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(54) REFRIGERANT LEAKAGE SPOT SPECIFYING METHOD

(57) Provided is a refrigerant leakage spot identifying method that is capable of identifying a refrigerant leakage spot when a refrigerant leakage has occurred while restraining an increase in cost. The refrigerant leakage spot identifying method applied to a refrigeration apparatus (100) is a method for identifying a refrigerant leakage spot when a leakage of refrigerant has occurred in a refrigerant circuit (RC) including a compressor (11) and a liquid-side closing valve (17), a gas-side closing valve (18), and a utilization-side expansion valve (32), the valves being capable of being in a closed state to block the flow of the refrigerant. The method includs a step for dividing the refrigerant circuit (RC) into a plurality of refrigerant flow paths by setting each of the valves to the closed state in the state of the compressor (11) being stopped; and a step for determining whether or not there is a leakage of the refrigerant in each of the refrigerant flow paths by detecting a change in the state of the refrigerant in each of the refrigerant flow paths after the first step.

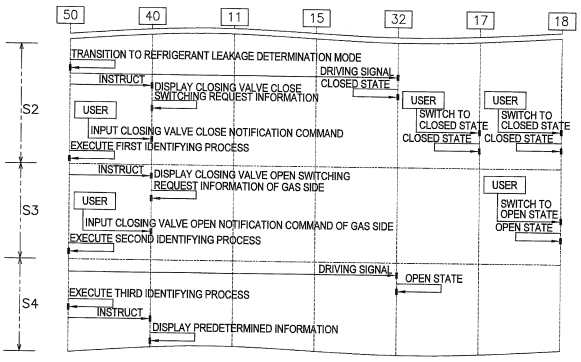

FIG. 7

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Description

TECHNICAL FIELD

[0001] The present invention relates to a method of identifying a refrigerant leakage spot.

BACKGROUND ART

[0002] In a device having a refrigerant circuit, leakage of refrigerant can occur for reasons such as damage to the pipe and degradation of components. In such a case, it is necessary to quickly detect that a refrigerant leakage has occurred from the standpoint of ensuring the safety of humans. Previously, the following method has been proposed as a method of detecting a refrigerant leakage.

[0003] Patent Document 1 (Japanese Laid-open Patent Publication No. 2014-95514) proposes a method of determining whether or not there is a leakage of a refrigerant by detecting, in a refrigerant circuit that includes a receiver, the height of the liquid level in the receiver after performing a refrigerant collection operation that collects the refrigerant in the receiver, and finding the amount of filled refrigerant to be insufficient by comparing the detected liquid level height and a predetermined reference value.

[0004] Also, Patent Document 2 (Japanese Laid-open Patent Publication No. 2011-226704) proposes a method of determining whether or not there is a leakage of a refrigerant by detecting, in a refrigerant circuit that includes a supercooling heat exchanger, the amount of filled refrigerant to be insufficient on the basis of the state (e.g. supercooling degree or the like) of the refrigerant at the outlet of the supercooling heat exchanger.

[0005] In addition, Patent Document 3 (Japanese Laid-open Patent Publication No. 2013-40730) proposes a method of identifying the fact that a refrigerant leakage has occurred and the utilization unit in which a refrigerant leakage has occurred in a refrigerant circuit that includes a plurality of utilization units, when a refrigerant leakage has occurred in any of the utilization units, by disposing a refrigerant leakage sensor capable of detecting a refrigerant leakage in each of the utilization units.

SUMMARY OF THE INVENTION

<Technical Problem>

[0006] Depending on the installation environment of the apparatus, when a refrigerant leakage has occurred, minimizing the number of repair steps, a quick restoration, and clarification of the leakage cause and the spot of responsibility becomes necessary. For this reason, it is necessary to quickly identify not only the fact that a refrigerant leakage has occurred but also the spot where the refrigerant leakage has occurred.

[0007] However, while it is possible to determine with the methods disclosed in Patent Document 1 and Patent Document 2 the fact that a refrigerant leakage has occurred, it is not possible to concretely identify the spot where the refrigerant leakage has occurred. In contrast, the method disclosed in Patent Document 3 can not only identify that the refrigerant leakage has occurred but also the spot where the refrigerant leakage has occurred, but since it is necessary to dispose a plurality of refrigerant leakage sensors, increasing cost becomes a concern.

[0008] The purpose of the present invention is to provide a method of identifying a refrigerant leakage spot that, when a refrigerant leakage has occurred in a refrigerant circuit, can identify the spot of the refrigerant leakage while restraining an increase in cost.

<Solution to Problem>

[0009] A method of identifying a refrigerant leakage spot according to a first aspect of the present invention is a method that identifies a refrigerant leakage spot when a leakage of a refrigerant has occurred in a refrigerant circuit including a compressor and a plurality of valves, each of the valve configured to be capable of being in a closed state to block the flow of the refrigerant. The method includes a first step and a second step. The first step is a step for dividing the refrigerant circuit into a plurality of refrigerant flow paths by setting each of the valves to the closed state in the state of the compressor being stopped. The second step is a step for determining whether or not there is a leakage of the refrigerant in the refrigerant flow paths by detecting a change in the state of the refrigerant in each of the refrigerant flow paths after the first step.

[0010] In the method of identifying a refrigerant leakage spot according to the first aspect of the present invention, in the first step the refrigerant circuit is divided into the plurality of refrigerant flow paths by each of the valves being set to the closed state in the state of the compressor being stopped, and in the second step the change in the state of the refrigerant in each of the refrigerant flow paths is detected, and whether or not there is the leakage of the refrigerant in each of the refrigerant flow paths is determined. Thereby, the refrigerant circuit is divided into the plurality of refrigerant flow paths, and whether or not there is a leakage of the refrigerant in each of the refrigerant flow paths is determined. As a result, it is possible to identify a refrigerant leakage spot without disposing a plurality of refrigerant leakage sensors. Hence, when a refrigerant leakage has occurred, the refrigerant leakage spot can be identified while restraining an increase in cost.

[0011] The "valve" that is used here, one that is capable of blocking the flow of the refrigerant is suitably selected, with for example a valve that can be controlled to the "closed state" by switching of the energized state (solenoid valve, motor-operated valve) and a closing valve that can be manually set to the "closed" state being envisaged.

[0012] The "refrigerant" here is not particularly limited,

and for example a slightly flammable refrigerant such as R32, a refrigerant having flammability such as propane, or a refrigerant having toxicity such as ammonia is envisaged.

[0013] The "state of the refrigerant" here is not particularly limited provided it is a variable that can identify the fact that the refrigerant leakage has occurred, and for example the pressure or temperature of the refrigerant is envisaged.

[0014] A method of identifying a refrigerant leakage spot according to a second aspect of the present invention is the method of identifying a refrigerant leakage spot according to the first aspect, in which in the second step, after detecting the state of the refrigerant in a first refrigerant flow path by a refrigerant state detection sensor, the valve dividing a second refrigerant flow path from the first refrigerant flow path is switched from the closed state to an open state, and a change in the state of the refrigerant in the second refrigerant flow path is detected by detecting a change in the state of the refrigerant with the refrigerant state detection sensor in the state of the first refrigerant flow path and the second refrigerant flow path being in communication with each other. The refrigerant state detection sensor is a sensor for detecting the state of the refrigerant. The open state is a state in which the valve allows the flow of the refrigerant. The first refrigerant flow path is a refrigerant flow path in which the refrigerant state detection sensor is disposed. The second refrigerant flow path is a refrigerant flow path in which the refrigerant state detection sensor is not disposed.

[0015] In the method of identifying a refrigerant leakage spot according to the second aspect of the present invention, in the second step, after detecting the state of the refrigerant in the first refrigerant flow path by the refrigerant state detection sensor, the valve that divides the second refrigerant flow path from the first refrigerant flow path is switched from the closed state to the open state, and the change in the state of the refrigerant in the second refrigerant flow path is detected by detecting the change in the state of the refrigerant with the refrigerant state detection sensor in the state of the first refrigerant flow path and the second refrigerant flow path being in communication with each other. Thereby, it is possible to detect the state of the refrigerant in the second refrigerant flow path in which the refrigerant state detection sensor is not disposed. As a result, it is possible to identify a refrigerant leakage spot even without disposing a refrigerant state detection sensor in each refrigerant flow path. Hence, when a refrigerant leakage has occurred, the refrigerant leakage spot can be identified while further restraining an increase in cost.

[0016] The "refrigerant state detection sensor" here, for example a pressure sensor that detects the pressure of the refrigerant or a temperature sensor that detects the temperature of the refrigerant is envisaged.

[0017] A method of identifying a refrigerant leakage spot according to a third aspect of the present invention is the method of identifying a refrigerant leakage spot according to the first aspect or the second aspect of the present invention, in which the first step includes a refrigerant collection step. The refrigerant collection step is a step for driving the compressor to collect a portion of the refrigerant in the refrigerant circuit into a container capable of storing the refrigerant. In the first step, after the completion of the refrigerant collection step, each of the valves is switched to the closed state after stopping the compressor so as to divide the refrigerant circuit into the plurality of refrigerant flow paths. Thereby, after collecting the refrigerant into the container, it is possible to detect a change in the state of the gas refrigerant that exists in each refrigerant flow path. That is, in the second step, it becomes possible to detect a change in the state of the gas refrigerant, in which the change in state is more noticeable than that of the liquid refrigerant in a case when a refrigerant leakage has occurred. Hence, it is possible to perform the determination with high precision.

[0018] A method of identifying a refrigerant leakage spot according to a fourth aspect of the present invention is the method of identifying a refrigerant leakage spot according to any one of the first aspect to the third aspect of the present invention, in which the first step is performed on the occasion of, in a filled refrigerant amount determination operation, the filled refrigerant amount being determined to be unsuitable, or a refrigerant leakage sensor having detected a refrigerant leakage. The filled refrigerant amount determination operation is an operation for determining the suitability of the filled refrigerant amount in the refrigerant circuit. The refrigerant leakage sensor is a sensor that detects the leakage of the refrigerant in the refrigerant circuit.

[0019] Thereby, the first step and the second step are performed after it has been determined that the filled refrigerant amount in the refrigerant circuit is insufficient. That is, the first step and the second step are performed with the main purpose of identifying the refrigerant leakage spot when a refrigerant leakage has occurred, and are not performed with the main purpose of detecting the fact that the refrigerant leakage has occurred. Therefore, the need can be eliminated to stop the compressor each time when determining whether or not there is the leakage of the refrigerant, and so degradation of components that are subject to temperature control is reduced, or a decrease in comfort is restrained.

[0020] The "refrigerant leakage sensor" here is a sensor for detecting the refrigerant that has leaked, and for example detects a refrigerant leakage by detecting a change in the electrical resistance value in accordance with the concentration of the leaked refrigerant. That is, the "refrigerant leakage sensor" differs from the "refrigerant state detection sensor" that detects the state of the refrigerant.

[0021] A method of identifying a refrigerant leakage spot according to a fifth aspect of the present invention is the method of identifying a refrigerant leakage spot according to any one of the first aspect to the fourth aspect of the present invention, in which in the second step,

an information output apparatus is made to output information that reports about the refrigerant flow path in which a refrigerant leakage is determined to have occurred. The information output apparatus is an apparatus that outputs information.

[0022] Thereby, when a refrigerant leakage has occurred, information that identifies the spot where the refrigerant leakage has occurred is output from the information output apparatus. As a result, when the leakage of the refrigerant has occurred, it becomes easy for the user to recognize the fact that the leakage of the refrigerant has occurred and the spot where the leakage of the refrigerant has occurred, and the user is prompted to take action. Hence, safety with regard to refrigerant leakages is enhanced.

<Advantageous Effects of Invention>

[0023] In the method of identifying a refrigerant leakage spot according to the first aspect of the present invention, the refrigerant circuit is divided into the plurality of refrigerant flow paths, and whether or not there is a leakage of the refrigerant in each refrigerant flow path is determined. As a result, the refrigerant leakage spot can be identified without disposing the plurality of refrigerant leakage sensors. Hence, a refrigerant leakage spot can be identified when a refrigerant leakage has occurred while restraining an increase in cost.

[0024] In the method of identifying a refrigerant leakage spot according to the second aspect of the present invention, it becomes possible to detect the state of the refrigerant in the second refrigerant flow path in which the refrigerant state detection sensor is not disposed. As a result, the refrigerant leakage spot can be identified without disposing a refrigerant state detection sensor in each refrigerant flow path. Hence, a refrigerant leakage spot can be identified when a refrigerant leakage has occurred while further restraining an increase in cost.

[0025] In the method of identifying a refrigerant leakage spot according to the third aspect of the present invention, after collecting the refrigerant into the container, it becomes possible to detect a change in the state of the gas refrigerant that exists in each refrigerant flow path. That is, in the second step, it becomes possible to detect the change in the state of the gas refrigerant, in which the change in state is more noticeable than that of the liquid refrigerant in a case when a refrigerant leakage has occurred. Hence, it is possible to perform the determination with high precision.

[0026] In the method of identifying a refrigerant leakage spot according to the fourth aspect of the present invention, the first step and the second step are performed in the state of the filled refrigerant amount in the refrigerant circuit having been determined to be insufficient. That is, the first step and the second step are performed with the main purpose of identifying the refrigerant leakage spot when the refrigerant leakage has occurred, and are not performed with the main purpose of detecting the fact that the refrigerant leakage has occurred. Therefore, the need is eliminated to stop the compressor each time when determining whether or not there is a leakage of the refrigerant, and so degradation of components that are subject to temperature control is reduced, or a decrease in comfort is restrained.

[0027] In the method of identifying a refrigerant leakage spot according to the fifth aspect of the present invention, when a leakage of the refrigerant has occurred, predetermined reporting information (information identifying the spot where the refrigerant leakage has occurred) is output. As a result, when the leakage of the refrigerant has occurred, it becomes easy for the user to recognize the fact that the leakage of the refrigerant has occurred and the spot where the leakage of the refrigerant has occurred, and the user is prompted to take action. Hence, safety with regard to refrigerant leakages is enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG. 1 is an outline configuration diagram of a refrigeration apparatus to which a method of identifying a refrigerant leakage spot according to one embodiment of the present invention is applied.

FIG. 2 is a diagram that schematically shows a first flow path, a second flow path and a third flow path included in a refrigerant circuit of the refrigeration apparatus.

FIG. 3 is a block diagram that conceptually shows a controller and each unit connected to the controller.

FIG. 4 is a flowchart that shows an example of the processing flow of the controller.

FIG. 5 is a flowchart that shows an example of the processing flow of the controller.

FIG. 6 is a sequence diagram that schematically shows the operation of each unit of the refrigeration apparatus in a mode of determining the amount of filled refrigerant.

FIG. 7 is a sequence diagram that schematically shows the operation of each unit of the refrigeration apparatus in a mode of determining a refrigerant leakage.

FIG. 8 is an outline configuration diagram of the refrigeration apparatus according to modification B to which the method of identifying a refrigerant leakage spot according to one embodiment of the present invention is applied.

FIG. 9 is a diagram that schematically shows a first flow path and a second flow path included in the refrigerant circuit of the refrigeration apparatus according to modification B.

DESCRIPTION OF EMBODIMENTS

[0029] Hereinbelow, a method of identifying a refriger-

ant leakage spot according to one embodiment of the present invention will be described with reference to the appended drawings. The embodiments described herein are exemplary of the present invention and not intended to limit the technical scope of the present invention, with suitable modifications being possible with a scope that does not depart from the spirit of the invention.

[0030] The method of identifying a refrigerant leakage spot according to the present embodiment is applied to a refrigeration apparatus 100.

(1) Refrigeration apparatus 100

[0031] FIG. 1 is an outline configuration diagram of the refrigeration apparatus 100 to which the method of identifying a refrigerant leakage spot according to one embodiment of the present invention is applied. The refrigeration apparatus 100 is an apparatus that, using a vapor compression type refrigeration cycle, performs cooling of the utilization-side space in the compartment of a refrigerating warehouse or a store showcase. The refrigeration apparatus 100 mainly has a heat source unit 10, a utilization unit 30, a liquid refrigerant communication pipe L1 that connects the heat source unit 10 to the utilization unit 30, a gas refrigerant communication pipe G1, a plurality of remote controllers 40 as input devices and display devices, and a controller 50 that controls the operation of the refrigeration apparatus 100.

[0032] In the refrigeration apparatus 100, a refrigerant circuit RC is constituted by the heat source unit 10 and the utilization unit 30 being connected via the liquid refrigerant communication pipe L1 and the gas refrigerant communication pipe G1. In the refrigeration apparatus 100, a refrigeration cycle is performed in which the refrigerant enclosed in the refrigerant circuit RC is compressed, cooled or condensed, decompressed, heated or evaporated, and afterwards again compressed. In the present embodiment, R32 is filled in the refrigerant circuit RC as the refrigerant for performing the vapor compression type refrigeration cycle.

(1-1) Heat source unit 10

[0033] The heat source unit 10 is connected with the utilization unit 30 via the liquid refrigerant communication pipe L1 and the gas refrigerant communication pipe G1, and constitutes a part of the refrigerant circuit RC. The heat source unit 10 mainly has a compressor 11, a heat source-side heat exchanger 12, a receiver 13, a supercooler 14, a heat source-side expansion valve 15 (expansion mechanism), an injection valve 16, a liquid-side closing valve 17, a gas-side closing valve 18, and a check valve 19.

[0034] Also, the heat source unit 10 has a first heat source-side gas refrigerant pipe P1 that connects the discharge side of the compressor 11 and the gas-side end of the heat source-side heat exchanger 12, a heat source-side liquid refrigerant pipe P2 that connects the liquid-side end of the heat source-side heat exchanger 12 and the liquid refrigerant communication pipe L1, and a second heat source-side gas refrigerant pipe P3 that connects the intake side of the compressor 11 and the gas refrigerant communication pipe G1.

