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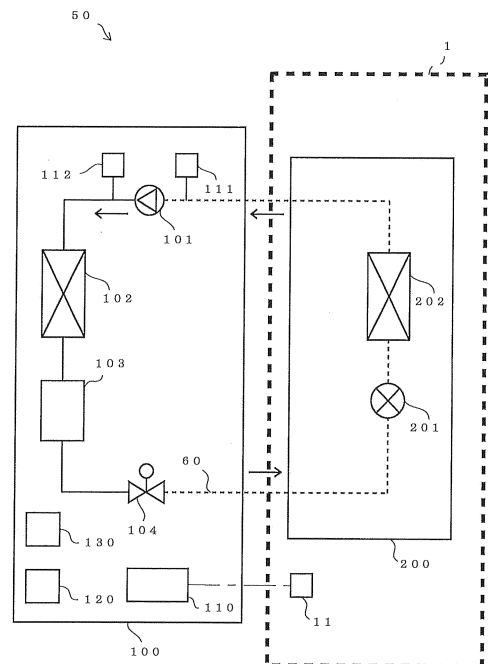
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(54) **REFRIGERATION DEVICE**

(57) A refrigeration apparatus 50 includes: a refrigerant circuit 60 including a compressor 101 configured to compress refrigerant, a condenser 102 configured to condense the refrigerant compressed by the compressor 101, a refrigerant tank 103 configured to store the refrigerant condensed by the condenser 102, and a valve device 104 configured to control passing of the refrigerant flowing out of the refrigerant tank 103; a refrigerant leakage detecting unit 11 configured to detect the refrigerant leaking from the refrigerant circuit 60; and a controller 110 configured to obtain a detection result from the refrigerant leakage detecting unit 11 and, when it is determined that the refrigerant is leaking, to bring the valve device 104 into a closed state to retain, in the refrigerant tank 103, the refrigerant, the refrigerant being compressed by the compressor 101 and condensed by the condenser 102.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a refrigeration apparatus configured to, when refrigerant leaks, retain the refrigerant in a refrigerant tank.

Background Art

[0002] A conventional air-conditioning apparatus is configured to stop the compressor from operating when refrigerant leaks (see Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 10-281569

Summary of Invention

Technical Problem

[0004] However, according to the conventional technique described in Patent Literature 1, because the operation of the compressor is simply stopped when the refrigerant leaks, the refrigerant keeps leaking from the location of leakage.

[0005] In view of the circumstances described above, it is an object of the present invention to provide a refrigeration apparatus capable of reducing the amount of leakage of the refrigerant by having the refrigerant retained in a refrigerant tank, when the refrigerant leaks.

Solution to Problem

[0006] A refrigeration apparatus according to an embodiment of the present invention includes: a refrigerant circuit including a compressor configured to compress refrigerant, a condenser configured to condense the refrigerant compressed by the compressor, a refrigerant tank configured to store the refrigerant condensed by the condenser, and a valve device configured to control passing of the refrigerant flowing out of the refrigerant tank; a refrigerant leakage detecting unit configured to detect the refrigerant leaking from the refrigerant circuit; and a controller configured to obtain a detection result from the refrigerant leakage detecting unit and, when determining that the refrigerant is leaking, to bring the valve device into a closed state to retain, in the refrigerant tank, the refrigerant being compressed by the compressor and condensed by the condenser.

Advantageous Effects of Invention

[0007] By using the refrigeration apparatus according

to the one embodiment of the present invention, it is possible to reduce the amount of leakage of the refrigerant by having the refrigerant retained in the refrigerant tank, when the refrigerant leaks.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a diagram schematically illustrating an example of a configuration of a refrigeration apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a chart for explaining an example of an operation of a heat source side unit illustrated in Fig. 1.

[Fig. 3] Fig. 3 is a chart for explaining Modification Example 1 of the present invention obtained by modifying the example in Fig. 2.

[Fig. 4] Fig. 4 is a chart for explaining Modification Example 2 of the present invention obtained by modifying the example in Fig. 3.

[Fig. 5] Fig. 5 is a diagram schematically illustrating an example of a configuration of a refrigeration apparatus according to Embodiment 2 of the present invention.

[Fig. 6] Fig. 6 is a diagram for explaining Modification Example 3 of the present invention obtained by modifying the example in Fig. 5.

