compresseur (11) lorsque toutes les unités intérieures (20a, 20b) sont dans l'état de fonctionnement, est inférieur à un seuil défini à l'avance, le dispositif de commande (30) est configuré pour, dans un cas dans lequel lorsque l'état de fonctionnement d'au moins l'une des unités intérieures (20a, 20b) passe d'un état de fonctionnement qui est le premier état à un état suspendu qui est le second état, le degré de surfusion de l'orifice de sortie de l'échangeur de chaleur extérieur (12) qui fonctionne comme un condenseur, ou le degré de surébullition du côté aspiration du compresseur (11), est inférieur au seuil, juger qu'une anomalie est présente dans l'une des vannes haute pression (41a, 41b) raccordées à l'une des unités intérieures (20a, 20b) qui est dans un état de fonctionnement et, dans un cas dans lequel le degré de surfusion de l'orifice de sortie de l'échangeur de chaleur extérieur (12) qui fonctionne comme un condenseur, ou le degré de surébullition du côté aspiration du compresseur (11), n'est pas inférieur au seuil, juger qu'une anomalie est présente dans l'une des vannes haute pression (41a, 41b) raccordées à l'une des unités intérieures (20a, 20b) qui est dans un état suspendu.

FIG. 1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JUDGING UNIT
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NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
1
10
40
13
17
12
15
16
61
P
19
11
18
T
53
14
41b
42b
46b
47a
41a
47b
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42a
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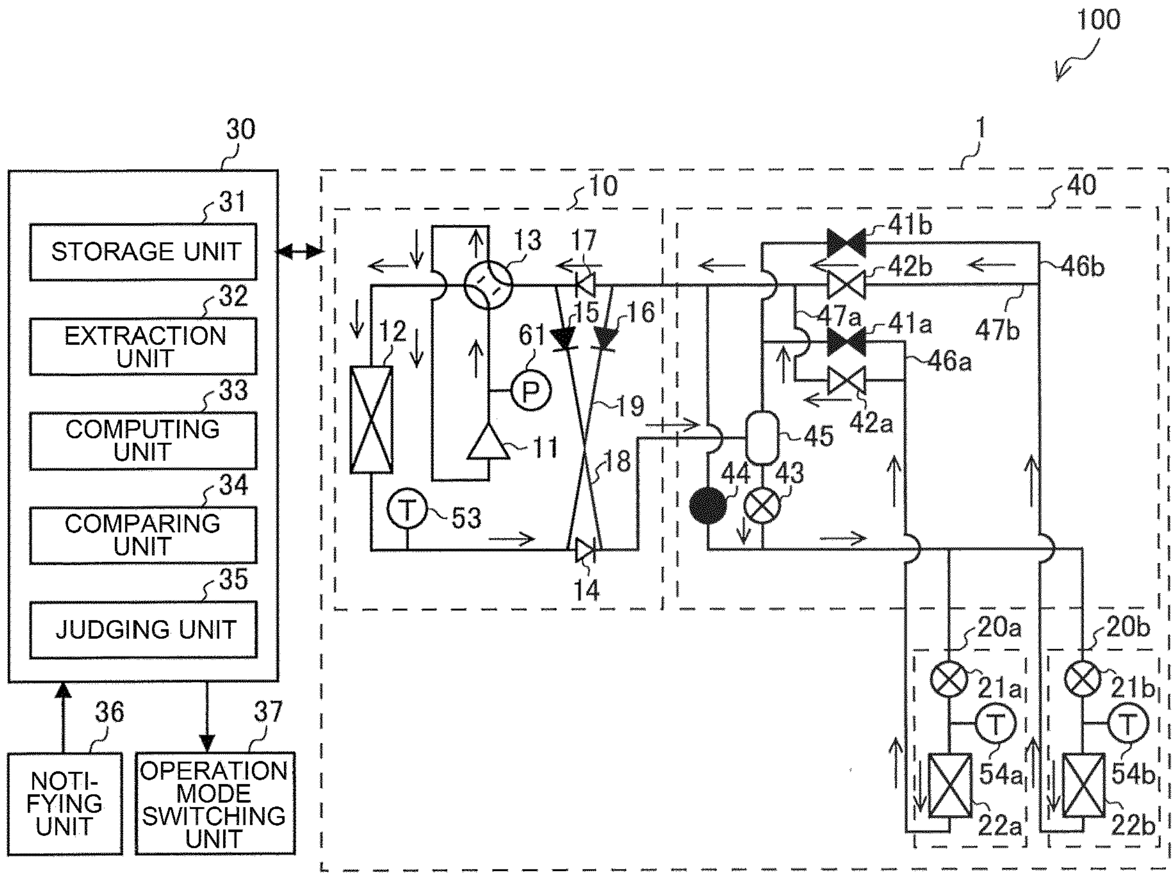
20a
20b
21a
21b
T
54a
54b
22a
22b

FIG. 2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OPERATION MODE SWITCHING UNIT
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P
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42b
46b
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41a
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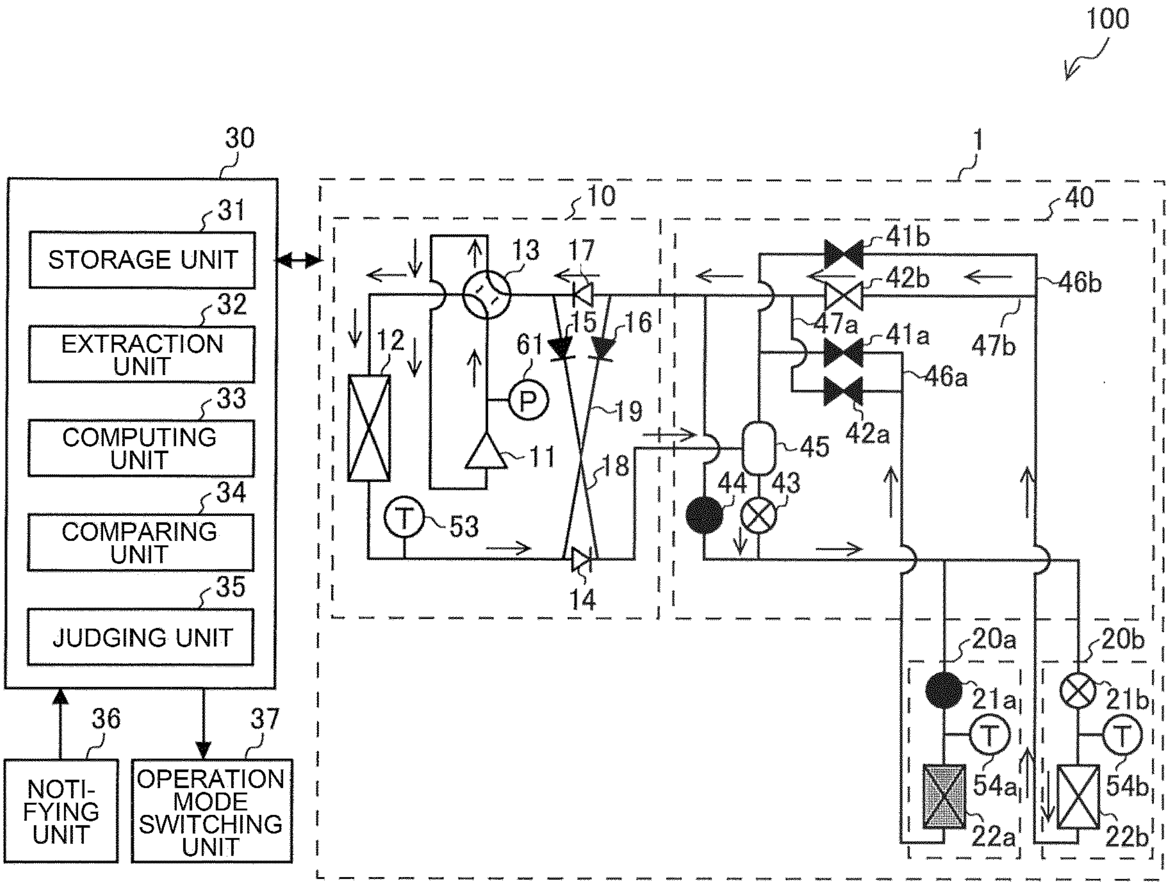
FIG. 3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NOTI-FYING UNIT
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OPERATION MODE SWITCHING UNIT
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40
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16
61
P
11
19
18
T
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14
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42b
46b
47a
41a
47b
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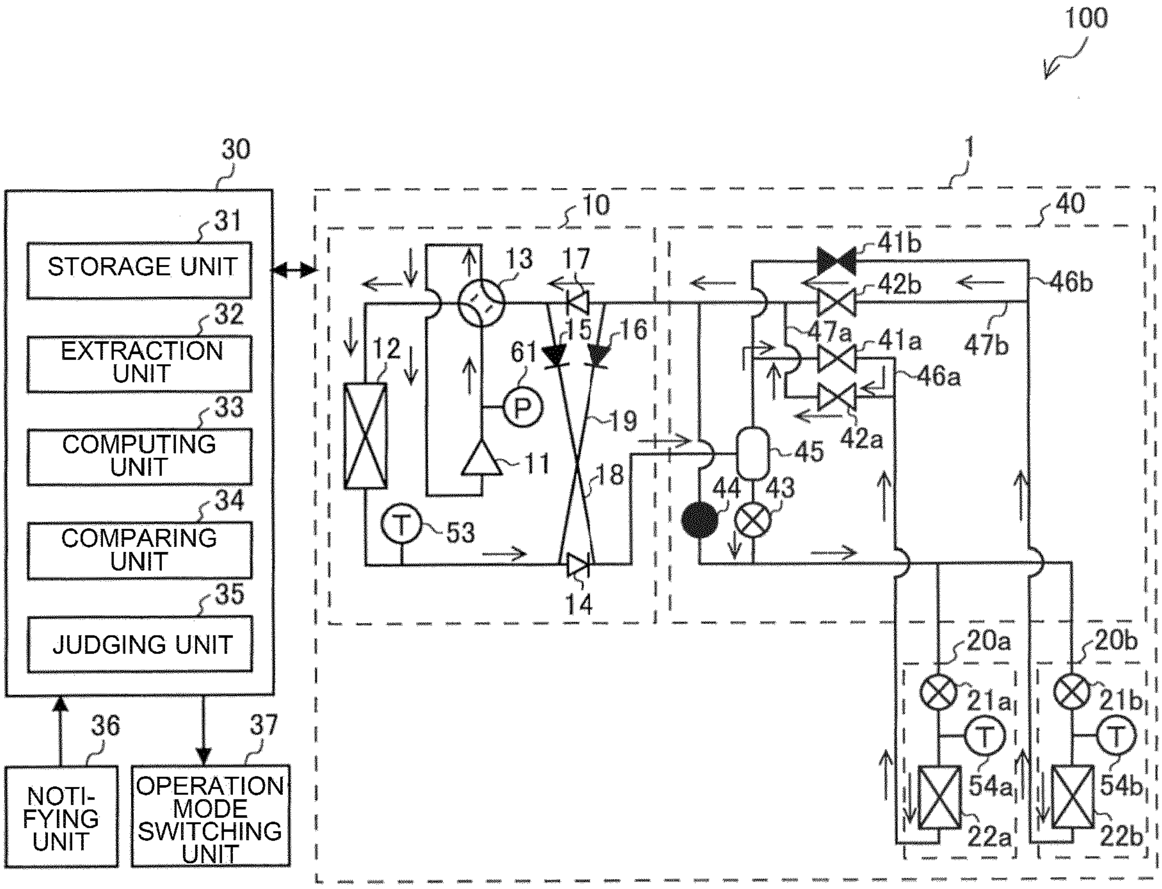
54b
22b