[0035] In addition, the heat source unit 10 has an injection pipe P4 that branches off a portion of the refrigerant flowing through the heat source-side liquid refrigerant pipe P2 for return to the compressor 11. The injection pipe P4 branches off from the downstream-side part of the supercooler 14 in the heat source-side liquid refrigerant pipe P2 and, after passing through the supercooler 14, is connected midway in the compression stroke of the compressor 11.

[0036] The compressor 11 is a device that compresses low-pressure refrigerant in the refrigeration cycle until reaching a high pressure. Here, a compressor with a sealed-type structure in which a volume-type compression element (not illustrated), such as a rotary-type or scroll type, is rotatably driven by a compressor motor M11, is used as the compressor 11. Here, control of the operation frequency of the compressor motor M11 is possible with an inverter, whereby capacity control of the compressor 11 becomes possible.

[0037] The heat source-side heat exchanger 12 is a heat exchanger that functions as a radiator or condenser of high-pressure refrigerant in the refrigeration cycle. Here, the heat source unit 10 has a heat source-side fan 20 for drawing air outside the refrigeration compartment (heat source-side air) within the heat source unit 10, and after being heat-exchanged with the refrigerant in the heat source-side heat exchanger 12, discharging the air to the outside. That is, the heat source unit 10 has the heat source-side fan 20 as a fan that supplies to the heat source-side heat exchanger 12 the heat source-side air as a cooling source of the refrigerant flowing through the heat source-side heat exchanger 12. The heat source-side fan 20 is rotatably driven by the heat source-side fan motor M20.

[0038] The receiver 13 is a container that temporarily collects the refrigerant condensed in the heat source-side heat exchanger 12, and is arranged in the heat source-side liquid refrigerant pipe P2.

[0039] The supercooler 14 is a heat exchanger that further cools the refrigerant temporarily collected in receiver 13, and is arranged at the downstream-side part of the receiver 13 in the heat source-side liquid refrigerant pipe P2.

[0040] The heat source-side expansion valve 15 (valve) is a motor-operated expansion valve in which opening control is possible, and is arranged at the downstream-side part of the supercooler 14 in the heat source-side liquid refrigerant pipe P2.

[0041] The injection valve 16 is arranged at the part of the injection pipe P4 prior to reaching the inlet of the supercooler 14. The injection valve 16 is a motor-operated expansion valve in which opening control is possible. Depending on the opening degree, the injection valve

16 decompresses the refrigerant flowing through the injection pipe P4 prior to being made to flow into the supercooler 14. In this way, the supercooler 14 is configured to cool the refrigerant temporarily collected in receiver 13, with the refrigerant branched off from the heat source-side liquid refrigerant pipe P2 via the injection pipe P4 serving as the cooling source.

[0042] The liquid-side closing valve 17 (valve) is a manual valve arranged at the connection part between the heat source-side liquid refrigerant pipe P2 and the liquid refrigerant communication pipe L1. One end of the liquid-side closing valve 17 is connected to the heat source-side liquid refrigerant pipe P2, and the other end is connected to the liquid refrigerant communication pipe L1. When the liquid-side closing valve 17 is set to the open state, the heat source-side liquid refrigerant pipe P2 and the liquid refrigerant communication pipe L1 are allowed to communicate, and when set to the closed state, the liquid-side closing valve 17 cuts off the communication between the heat source-side liquid refrigerant pipe P2 and the liquid refrigerant communication pipe L1. The liquid-side closing valve 17 is normally set to the open state.

[0043] The gas-side closing valve 18 (valve) is a manual valve that is arranged at the connection part between the second heat source-side gas refrigerant pipe P3 and the gas refrigerant communication pipe G1. One end of the gas-side closing valve 18 is connected to the second heat source-side gas refrigerant pipe P3, and the other end is connected to the gas refrigerant communication pipe G1. When the gas-side closing valve 18 is set to the open state, the second heat source-side gas refrigerant pipe P3 and the gas refrigerant communication pipe G1 are allowed to communicate, and when set to the closed state, the gas-side closing valve 18 cuts off the communication between the second heat source-side gas refrigerant pipe P3 and the gas refrigerant communication pipe G1. The gas-side closing valve 18 is normally set to the open state.

[0044] The check valve 19 is arranged in the heat source-side liquid refrigerant pipe P2. More specifically, the check valve 19 is arranged on the outlet side of the heat source-side heat exchanger 12 and the inlet side of the receiver 13. The check valve 19 allows the flow of refrigerant from the outlet side of the heat source-side heat exchanger 12 and blocks the flow of refrigerant from the inlet side of the receiver 13.

[0045] Various sensors that are electrically connected to a heat-source-unit control unit 26 are arranged in the heat source unit 10. Specifically, an intake pressure sensor 21 (refrigerant state detection sensor) that detects an intake pressure LP, which is the pressure of the refrigerant on the intake side of the compressor 11, and a discharge pressure sensor 22 (refrigerant state detection sensor) that detects a discharge pressure HP, which is the pressure of the refrigerant on the discharge side of the compressor 11, are arranged in the vicinity of the compressor 11 in the heat source unit 10. Also, a receiver outlet temperature sensor 23 that detects a receiver outlet temperature TL, which is the temperature of the refrigerant at the outlet of the receiver 13, is arranged in the heat source-side liquid refrigerant pipe P2, in the part between the outlet of the receiver 13 and the inlet of the supercooler 14. Moreover, a heat source-side air sensor 24 that detects a temperature Ta of the heat source-side air drawn into the heat source unit 10 is arranged in the vicinity of the heat source-side heat exchanger 12 or the heat source-side fan 20. A liquid level detection sensor 25 that detects a liquid level height Lh, which is the height of the liquid level of the liquid refrigerant accommodated in the receiver, is arranged in the receiver 13.

[0046] The heat source unit 10 has the heat-source-unit control unit 26 that controls the operation of each of the elements constituting the heat source unit 10. The heat-source-unit control unit 26 has a microcomputer containing a CPU, memory, and the like. The heat-source-unit control unit 26 is connected via a communication line cb1 with a utilization-unit control unit 38 of each utilization unit 30, and thereby performs sending and receiving of control signals.

(1-2) Utilization unit 30

[0047] The utilization unit 30 is connected with the heat source unit 10 via the liquid refrigerant communication pipe L1 and the gas refrigerant communication pipe G1, and constitutes a part of the refrigerant circuit RC.

[0048] The utilization unit 30 has a heating pipe 31, a utilization-side expansion valve 32, a utilization-side heat exchanger 33 (evaporator), and a drain pan 34. The utilization unit 30 also has a first utilization-side liquid refrigerant pipe P5 that connects the liquid refrigerant communication pipe L1 and the utilization-side expansion valve 32, a second utilization-side liquid refrigerant pipe P6 that connects the liquid side end of the utilization-side heat exchanger 33 and the utilization-side expansion valve 32, and a utilization-side gas refrigerant pipe P7 that connects the gas-side end of the utilization-side heat exchanger 33 and the gas refrigerant communication pipe G1.

[0049] The heating pipe 31 is a refrigerant pipe through which passes high-pressure liquid refrigerant sent from the heat source unit 10. The heating pipe 31 is a pipe for melting ice mass generated by the freezing of the drain water in the drain pan 34, and is thermally connected to the drain pan 34. The heating pipe 31 is contained in the first utilization-side liquid refrigerant pipe P5.

[0050] The utilization-side expansion valve 32 (valve) is a diaphragm mechanism that functions as a decompression means (expansion means) for the high-pressure refrigerant sent from the heat source unit 10. The utilization-side expansion valve 32 is an opening adjustable motor-operated valve of which the opening changes depending on the supply of a predetermined drive voltage. One end of the utilization-side expansion valve 32 is connected to the first utilization-side liquid refrigerant

pipe P5, and the other end is connected to the second utilization-side liquid refrigerant pipe P6. When the utilization-side expansion valve 32 is set to the minimum opening (closed state), the flow of refrigerant is blocked between the first utilization-side liquid refrigerant pipe P5 and the second utilization-side liquid refrigerant pipe P6.

[0051] The utilization-side heat exchanger 33 is a heat exchanger that functions as an evaporator of low-pressure refrigerant in the refrigeration cycle to cool the in-compartment air (utilization-side air). Here, the utilization unit 30 has a utilization-side fan 36 for drawing the utilization-side air in the utilization unit 30 and, after being heat-exchanged with the refrigerant in the utilization-side heat exchanger 33, supplying the air to the utilization-side space. That is, the utilization unit 30 has the utilization-side fan 36 as a fan that supplies to the utilization-side heat exchanger 33 the utilization-side air serving as a heating source for refrigerant flowing through the utilization-side heat exchanger 33. In the utilization unit 30 in the operating state, the utilization-side fan 36 is rotatably driven by an utilization-side fan motor M36.

[0052] The drain pan 34 receives and collects the drain water generated in the utilization-side heat exchanger 33. The drain pan 34 is disposed below the utilization-side heat exchanger 33.

[0053] In addition, the utilization unit 30 has the utilization-unit control unit 38 that controls the operation of each of the elements constituting the utilization unit 30. The utilization-unit control unit 38 has a microcomputer containing a CPU, memory, and the like. The utilization-unit control unit 38 is connected via the communication line cb1 with the heat-source-unit control unit 26, and thereby performs sending and receiving of control signals.

(1-3) Remote controller 40 (information output part)

[0054] The remote controller 40 is an input device for a user to input various commands for switching the operation state of the refrigeration apparatus 100. For example, commands for starting and stopping of the refrigeration apparatus 100 and switching the set temperature are input to the remote controller 40 by the user. Various commands are input by the user in a refrigerant leakage determination mode (described below) using the remote controller 40.

[0055] For example, the user inputs to the remote controller 40 a command (closing valve close notification command) for notifying the controller 50 that both the liquid-side closing valve 17 and the gas-side closing valve 18 have been switched to the closed state. Also, the user inputs to the remote controller 40 a command (liquid-side closing valve open notification command) for notifying the controller 50 that the liquid-side closing valve 17 has been switched to the open state. The user also inputs to the remote controller 40 a command (gas-side closing valve open notification command) for notifying the controller 50 that the gas-side closing valve 18 has been switched to the open state.

[0056] The closing valve close notification command, the liquid-side closing valve open notification command, and the gas-side closing valve open notification command are commands for prompting the start of a refrigerant leakage spot identifying process (described below) in the controller 50.

[0057] The remote controller 40 also functions as a display device for displaying a variety of information to the user. For example, the remote controller 40 displays the operational status (set temperature and the like) of the refrigeration apparatus 100. Also, the remote controller 40, in the refrigerant leakage determination mode, displays closing valve close switching request information (described below) that requests the user to switch the liquid-side closing valve 17 and the gas-side closing valve 18 to the closed state; liquid-side closing valve open switching request information (described below) that requests the user to switch the liquid-side closing valve 17 to the open state; and gas-side closing valve open switching request information (described below) that requests the user to switch the gas-side closing valve 18 to the open state.

[0058] The remote controller 40 is connected with the utilization-unit control unit 38 via the communication line, with signal transmission and reception performed mutually therebetween. The remote controller 40 transmits commands input by the user to the utilization-unit control unit 38 via the communication line. The remote controller 40 also displays information in accordance with instructions received via the communication line.

(1-4) Controller 50

[0059] In the refrigeration apparatus 100, the heat-source-unit control unit 26 and each utilization-unit control unit 38 are connected via the communication line cb1, whereby the controller 50, which controls the operation of the refrigeration apparatus 100, is constituted. The controller 50 will be described in detail in "(4) Details of controller 50" given later.

(2) Flow of refrigerant in the refrigerant circuit RC during cooling operation

[0060] Hereinbelow, the flow of the refrigerant in the refrigerant circuit RC during in each operation mode will be described. During running of the refrigeration apparatus 100, a cooling operation (refrigeration cycle operation) is performed in which the refrigerant that is filled in the refrigerant circuit RC circulates mainly in the order of the compressor 11, the heat source-side heat exchanger 12 (radiator), the receiver 13, the supercooler 14, the heat source-side expansion valve 15 (expansion mechanism), the utilization-side expansion valve 32, and the utilization-side heat exchanger 33 (evaporator). In this cooling operation, a portion of the refrigerant that flows through the heat source-side liquid refrigerant pipe

P2 is branched off via the injection pipe P4 and, after passing through the supercooler 14, is returned to the compressor 11.

[0061] When the cooling operation is started, the refrigerant in the refrigerant circuit RC is drawn into the compressor 11, compressed and then discharged. Low pressure in the refrigeration cycle is the intake pressure LP that is detected by the intake pressure sensor 21, and high pressure in the refrigeration cycle is the discharge pressure HP that is detected by the discharge pressure sensor 22.

[0062] In the compressor 11, capacity control according to the cooling load required in the utilization unit 30 is performed. Specifically, a target value of the intake pressure LP is set in accordance with the cooling load required in the utilization unit 30, and the operation frequency of the compressor 11 is controlled so that the intake pressure LP becomes the target value. The gas refrigerant discharged from the compressor 11 flows into the gas side end of the heat source-side heat exchanger 12 via the first heat source-side gas refrigerant pipe P1.

[0063] The gas refrigerant that has flowed into the gas-side end of the heat source-side heat exchanger 12 undergoes heat exchange with heat source-side air supplied by the heat source-side fan 20, whereby heat is released, and condensation occurs resulting in liquid refrigerant in a supercooled state that flows out from the liquid-side end of the heat source-side heat exchanger 12.

[0064] The liquid refrigerant that has flowed out from the liquid-side end of the heat source-side heat exchanger 12 passes the part of the heat source-side liquid refrigerant pipe P2 extending from the heat source-side heat exchanger 12 to the receiver 13, and flows into the inlet of the receiver 13. The liquid refrigerant that has flowed into the receiver 13, after being temporarily accumulated as a liquid refrigerant in a saturated state in the receiver 13, flows out from the outlet of the receiver 13. Here, the temperature of the refrigerant at the outlet of the receiver 13 is the receiver outlet temperature TL detected by the receiver outlet temperature sensor 23.

[0065] The liquid refrigerant that has flowed out from the outlet of the receiver 13 passes the part of the heat source-side liquid refrigerant pipe P2 extending from the receiver 13 to the supercooler 14 and flows into the inlet of the supercooler 14 on the heat source-side liquid refrigerant pipe P2 side.

[0066] In the supercooler 14, the liquid refrigerant that has flowed into the supercooler 14 is further cooled by undergoing heat exchange with the refrigerant flowing through the injection pipe P4 to become liquid refrigerant in a supercooled state, which flows out from the outlet of the supercooler 14 on the heat source-side liquid refrigerant pipe P2 side.

[0067] The liquid refrigerant that has flowed out from the outlet of the supercooler 14 on the heat source-side liquid refrigerant pipe P2 side passes the part of the heat source-side liquid refrigerant pipe P2 between the supercooler 14 and the heat source-side expansion valve 15 to flow into the heat source-side expansion valve 15. At this time, a portion of the liquid refrigerant that has flowed out from the outlet of the supercooler 14 on the heat source-side liquid refrigerant pipe P2 side is branched off to the injection pipe P4 from the part of the heat source-side liquid refrigerant pipe P2 between the supercooler 14 and the heat source-side expansion valve 15.

[0068] The refrigerant flowing through the injection pipe P4 is decompressed to an intermediate pressure in the refrigeration cycle by the injection valve 16. The refrigerant flowing through the injection pipe P4 after being decompressed by the injection valve 16 flows into the inlet of the supercooler 14 on the injection pipe P4 side. The refrigerant that has flowed into the inlet of the supercooler 14 on the injection pipe P4 side undergoes heat exchange in the supercooler 14 with the refrigerant flowing through the heat source-side liquid refrigerant pipe P2 and is thereby heated to become gas refrigerant. The refrigerant heated in the supercooler 14 flows out from the outlet of the supercooler 14 on the injection pipe P4 side and is returned to the compressor 11 midway in the compression stroke.

[0069] The liquid refrigerant that has flowed from the heat source-side liquid refrigerant pipe P2 into the heat source-side expansion valve 15, after being decompressed by the heat source-side expansion valve 15, flows into the utilization unit 30 via the liquid-side closing valve 17 and the liquid refrigerant communication pipe L1.

[0070] The refrigerant that has flowed into the utilization unit 30 flows into the utilization-side expansion valve 32 by way of the first utilization-side liquid refrigerant pipe P5 (heating pipe 31). The refrigerant that has flowed into the utilization-side expansion valve 32 is decompressed to a low pressure in the refrigeration cycle by the utilization-side expansion valve 32, and then flows into the liquid-side end of the utilization-side heat exchanger 33 via the second utilization-side liquid refrigerant pipe P6.

[0071] The refrigerant that has flowed into the liquid-side end of utilization-side heat exchanger 33 undergoes heat exchange in the utilization-side heat exchanger 33 with utilization-side air supplied by the utilization-side fan 36 and evaporates into gas refrigerant that then flows out from the gas-side end of the utilization-side heat exchanger 33.

[0072] The gas refrigerant that flowed out from the gas-side end of the utilization-side heat exchanger 33 is again drawn into the compressor 11 by way of the utilization-side gas refrigerant pipe P7, the gas refrigerant communication pipe G1, the gas-side closing valve 18, and the second heat source-side gas refrigerant pipe P3.

(3) Refrigerant flow paths included in refrigerant circuit RC

[0073] FIG. 2 is a diagram that schematically shows a first flow path RP1, a second flow path RP2, a third flow

path RP3 included in the refrigerant circuit RC. As shown in FIG. 2, the refrigerant circuit RC is mainly divided into the first flow path RP1, the second flow path RP2, and the third flow path RP3.

[0074] The first flow path RP1 (first refrigerant flow path) is a refrigerant flow path constituted in the heat source unit 10 (more precisely, between one end side of the liquid-side closing valve 17 and one end side of the gas-side closing valve 18). Specifically, the first flow path RP1 is a refrigerant flow path constituted by the first heat source-side gas refrigerant pipe P1, the heat source-side liquid refrigerant pipe P2, the second heat source-side gas refrigerant pipe P3, and the injection pipe P4. That is, the first flow path RP1 is a refrigerant flow path that includes the compressor 11, the heat source-side heat exchanger 12, the receiver 13, the supercooler 14, the heat source-side expansion valve 15, and the injection valve 16.