Description of Embodiments

[0009] Embodiments of the present invention will be described hereinafter with reference to the drawings. In the drawings, some of the elements that are the same as or correspond to each other will be referred to by using the same reference characters, and the explanations thereof will be either omitted or simplified as appropriate. Further, with respect to the constituent elements illustrated in the drawings, it is possible to change the shapes, the sizes, the positional arrangements, and other properties thereof as appropriate, within the scope of the present invention.

<A refrigeration apparatus>

Embodiment 1.

[0010] Fig. 1 is a diagram schematically illustrating an example of a configuration of a refrigeration apparatus according to Embodiment 1 of the present invention. A refrigeration apparatus 50 according to the present embodiment is, for example, configured to cool the contents such as food and/or other items stored indoors on the inside of a chamber 1. The refrigeration apparatus 50 includes a refrigerant leakage detecting unit 11 provided on the inside of the chamber 1. The refrigerant leakage detecting unit 11 may be, for example, a refrigerant leak-

age detecting device configured to detect refrigerant leaking from a refrigerant circuit 60. The refrigeration apparatus 50 according to the present embodiment is configured to reduce the amount of leakage of the refrigerant by having the refrigerant retained in a refrigerant tank 103, when the refrigerant leaks.

[0011] The refrigeration apparatus 50 includes the refrigerant circuit 60 in which the refrigerant circulates. In Fig. 1, the part of the refrigerant circuit 60 indicated with the dotted line corresponds to refrigerant pipes between the suction side of the compressor 101 and the valve device 104. The part of the refrigerant circuit 60 indicated with the solid line corresponds to refrigerant pipes between the discharge side of the compressor 101 and the valve device 104. The refrigerant used in the present embodiment may be, for example, refrigerant having a small Global Warming Potential (GWP) value such as R410A, R32, or CO₂. Alternatively, the refrigerant may be refrigerant mixture containing at least one selected from among those or may be another type of refrigerant different from any of those. The refrigerant circuit 60 is structured by connecting together, with refrigerant pipes, at least the compressor 101, a condenser 102, a refrigerant tank 103, the valve device 104, a pressure reducing device 201, and an evaporator 202. The refrigerant circuit 60 may further include, for example, an oil separator or a gas-liquid separator for the purpose of protecting the compressor 101, a heat exchanger for the purpose of adjusting the degree of subcooling, and other elements. The refrigeration apparatus 50 according to the present embodiment includes a heat source side unit 100 and a load side unit 200 connected to each other with refrigerant pipes.

<The heat source side unit>

[0012] The heat source side unit 100 is provided outdoors on the outside of the chamber 1. The heat source side unit 100 includes the compressor 101, the condenser 102, the refrigerant tank 103, the valve device 104, a controller 110, a storage unit 120, an alarm device 130, a suction side pressure sensor 111, and a discharge side pressure sensor 112. The compressor 101 may be, for example, an inverter compressor controlled by using an inverter. By arbitrarily changing the operation frequency of the compressor 101, it is possible to change the capacity thereof (the volume of refrigerant output by the compressor 101 per unit time period). The compressor 101 may be a constant speed compressor configured to operate at a constant operation frequency. Also, although Fig. 1 illustrates the one compressor 101, two or more compressors 101 may be provided.

[0013] The condenser 102 is configured, for example, to condense the refrigerant, by exchanging heat between the refrigerant flowing through the condenser 102 and air. For example, a fan (not illustrated) configured to introduce the air to the condenser 102 is installed in the vicinity of the condenser 102. The refrigerant tank 103 is

a container configured to store the refrigerant condensed by the condenser 102. The refrigerant tank 103 also has a function of storing refrigerant and causing liquid refrigerant to flow out. The valve device 104 is configured to control passing of the refrigerant flowing out of the refrigerant tank 103 by opening and closing. For example, the valve device 104 may be structured by using a solenoid valve or other elements.

[0014] The controller 110 is configured to control the entirety of the heat source side unit 100. The controller 110 is structured to include an analog circuit, a digital circuit, a CPU, or a set made up of at least two selected from among these. For example, by using a detection result obtained by the refrigerant leakage detecting unit 11 provided on the inside of the chamber 1, the controller 110 controls the heat source side unit 100. Alternatively, the controller 110 may be configured to control the entirety of the refrigeration apparatus 50. The storage unit 120 is structured to include a non-volatile memory, for example. The storage unit 120 stores data, a program, and other information used for controlling the heat source side unit 100. The alarm device 130 is configured to issue an alarm in response to an instruction received from the controller 110. The alarm device 130 is structured to include, for example, a lamp configured to issue an alarm with light, a buzzer configured to issue an alarm with sound, or other devices.