FIG. 4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NOTI-FYING UNIT
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OPERATION MODE SWITCHING UNIT
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40
13
17
12
61
15
16
P
19
11
18
T
53
14
41b
42b
46b
47a
41a
47b
46a
42a
45
44
43
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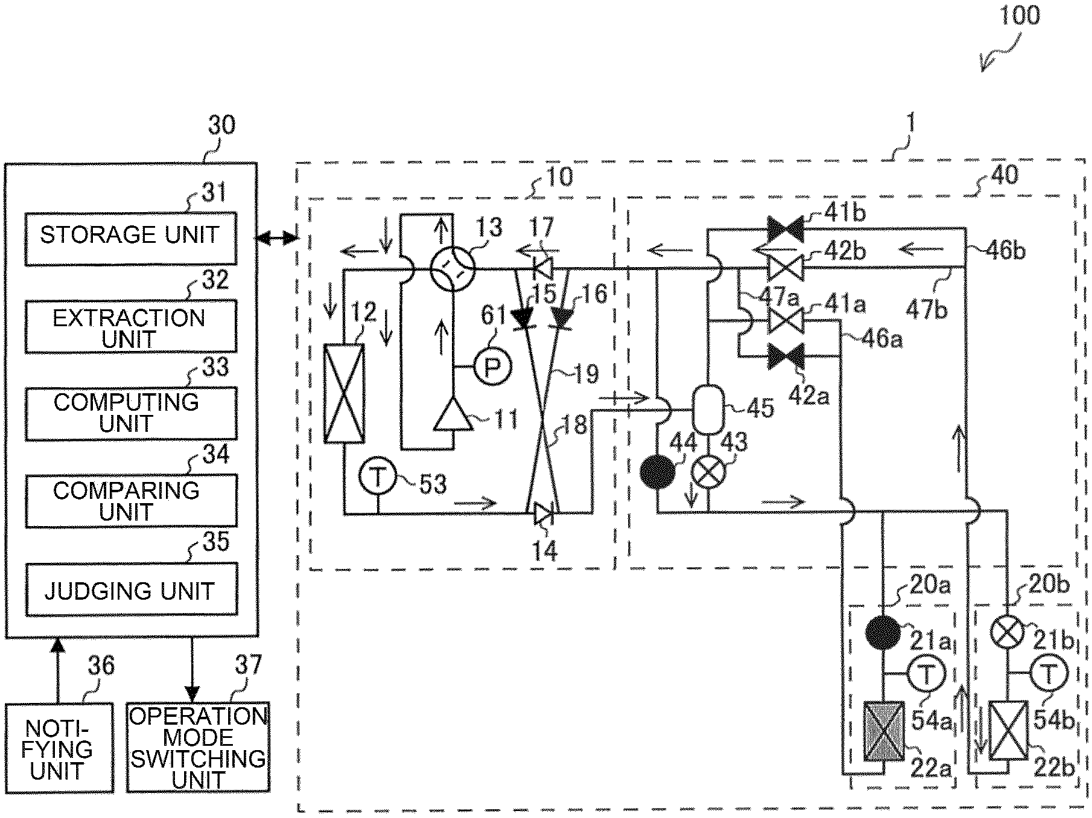
21a
T
54a
22a
20b
21b
T
54b
22b

FIG. 5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EXTRACTION UNIT
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COMPUTING UNIT
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COMPARING UNIT
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JUDGING UNIT
36
37
NOTI-FYING UNIT
OPERATION MODE SWITCHING UNIT
13
17
15
16
12
61
P
19
11
18
T
53
14
41b
42b
46b
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41a
47b
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T
54b
22b

FIG. 6

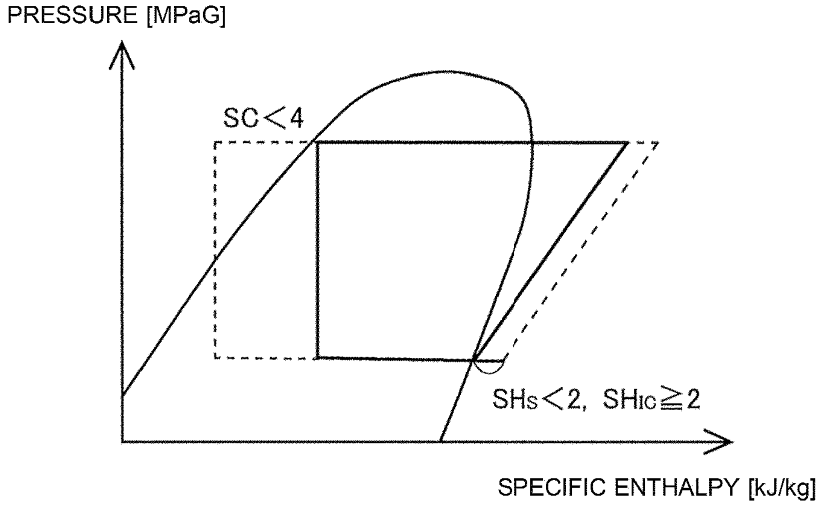

PRESSURE [MPaG]
SC<4
SHs<2, SHic≧2
SPECIFIC ENTHALPY [kJ/kg]