[0075] The second flow path RP2 (second refrigerant flow path) is a refrigerant flow path constituted from a part of the utilization unit 30 to the gas refrigerant communication pipe G1 (more precisely, between one end side of the utilization-side expansion valve 32 and the other end side of the gas-side closing valve 18). Specifically, the second flow path RP2 is a refrigerant flow path constituted by the second utilization-side liquid refrigerant pipe P6, the utilization-side gas refrigerant pipe P7, and the gas refrigerant communication pipe G1. That is, the second flow path RP2 is a refrigerant flow path that includes the utilization-side heat exchanger 33.

[0076] The third flow path RP3 (second refrigerant flow path) is a refrigerant flow path constituted from the liquid refrigerant communication pipe L1 to a part of the utilization unit 30 (more precisely, between the other end side of the liquid-side closing valve 17 and the other end side of the utilization-side expansion valve 32). Specifically, the third flow path RP3 is a refrigerant flow path constituted by the liquid refrigerant communication pipe L1 and the first utilization-side liquid refrigerant pipe P5. That is, the third flow path RP3 is a refrigerant flow path that includes the heating pipe 31.

[0077] That is, the refrigerant circuit RC is divided into the plurality of refrigerant flow paths (RP1, RP2, and RP3) by each of the valves (specifically, the liquid-side closing valve 17, the gas-side closing valve 18, and the utilization-side expansion valve 32) being set to the closed state.

(4) Details of controller 50

[0078] In the refrigeration apparatus 100, the controller 50 is constituted by the heat-source-unit control unit 26 and the utilization-unit control unit 38 being connected by a communication line. FIG. 3 is a block diagram that conceptually shows the controller 50 and each unit connected to the controller 50.

[0079] The controller 50 has a plurality of control modes and controls the operation of the refrigeration apparatus 100 in accordance with the control mode which has been changed to. In the present embodiment, the controller 50 has as control modes a normal operation mode that is usually changed to, a filled refrigerant amount determination mode that is changed to when determining the suitability of the amount of filled refrigerant (whether or not there is the leakage of the refrigerant), and a refrigerant leakage determination mode that is changed to when the refrigerant leakage has occurred.

[0080] The controller 50 is electrically connected with each of actuators (specifically the compressor 11 (compressor motor M11), the heat source-side expansion valve 15, the injection valve 16, and the heat source-side fan 20 (heat source side fan motor M20)) and the various sensors (the intake pressure sensor 21, the discharge pressure sensor 22, the receiver outlet temperature sensor 23, the heat source-side air sensor 24 and the liquid level detection sensor 25), the actuators and sensors being included in the heat source unit 10. In addition, the controller 50 is electrically connected with the actuators included in the utilization unit 30 (specifically, the utilization-side fan 36 (utilization-side fan motor M36). The controller 50 is also electrically connected with the remote controller 40.

[0081] The controller 50 mainly has a storage unit 51, a communication unit 52, a mode control unit 53, an actuator control unit 54, a filled refrigerant amount shortage discriminating unit 55, a display control unit 56, and a refrigerant leakage spot identifying unit 57. These units in the controller 50 are realized by the parts included in the heat-source-unit control unit 26 and/or the utilization-unit control unit 38 functioning integrally.

(4-1) Storage unit 51

[0082] The storage unit 51 is constituted by for example ROM, RAM, flash memory, and the like, and includes a volatile storage region and a nonvolatile storage region. A control program that defines the process in each unit of the controller 50 is stored in the storage unit 51.

[0083] The storage unit 51 includes a detection value storage region 510 that stores the detection value of each sensor. For example, the detection value of the intake pressure sensor 21 (intake pressure LP), the detection value of the discharge pressure sensor 22 (discharge pressure HP), the detection value of the liquid level detection sensor 25 (liquid level height Lh) and the like are stored in the detection value storage region 510.

[0084] The storage unit 51 includes a reference value storage region 511 that stores a reference value Sh used in the filled refrigerant amount determination that will be described below. The reference value Sh is a reference value of the liquid level height in the receiver 13 after completion of a refrigerant collection operation described below. The reference value Sh is set beforehand in accordance with the refrigerant amount filled in the refrigerant circuit RC and the capacity of the receiver 13.

[0085] The storage unit 51 further includes a pressure

reference value storage region 512 that stores a pressure reference value table (not illustrated). In the pressure reference value table, the pressure reference values of the intake pressure and the discharge pressure are defined by situation in accordance with the detection values of the receiver outlet temperature sensor 23 and the heat source-side air sensor 24 (TL and Ta), the refrigerant circulation amount determined from the characteristics of the compressor 11, and the lengths of each refrigerant pipe.

[0086] A plurality of flags having a predetermined number of bits are provided in the storage unit 51.

[0087] For example, a control mode discrimination flag 513 capable of discriminating the control mode to which the controller 50 has changed is provided in the storage unit 51. The control mode discrimination flag 513 includes a predetermined number of bits, so that a predetermined bit is raised in accordance with the control mode that has been changed to.

[0088] A refrigerant collection completion flag 514 that discriminates whether the refrigerant collection operation (described below) executed in the refrigerant leakage determination mode has been completed is provided in the storage unit 51. The refrigerant collection completion flag 514 is raised when the refrigerant collection operation executed in the refrigerant leakage determination mode is completed.

[0089] A filled refrigerant amount determination completion flag 515 that discriminates whether the filled refrigerant amount determination, which determines whether the refrigerant amount filled in the refrigerant circuit RC is insufficient, has been completed is provided in the storage unit 51. The filled refrigerant amount determination completion flag 515 is raised when the filled refrigerant amount determination has been completed.

[0090] A filled refrigerant amount shortage discrimination flag 516 for discriminating whether the refrigerant amount filled in the refrigerant circuit RC is insufficient (that is, whether the filled refrigerant amount when filling refrigerant in the refrigerant circuit RC is not suitable, or whether a refrigerant leakage has occurred in the refrigerant circuit RC) is provided in the storage unit 51. The filled refrigerant amount shortage discrimination flag 516 is raised when the refrigerant amount filled in the refrigerant circuit RC is insufficient (that is, when the filled refrigerant amount when filling refrigerant in the refrigerant circuit RC is not suitable, or when a refrigerant leakage has occurred in the refrigerant circuit RC).

[0091] A identifying process progress flag 517 that indicates the degree of progress of the refrigerant leakage spot identifying process (described below) executed in the refrigerant leakage determination mode is provided in the storage unit 51. The identifying process progress flag 517 includes a predetermined number of bits, so that a predetermined bit is raised in accordance with the progress situation of the refrigerant leakage spot identifying process being executed.

[0092] A refrigerant leakage spot discrimination flag 518 that discriminates the refrigerant leakage spot identified in the refrigerant leakage spot identifying process is provided in the storage unit 51. The refrigerant leakage spot discrimination flag 518 includes a predetermined number of bits, so that a predetermined bit is raised in accordance with the refrigerant leakage spot identified in the refrigerant leakage spot identifying process.

[0093] A command discrimination flag 519 for discriminating whether a predetermined command (described below) has been input via the remote controller 40 is provided in the storage unit 51. The command discrimination flag 519 includes a predetermined number of bits, so that a corresponding bit is raised when the predetermined command has been input in accordance with the situation. For example, in the refrigeration leakage determination mode, when the closing valve close notification command, the liquid-side closing valve open notification command, and the gas-side closing valve open notification command input by the user have been received, the bits corresponding to the received commands are raised in the command discrimination flag 519.

(4-2) Communication unit 52

[0094] The communication unit 52 is a function part that plays the role of a communication interface for performing transmission and reception of signals with each of the devices connected to the controller 50. The communication unit 52 receives a request from the actuator control unit 54 and transmits a predetermined signal to a designated actuator. The communication unit 52, upon receiving signals output from the sensors (21 to 25) and the remote controller 40, also performs storage in the corresponding storage region of the storage unit 51 and raises a predetermined flag.

(4-3) Mode control unit 53

[0095] The mode control unit 53 is a function part that switches the control mode. The mode control unit 53 raises the control mode discrimination flag 513 in accordance with the control mode that has been switched to. The mode control unit 53 normally switches the control mode to the normal operation mode.

[0096] The mode control unit 53 switches the control mode from the normal operation mode to the filled refrigerant amount determination mode by the input of a refrigerant amount determination start command, which instructs execution of the filled refrigerant amount determination, by a user via the remote controller 40. As a result, the control mode is switched to the filled refrigerant amount determination mode at a timing desired by the user.

[0097] When the filled refrigerant amount determination completion flag 515 has been raised and the filled refrigerant amount shortage discrimination flag 516 has been raised in the filled refrigerant amount determination mode, the mode control unit 53 switches the control mode

to the refrigerant leakage determination mode. Subsequently, the mode control unit 53 clears the filled refrigerant amount determination completion flag 515 and the filled refrigerant amount shortage discrimination flag 516.

[0098] On the other hand, when the filled refrigerant amount shortage discrimination flag 516 is not raised in the state of the filled refrigerant amount determination completion flag 515 having been raised in the filled refrigerant amount determination mode, the mode control unit 53 switches the control mode to the normal operation mode. Subsequently, the mode control unit 53 clears the filled refrigerant amount determination completion flag 515.

(4-4) Actuator control unit 54

[0099] The actuator control unit 54 controls, in accordance with the control program, the operation of the actuators (for example, the compressor 11, the heat source-side expansion valve 15, the injection valve 16, the utilization-side expansion valve 32 and the like) included in the refrigeration apparatus 100 (the heat source unit 10 and the utilization unit 30) depending on the situation. The actuator control unit 54 discriminates the control mode that has been changed to by referring to the control mode discrimination flag 513, and controls the operation of each actuator on the basis of the control mode that has been changed to.

[0100] For example, in the normal operation mode, the actuator control unit 54 controls in real time the operating capacity of the compressor 11, the rotation frequency of the heat source-side fan 20 and the utilization-side fan 36, and the opening degree of the heat source-side expansion valve 15 and the injection valve 16 so that the cooling operation is performed in accordance with the set temperature and the detection values of the various sensors.

[0101] The actuator control unit 54 also controls the operation of each actuator so that the refrigerant collection operation is performed during the filled refrigerant amount determination mode. The refrigerant collection operation is an operation of collecting a portion of the refrigerant in the refrigerant circuit RC to the heat source unit 10 (especially the receiver 13). Specifically, during the refrigerant collection operation, the actuator control unit 54 sets the heat source-side expansion valve 15 and the injection valve 16 to a closed state that blocks flow of the refrigerant, and causes the compressor 11 to operate at the rotational frequency for the refrigerant collection operation. Thereby, a portion of the refrigerant in the refrigerant circuit RC is collected to the heat source unit 10. In the present embodiment, the rotational frequency of the compressor 11 during the refrigerant collection operation is set to the maximum rotational frequency so that refrigerant collection may be completed in a shortest time.

[0102] The actuator control unit 54, after the start of the refrigerant collection operation, completes the refrigerant collection operation on the occasion of a state having arisen in which the refrigerant collection is presumed to have been ended (specifically, the state in which the intake pressure LP is less than a predetermined threshold value ΔTh). The actuator control unit 54 then stops the compressor 11 and raises the refrigerant collection completion flag 514. Note that the threshold value ΔTh is set to a value that does not go below atmospheric pressure on the basis of the refrigerant amount enclosed in the refrigerant circuit RC and the refrigerant circulation amount determined from the characteristics of the compressor 11. In the present embodiment, the threshold value ΔTh is set to 0.3 MPa.

(4-5) Filled refrigerant amount shortage discriminating unit 55

[0103] When the refrigerant collection completion flag 514 is raised during the filled refrigerant amount determination mode (that is, when the refrigerant collection operation is completed), the filled refrigerant amount shortage discriminating unit 55 performs determination of the filled refrigerant amount that determines whether or not the refrigerant amount filled in the refrigerant circuit RC is suitable. Specifically, the filled refrigerant amount shortage discriminating unit 55, in the filled refrigerant amount determination, refers to the detection value of the liquid level detection sensor 25 stored in the storage unit 51 (liquid level height Lh) and determines whether the liquid level height Lh is less than the predetermined reference value Sh.

[0104] When the liquid level height Lh is equal to or greater than the reference value Sh, the filled refrigerant amount shortage discriminating unit 55 raises the filled refrigerant amount determination completion flag 515 indicating that determination of the suitability of the filled refrigerant amount is completed. On the other hand, when the liquid level height Lh is less than the reference value Sh, the filled refrigerant amount shortage discriminating unit 55 raises the filled refrigerant amount determination completion flag 515 and also raises the filled refrigerant amount shortage discrimination flag 516 indicating that the refrigerant amount filled in the refrigerant circuit RC is insufficient

(4-6) Display control unit 56

[0105] The display control unit 56 is a function part that controls operation of the remote controller 40 as a display device. The display control unit 56 causes the remote controller 40 to output predetermined information for displaying information concerning the operational state or situation to the user. For example, the display control unit 56 causes the remote controller 40 to display various information such as a set temperature during the cooling operation in the normal mode.

[0106] The display control unit 56 causes the remote controller 40 to display various information indicating that

the refrigerant collection operation is being performed during the refrigerant collection operation in the filled refrigerant amount determination mode.

[0107] The display control unit 56 displays information urging the user a predetermined action during the refrigerant leakage determination mode.

[0108] For example, the display control unit 56 causes the remote controller 40 to display text information requesting the user to switch the liquid-side closing valve 17 and the gas-side closing valve 18 to the closed state (closing valve close switching request information) when a bit in the control mode discrimination flag 513 identifying a switch to the refrigerant leakage determination mode has been raised (that is, when changed to the refrigerant leakage determination mode).

[0109] The display control unit 56 also causes the remote controller 40 to display text information requesting the user to switch the gas-side closing valve 18 to the open state (gas-side closing valve open switching request information) when a bit in the identifying process progress flag 517 indicating that a first identifying process (described below) is completed has been raised and a bit in the refrigerant leakage spot discrimination flag 518 identifying that a refrigerant leakage has occurred in the first flow path RP1 has not been raised (that is, when it is assumed that the first identifying process has ended and that a refrigerant leakage has not occurred in the first flow path RP1) during the refrigerant leakage determination mode.

[0110] The display control unit 56 also causes the remote controller 40 to display text information requesting the user to switch the liquid-side closing valve 17 to the open state (liquid-side closing valve open switching request information) when a bit in the identifying process progress flag 517 indicating that a third identifying process (described below) is completed has been raised and a bit in the refrigerant leakage spot discrimination flag 518 identifying that a refrigerant leakage has occurred in the third flow path RP3 has not been raised (that is, when it is assumed that the third identifying process has ended and that a refrigerant leakage has not occurred in the third flow path RP3) during the refrigerant leakage determination mode.

[0111] The display control unit 56, when any bit of the refrigerant leakage spot discrimination flag 518 has been raised, also causes the remote controller 40 to display information for reporting that a refrigerant leakage has occurred in accordance with the spot corresponding to the raised bit (refrigerant leakage spot reporting information) and information requesting that a serviceman be notified.

[0112] The controller 50 also causes the remote controller 40 to display information reporting that the filled refrigerant amount in the refrigerant circuit RC is not suitable (insufficient) (filled refrigerant amount shortage reporting information) when any bit of the refrigerant leakage spot discrimination flag 518 has not been raised in the case of the identifying process progress flag 517 having indicated that the third identifying process is completed (that is, when a refrigerant leakage spot is not identified in the case of the refrigerant leakage spot identifying process being completed).

(4-7) Refrigerant leakage spot identifying unit 57

[0113] The refrigerant leakage spot identifying unit 57 executes a refrigerant leakage spot identifying process when a bit is raised in the control mode discrimination flag 513 identifying a switch to the refrigerant leakage determination mode (that is, a transition to the refrigerant leakage determination mode).

[0114] The first identifying process, a second identifying process, and the third identifying process are mainly included in the refrigerant leakage spot identifying process. The first identifying process is a process for discriminating whether or not there is a leakage of the refrigerant in the first flow path RP1 (refer to FIG. 2). The second identifying process is a process for discriminating whether or not there is a leakage of the refrigerant in the second flow path RP2 (refer to FIG. 2). The third identifying process is a process for discriminating whether or not there is a leakage of the refrigerant in the third flow path RP3 (refer to FIG. 2).

[0115] Specifically, the refrigerant leakage spot identifying unit 57 refers to the command discrimination flag 519 during the refrigerant leakage determination mode, and upon discriminating that a closing valve close notification command has been received, executes the first identifying process. Here, the situation of the closing valve close notification command being received is a situation presumed as the liquid-side closing valve 17 and the gas-side closing valve 18 having been switched to the closed state by the user, and a situation presumed as the first flow path RP1, the second flow path RP2 and the third flow path RP3 each being in a divided state.

[0116] In the first identifying process, the refrigerant leakage spot identifying unit 57 determines whether or not there is a leakage of the refrigerant in the first flow path RP1 by referring to the detection value of the intake pressure sensor 21 (intake pressure LP) and also referring to the detection value of the discharge pressure sensor 22 (discharge pressure HP). More specifically, in the first identifying process, the refrigerant leakage spot identifying unit 57 determines whether there is a leakage of the refrigerant in the second heat source-side gas refrigerant pipe P3 (low-pressure side) by referring to the detection value of the intake pressure sensor 21 (intake pressure LP) and determining whether or not a fluctuation in the intake pressure LP by a percentage exceeding a predetermined threshold is continuous. The refrigerant leakage spot identifying unit 57 determines whether or not there is a leakage of the refrigerant in the first heat source-side gas refrigerant pipe P1 and the heat source-side liquid refrigerant pipe P2 (high-pressure side) by referring to the detection value of the discharge pressure sensor 22 (discharge pressure HP) and determining

whether or not a fluctuation in the discharge pressure HP by a percentage exceeding a predetermined threshold is continuous.