[0015] The suction side pressure sensor 111 is provided between the suction side of the compressor 101 and the evaporator 202 and is configured to detect the pressure of the refrigerant sucked by the compressor 101. The discharge side pressure sensor 112 is provided between the discharge side of the compressor 101 and the condenser 102 and is configured to detect the pressure of the refrigerant discharged from the compressor 101.

<The load side unit>

[0016] The load side unit 200 is provided indoors on the inside of the chamber 1 and includes the pressure reducing device 201 and the evaporator 202. The pressure reducing device 201 is configured to reduce the pressure of the refrigerant flowing to the pressure reducing device 201. For example, the pressure reducing device 201 may be an electronic expansion valve of which the opening degree is adjustable or may be a capillary tube or other devices. The evaporator 202 is configured, for example, to evaporate the refrigerant by exchanging heat between the refrigerant flowing to the evaporator 202 and air. For example, a fan (not illustrated) configured to introduce the air to the evaporator 202 is installed in the vicinity of the evaporator 202.

<A normal operation of the refrigeration apparatus>

[0017] Next, a normal operation of the refrigeration apparatus 50 will be explained. For example, the refrigeration apparatus 50 is configured to cool the inside of the

chamber 1 by performing a normal operation when the refrigeration apparatus 50 is not in an abnormal state, while the inside of the chamber 1 is not sufficiently cooled. The determination of whether the refrigeration apparatus 50 is in an abnormal state or not is made, for example, by using a detection result obtained by the refrigerant leakage detecting unit 11, as well as either temperatures or pressure levels in various locations within the refrigerant circuit 60, and/or other factors. During the normal operation of the refrigeration apparatus 50, the valve device 104 is in an open state.

[0018] The refrigerant compressed by the compressor 101 included in the heat source side unit 100 flows into the condenser 102. The refrigerant is condensed by the condenser 102, as a result of the heat exchange process with the air. The refrigerant condensed by the condenser 102 flows into the refrigerant tank 103. The refrigerant flowing out of the refrigerant tank 103 passes through the valve device 104, and the pressure thereof is reduced by the pressure reducing device 201 included in the load side unit 200. The refrigerant of which the pressure has been reduced by the pressure reducing device 201 is evaporated by the evaporator 202 as a result of the heat exchange process with the air. The refrigerant evaporated by the evaporator 202 is sucked into the compressor 101 included in the heat source side unit 100 and is compressed again. During the normal operation of the refrigeration apparatus 50, the controller 110 adjusts the temperature on the inside of the chamber 1, by controlling the compressor 101 and other elements, with the use of detection results obtained from, for example, the suction side pressure sensor 111, the discharge side pressure sensor 112, a temperature sensor (not illustrated), a pressure sensor (not illustrated), and/or other elements.

<An operation of the heat source side unit>

[0019] Next, an example of an operation of the heat source side unit 100 according to the present embodiment will be explained. Fig. 2 is a chart for explaining the example of the operation of the heat source side unit illustrated in Fig. 1. At step S02 in Fig. 2, the refrigeration apparatus 50 is performing the normal operation. At step S04, the controller 110 illustrated in Fig. 1 obtains a detection result from the refrigerant leakage detecting unit 11 and determines whether or not the refrigerant is leaking.

[0020] At step S04 in Fig. 2, when it is determined that the refrigerant is not leaking, the process proceeds to step S06. At step S06, the controller 110 illustrated in Fig. 1 brings the valve device 104 into an open state and sets a low pressure threshold pressure value of the compressor 101 to a first low pressure threshold pressure value A (MPa), and the process returns to step S04. The low pressure threshold pressure value is a value related to a suction pressure value P1 on the suction side of the compressor 101. When the suction pressure value P1 on the suction side of the compressor 101 becomes equal

to or smaller than the low pressure threshold pressure value, the controller 110 stops the compressor 101. The first low pressure threshold pressure value A (MPa) is a low pressure threshold pressure value for when the refrigerant is not leaking and is stored in the storage unit 120 in advance. When the operation is performed in the order of step S02, step S04, and step S06, the open state of the valve device 104 is maintained at step S06, while the low pressure threshold pressure value of the compressor 101 is kept at the first low pressure threshold pressure value A (MPa).