FIG. 7

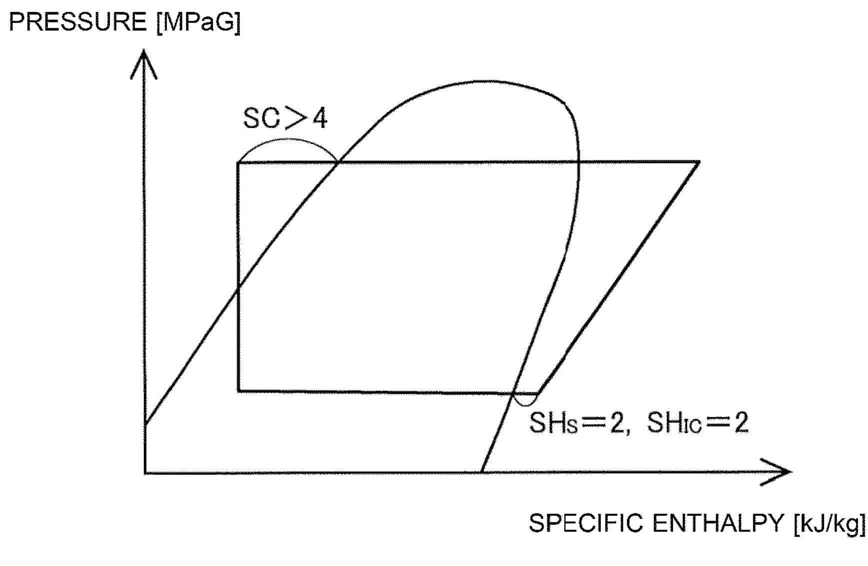


FIG. 8

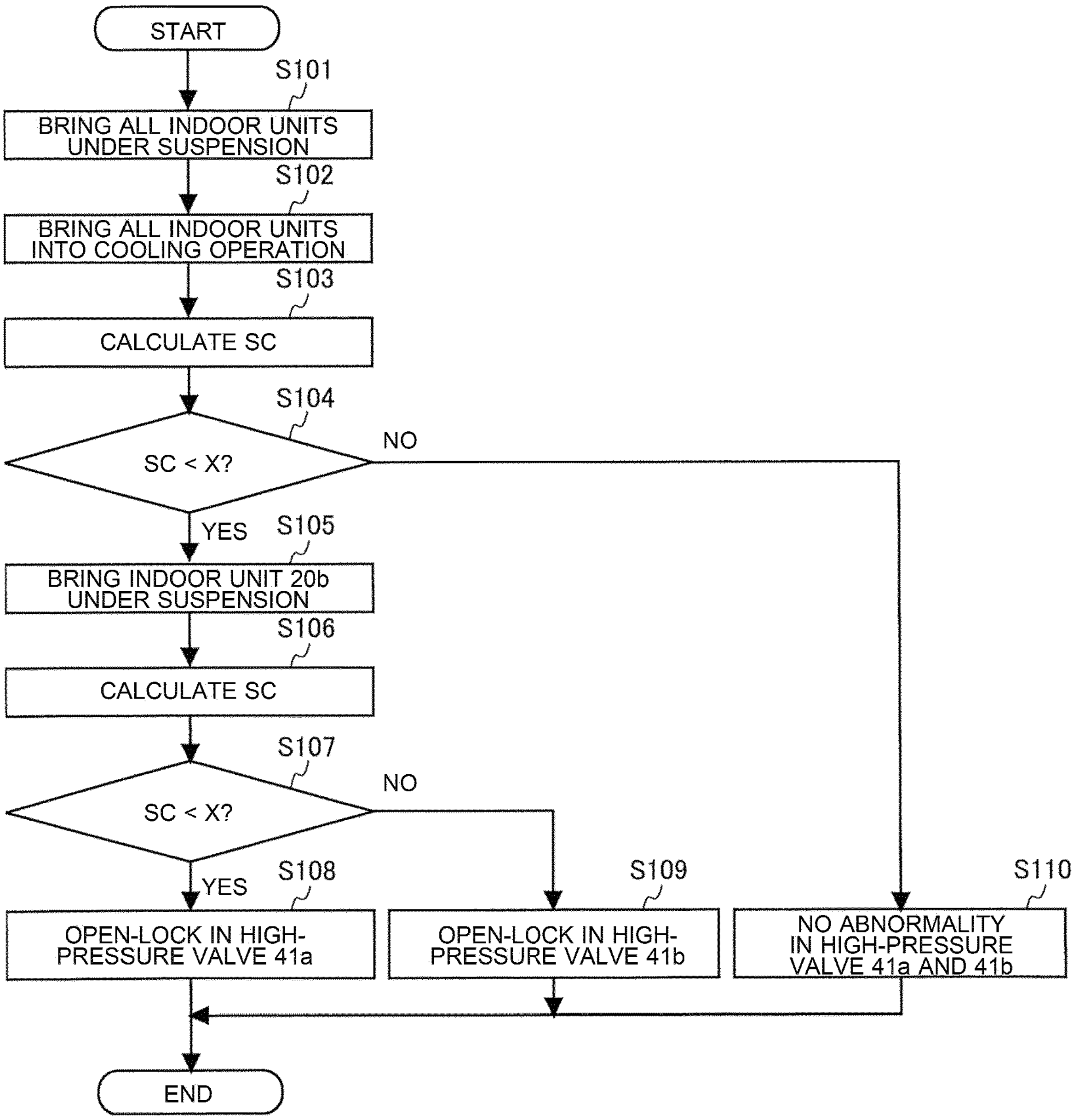

START
S101
BRING ALL INDOOR UNITS UNDER SUSPENSION
S102
BRING ALL INDOOR UNITS INTO COOLING OPERATION
S103
CALCULATE SC
S104
SC < X?
NO
YES
S105
BRING INDOOR UNIT 20b UNDER SUSPENSION
S106
CALCULATE SC
S107
SC < X?
NO
YES
S108
OPEN-LOCK IN HIGH-PRESSURE VALVE 41a
S109
OPEN-LOCK IN HIGH-PRESSURE VALVE 41b
S110
NO ABNORMALITY IN HIGH-PRESSURE VALVE 41a AND 41b
END

FIG. 9

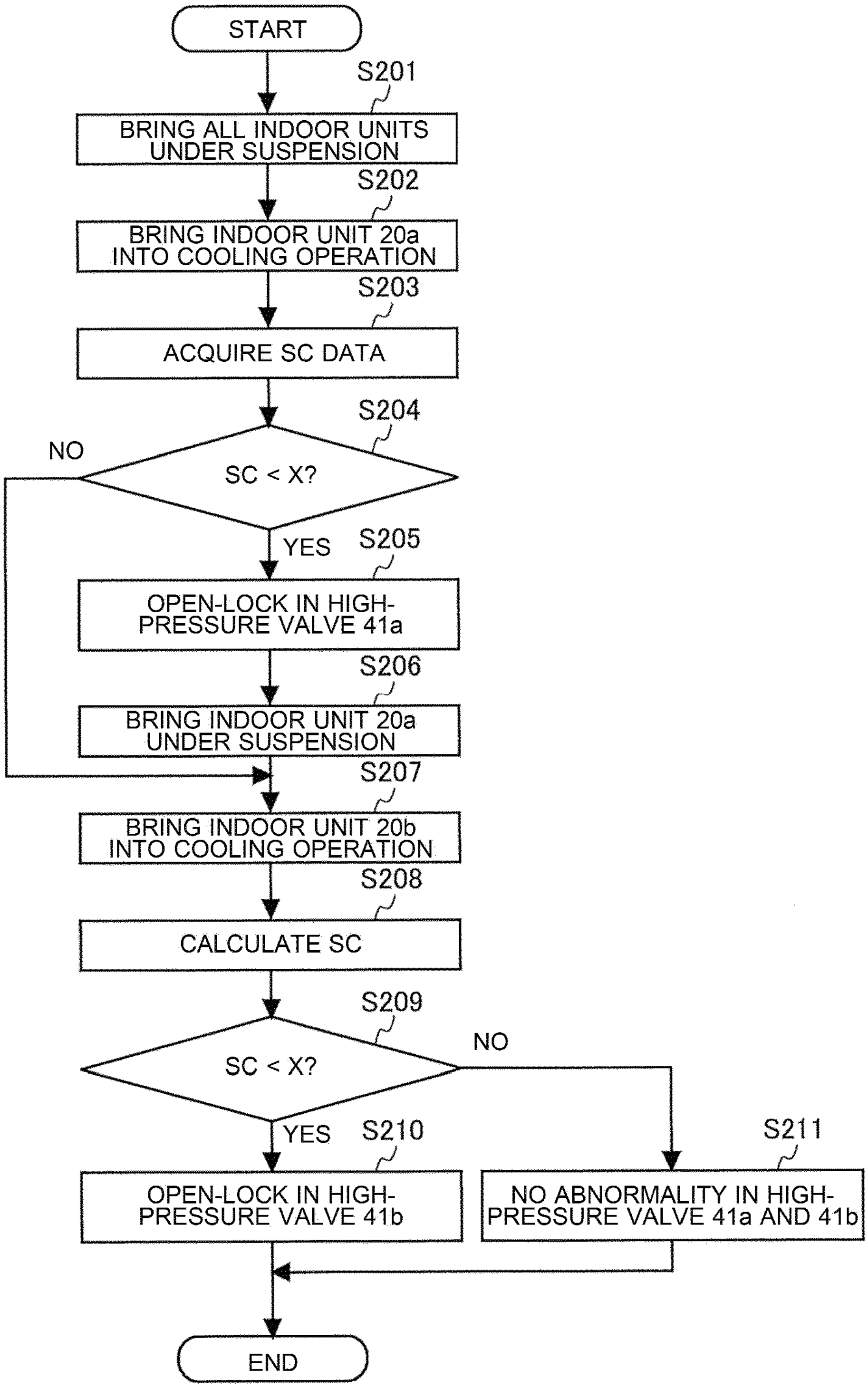
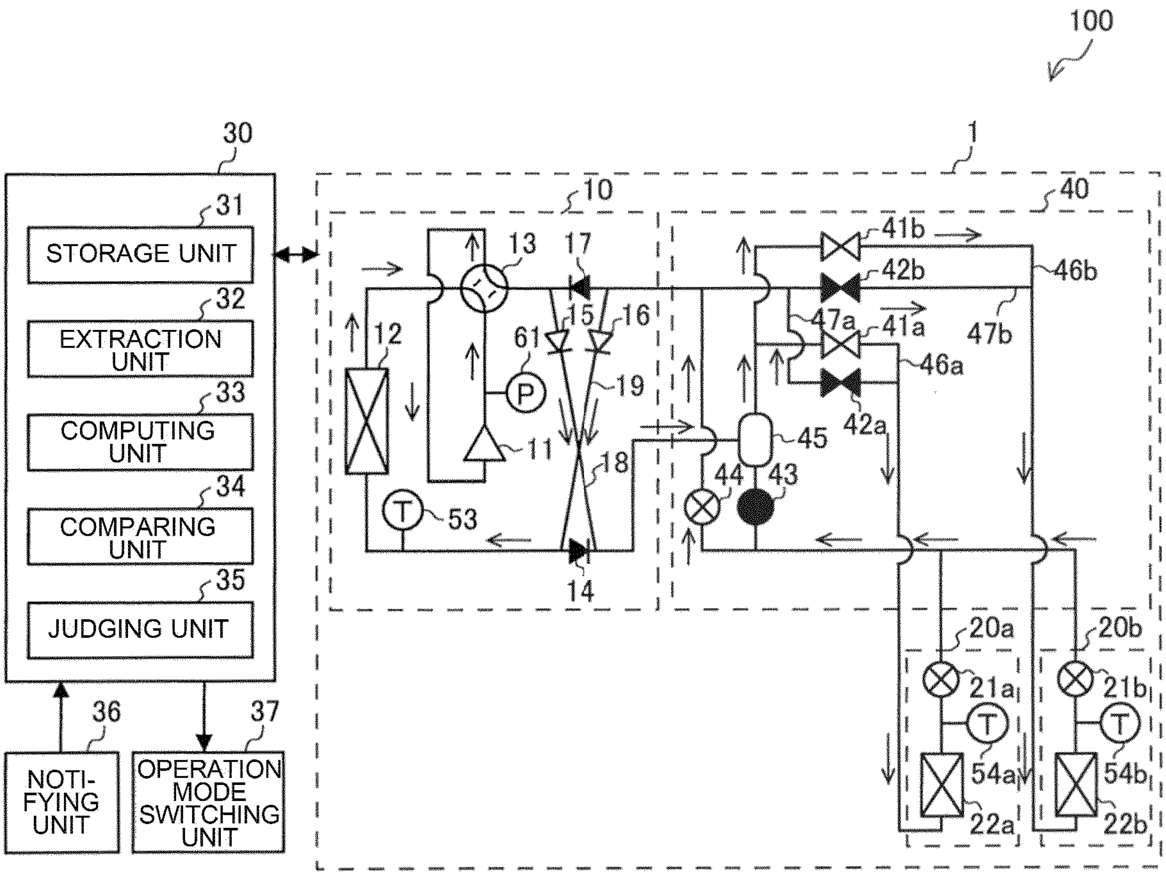

START
S201
BRING ALL INDOOR UNITS UNDER SUSPENSION
S202
BRING INDOOR UNIT 20a INTO COOLING OPERATION
S203
ACQUIRE SC DATA
S204
SC < X?
NO
YES
S205
OPEN-LOCK IN HIGH-PRESSURE VALVE 41a
S206
BRING INDOOR UNIT 20a UNDER SUSPENSION
S207
BRING INDOOR UNIT 20b INTO COOLING OPERATION
S208
CALCULATE SC
S209
SC < X?
NO
YES
S210
OPEN-LOCK IN HIGH-PRESSURE VALVE 41b
S211
NO ABNORMALITY IN HIGH-PRESSURE VALVE 41a AND 41b
END