[0117] The refrigerant leakage spot identifying unit 57, upon determining that a refrigerant leakage has occurred in the first flow path RP1 as a result of the first identifying process, raises a bit corresponding to the first flow path RP1 in the refrigerant leakage spot discrimination flag 518 so as to indicate that information. In that event, the refrigerant leakage spot identifying unit 57 raises the bit corresponding to the low-pressure side of the first flow path RP1 when a refrigerant leakage has occurred on the low-pressure side of the first flow path RP1, and raises the bit corresponding to the high-pressure side of the first flow path RP1 when a refrigerant leakage has occurred on the high-pressure side.

[0118] The refrigerant leakage spot identifying unit 57, upon discriminating the reception of the gas-side closing valve open notification command, executes the second identifying process. Here, the situation of the gas-side closing valve open notification command being received is a situation presumed as the gas-side closing valve 18 having been switched to the open state by the user, and a situation presumed as the inlet side of the first flow path RP1 and the outlet side of the second flow path RP2 being in a state of communication with each other, and the inlet side of the second flow path RP2 and the outlet side of the third flow path RP3 being in the divided state. The refrigerant leakage spot identifying unit 57, in the second identifying process, determines whether or not there is a leakage of the refrigerant in the second flow path RP2 by referring to the detection value of the intake pressure sensor 21 (intake pressure LP) and determining whether or not a fluctuation in the intake pressure LP by a percentage exceeding a predetermined threshold is continuous. The refrigerant leakage spot identifying unit 57, upon determining that a refrigerant leakage has occurred in the second flow path RP2 based on the result of the second identifying process, raises the bit corresponding to the second flow path RP2 in the refrigerant leakage spot discrimination flag 518 so as to indicate that information.

[0119] The refrigerant leakage spot identifying unit 57, in the event of having determined that a refrigerant leakage has not occurred in the second flow path RP2 upon completion of the second identifying process, after setting the utilization-side expansion valve 32 to a predetermined opening degree to switch the utilization-side expansion valve 32 from the closed state to the open state, executes the third identifying process. Here, the situation of the utilization-side expansion valve 32 being switched to the open state after completion of the second identifying process is a situation presumed as the state of the inlet side of the second flow path RP2 (in greater detail, the first flow path RP1) and the outlet side of the third flow path RP3 being in communication with each other, and the outlet side of the first flow path RP1 and the inlet side of the third flow path RP3 being divided. In the third identifying process, the refrigerant leakage spot identifying unit 57 determines whether or not there is a leakage of the refrigerant in the third flow path RP3 by referring to the detection value of the intake pressure sensor 21 (intake pressure LP) and determining whether or not a fluctuation in the intake pressure LP by a percentage exceeding a predetermined threshold is continuous. The refrigerant leakage spot identifying unit 57, upon determining that a refrigerant leakage has occurred in the third flow path RP3 based on the result of the third identifying process, raises the bit corresponding to the third flow path RP3 in the refrigerant leakage spot discrimination flag 518 so as to indicate that information.

[0120] The threshold values used in the first identifying process, the second identifying process, and the third identifying process are suitably set in accordance with the design specifications and installation environment. For example, the refrigerant leakage spot identifying unit 57 sets the threshold values based on the pressure reference value table stored in the pressure reference value storage region 512. In the control program, the threshold values may be set beforehand.

[0121] In the refrigerant leakage spot identifying processes performed in the above manner, the determination of whether or not there is leakage of the refrigerant in the second flow path RP2 and the third flow path RP3 is performed on the basis of the detection value of the intake pressure sensor 21 (refrigerant state detection sensor) disposed in the first flow path RP1. That is, it is possible to individually determine whether or not there is a leakage of the refrigerant in each refrigerant flow path even without disposing a refrigerant state detection sensor such as a pressure sensor or temperature sensor in each refrigerant flow path.

(5) Processing flow of controller 50

[0122] An example of the processing flow of the controller 50 will be described below while referring to FIG. 4 and FIG. 5. FIG. 4 and FIG. 5 are flowcharts that show an example of the processing flow of the controller 50.

[0123] When power is turned on, the controller 50 performs processing by the flow shown from Steps S101 to S125 in FIG. 4 and FIG. 5. In FIG. 4 and FIG. 5, processing in the case of transition to the normal operation mode is shown from Steps S102 to S104, processing in the case of transition to the filled refrigerant amount determination mode is shown from Steps S105 to S110, and processing in the case of transition to the refrigerant leakage determination mode is shown from Steps S111 to S125. In greater detail, it is shown that the cooling operation is performed in Step S104, the refrigerant collection operation is performed in Steps S106 and S107, the filled refrigerant amount determination is performed in Steps S109 and S110, and the refrigerant leakage spot identifying process is performed from Steps S111 to S124.

[0124] Note that the processing flows shown in FIG. 4 and FIG. 5 are merely exemplary and may be suitably

modified. For example, the order of the steps may be changed within a scope in which contradictions do not arise, and some steps may be executed in parallel with other steps.

[0125] In Step S101, the controller 50 advances to Step S105 when a refrigerant amount determination start command has been input. In contrast, when a refrigerant amount determination start command has not been input, the process advances to Step S102.

[0126] In Step S102, the controller 50 transitions to the normal operation mode. Thereafter, the process advances to Step S103.

[0127] In Step S103, the controller 50 returns to Step S101 when an operation command (operation start instruction) has not been input. In contrast, when an operation command has been input, the process advances to Step S104.

[0128] In Step S104, the controller 50 performs the cooling operation by controlling in real time the state of each actuator in accordance with the set temperature that has been set and the detection values of the various sensors (20 to 25). Also, the controller 50 causes various information such as the set temperature to be displayed in the remote controller 40. Thereafter, the process returns to Step S101.

[0129] In Step S105, the controller 50 transitions to the filled refrigerant amount determination mode. Thereafter, the process advances to Step S106.

[0130] In Step S106, the controller 50 starts the refrigerant collection operation, which collects the refrigerant in the refrigerant circuit RC in the receiver 13, by performing control to put the heat source-side expansion valve 15 and the injection valve 16 into a closed state, and causing the compressor 11 to operate at a predetermined rotational frequency (here, the maximum rotational frequency). Then, the process advances to Step S107.

[0131] In Step S107, the controller 50 determines whether or not the intake pressure LP is less than the threshold value ΔTh. As a result of the determination, when the intake pressure LP is equal to or greater than the threshold value ΔTh, the determination is repeated in Step S107. On the other hand, when the intake pressure LP is less than the threshold value ΔTh, the process advances to Step S108.

[0132] In Step S108, in response to the situation having arisen in which it is presumed that the intake pressure LP is less than the threshold value ΔTh, and the refrigerant collection to the receiver 13 is completed, the controller 50 stops the compressor 11 to complete the refrigerant collection operation. Then, the process advances to Step S109.

[0133] In Step S109, the controller 50 starts the filled refrigerant amount determination that determines whether or not the refrigerant amount filled in the refrigerant circuit RC is suitable, and whether or not a refrigerant leakage has occurred in the refrigerant circuit RC. Then the process advances to Step S110.

[0134] In Step S110, the controller 50 determines whether or not the liquid level height Lh is equal to or greater than the reference value Sh. As a result of the determination, when the liquid level height Lh is equal to or greater than the reference value Sh, the process returns to Step S102. On the other hand, when the liquid level height Lh is less than the reference value Sh, the process advances to Step Sill.

[0135] In Step Sill, the controller 50 transitions to the refrigerant leakage determination mode. Then, the process advances to Step S112.

[0136] In Step S112, the controller 50 switches the utilization-side expansion valve 32 to the closed state. Also, the controller 50 causes the remote controller 40 to display closing valve close switching request information requesting the user to switch (information that requests switching of the closing valve, so that the user is requested) the liquid-side closing valve 17 and the gas-side closing valve 18 to the closed state. Then, the process advances to Step S113.

[0137] In Step S113, when the closing valve close notification command has not been input to the remote controller 40 by the user (that is, when it is presumed that the switch to the closed state of the liquid-side closing valve 17 and the gas-side closing valve 18 has not been performed), the controller 50 advances to Step S125. On the other hand, when the closing valve close notification command has been input to the remote controller 40 by the user (that is, when it is presumed that the switch to the closed state of the liquid-side closing valve 17 and the gas-side closing valve 18 is completed), the controller 50 advances to Step S114.

[0138] In Step S114, the controller 50 starts the first identifying process in the refrigerant leakage spot identifying process. Specifically, the controller 50 determines whether or not there is a leakage of the refrigerant in the first flow path RP1 by determining whether or not the intake pressure LP is fluctuating by a percentage exceeding a predetermined threshold value, and whether or not the discharge pressure HP is fluctuating by a percentage exceeding a predetermined threshold value. Then, the controller 50 advances to Step S115.

[0139] In Step S115, when as a result of the first identifying process a refrigerant leakage is presumed to have occurred in the first flow path RP1 (that is, when the intake pressure LP or the discharge pressure HP is fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S124. On the other hand, when as a result of the first identifying process a refrigerant leakage is presumed to have not occurred in the first flow path RP1 (that is, when the intake pressure LP or the discharge pressure HP is not fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S116.

[0140] In Step S116, the controller 50 causes the remote controller 40 to display gas-side closing valve open switching request information requesting the user to switch the gas-side closing valve 18 to the open state.

Then, the controller 50 advances to Step S117.

[0141] In Step S117, when the gas-side closing valve open notification command has not been input to the remote controller 40 by the user (that is, when it is presumed that the switch to the open state of the gas-side closing valve 18 has not been performed), the controller 50 advances to Step S125. On the other hand, when the gas-side closing valve open notification command has been input to the remote controller 40 by the user (that is, when it is presumed that the switch to the open state of the gas-side closing valve 18 is completed), the controller advances to Step S118.

[0142] In Step S118, the controller 50 starts the second identifying process in the refrigerant leakage spot identifying process. Specifically, the controller 50 determines whether or not there is a leakage of the refrigerant in the second flow path RP2 by determining whether or not the intake pressure LP is fluctuating by a percentage exceeding a predetermined threshold value. Then, the controller 50 advances to Step S119.

[0143] In Step S119, when as a result of the second identifying process a refrigerant leakage is presumed to have occurred in the second flow path RP2 (that is, when the intake pressure LP is fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S124. On the other hand, when as a result of the second identifying process a refrigerant leakage is presumed to have not occurred in the second flow path RP2 (that is, when the intake pressure LP is not fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S120.

[0144] In Step S120, the controller 50 sets the utilization-side expansion valve 32 to a predetermined opening degree to switch the utilization-side expansion valve 32 from the closed state to the open state. Then the controller 50 advances to Step S121.

[0145] In Step S121, the controller starts the third identifying process in the refrigerant leakage spot identifying process. Specifically, the controller 50 determines whether or not there is a leakage of the refrigerant in the third flow path RP3 by determining whether or not the intake pressure LP is fluctuating by a percentage exceeding a predetermined threshold value. Then, the controller 50 advances to Step S122.

[0146] In Step S122, when as a result of the third identifying process a refrigerant leakage is presumed to have occurred in the third flow path RP3 (that is, when the intake pressure LP is fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S124. On the other hand, when as a result of the third identifying process a refrigerant leakage is presumed to have not occurred in the third flow path RP3 (that is, when the intake pressure LP is not fluctuating by a percentage exceeding the predetermined threshold value), the controller 50 advances to Step S123.

[0147] In Step S123, in response to a refrigerant leakage spot not being identified as a result of the refrigerant leakage spot identifying process, the controller 50 causes filled refrigerant amount shortage reporting information reporting that the filled refrigerant amount in the refrigerant circuit RC is not suitable (insufficient) to be displayed in the remote controller 40 and then stands by.

[0148] In Step S124, in response to a refrigerant leakage spot being identified as a result of the refrigerant leakage spot identifying process, the controller 50 causes the refrigerant leakage spot reporting information reporting the spot where the refrigerant leakage has occurred to be displayed in the remote controller 40 and then stands by.

[0149] In Step S125, in response to the presumption that the closing valve close notification command has not been input to the remote controller 40 by the user in spite of closing valve close switching request information is displayed (that is, switching of the liquid-side closing valve 17 and the gas-side closing valve 18 to the closed state not being performed), or that the gas-side closing valve open notification command has not been input to the remote controller 40 by the user in spite of gas-side closing valve open switching request information is displayed (that is, switching of the gas-side closing valve 18 to the open state not being performed), the controller 50 causes error information to be displayed in the remote controller 40 reporting that the refrigerant leakage spot identifying process cannot be executed and then stands by.

(6) The operation state of each unit of the refrigeration apparatus 100

[0150] Here, the operation of each unit of the refrigeration apparatus 100 in the filled refrigerant amount determination mode and the refrigerant leakage determination mode is described. FIG. 6 is a sequence diagram that schematically shows the operation of each unit of the refrigeration apparatus 100 in the filled refrigerant amount determination mode. FIG. 7 is a sequence diagram that schematically shows the operation of each unit of the refrigeration apparatus 100 in the refrigerant leakage determination mode. FIG. 6 and FIG. 7 show that the filled refrigerant amount determination is performed in period S1, the first identifying process is performed in period S2, the second identifying process is performed in period S3, and the third identifying process is performed in period S4.

(6-1) Period S1

[0151] In period S1, the control mode of the controller 50 transitions to the filled refrigerant amount determination mode on the occasion of the refrigerant amount determination start command being input to the remote controller 40.

[0152] As a process related to the filled refrigerant amount determination mode, the controller 50 outputs a

drive signal to heat source-side expansion valve 15 (and the injection valve 16) to switch the heat source-side expansion valve 15 (and the injection valve 16) to the closed state. In response, the heat source-side expansion valve 15 (and the injection valve 16) is switched to the closed state.

[0153] The controller 50 outputs a drive signal to the compressor 11 to cause the compressor 11 to be driven at a predetermined rotational frequency (maximum rotational frequency). In response, the compressor 11 is driven at the maximum rotational frequency.

[0154] Next, the controller 50 sends an instruction to the remote controller 40 to cause the remote controller 40 to display that the filled refrigerant amount determination operation is underway. In response, the remote controller 40 displays that the filled refrigerant amount determination operation is underway.

[0155] Then, the controller 50, in response to the intake pressure LP being less than the threshold value ΔTh, determines that the refrigerant collection is completed and outputs a stop signal to the compressor 11 in order to stop the compressor 11. In response, the compressor 11 stops driving.

[0156] The controller 50 executes the filled refrigerant amount determination, and as a result of the determination, determines that the filled refrigerant amount is insufficient. As a result, the controller 50 transitions to the refrigerant leakage determination mode.

(6-2) Period S2

[0157] In period S2, the controller 50, after transition to the refrigerant leakage determination mode, outputs a drive signal to the utilization-side expansion valve 32 to switch the utilization-side expansion valve 32 to the closed state. In response, the utilization-side expansion valve 32 is switched to the closed state.

[0158] The controller 50 also sends an instruction to the remote controller 40 to display closing valve close switching request information for dividing the first flow path RP1, the second flow path RP2, and the third flow path RP3. In response, the remote controller 40 displays the closing valve close switching request information.

[0159] After the closing valve close switching request information is displayed, the user switches the liquid-side closing valve 17 and the gas-side closing valve 18 to the closed state, and inputs the closing valve close notification command to the remote controller 40.

[0160] Subsequently, the controller 50 executes the first identifying process for discriminating whether or not there is a leakage of the refrigerant in the first flow path RP1.

[0161] In this way, in period S2, after a step (first step) is performed in which the refrigerant circuit RC is divided into the plurality of refrigerant flow paths by setting each of the valves (32, 17 and 18) to the closed state in the state of the compressor 11 being stopped, a step (second step) is performed for determining whether or not there is a leakage of the refrigerant by detecting a change in the state of the refrigerant in the first flow path RP1.

(6-3) Period S3

[0162] In period S3, following the completion of the first identifying process, the controller 50, in response to a result that a refrigerant leakage spot has not been identified, sends an instruction to the controller 40 to display gas-side closing valve open switching request information for putting the inlet side (gas side) of the first flow path RP1 and the outlet side of the second flow path RP2 into communication. In response, the remote controller 40 displays gas-side closing valve open switching request information.

[0163] After the gas-side closing valve open switching request information is displayed, the user switches the gas-side closing valve 18 to the open state, and inputs the gas-side closing valve open notification command to the remote controller 40.

[0164] Subsequently, the controller 50 executes the second identifying process for discriminating whether or not there is a leakage of refrigerant in the second flow path RP2.

[0165] In this way, in period S3, a change in the state of the refrigerant in the second flow path RP2 is detected by switching the gas-side closing valve 18, which divides the first flow path RP1 with the intake pressure sensor 21 (refrigerant state detection sensor) being disposed and the second flow path RP2 without the intake pressure sensor 21, to the open state, and detecting a change in the intake pressure LP by the intake pressure sensor 21 in the state of the first flow path RP1 and the second flow path RP2 being put in communication with each other.

(6-4) Period S4

[0166] In period S4, following the completion of the second identifying process, the controller 50, in response to a result that a refrigerant leakage spot has not been identified, in order to set the utilization-side expansion valve 32 to a predetermined opening degree to switch the utilization-side expansion valve 32 to an open state and put the inlet side (gas side) of the first flow path RP1 and the outlet side of the third flow path RP3 into communication. In response, the utilization-side expansion valve 32 is switched to the open state.

[0167] Next, the controller 50 executes the third identifying process for discriminating whether or not there is a leakage of the refrigerant in the third flow path RP3.

[0168] In this way, in period S4, a change in the state of the refrigerant in the third flow path RP3 is detected by switching the utilization-side expansion valve 32, which divides the first flow path RP1 with the intake pressure sensor 21 (refrigerant state detection sensor) from the third flow path RP3 without the intake pressure sensor 21, to the open state, and detecting a change in the intake pressure LP by the intake pressure sensor 21 in the state

of the first flow path RP1 and the third flow path RP3 being put in communication with each other.

[0169] Subsequently, in accordance with the result of the third identifying process (refrigerant leakage spot identifying process), the controller 50 sends an instruction to the remote controller 40 to display predetermined information (refrigerant leakage spot reporting information or filled refrigerant amount shortage reporting information). In response, the remote controller 40 displays the instructed information.