[0021] At step S04 in Fig. 2, when it is determined that the refrigerant is leaking, the process proceeds to step S08. At step S08, the controller 110 illustrated in Fig. 1 switches the valve device 104 into a closed state and changes the low pressure threshold pressure value of the compressor 101 to a second low pressure threshold pressure value B (MPa). As illustrated in Fig. 1, when the valve device 104 has been switched into the closed state, the refrigerant circuit 60 is divided into a section positioned on the suction side of the compressor 101 and another section positioned on the discharge side of the compressor 101. Accordingly, the refrigerant positioned in the section from the valve device 104 to the suction side of the compressor 101 moves to the section from the discharge side of the compressor 101 to the valve device 104. In other words, the refrigerant in the section from the valve device 104 to the suction side of the compressor 101 is sucked into the compressor 101 and compressed. The refrigerant compressed by the compressor 101 is condensed by the condenser 102 and is retained in the refrigerant tank 103. Further, when it is determined that the refrigerant is leaking, the low pressure threshold pressure value of the compressor 101 is set to the second low pressure threshold pressure value B (MPa) that is smaller than the first low pressure threshold pressure value A to which the low pressure threshold pressure value is set when it is determined that the refrigerant is not leaking. Consequently, even when the amount of the refrigerant positioned on the suction side of the compressor 101 becomes smaller and the pressure on the suction side of the compressor 101 becomes lower, the compressor 101 keeps operating. It is therefore possible to decrease the amount of refrigerant remaining on the suction side of the compressor 101 and to increase the amount of refrigerant retained on the discharge side of the compressor 101. In this situation, the second low pressure threshold pressure value B (MPa) is a value set in advance and is stored in the storage unit 120 in advance. The second low pressure threshold pressure value B (MPa) may be, for example, equal to or larger than 0 (MPa) in gauge pressure. In this example in the present embodiment, the second low pressure threshold pressure value B (MPa) is set to 0.01 (MPa) in gauge pressure. Because the second low pressure threshold pressure value B (MPa) is equal to or larger than 0 (MPa) in gauge pressure, the possibility of having air entering the inside of the refrigerant circuit 60 through the refrigerant

leakage location of the refrigerant circuit 60 is reduced. When the procedure at step S08 in Fig. 2 has been performed, the process returns to step S04. When the process returns from step S08 to step S04, and it is determined at step S04 that the refrigerant is not leaking, the process proceeds to step S06. The controller 110 switches the valve device 104 into an open state and changes the low pressure threshold pressure value of the compressor 101 to the first low pressure threshold pressure value A (MPa). The process then returns to step S04. When the process returns from step S08 to step S04 and it is determined that the refrigerant is leaking at step S04, the process proceeds to step S08.

[0022] The controller 110 illustrated in Fig. 1 obtains a detection result from the suction side pressure sensor 111. Preferably, the controller 110 is configured to stop the operation of the compressor 101, when the suction pressure value P1 on the suction side of the compressor 101 becomes equal to or smaller than the second low pressure threshold pressure value B (MPa). The reasons is that, when the suction pressure value P1 on the suction side of the compressor 101 becomes equal to or smaller than the second low pressure threshold pressure value B (MPa), it is assumed that the refrigerant positioned on the suction side of the compressor 101 in the refrigerant circuit 60 has been retained in the discharge side of the compressor 101. Also, if the compressor 101 was kept operating after the suction pressure value P1 on the suction side of the compressor 101 becomes equal to or smaller than the second low pressure threshold pressure value B (MPa), air might enter the inside of the refrigerant circuit 60 through the refrigerant leakage location of the refrigerant circuit 60. For this reason, when the suction pressure value P1 on the suction side of the compressor 101 becomes equal to or smaller than the second low pressure threshold pressure value B (MPa) and the operation of the compressor 101 is stopped, the controller 110 does not allow the heat source side unit 100 to perform the normal operation until an instruction indicating that the abnormality of the refrigeration apparatus 50 is resolved is received from the user.