FIG. 10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STORAGE UNIT
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EXTRACTION UNIT
33
COMPUTING UNIT
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COMPARING UNIT
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JUDGING UNIT
36
NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
10
40
13
17
12
15
16
61
P
19
11
18
T
53
14
41b
42b
46b
47a
41a
47b
46a
42a
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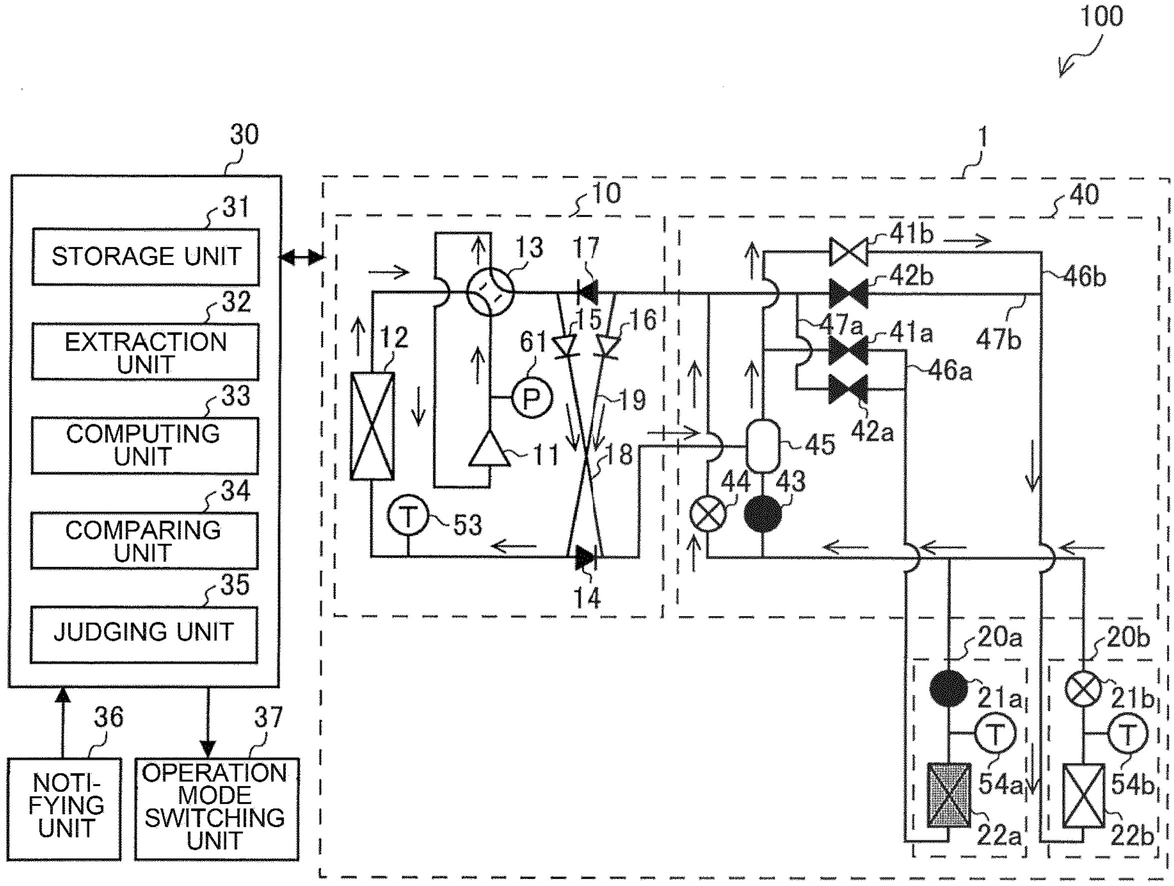
43
20a
20b
21a
21b
T
54a
54b
22a
22b

FIG. 11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37
OPERATION MODE SWITCHING UNIT
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40
13
17
41b
42b
46b
12
61
15
16
47a
41a
47b
46a
P
19
42a
11
18
45
44
43
T
53
14
20a
20b
21a
21b
T
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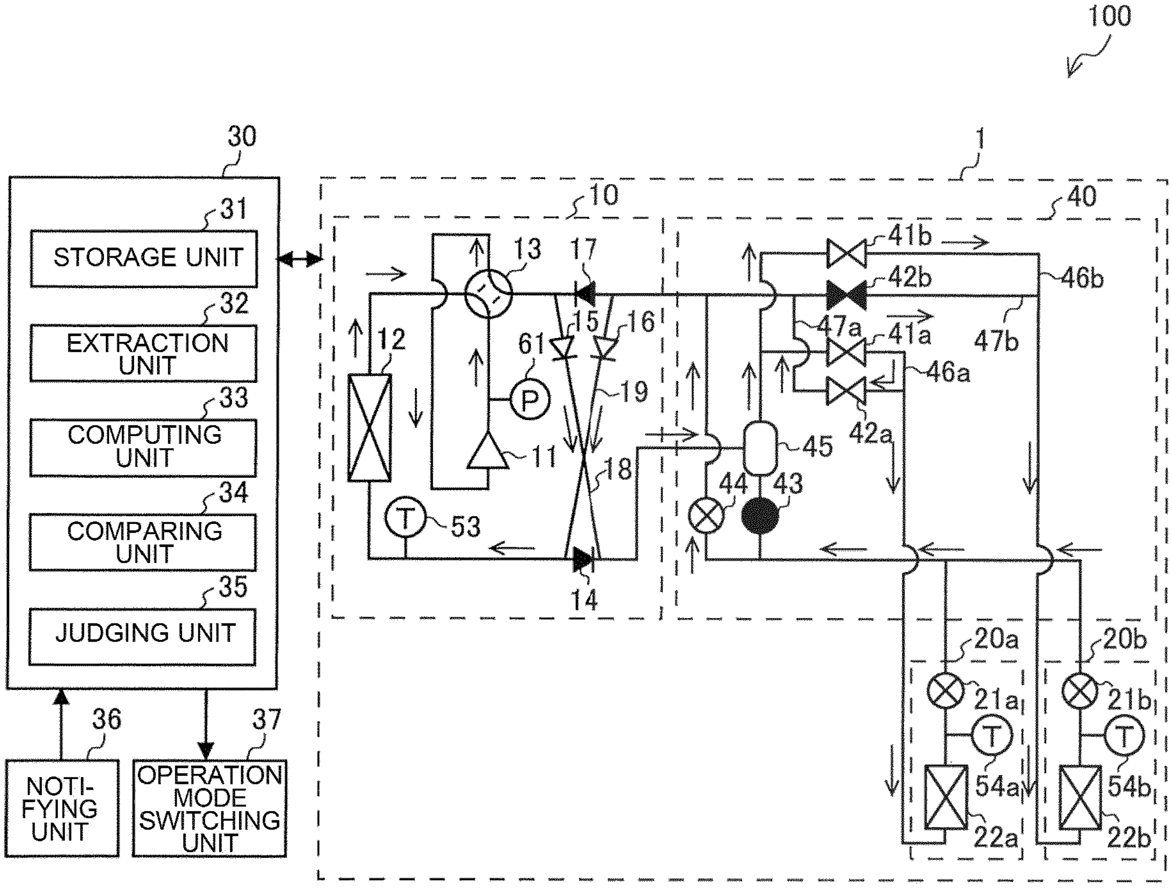
54b
22a
22b

FIG. 12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OPERATION MODE SWITCHING UNIT
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12
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16
61
P
19
11
18
T
53
14
41b
42b
46b
47a
41a
47b
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20a
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21a
21b
T
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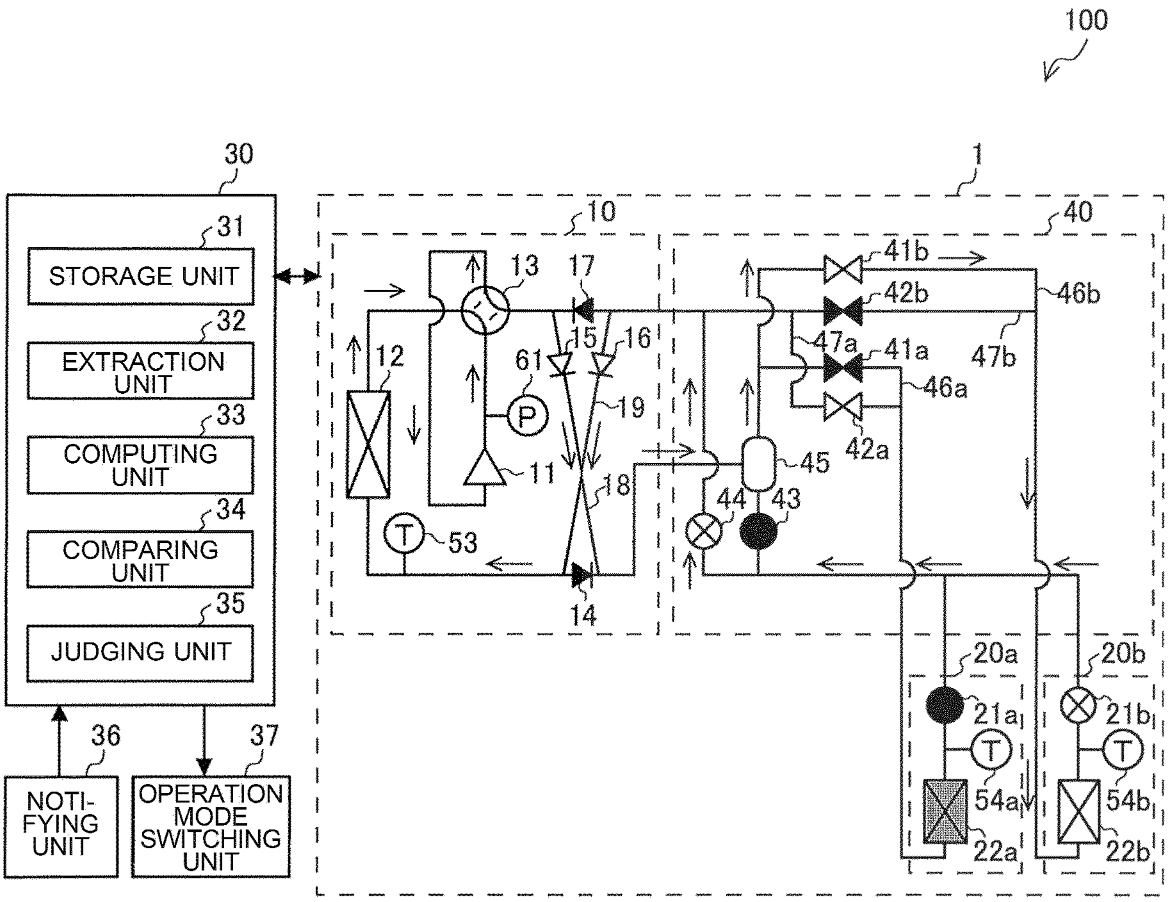
22a
22b