(7) Characteristics of the refrigeration apparatus 100

(7-1)

[0170] According to the method of identifying a refrigerant leakage spot of the embodiment, it is possible to provide a method of identifying a refrigerant leakage spot that is capable of identifying a refrigerant leakage spot when a refrigerant leakage has occurred in a refrigerant circuit RC while restraining an increase in cost.

[0171] That is, in an apparatus that has a refrigerant circuit, when a refrigerant leakage occurs for reasons such as damage to the pipe and degradation of components, it is necessary to quickly detect that a refrigerant leakage has occurred from the standpoint of ensuring the safety of humans. Depending on the installation environment of the apparatus, when a refrigerant leakage has occurred, since minimizing the number of repair steps, a quick restoration, and clarification of the cause and the spot of responsibility become necessary, it is necessary to quickly identify not only the fact that a refrigerant leakage has occurred but also the spot where the refrigerant leakage has occurred.

[0172] However, while it is possible to determine the fact that a refrigerant leakage has occurred according to previously proposed methods, it is not possible to concretely identify the spot where a refrigerant leakage has occurred. In addition, while it is possible to identify not only that a refrigerant leakage has occurred but also the spot where the refrigerant leakage has occurred, since installation of a plurality of refrigerant leakage sensors is required, increasing cost becomes a concern.

[0173] On this point, the method of identifying a refrigerant leakage spot of the aforedescribed embodiment includes: a step (first step) in which the refrigerant circuit RC is divided into the plurality of refrigerant flow paths by each of the valves (the liquid-side closing valve 17, the gas-side closing valve 18, and the utilization-side expansion valve 32) being set to the closed state in the state of the compressor 11 being stopped; and a step (second step) for determining whether or not there is leakage of the refrigerant in each refrigerant flow path (RP1, RP2, RP3) by detecting a change in the pressure of the refrigerant in each refrigerant flow path.

[0174] Thereby, the refrigerant circuit RC is divided into the plurality of refrigerant flow paths (RP1, RP2, RP3), and whether or not there is a leakage of the refrigerant in each refrigerant flow path is determined. As a result, a refrigerant leakage spot can be identified without installing a plurality of refrigerant leakage sensors. Therefore, it is possible to identify a refrigerant leakage spot when a refrigerant leakage has occurred while restraining an increase in cost.

(7-2)

[0175] The method of identifying a refrigerant leakage spot of the aforedescribed embodiment identifies whether or not there is a leakage of the refrigerant in each refrigerant flow path by detecting a change in the pressure of the refrigerant in each refrigerant flow path (RP1, RP2, RP3). In the steps, the pressure of the refrigerant in the first flow path RP1 in which a pressure sensor (intake pressure sensor 21 or discharge pressure sensor 22) is disposed is detected by the pressure sensor. Then, the gas-side closing valve 18 that divides the first flow path RP1 and the second flow path RP2, or the utilization-side expansion valve 32 that divides the first flow path RP1 from the third flow path RP3 is switched from the closed state to the open state by the user. In the state of the first flow path RP1 and the second flow path RP2 or the third flow path RP3 being in communication with each other, a change in the pressure of the refrigerant in the second flow path RP2 or the third flow path RP3 in which a pressure sensor is not disposed is detected by the intake pressure sensor 21 disposed in the first flow path RP1.

[0176] Thereby, it becomes possible to detect the state of the refrigerant in the second flow path RP2 and the third flow path RP3 in which a refrigerant state detection sensor such as a pressure sensor or a temperature sensor is not disposed. As a result, a refrigerant leakage spot in the refrigerant circuit RC can be identified without disposing a refrigerant state detection sensor in each refrigerant flow path. Therefore, it is possible to identify a refrigerant leakage spot when a refrigerant leakage has occurred while restraining an increase in cost.

(7-3)

[0177] A method of identifying a refrigerant leakage spot of the aforedescribed embodiment includes a step for collecting a portion of the refrigerant in the refrigerant circuit RC in a receiver 13 that is capable of storing the refrigerant, and after the completion of the step that collects the refrigerant, the refrigerant circuit RC is divided into a plurality of refrigerant flow paths by switching each of the valves (the liquid-side closing valve 17, the gas-side closing valve 18, and the utilization-side expansion valve 32) to a closed state after the compressor 11 is stopped. Thereby, it becomes possible to detect a change in the state of the gas refrigerant that exists in each refrigerant flow path (RP1, RP2, and RP3) after collecting the liquid refrigerant in the receiver 13. That is, in the step for determining whether or not there is a leak-

age of the refrigerant in each refrigerant flow path by detecting a change in the pressure of the refrigerant, it becomes possible to detect a change in the pressure of a gas refrigerant, in which the change in pressure when a refrigerant leakage has occurred is more noticeable (earlier) than a liquid refrigerant. Therefore, it is possible to perform the determination with high precision, and it is possible to perform the determination in a shorter time compared to the case of performing the determination by detecting a change in pressure of a liquid refrigerant.

(7-4)

[0178] In the method of identifying a refrigerant leakage spot of the aforedescribed embodiment, on the occasion of the filled refrigerant amount being determined to be unsuitable in the filled refrigerant amount determination operation, a step is performed that stops the compressor 11 and switches each of the valves (the liquid-side closing valve 17, the gas-side closing valve 18, and the utilization-side expansion valve 32) to a closed state to divide the refrigerant circuit RC into a plurality of refrigerant flow paths.

[0179] Thereby, after it is determined that the filled refrigerant amount in the refrigerant circuit RC is insufficient, a step for stopping the compressor 11 and dividing the refrigerant circuit RC into a plurality of refrigerant flow paths and a step for determining whether or not there is a leakage of the refrigerant in any of the refrigerant flow paths (that is, a step for determining a refrigerant leakage spot) are performed. That is, a configuration that does not require the compressor 11 to be stopped each time to determine whether or not there is a leakage of the refrigerant decreases degradation of components that are subject to temperature control and restrains a decrease in comfort.

(7-5)

[0180] The method of identifying a refrigerant leakage spot of the aforedescribed embodiment includes a step for outputting to the remote controller 40 refrigerant leakage spot reporting information that reports the refrigerant flow path (RP1, RP2, and RP3) where it was determined that a leakage of the refrigerant has occurred.

[0181] Thereby, when a leakage of the refrigerant has occurred, the refrigerant leakage spot reporting information that identifies the spot where a leakage of the refrigerant has occurred is displayed in the remote controller 40. As a result, when a leakage of the refrigerant has occurred, it becomes easy for the user to recognize the fact that a leakage of the refrigerant has occurred and the spot where the leakage of the refrigerant has occurred, and the user is prompted to take action. Thereby, safety with regard to refrigerant leakages is enhanced.

(8) Modifications

[0182] The aforedescribed embodiment can be suitably modified as indicated by the following modifications. The modifications may be combined with or applied to other modifications within a scope in which contradictions do not arise.

(8-1) Modification A

[0183] In the aforedescribed embodiment, the manual gas-side closing valve 18 is used as a valve for dividing the inlet side (gas side) of the first flow path RP1 from the outlet side of the second flow path RP2, and the manual liquid-side closing valve 17 is used as a valve for dividing the outlet side (liquid side) of the first flow path RP 1 and the inlet side of the third flow path RP3.

[0184] However, a solenoid valve that is switchable to an open state or a closed state by being energized, or a motor-operated valve whose opening degree (including closed state) is switchable by the supply of a predetermined drive voltage may be used as the liquid-side closing valve 17 and/or the gas-side closing valve 18.

[0185] In this case, in the process according to the refrigerant leakage determination mode the need is eliminated to switch the liquid-side closing valve 17 or the gas-side closing valve 18 to the closed state or open state by the user, and the need is eliminated to display the closing valve open switching request information or the gas-side closing valve open switching request information in the remote controller 40. Therefore, Step S112 of FIG. 5 may be configured so as to switch the liquid-side closing valve 17 and the gas-side closing valve 18 constituted by a motor-operated valve or a solenoid valve to the closed state by supplying or blocking a predetermined drive voltage to the liquid-side closing valve 17 and the gas-side closing valve 18, instead of causing closing valve close switching request information to be displayed in the remote controller 40. Also, Step S116 of FIG. 5 may be configured so as to switch the gas-side closing valve 18 to the open state by supplying or blocking a predetermined drive voltage to the gas-side closing valve 18 constituted by a motor-operated valve or a solenoid valve, instead of causing gas-side closing valve open switching request information to be displayed in the remote controller 40.

[0186] As a result, it is possible to execute the step for identifying a refrigerant leakage spot without manual intervention. That is, the method of identifying a refrigerant leakage spot of the embodiment is automatically executed. In this case, the refrigeration apparatus 100 functions as a refrigerant leakage spot identifying apparatus that is capable of automatically identifying a refrigerant leakage spot.

(8-2) Modification B

[0187] The method of identifying a refrigerant leakage

spot of the aforedescribed embodiment was applied to the refrigeration apparatus 100 that performs cooling of the compartment of a refrigerating warehouse or a store showcase. However, the present invention, without being limited thereto, can also be applied to other refrigeration apparatuses. For example, the present invention may also be applied to an air conditioning system (air-conditioner) that achieves air conditioning by performing cooling and other in a building. The present invention can also be applied to for example a refrigeration apparatus that is constituted so as to have the utilization-side heat exchanger 33 function as a radiator or condenser of refrigerant by disposing a four-way switching valve or rearranging the refrigerant pipe in the refrigerant circuit RC in FIG. 1 so as to perform a heating operation or room heating operation of a space in which the utilization unit 30 is disposed.

[0188] Alternatively, the method of identifying a refrigerant leakage spot of the present invention may be applied to a refrigeration apparatus 200 for example as shown in FIG. 8. The refrigeration apparatus 200 is a refrigeration apparatus that performs cooling in a transport container (in a compartment). Hereinbelow, the parts of the refrigeration apparatus 200 differing from the refrigeration apparatus 100 will be described.

[0189] The refrigeration apparatus 200 has a heat source unit 10a that functions as an outdoor unit in place of the heat source unit 10, and a utilization unit 30a that functions has an indoor unit in place of the utilization unit 30. A refrigerant circuit RC1 is constituted in place of the refrigerant circuit RC in the refrigeration apparatus 200.

[0190] The refrigeration apparatus 200 has, in the heat source unit 10a, a third heat source-side gas refrigerant pipe P8 that branches off from the first heat source-side gas refrigerant pipe P1 and has a fourth heat source-side gas refrigerant pipe P9 that branches off from the third heat source-side gas refrigerant pipe P8. The refrigeration apparatus 200 also has a third utilization-side liquid refrigerant pipe P10 in the utilization unit 30a.

[0191] The liquid-side closing valve 17 and the gas-side closing valve 18 are omitted from the refrigeration apparatus 200. A first gas-side on/off valve 71 (valve) that connects one end of the second heat source-side gas refrigerant pipe P3 and one end of the utilization-side gas refrigerant pipe P7 is disposed in the refrigeration apparatus 200. A second gas-side on/off valve 72 (valve) that connects one end of the third heat source-side gas refrigerant pipe P8 and one end of the second utilization-side liquid refrigerant pipe P6 is disposed in the refrigeration apparatus 200. A third gas-side on/off valve 73 (valve) that connects one end of the fourth heat source-side gas refrigerant pipe P9 and one end of the third utilization-side liquid refrigerant pipe P10 is disposed in the refrigeration apparatus 200. The first gas-side on/off valve 71, the second gas-side on/off valve 72, and the third gas-side on/off valve 73 are solenoid valves that are switched between the open state and the closed state by being energized.

[0192] A capillary tube 32a is disposed as a low-pressure means in place of the utilization-side expansion valve 32 of the refrigeration apparatus 200. In addition, the heating pipe 31 is included in the third utilization-side liquid refrigerant pipe P10 of the refrigeration apparatus 200.

[0193] The refrigerant circuit RC1 that is constituted in the refrigeration apparatus 200 is mainly divided into a first flow path RP1' and a second flow path RP2' as shown in FIG. 9. FIG. 9 is a diagram that schematically shows the first flow path RP1' and the second flow path RP2' included in the refrigerant circuit RC1.

[0194] The first flow path RP1' (first refrigerant flow path) is a refrigerant flow path that is constituted in the heat source unit 10a. Specifically, the first flow path RP1' is a refrigerant flow path that is constituted by the first heat source-side gas refrigerant pipe P1, the heat source-side liquid refrigerant pipe P2, the second heat source-side gas refrigerant pipe P3, the injection pipe P4, the third heat source-side gas refrigerant pipe P8, and the fourth heat source-side gas refrigerant pipe P9.

[0195] The second flow path RP2' (second refrigerant flow path) is a refrigerant flow path that is constituted in the utilization unit 30a. Specifically, the second flow path RP2' is a refrigerant flow path that is constituted by the first utilization-side liquid refrigerant pipe P5, the second utilization-side liquid refrigerant pipe P6, the third utilization-side liquid refrigerant pipe P10, and the utilization-side gas refrigerant pipe P7. That is, the second flow path RP2' is a refrigerant flow path that includes the heating pipe 31, the capillary tube 32a, and the utilization-side heat exchanger 33.

[0196] That is, the refrigerant circuit RC1 is divided into the plurality of refrigerant flow paths (RP1' and RP2') by each of the valves (specifically, the first gas-side on/off valve 71, the second gas-side on/off valve 72, the third gas-side on/off valve 73, and the heat source-side expansion valve 15) being set to the closed state.

[0197] In the refrigerant leakage determination mode of the refrigeration apparatus 200, the first gas-side on/off valve 71, the second gas-side on/off valve 72, and the third gas-side on/off valve 73 can be set to the closed state by switching the energized states thereof, instead of causing the remote controller 40 to display closing valve open switching request information or gas-side closing valve open switching request information or the like. The first gas-side on/off valve 71 can be set to the open state by switching the energized state thereof instead of causing the remote controller 40 to display gas-side closing valve open switching request information.

[0198] By performing this processing in the refrigerant leakage determination mode, it is possible to apply the method of identifying a refrigerant leakage spot according to an embodiment of the present invention also to the refrigeration apparatus 200, thereby exhibiting the same effect as the aforedescribed embodiment.

(8-3) Modification C

[0199] In the aforedescribed embodiment, the refrigerant collection operation was configured to be completed when the refrigerant collection is treated as completed by the detection value (intake pressure LP) of the intake pressure sensor 21 being less than the predetermined threshold value ΔTh (refer to Step S107 and Step S108 in FIG. 4). However, the trigger for completion of the refrigeration collection operation may be suitably changed in accordance with the design specifications and installation environment.

[0200] For example, the refrigerant collection operation may be configured to be completed when the refrigerant collection is treated as completed by the detection value of the discharge pressure sensor 22 (discharge pressure HP) being less than a predetermined value.

[0201] For example the refrigerant collection operation may also be configured to be completed on the occasion of the passage of a preset predetermined time after the start of the refrigerant collection operation.

[0202] In the aforedescribed embodiment, the threshold value ΔTh was set to 0.3 Mpa but is not necessarily limited to 0.3 MPa, and may be set to a suitable value in accordance with the design specifications and installation environment. For example, the threshold value ΔTh may be set to 0.1 MPa, or may be set to 0.4 MPa.

(8-4) Modification D

[0203] In the aforedescribed embodiment, the controller 50 determined the suitability of the filled refrigerant amount in the refrigerant circuit RC (whether or not there is a leakage of the refrigerant) by comparing the detection value of the liquid level detection sensor 25 (liquid level height Lh) and the reference value Sh. However, the method of determining the suitability of the filled refrigerant amount in the refrigerant circuit RC is not necessarily limited thereto, and may be any method provided it is a method capable of determining the suitability of the filled refrigerant amount in the refrigerant circuit RC. For example, the suitability of the filled refrigerant amount in the refrigerant circuit RC may be determined using the detection value of the intake pressure sensor 21 (intake pressure LP), the detection value of the discharge pressure sensor 22 (discharge pressure HP), or the detection value of the receiver outlet temperature sensor 23 (receiver outlet temperature TL).

[0204] A refrigerant leakage sensor capable of detecting a refrigerant leakage by detecting refrigerant that has leaked may be disposed in either of the heat source unit 10 or the utilization unit 30, and on the basis of the detection result of the refrigerant leakage sensor, whether or not there is a leakage of the refrigerant in the refrigerant circuit RC may be determined. In this case, the transition to the refrigerant leakage determination mode is made on the occasion of the refrigerant leakage sensor detecting a refrigerant leakage. That is, the refrigerant circuit RC is divided into the plurality of refrigerant flow paths, and whether or not there is a leakage of the refrigerant in each of the refrigerant flow paths is determined on the occasion of the refrigerant leakage sensor having detected a refrigerant leakage.

(8-5) Modification E

[0205] In the aforedescribed embodiment, in accordance with the input of a refrigerant leakage determination command, the transition to the filled refrigerant amount determination mode occurs, and determination of the filled refrigerant amount is performed. However, the event serving as the trigger for determination of the filled refrigerant amount being performed is not necessarily limited thereto and can be suitably changed in accordance with the design specifications and installation environment.

[0206] For example, the determination of the filled refrigerant amount may be performed at the time of a trial run during construction or maintenance, or during a regular inspection. That is, it is not always necessary to transit to the filled refrigerant amount determination mode during operation. The transition to the filled refrigerant amount determination mode may occur on the occasion of the input of a predetermined command when operation is stopped, whereby the filled refrigerant amount determination may be performed.

[0207] Alternatively, with the arrangement of a counter capable of measuring time, the controller 50 (mode control unit 53) may be configured to switch from the normal mode to the filled refrigerant amount determination mode on the occasion of the passage of a predetermined time t1 from after the transition to the normal operation mode. In this case, the controller 50 periodically transitions to the filled refrigerant amount determination mode. The predetermined time t1 is suitably set in accordance with the design specifications and installation environment.