[0023] As explained above, the refrigeration apparatus 50 according to the present embodiment includes: the refrigerant circuit 60 including the compressor 101 configured to compress the refrigerant, the condenser 102 configured to condense the refrigerant compressed by the compressor 101, the refrigerant tank 103 configured to store the refrigerant condensed by the condenser 102, and the valve device 104 configured to control the passing of the refrigerant flowing out of the refrigerant tank 103; the refrigerant leakage detecting unit 11 configured to detect the refrigerant leaking from the refrigerant circuit 60, and the controller 110 configured to obtain the detection result from the refrigerant leakage detecting unit 11 and, when it is determined that the refrigerant is leaking, to bring the valve device 104 into the closed state to retain, in the refrigerant tank 103, the refrigerant, the refrigerant being compressed by the compressor 101 and

condensed by the condenser 102. By using the refrigeration apparatus 50 according to the present embodiment, it is possible to lower the possibility of having the refrigerant keep leaking through the leakage location, because the refrigerant is retained in the refrigerant tank 103 when the refrigerant leaks.

[0024] Further, in the present embodiment, when the suction pressure value P1 on the suction side of the compressor 101 becomes equal to or smaller than the low pressure threshold pressure value that is determined in advance, the control to stop the operation of the compressor 101 is performed. The controller 110 controls the compressor 101 by, when determining that the refrigerant is leaking, setting the low pressure threshold pressure value to the second low pressure threshold pressure value B that is smaller than the first low pressure threshold pressure value A set when determining that the refrigerant is not leaking. Accordingly, in the present embodiment, the compressor 101 keeps operating, even when the amount of the refrigerant positioned on the suction side of the compressor 101 becomes smaller and the pressure on the suction side of the compressor 101 becomes lower. It is therefore possible to decrease the amount of refrigerant remaining on the suction side of the compressor 101 in the refrigerant circuit 60 and to increase the amount of refrigerant retained on the discharge side of the compressor 101 in the refrigerant circuit 60.

[0025] Further, in the present embodiment, the second low pressure threshold pressure value B serving as the low pressure threshold pressure value for when it is determined that the refrigerant is leaking is arranged to be equal to or larger than 0 (MPa) in gauge pressure. Consequently, the possibility of having air entering the inside of the refrigerant circuit 60 is reduced.

[0026] Further, in the present embodiment, the refrigerant circuit 60 includes the evaporator 202 provided on the inside of the chamber 1 and configured to evaporate the refrigerant, while the refrigerant leakage detecting unit 11 is installed inside the chamber 1. Consequently, according to the present embodiment, the possibility of having the interior of the chamber 1 filled with the refrigerant is reduced.

[0027] Further, the refrigeration apparatus 50 according to the present embodiment includes the heat source side unit 100 structured to include the compressor 101 and the controller 110. In the present embodiment, because the heat source side unit 100 takes measures against the leakage of the refrigerant, the measures against refrigerant leakage are taken, regardless of the specification of the load side unit 200 and other factors.

[0028] In general, a heat source side unit and a load side unit constituting a refrigeration apparatus often have mutually-different manufacturers and mutually-different specifications. Further, it is often the case that a heat source side unit and a load side unit having mutually-different manufacturers and having mutually-different specifications are controlled independently of each other.

In those situations, measures taken against refrigerant leakage are insufficient.

[0029] In contrast to such a generally-used refrigeration apparatus as described above, the refrigeration apparatus 50 according to the present embodiment is configured so that the heat source side unit 100 takes the measures against refrigerant leakage occurring on the inside of the chamber 1 where the load side unit 200 is provided. Accordingly, the measures taken against refrigerant leakage are improved. In a preferred embodiment, the heat source side unit 100 is installed outside the chamber 1, so that the heat source side unit 100 installed on the outside of the chamber 1 takes measures against refrigerant leakage occurring on the inside of the chamber 1. As a result, the measures taken by the refrigeration apparatus 50 against refrigerant leakage are improved.

[0030] Further, in the present embodiment, because the refrigerant tank 103 and the valve device 104 are installed outdoors, when the refrigerant leaks, the refrigerant is retained in the section of the refrigerant circuit 60 positioned outdoors. As a result, according to the present embodiment, the possibility of having the interior of the chamber 1 filled with the refrigerant is reduced. In a preferred embodiment, as illustrated in Fig. 1, the compressor 101, the condenser 102, the refrigerant tank 103, the valve device 104, and the refrigerant pipes connecting these elements together are provided outdoors. As illustrated in Fig. 1, because the part indicated with the solid line where the refrigerant is retained is provided outdoors, the possibility of having the interior of the chamber 1 filled with the refrigerant is reduced.