FIG. 13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JUDGING UNIT
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NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
1
10
40
13
17
15
16
12
61
P
19
11
18
T
53
14
41b
42b
46b
47a
41a
47b
46a
42a
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44
43
20a
20b
21a
21b
T
54a
54b
22a
22b

FIG. 14

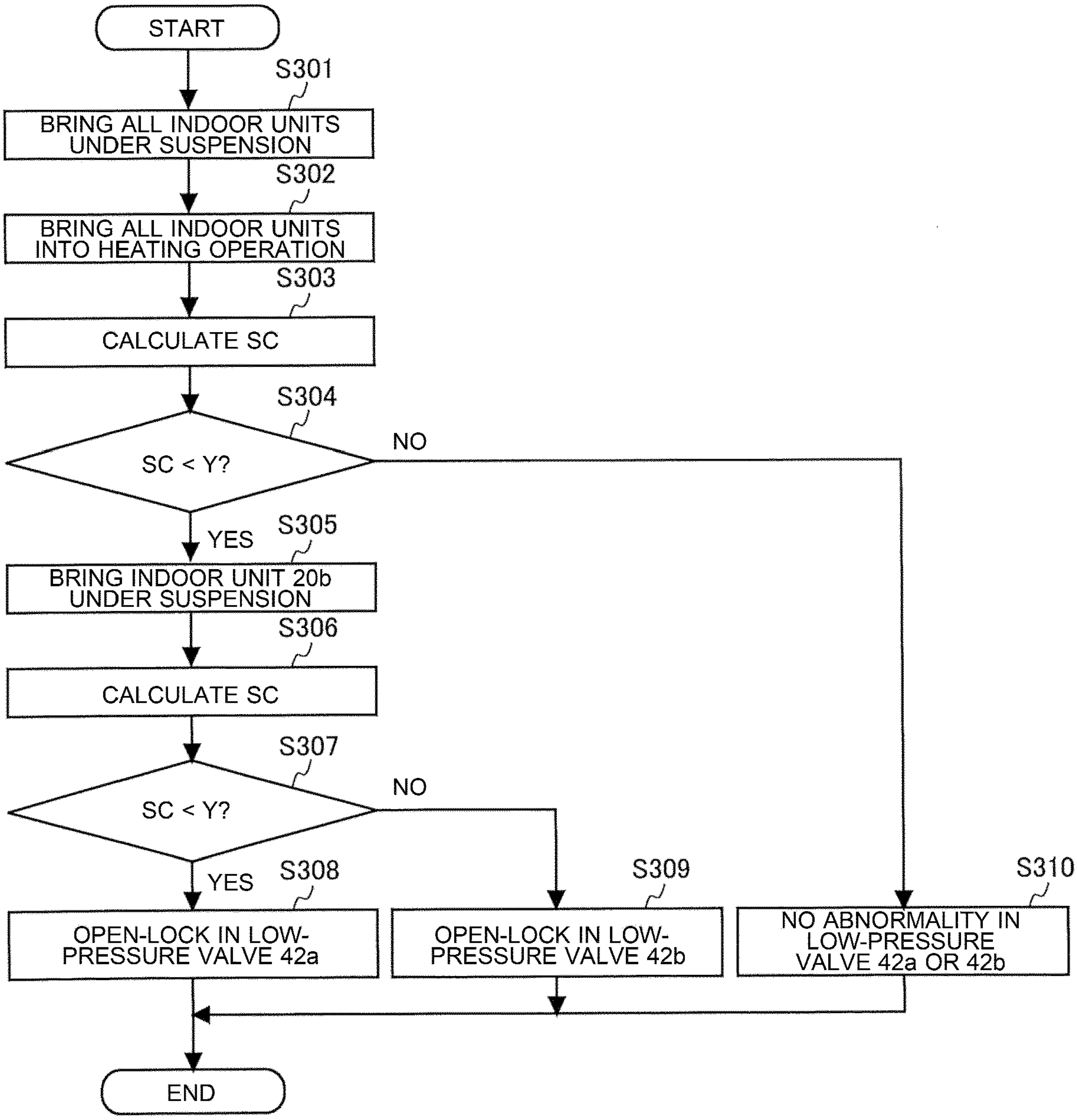

START
S301
BRING ALL INDOOR UNITS UNDER SUSPENSION
S302
BRING ALL INDOOR UNITS INTO HEATING OPERATION
S303
CALCULATE SC
S304
SC < Y?
NO
YES
S305
BRING INDOOR UNIT 20b UNDER SUSPENSION
S306
CALCULATE SC
S307
SC < Y?
NO
YES
S308
OPEN-LOCK IN LOW-PRESSURE VALVE 42a
S309
OPEN-LOCK IN LOW-PRESSURE VALVE 42b
S310
NO ABNORMALITY IN LOW-PRESSURE VALVE 42a OR 42b
END

FIG. 15

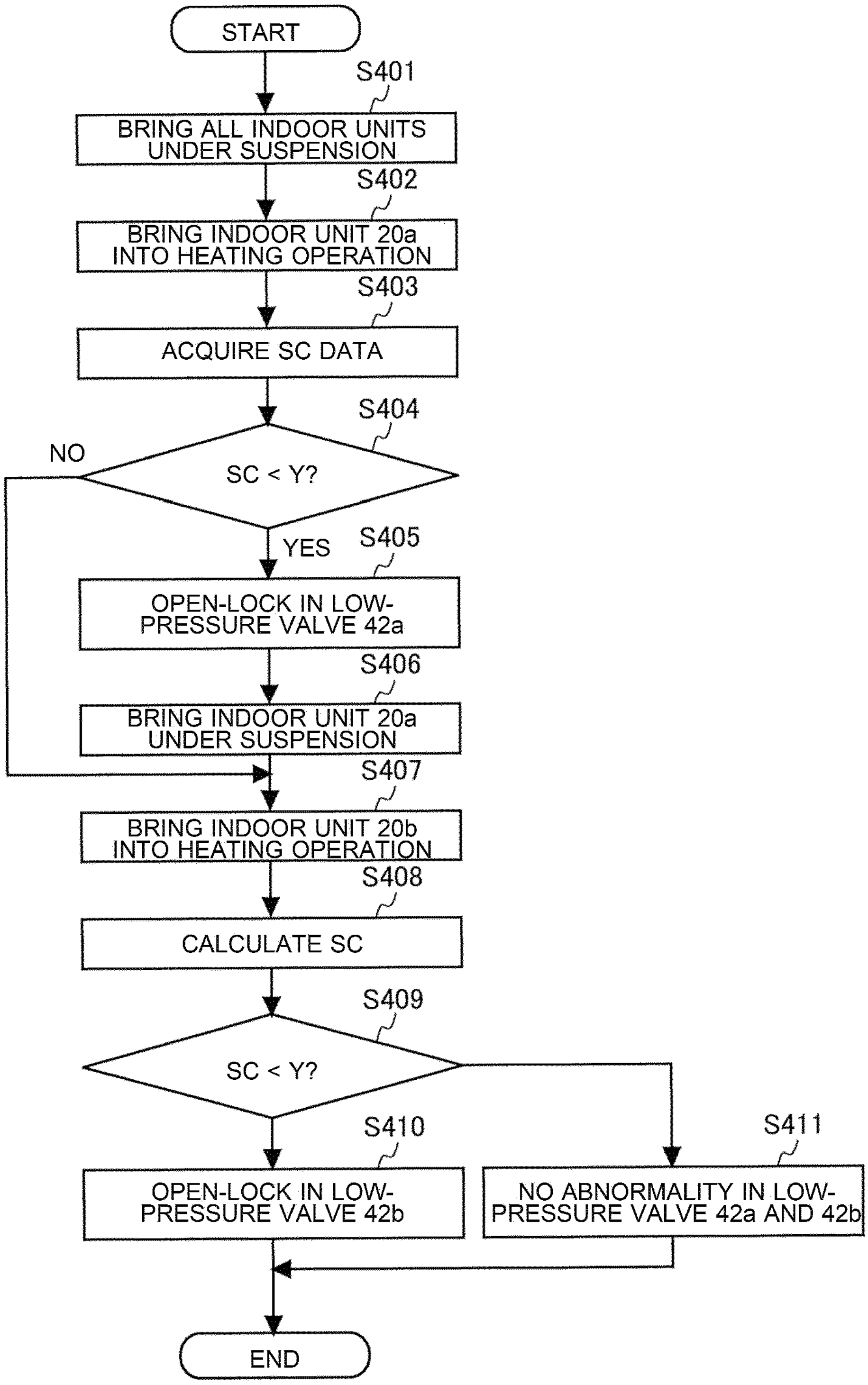
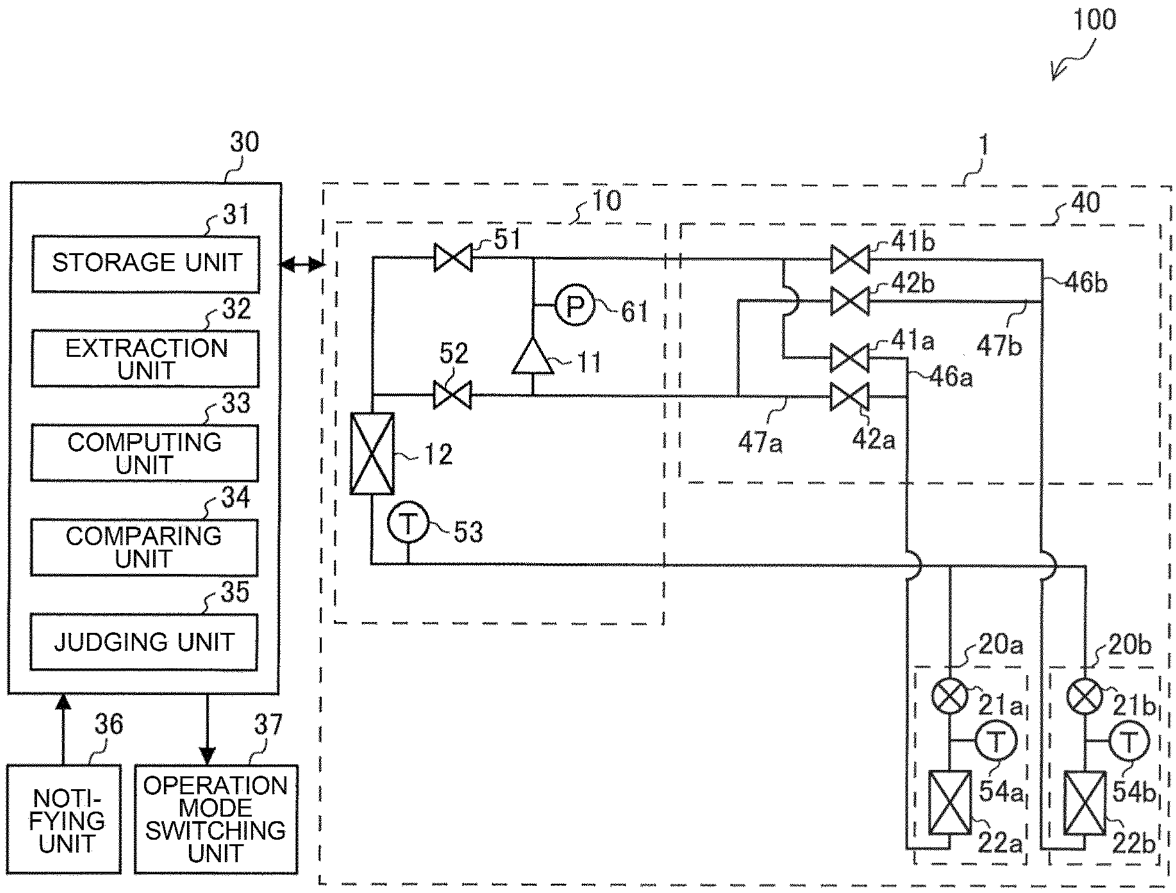