(8-6) Modification F

[0208] In the aforedescribed embodiment, for identifying the refrigerant leakage spot in the refrigerant circuit RC, whether or not there is a leakage of the refrigerant in the first flow path RP1, the second flow path RP2, and the third flow path RP3 is determined by detecting a fluctuation in the intake pressure LP.

[0209] However, whether or not there is a leakage of the refrigerant in the first flow path RP1, the second flow path RP2, and the third flow path RP3 need not be determined on the basis of the intake pressure LP, and may be determined on the basis of another value. For example, whether or not there is a leakage of the refrigerant in the first flow path RP1, the second flow path RP2, and the third flow path RP3 may be determined by detecting whether or not the discharge pressure HP fluctuates by a percentage exceeding a predetermined threshold value.

[0210] Alternatively, whether or not there is a leakage of the refrigerant in the first flow path RP1, the second flow path RP2, and the third flow path RP3 may also be determined by for example disposing a temperature sensor in the heat source unit 10 for detecting the temperature of the refrigerant drawn into the compressor 11 (intake temperature LT) or the temperature of the refrigerant discharged from the compressor 11 (discharge temperature HT), and detecting whether or not the intake temperature LT or discharge temperature HT fluctuates by a percentage exceeding a predetermined threshold value.

[0211] Alternatively, a refrigerant state detection sensor that detects the state of the refrigerant (for example, a pressure sensor that detects the pressure of the refrigerant, or a temperature sensor that detects the temperature of the refrigerant) may be disposed in the second flow path RP2 and/or the third flow path RP3, and whether or not there is a leakage of the refrigerant in the second flow path RP2 and/or the third flow path RP3 may be determined in accordance with the detection result of the refrigerant state detection sensor.

(8-7) Modification G

[0212] In the aforedescribed embodiment, the liquid-side closing valve 17 was disposed in the refrigerant circuit RC as a valve for dividing the first flow path RP1 from the third flow path RP3, but the heat source-side expansion valve 15 may be made to function as a valve for dividing the first flow path RP1 and the third flow path RP3. In this case, it is possible to omit the liquid-side closing valve 17.

(8-8) Modification H

[0213] In the aforedescribed embodiment, the controller 50, which controls the operation of the refrigeration apparatus 100, was constituted by the heat-source-unit control unit 26 and each utilization-unit control unit 38 being connected via the communication line cb1 in the refrigeration apparatus 100. However, the configuration embodiment of the controller 50 is not necessarily limited thereto and can be suitably changed in accordance with the design specifications and installation environment. For example, some or all of the elements included in the controller 50 (the storage unit 51, the communication unit 52, the mode control unit 53, the actuator control unit 54, the filled refrigerant amount shortage discriminating unit 55, the display control unit 56, and the refrigerant leakage spot identifying unit 57) do not necessarily need to be disposed in the heat source unit 10 and/or the utilization unit 30, and may be arranged in another apparatus in a remote place connected by a communication network, or may be independently arranged. That is, provided the components included in the controller 50 (the storage unit 51, the communication unit 52, the mode control unit 53, the actuator control unit 54, the filled refrigerant amount shortage discriminating unit 55, the display control unit 56, and the refrigerant leakage spot identifying unit 57) are achievable, the configuration embodiment of the controller 50 is not particularly limited.

(8-9) Modification I

[0214] In the aforedescribed embodiment, the controller 50 caused the remote controller 40 to output predetermined information as an "information output unit". In particular, the controller 50 caused the remote controller 40 to output the refrigerant leakage spot reporting information. On this point, when a refrigerant leakage has occurred, provided the refrigerant leakage spot reporting information is reportable to the user, a unit other than the remote controller 40 may be made to function as the "information output unit".

[0215] For example, by arranging a speaker capable of outputting audio and causing the speaker to output a predetermined alarm sound or message voice, the speaker may be made to function as an "information output unit" that outputs the refrigerant leakage spot reporting information. Also, by arranging a light source such as an LED lamp or the like and causing the light source to blink or turn on, the light source may be made to function as an "information output unit" that outputs the refrigerant leakage spot reporting information. In addition, by arranging a unit capable of outputting the refrigerant leakage spot reporting information in an apparatus such as a central processing device disposed at a remote spot separated from the facility or site where the refrigeration apparatus 100 is applied, the unit may be made to function as the "information output unit".

(8-10) Modification J

[0216] In the aforedescribed embodiment, only one each of the heat source unit 10 and the utilization unit 30 were included in the refrigeration apparatus 100. However, the number of the heat source unit 10 and/or the utilization unit 30 is not limited thereto, and there may also be a plurality.

[0217] In the aforedescribed embodiment, there was one compressor 11 disposed in the refrigerant circuit RC. However, the number of the compressor 11 is not limited thereto and there may also be a plurality thereof.

(8-11) Modification K

[0218] In the aforedescribed embodiment, in the refrigeration apparatus 100, a motor-operated valve was adopted for the utilization-side expansion valve 32, but the type of valve is not limited thereto, and for example a temperature sensitive type expansion valve that operates in accordance with the temperature change of temperature sensitive cylinder may also be adopted. In this case, a solenoid valve or motor-operated valve may be disposed in the front stage or rear state of the utilization-

side expansion valve 32, and the solenoid valve or motor-operated valve may be switched to the closed state, so as to divide the second flow path RP2 from the third flow path RP3.

(8-12) Modification L

[0219] In the aforedescribed embodiment, R32 was used as the refrigerant that circulates in the refrigerant circuit RC. However, the refrigerant used in the refrigerant circuit RC is not particularly limited. For example, HFO1234yf, HFO1234ze(E), and a mixture of these refrigerants may be used in place of R32 in the refrigerant circuit RC. An HFC-type refrigerant such as R407C or R410A may also be used in the refrigerant circuit RC.

INDUSTRIAL APPLICABILITY

[0220] The present invention can be used as a method of identifying a refrigerant leakage spot that identifies a refrigerant leakage spot in a refrigeration apparatus including a refrigerant circuit.

REFERENCE SIGNS LIST

[0221]

10, 10a:	heat source unit
11:	compressor
12:	heat source-side heat exchanger
13:	receiver
14:	supercooler
15:	heat source-side expansion valve (valve)
16:	injection valve
17:	liquid-side closing valve (valve)
18:	gas-side closing valve
19:	check valve
20:	heat source-side fan
21:	intake pressure sensor (refrigerant state detection sensor)
22:	discharge pressure sensor (refrigerant state detection sensor)
23:	receiver outlet temperature sensor (refrigerant state detection sensor)
24:	heat source-side air sensor
25:	liquid level detection sensor (refrigerant state detection sensor)
26:	heat-source-unit control unit
30, 30a:	utilization unit
31:	heating pipe
32:	utilization-side expansion valve (valve)
32a:	capillary tube
33:	utilization-side heat exchanger
34:	drain pan
36:	utilization-side fan
38:	utilization-unit control unit
40:	remote controller (information output unit)
50:	controller
51:	storage unit
52:	communication unit
53:	mode control unit
54:	actuator control unit
55:	filled refrigerant amount shortage discriminating unit
56:	display control unit
57:	refrigerant leakage spot identifying unit
71:	first gas-side on/off valve (valve)
72:	second gas-side on/off valve (valve)
73:	third gas-side on/off valve (valve)
100, 200:	refrigeration apparatus
G1:	gas refrigerant communication pipe
L1:	liquid refrigerant communication pipe
P1:	first heat source-side gas refrigerant pipe
P2:	heat source-side liquid refrigerant pipe
P3:	second heat source-side gas refrigerant pipe
P4:	injection pipe
P5:	first utilization-side liquid refrigerant pipe
P6:	second utilization-side liquid refrigerant pipe
P7:	utilization-side gas refrigerant pipe
P8:	third heat source-side gas refrigerant pipe
P9:	fourth heat source-side gas refrigerant pipe
P10:	third utilization-side liquid refrigerant pipe
RC, RC1:	refrigerant circuit
RP1, RP1':	first flow path (first refrigerant flow path)
RP2, RP2':	second flow path (second refrigerant flow path)
RP3:	third flow path (second refrigerant flow path)
cb1:	communication line

CITATION LIST

PATENT LITERATURE

[0222]

<Patent Document 1> Japanese Laid-open Patent Publication No. 2014-95514
<Patent Document 2> Japanese Laid-open Patent Publication No. 2011-226704
<Patent Document 3> Japanese Laid-open Patent Publication No. 2013-40730

Claims

1. A method of identifying a refrigerant leakage spot when a leakage of a refrigerant has occurred in a refrigerant circuit (RC, RC1) including a compressor (11) and a plurality of valves (15, 17, 18, 32, 71, 72, 73), each valve configured to be capable of being in a closed state that blocks flow of the refrigerant, the method comprising:

a first step for dividing the refrigerant circuit into a plurality of refrigerant flow paths (RP1, RP2, RP3, RP1', RP2') by setting each of the valves to the closed state in a state of the compressor being stopped; and
a second step for determining whether or not there is a leakage of the refrigerant in each of the refrigerant flow paths by detecting a change in the state of the refrigerant in each of the refrigerant flow paths after the first step.

2. The method of identifying a refrigerant leakage spot according to claim 1, wherein

in the second step,
after detecting in a first refrigerant flow path (RP1, RP1') in which a refrigerant state detection sensor (21, 22) is disposed for detecting a change in the state of a refrigerant, the state of the refrigerant by the refrigerant state detection sensor,
the valve that divides a second refrigerant flow path (RP2, RP3, RP2') in which the refrigerant state detection sensor is not disposed from the first refrigerant flow path is switched from the closed state to an open state allowing the flow of the refrigerant; and
a change in the state of the refrigerant in the second refrigerant flow path is detected by detecting a change in the state of the refrigerant with the refrigerant state detection sensor in the state of the first refrigerant flow path and the second refrigerant flow path being in communication with each other.

3. The method of identifying a refrigerant leakage spot according to claims 1 or 2, wherein

the first step includes a refrigerant collection step that drives the compressor to collect a portion of the refrigerant in the refrigerant circuit into a container capable of storing the refrigerant; and
in the first step, after the completion of the refrigerant collection step, each of the valves is switched to the closed state after stopping the compressor so as to divide the refrigerant circuit into the plurality of refrigerant flow paths.

4. The method of identifying a refrigerant leakage spot according to any one of claims 1 to 3, wherein
the first step is performed on the occasion of, in a filled refrigerant amount determination operation for determining the suitability of a filled refrigerant amount in the refrigerant circuit, the filled refrigerant amount being determined to be unsuitable, or a refrigerant leakage sensor that detects a leakage of the refrigerant in the refrigerant circuit having detected a refrigerant leakage.

5. The method of identifying a refrigerant leakage spot according to any one of claims 1 to 4, wherein
in the second step, an information output apparatus (40) is made to output information that reports about the refrigerant flow path in which a refrigerant leakage is determined to have occurred.

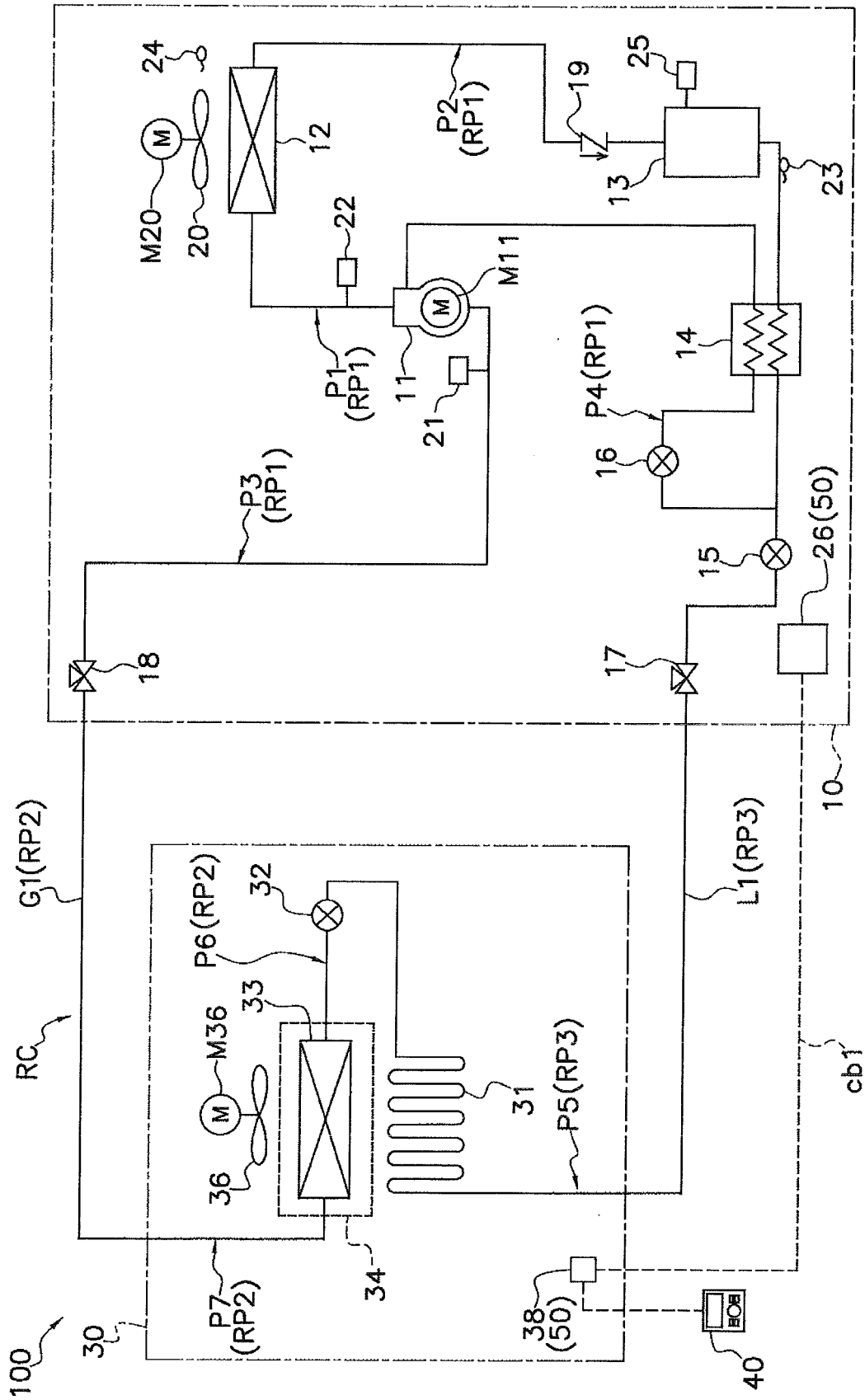

100
30
RC
G1(RP2)
P7 (RP2)
34
36
M36
33
32
P6(RP2)
31
P5(RP3)
L1(RP3)
cb1
10
38 (50)
40
18
17
15
26(50)
16
P4(RP1)
14
P3 (RP1)
P1 (RP1)
11
21
22
M11
M20
20
24
12
P2 (RP1)
19
25
13
23