START
S401
BRING ALL INDOOR UNITS UNDER SUSPENSION
S402
BRING INDOOR UNIT 20a INTO HEATING OPERATION
S403
ACQUIRE SC DATA
S404
SC < Y?
NO
YES
S405
OPEN-LOCK IN LOW-PRESSURE VALVE 42a
S406
BRING INDOOR UNIT 20a UNDER SUSPENSION
S407
BRING INDOOR UNIT 20b INTO HEATING OPERATION
S408
CALCULATE SC
S409
SC < Y?
S410
OPEN-LOCK IN LOW-PRESSURE VALVE 42b
S411
NO ABNORMALITY IN LOW-PRESSURE VALVE 42a AND 42b
END

FIG. 16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JUDGING UNIT
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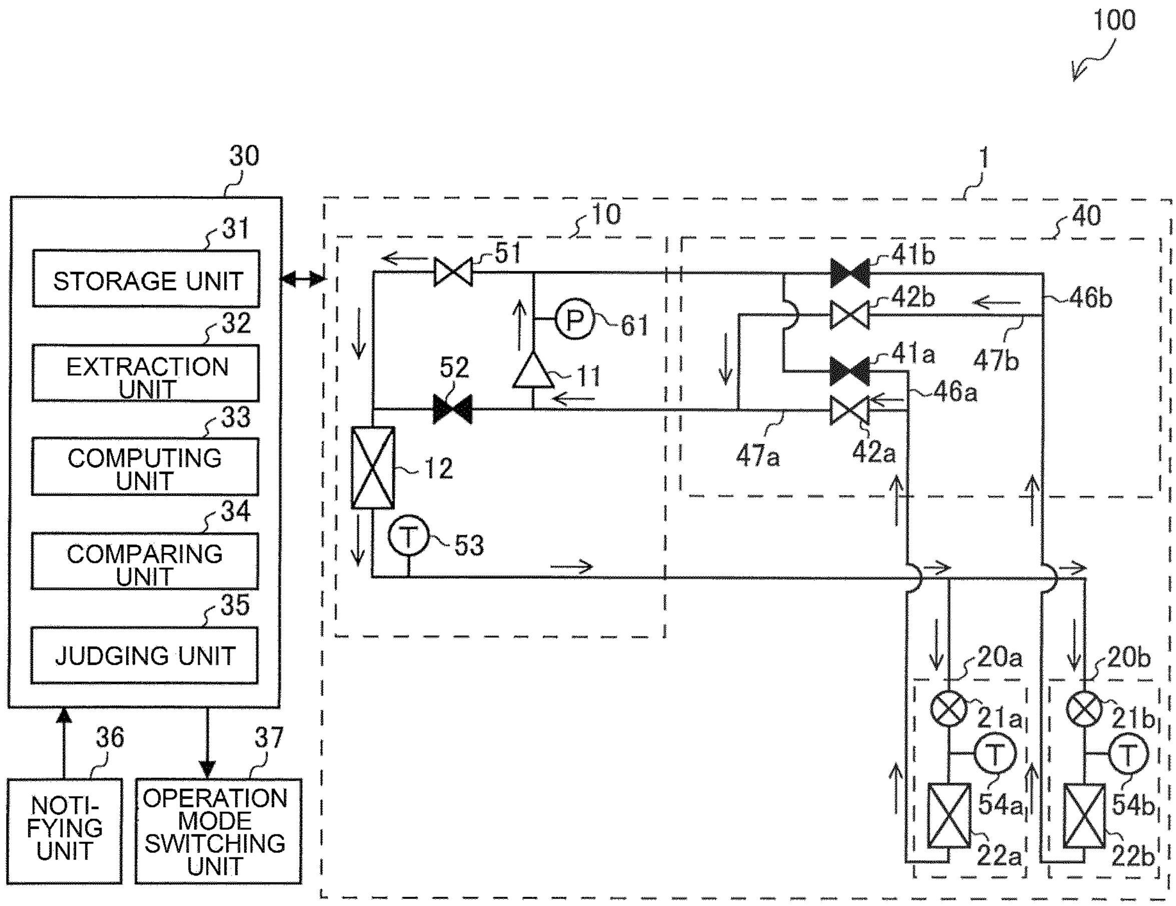
NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
1
10
40
51
61
52
11
12
53
41b
42b
46b
41a
47b
46a
47a
42a
20a
21a
54a
22a
20b
21b
54b
22b

FIG. 17



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COMPUTING UNIT
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JUDGING UNIT
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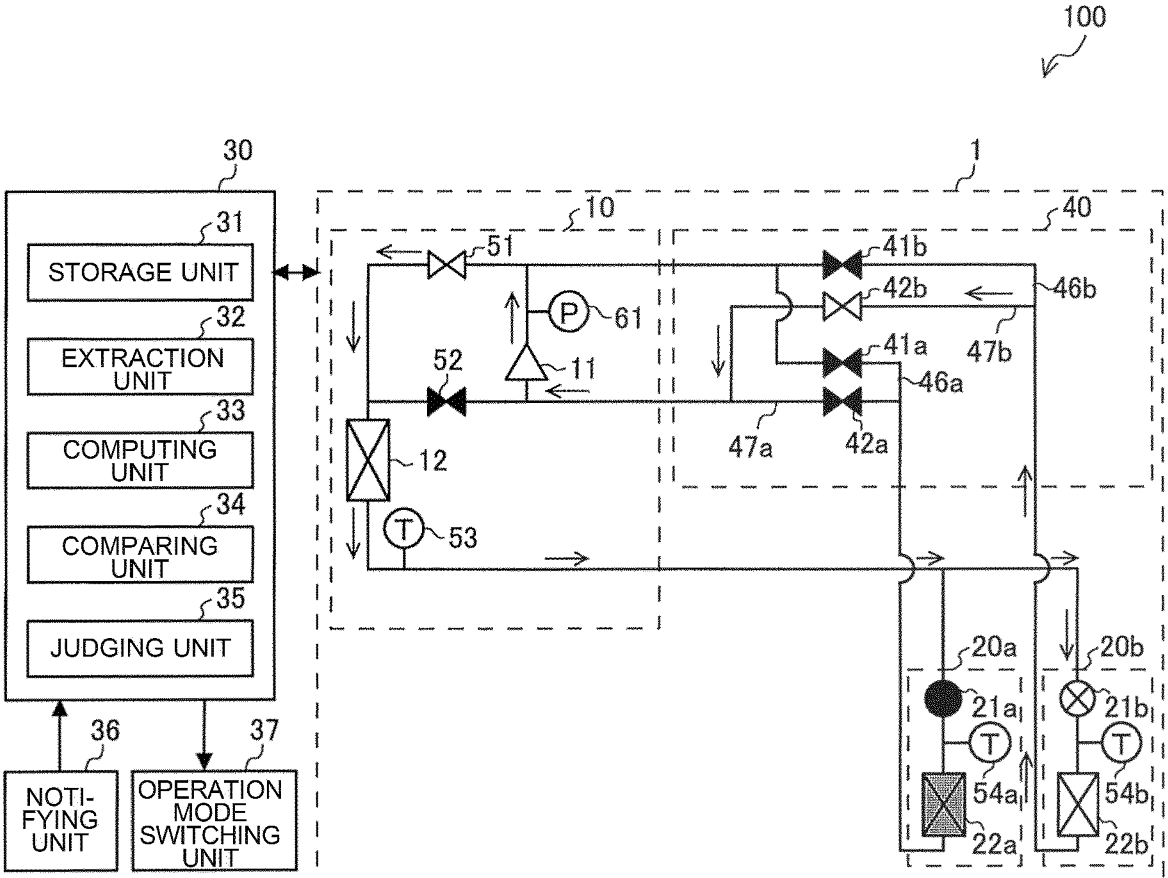
NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
1
10
51
61
52
11
12
53
40
41b
42b
46b
41a
47b
46a
47a
42a
20a
21a
54a
22a
20b
21b
54b
22b