FIG. 1

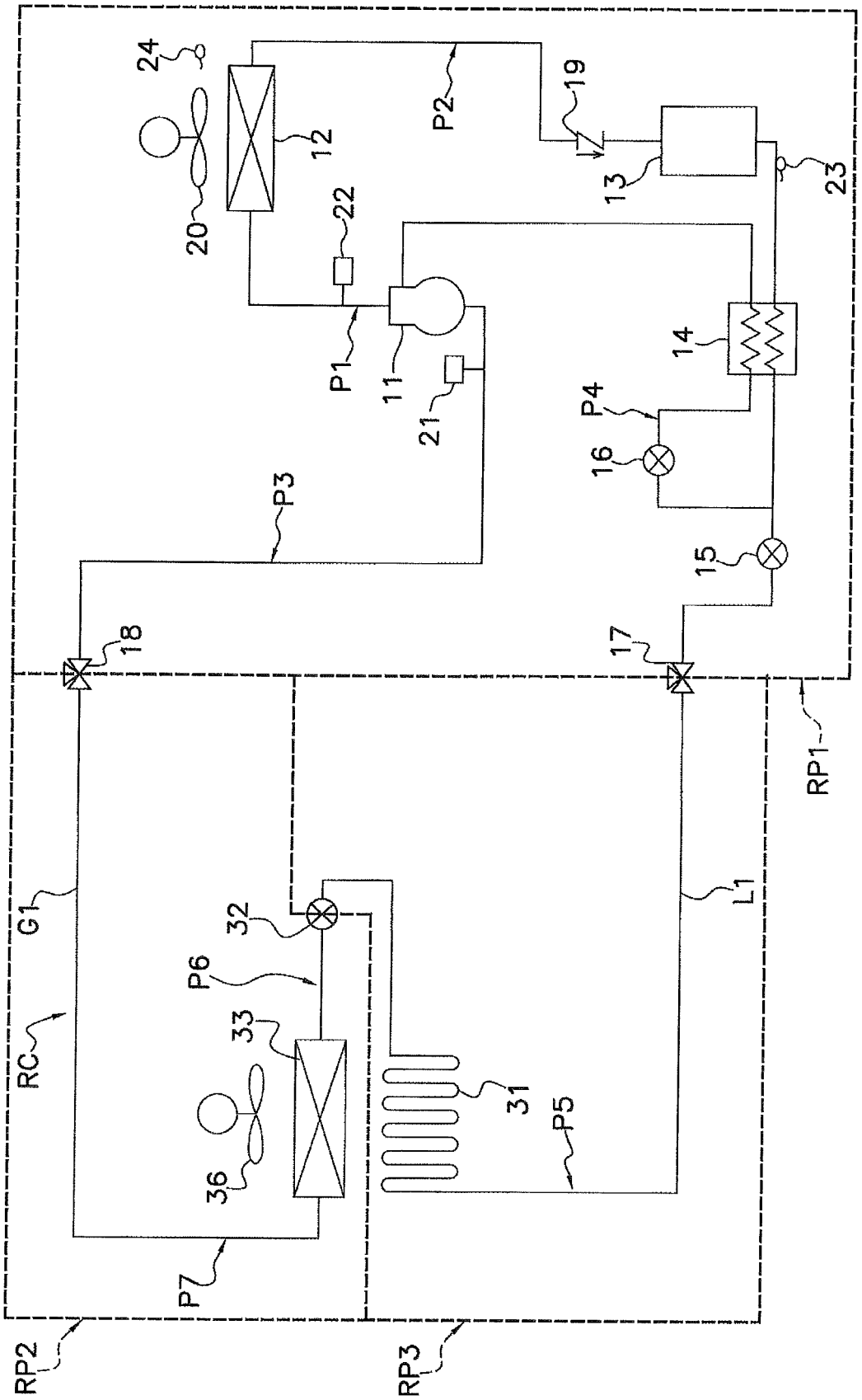

24
20
12
P2
19
13
23
22
P1
11
21
14
P4
16
P3
15
18
17
RP1
G1
32
P6
33
RC
31
P5
36
L1
P7
RP2
RP3

FIG. 2

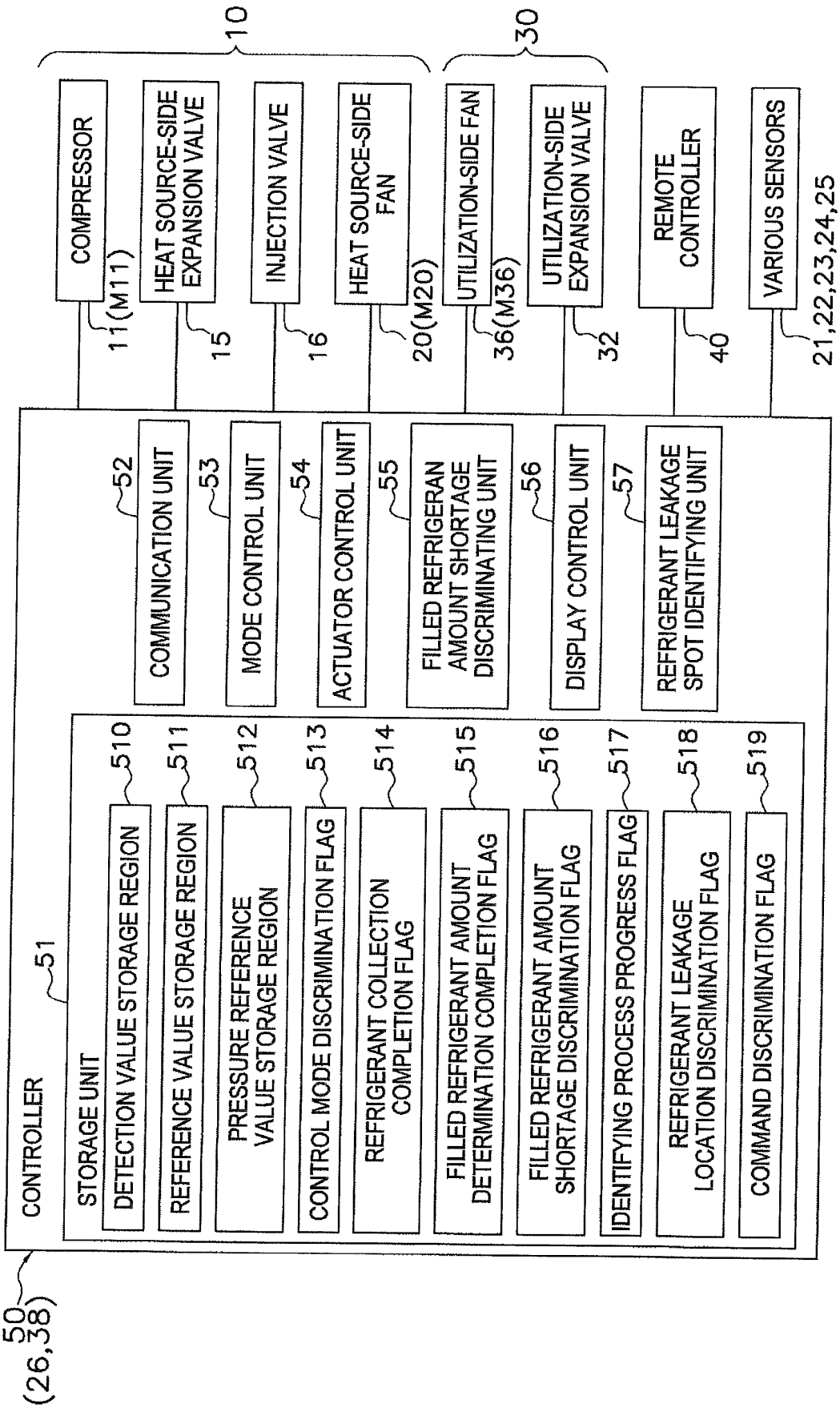

10
30
COMPRESSOR
11(M11)
HEAT SOURCE-SIDE EXPANSION VALVE
15
INJECTION VALVE
16
HEAT SOURCE-SIDE FAN
20(M20)
UTILIZATION-SIDE FAN
36(M36)
UTILIZATION-SIDE EXPANSION VALVE
32
REMOTE CONTROLLER
40
VARIOUS SENSORS
21,22,23,24,25
50
(26,38)
CONTROLLER
51
STORAGE UNIT
DETECTION VALUE STORAGE REGION
510
REFERENCE VALUE STORAGE REGION
511
PRESSURE REFERENCE VALUE STORAGE REGION
512
CONTROL MODE DISCRIMINATION FLAG
513
REFRIGERANT COLLECTION COMPLETION FLAG
514
FILLED REFRIGERANT AMOUNT DETERMINATION COMPLETION FLAG
515
FILLED REFRIGERANT AMOUNT SHORTAGE DISCRIMINATION FLAG
516
IDENTIFYING PROCESS PROGRESS FLAG
517
REFRIGERANT LEAKAGE LOCATION DISCRIMINATION FLAG
518
COMMAND DISCRIMINATION FLAG
519
52
COMMUNICATION UNIT
53
MODE CONTROL UNIT
54
ACTUATOR CONTROL UNIT
55
FILLED REFRIGERAN AMOUNT SHORTAGE DISCRIMINATING UNIT
56
DISPLAY CONTROL UNIT
57
REFRIGERANT LEAKAGE SPOT IDENTIFYING UNIT

FIG. 3

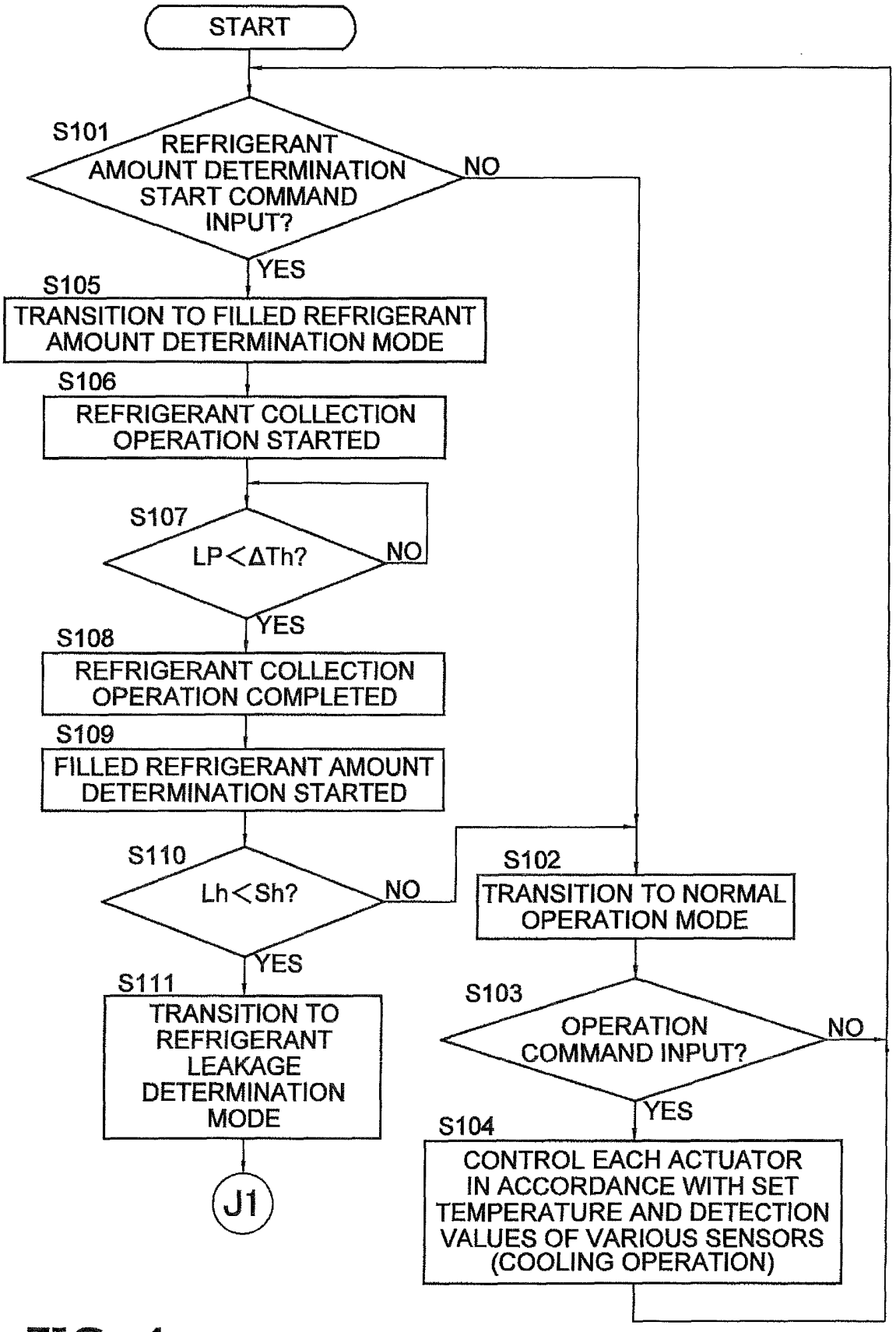
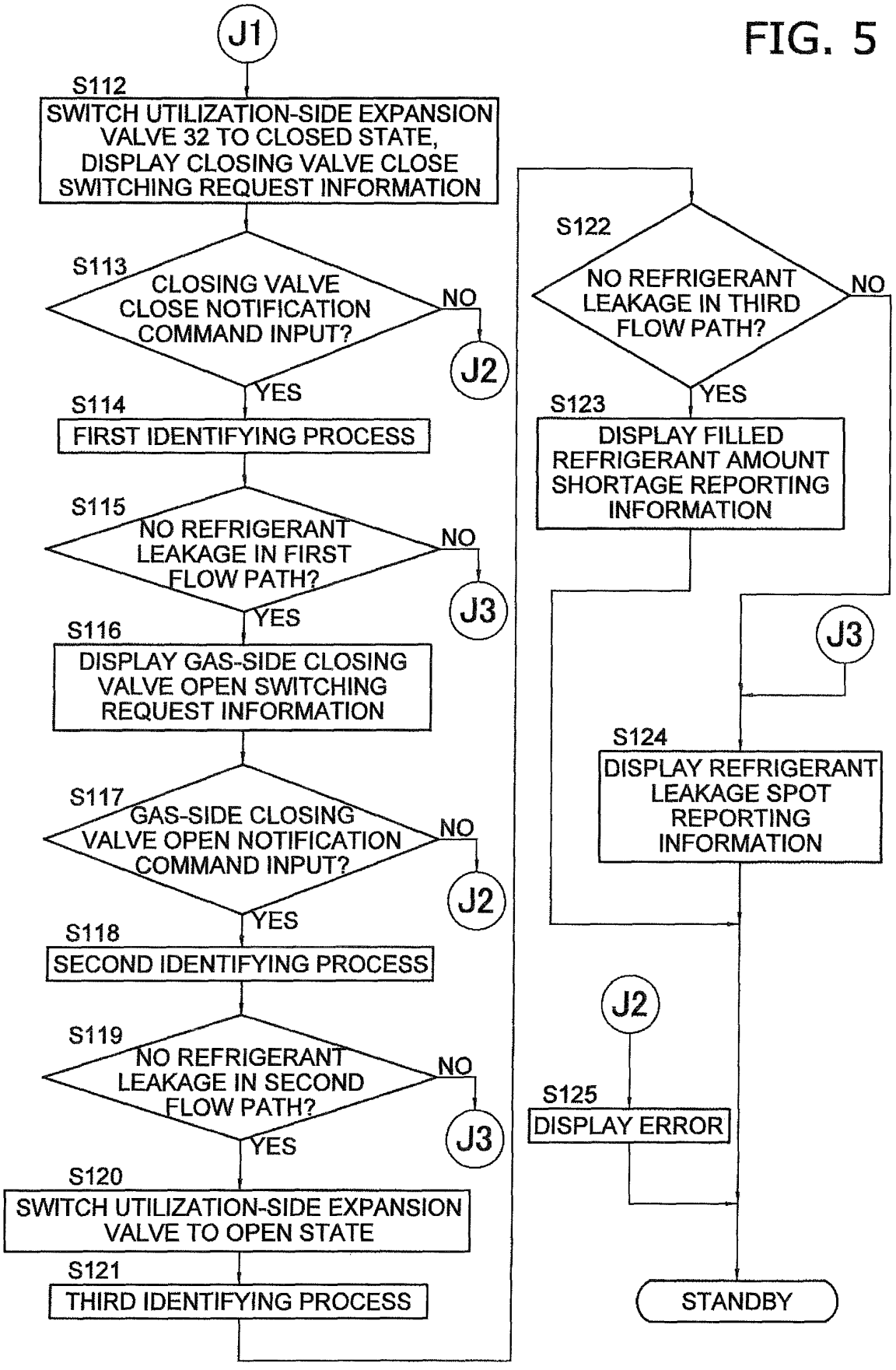

START
S101
REFRIGERANT AMOUNT DETERMINATION START COMMAND INPUT?
NO
YES
S105
TRANSITION TO FILLED REFRIGERANT AMOUNT DETERMINATION MODE
S106
REFRIGERANT COLLECTION OPERATION STARTED
S107
LP<ΔTh?
NO
YES
S108
REFRIGERANT COLLECTION OPERATION COMPLETED
S109
FILLED REFRIGERANT AMOUNT DETERMINATION STARTED
S110
Lh<Sh?
NO
YES
S111
TRANSITION TO REFRIGERANT LEAKAGE DETERMINATION MODE
J1
S102
TRANSITION TO NORMAL OPERATION MODE
S103
OPERATION COMMAND INPUT?
NO
YES
S104
CONTROL EACH ACTUATOR IN ACCORDANCE WITH SET TEMPERATURE AND DETECTION VALUES OF VARIOUS SENSORS (COOLING OPERATION)

FIG. 4

FIG. 5


J1
S112
SWITCH UTILIZATION-SIDE EXPANSION VALVE 32 TO CLOSED STATE, DISPLAY CLOSING VALVE CLOSE SWITCHING REQUEST INFORMATION
S113
CLOSING VALVE CLOSE NOTIFICATION COMMAND INPUT?
NO
J2
YES
S114
FIRST IDENTIFYING PROCESS
S115
NO REFRIGERANT LEAKAGE IN FIRST FLOW PATH?
NO
J3
YES
S116
DISPLAY GAS-SIDE CLOSING VALVE OPEN SWITCHING REQUEST INFORMATION
S117
GAS-SIDE CLOSING VALVE OPEN NOTIFICATION COMMAND INPUT?
NO
J2
YES
S118
SECOND IDENTIFYING PROCESS
S119
NO REFRIGERANT LEAKAGE IN SECOND FLOW PATH?
NO
J3
YES
S120
SWITCH UTILIZATION-SIDE EXPANSION VALVE TO OPEN STATE
S121
THIRD IDENTIFYING PROCESS
S122
NO REFRIGERANT LEAKAGE IN THIRD FLOW PATH?
NO
YES
S123
DISPLAY FILLED REFRIGERANT AMOUNT SHORTAGE REPORTING INFORMATION
J3
S124
DISPLAY REFRIGERANT LEAKAGE SPOT REPORTING INFORMATION
J2
S125
DISPLAY ERROR
STANDBY