FIG. 18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37
OPERATION MODE SWITCHING UNIT
1
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41b
42b
46b
41a
47b
46a
47a
42a
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21a
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54a
22a
20b
21b
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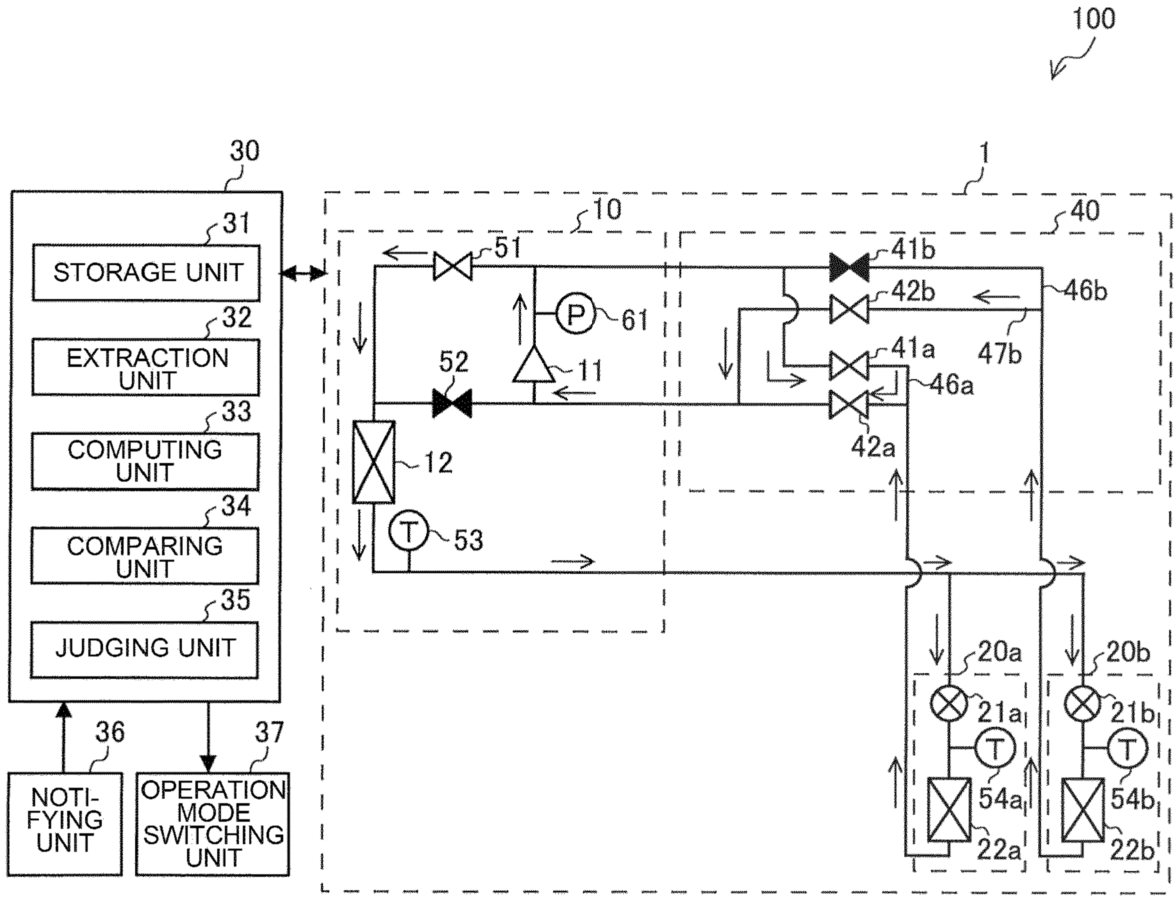
54b
22b

FIG. 19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NOTI-FYING UNIT
37
OPERATION MODE SWITCHING UNIT
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61
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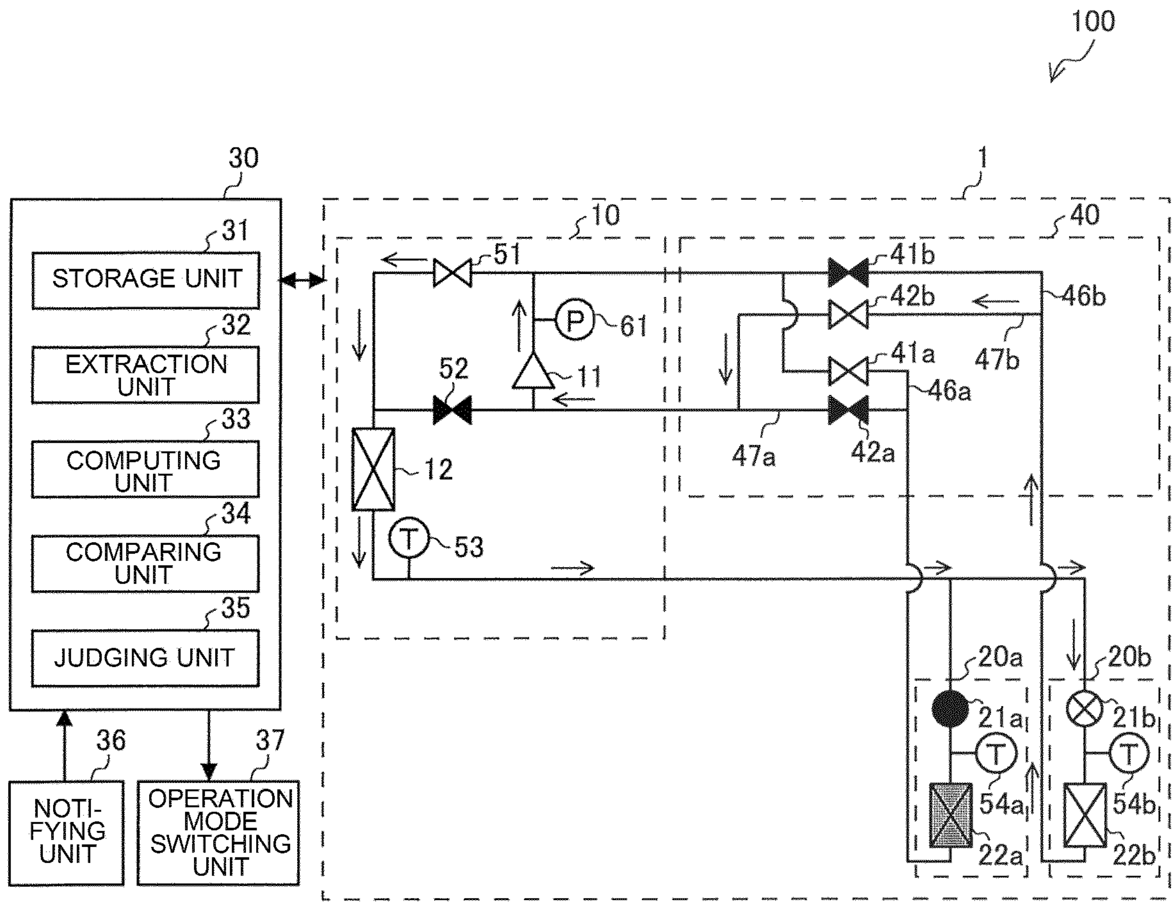
53
41b
42b
46b
41a
47b
46a
42a
20a
20b
21a
21b
54a
54b
22a
22b