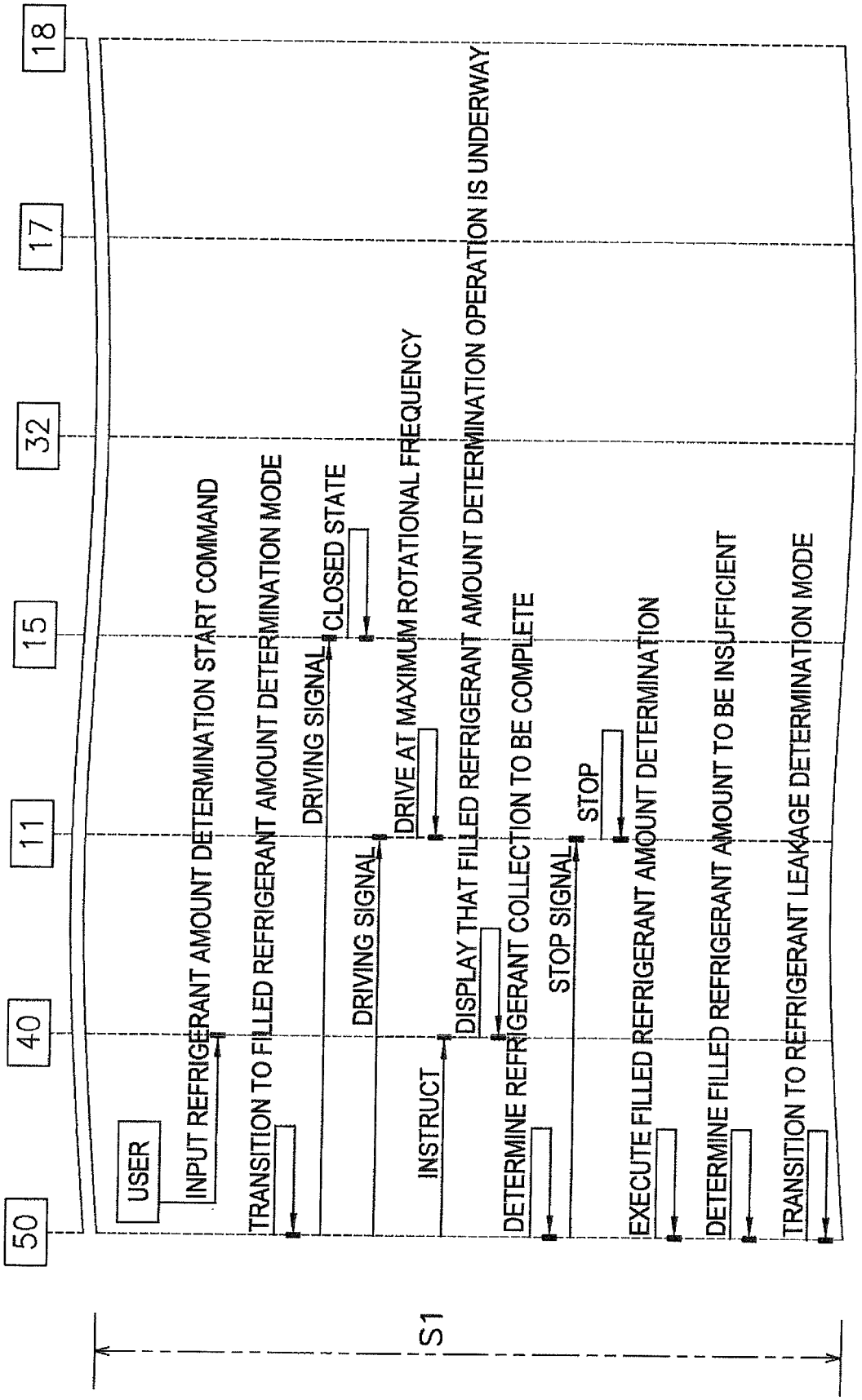

50
40
11
15
32
17
18
USER
INPUT REFRIGERANT AMOUNT DETERMINATION START COMMAND
TRANSITION TO FILLED REFRIGERANT AMOUNT DETERMINATION MODE
DRIVING SIGNAL
CLOSED STATE
DRIVING SIGNAL
DRIVE AT MAXIMUM ROTATIONAL FREQUENCY
INSTRUCT
DISPLAY THAT FILLED REFRIGERANT AMOUNT DETERMINATION OPERATION IS UNDERWAY
DETERMINE REFRIGERANT COLLECTION TO BE COMPLETE
STOP SIGNAL
STOP
EXECUTE FILLED REFRIGERANT AMOUNT DETERMINATION
DETERMINE FILLED REFRIGERANT AMOUNT TO BE INSUFFICIENT
TRANSITION TO REFRIGERANT LEAKAGE DETERMINATION MODE
S1

FIG. 6

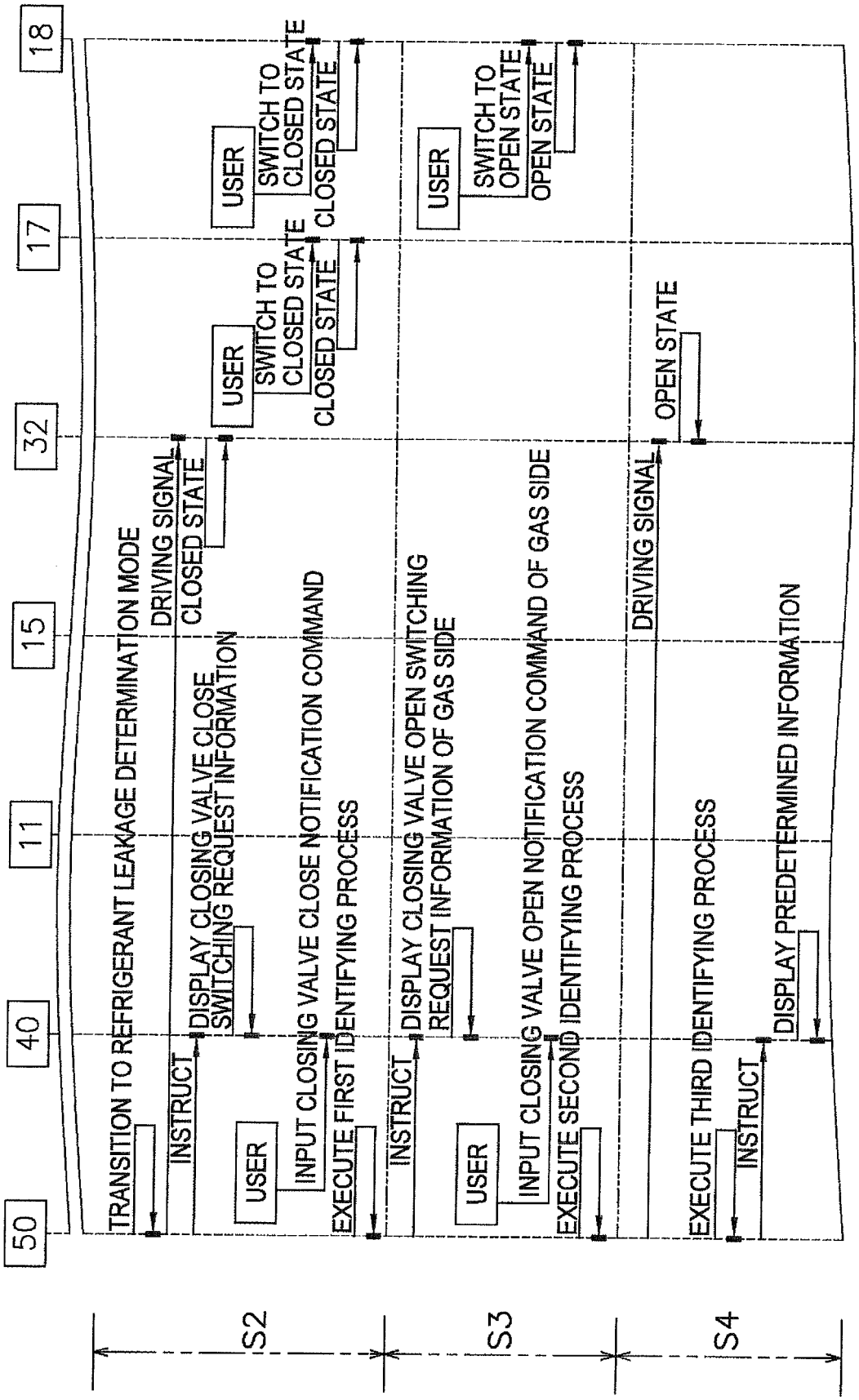

50
40
11
15
32
17
18
TRANSITION TO REFRIGERANT LEAKAGE DETERMINATION MODE
DRIVING SIGNAL
CLOSED STATE
INSTRUCT
DISPLAY CLOSING VALVE CLOSE SWITCHING REQUEST INFORMATION
USER
INPUT CLOSING VALVE CLOSE NOTIFICATION COMMAND
EXECUTE FIRST IDENTIFYING PROCESS
USER
SWITCH TO CLOSED STATE
CLOSED STATE
INSTRUCT
DISPLAY CLOSING VALVE OPEN SWITCHING REQUEST INFORMATION OF GAS SIDE
USER
INPUT CLOSING VALVE OPEN NOTIFICATION COMMAND OF GAS SIDE
EXECUTE SECOND IDENTIFYING PROCESS
USER
SWITCH TO CLOSED STATE
CLOSED STATE
USER
SWITCH TO OPEN STATE
OPEN STATE
DRIVING SIGNAL
OPEN STATE
EXECUTE THIRD IDENTIFYING PROCESS
INSTRUCT
DISPLAY PREDETERMINED INFORMATION
S2
S3
S4

FIG. 7

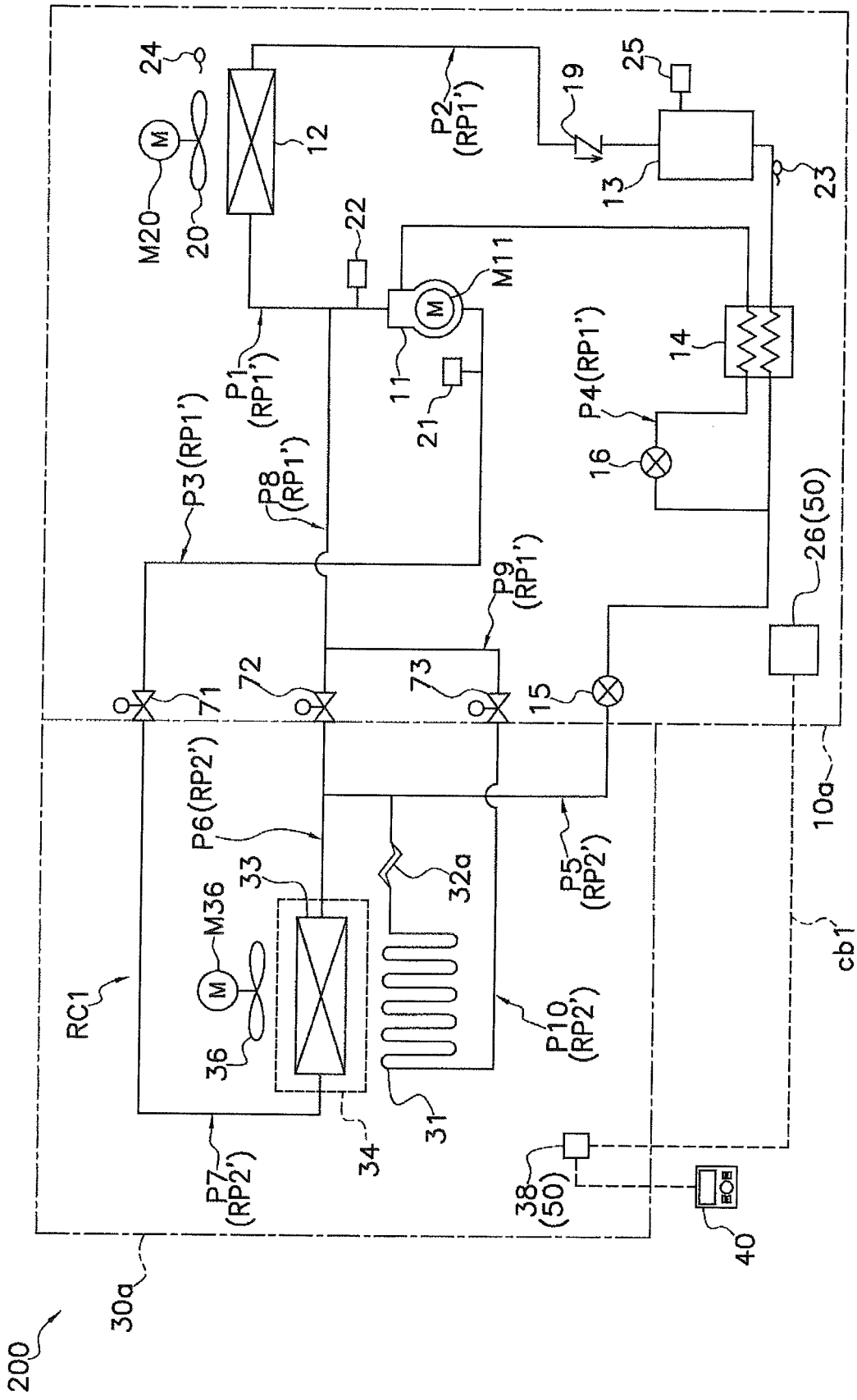

200
30a
RC1
M36
36
33
34
31
32a
P7 (RP2')
P6 (RP2')
P10 (RP2')
P5 (RP2')
38 (50)
40
10a
cb1
71
72
73
15
P3 (RP1')
P8 (RP1')
P9 (RP1')
P1 (RP1')
P2 (RP1')
P4 (RP1')
26(50)
16
14
11
21
22
M11
M20
20
24
12
19
25
13
23

FIG. 8

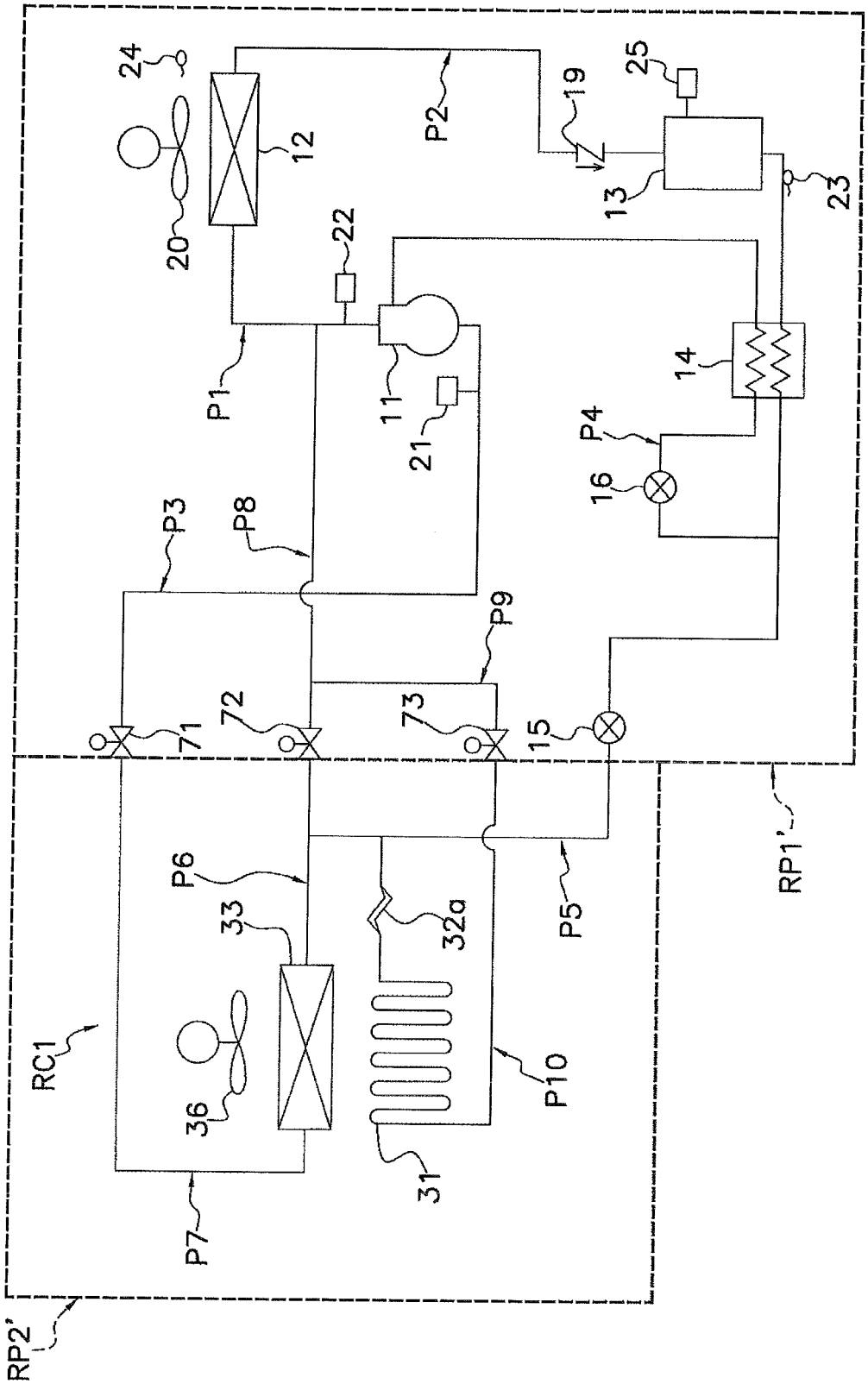

24
20
12
P2
19
25
13
23
22
P1
11
21
14
P4
16
P3
P8
P9
71
72
73
15
RP1'
P6
33
32a
P5
RC1
36
P10
31
P7
RP2'

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/078489

A. CLASSIFICATION OF SUBJECT MATTER
F25B49/02(2006.01)i, *F24F11/02*(2006.01)i, *F25B45/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B45/00, F25B49/02, F24F11/02, G01M3/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2005-241050 A (Mitsubishi Electric Building Techno-Service Co., Ltd.), 08 September 2005 (08.09.2005), paragraphs [0006] to [0008], [0013], [0016] to [0028] (Family: none)	1,4-5 4-5 2-3
X Y A	JP 5306449 B2 (Mitsubishi Electric Corp.), 02 October 2013 (02.10.2013), paragraphs [0011], [0070], [0093] to [0103], [0110] to [0116]; fig. 5, 9 & US 2011/0302941 A1 paragraphs [0013], [0094], [0123] to [0151]; fig. 5, 9 & WO 2010/109617 A1 & EP 2413056 A1 & CN 102365502 A	1,4 4-5 2-3

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2016 (14.12.16)	27 December 2016 (27.12.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/078489

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2014-95514 A (Panasonic Corp.), 22 May 2014 (22.05.2014), paragraphs [0041] to [0048] (Family: none)	4
A	JP 5-118720 A (Hitachi, Ltd.), 14 May 1993 (14.05.1993), paragraphs [0015], [0018]; fig. 1, 3 (Family: none)	1-5
A	JP 2013-53756 A (Fujitsu General Ltd.), 21 March 2013 (21.03.2013), entire text; all drawings (Family: none)	1-5
A	JP 2013-108856 A (Mitsubishi Electric Corp.), 06 June 2013 (06.06.2013), entire text; all drawings (Family: none)	1-5
A	JP 2011-226704 A (Mitsubishi Electric Corp.), 10 November 2011 (10.11.2011), entire text; all drawings (Family: none)	1-5
A	JP 2013-40730 A (Mitsubishi Electric Corp.), 28 February 2013 (28.02.2013), entire text; all drawings & EP 2559959 A2 & CN 102954614 A	1-5

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2014095514 A **[0003] [0222]**
- JP 2011226704 A **[0004] [0222]**
- JP 2013040730 A **[0005] [0222]**