FIG. 20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37
OPERATION MODE SWITCHING UNIT
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41b
42b
46b
41a
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20b
21b
54b
22b
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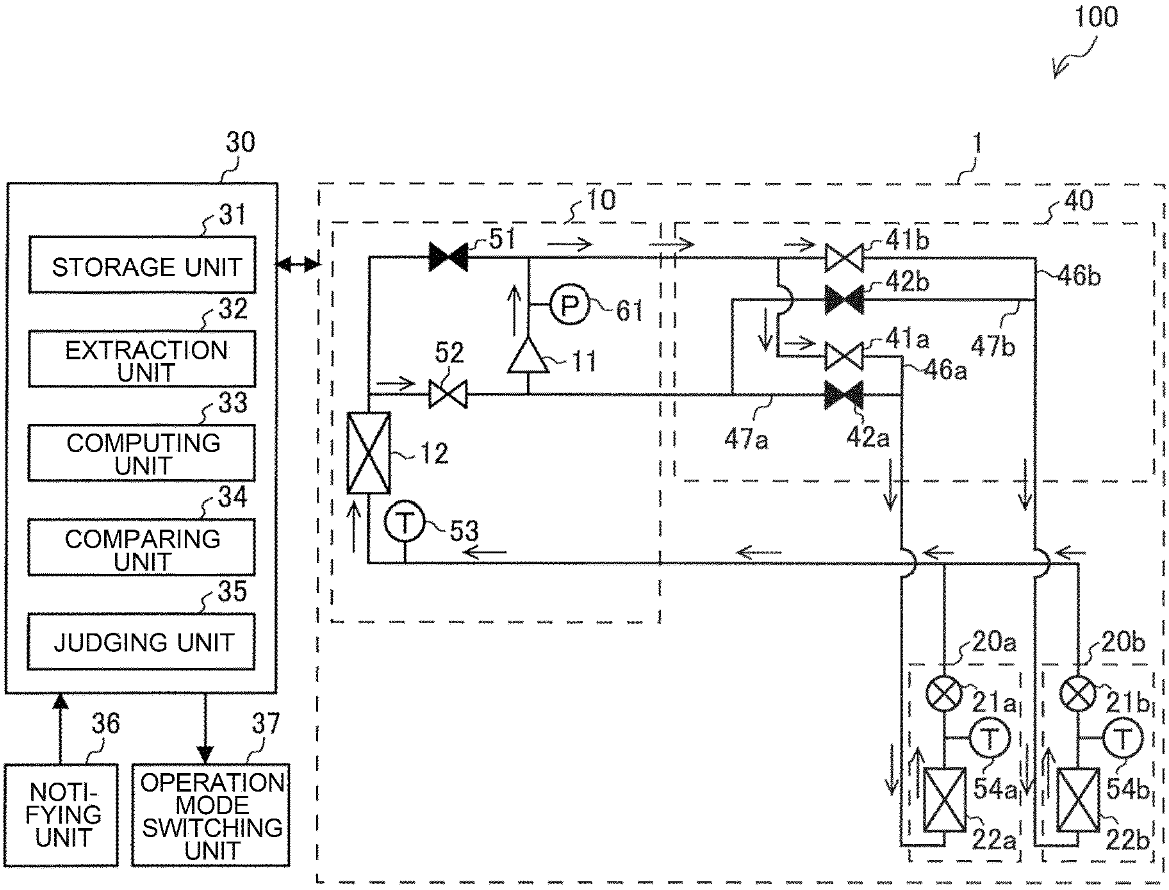
FIG. 21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NOTI-FYING UNIT
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OPERATION MODE SWITCHING UNIT
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22a
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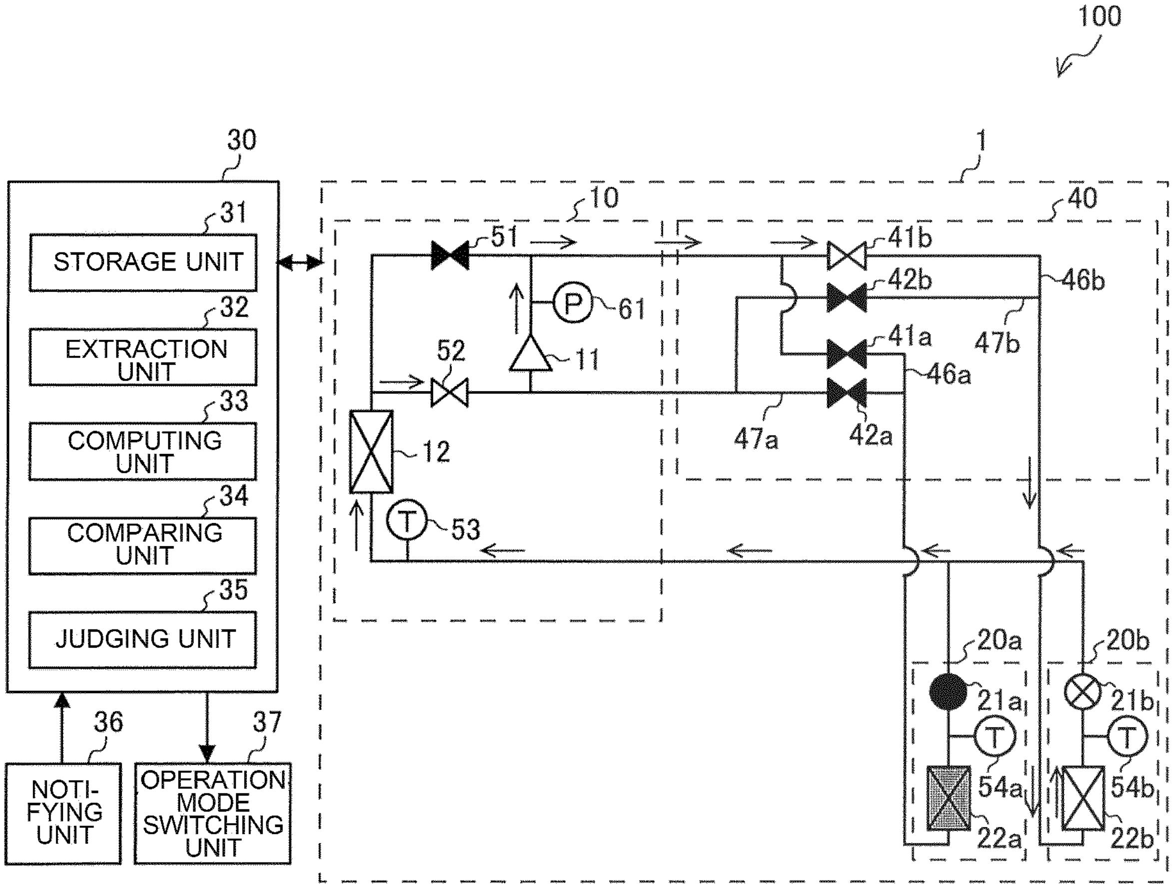
FIG. 22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OPERATION MODE SWITCHING UNIT
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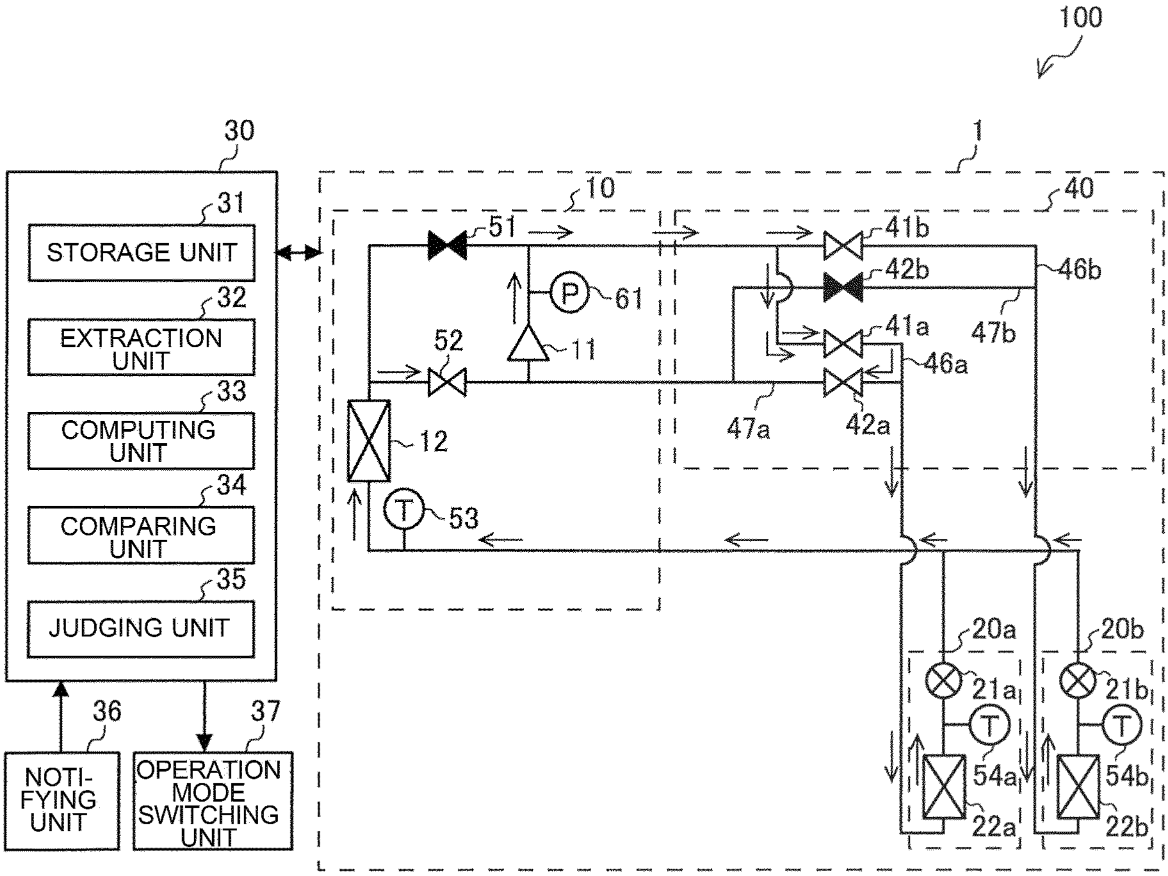
21b
54a
54b
22a
22b

FIG. 23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OPERATION MODE SWITCHING UNIT
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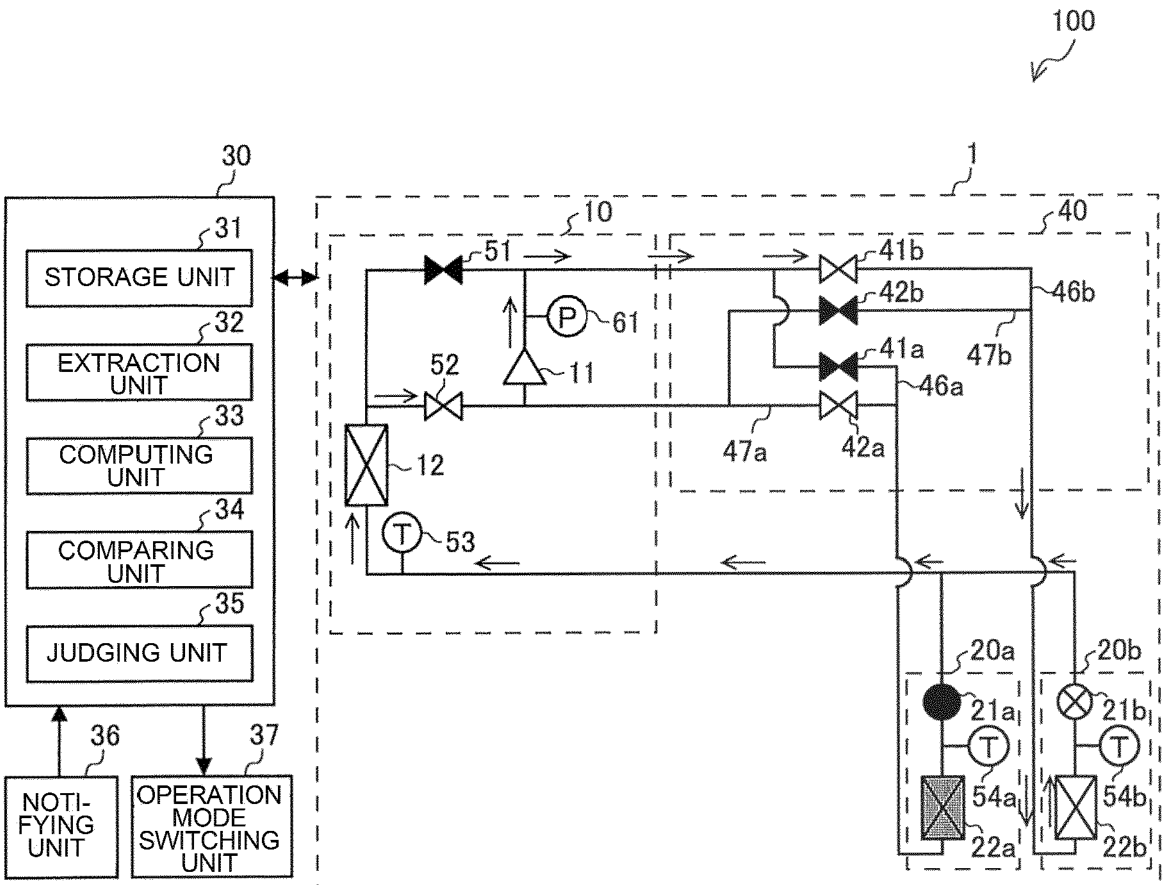
22b

FIG. 24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20b
21a
21b
54a
54b
22a
22b

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