[0031] Because the refrigeration apparatus 50 according to the present embodiment is configured to cool the contents such as food and/or other items stored indoors on the inside of the chamber 1, abnormalities occurring on the inside of the chamber 1, in particular, are not easily noticed. According to the present embodiment, when the refrigerant leaks on the inside of the chamber 1, because the heat source side unit 100 takes the measures against the leakage of the refrigerant, the measures taken against refrigerant leakage are improved.

<Modification Example 1>

[0032] Fig. 3 is a chart for explaining Modification Example 1 of the present invention obtained by modifying the example in Fig. 2. In comparison to the example according to Embodiment 1 illustrated in Fig. 2, Modification Example 1 illustrated in Fig. 3 has steps S21 and S22 added thereto. Steps S02 through S08 in Modification Example 1 illustrated in Fig. 3 are the same as steps S02 through S08 in the example according to Embodiment 1 illustrated in Fig. 2. Accordingly, the explanations thereof will be either simplified or omitted.

[0033] At step S04 in Fig. 3, when it is determined that the refrigerant is leaking, the procedure at step S08 is performed, and the process proceeds to step S21. At

step S21, the controller 110 illustrated in Fig. 1 causes the alarm device 130 to issue an abnormality alarm. At step S22, the controller 110 determines whether or not the abnormality alarm has been reset. When the abnormality alarm has been reset, the process returns to step S04. The abnormality alarm is reset by a user who received the abnormality alarm or other parties. For example, the refrigeration apparatus 50 includes an alarm cancelling device such as a switch or other devices (not illustrated). When having confirmed that the refrigeration apparatus 50 has no abnormality, the user resets the abnormality alarm by operating the alarm cancelling device.

[0034] As explained above, according to Modification Example 1, the alarm device 130 configured to issue the alarm is provided. When the refrigerant leaks, the controller 110 causes the alarm device 130 to issue the alarm. Consequently, according to Modification Example 1, for example, the user who receives the alarm indicating that the refrigerant is leaking is able to check on the state of the refrigeration apparatus 50.

[0035] Further, in Modification Example 1, the refrigerant keeps being retained on the discharge side of the compressor 101 until the user resets the abnormality alarm. Also, even after the user resets the abnormality alarm, the refrigerant keeps being retained on the discharge side of the compressor 101 until the controller 110 determines that the refrigerant is no longer leaking. According to Modification Example 1, the refrigeration apparatus 50 is brought into normal operation when the abnormality alarm is reset, and also, the controller 110 determines that the refrigerant is no longer leaking. Consequently, the measures taken by the refrigeration apparatus 50 against refrigerant leakage are improved.

<Modification Example 2>

[0036] Fig. 4 is a chart for explaining Modification Example 2 of the present invention obtained by modifying the example in Fig. 3. In comparison to Modification Example 1 illustrated in Fig. 3, Modification Example 2 illustrated in Fig. 4 has step S31 added thereto. Steps S02 through S08, steps S21 and S22 in Modification Example 2 illustrated in Fig. 4 are the same as steps S02 through S08, steps S21 and S22 in Modification Example 1. Accordingly, the explanations thereof will be either simplified or omitted.

[0037] At step S31 in Fig. 4, the controller 110 illustrated in Fig. 1 determines whether or not the refrigerant leakage detecting unit 11 is connected. When the refrigerant leakage detecting unit 11 is connected, the process proceeds to step S02. In other words, Modification Example 2 is provided with an interlocking function where the refrigeration apparatus 50 is not allowed to operate when the refrigerant leakage detecting unit 11 is not connected. For example, an interlocking unit configured to realize the interlocking function is structured to include the controller 110 and the refrigerant leakage detecting

unit 11. When the controller 110 receives a signal from the refrigerant leakage detecting unit 11, the controller 110 determines that the refrigerant leakage detecting unit 11 is connected.

[0038] As explained above, in Modification Example 2, the refrigeration apparatus 50 is configured so as not to operate when the refrigerant leakage detecting unit 11 is not connected to the controller 110. Accordingly, the measures taken by the refrigeration apparatus 50 against the leakage of the refrigerant explained in the example in Embodiment 1 or Modification Example 1 are implemented reliably.

Embodiment 2.

[0039] Fig. 5 is a diagram schematically illustrating an example of a configuration of a refrigeration apparatus according to Embodiment 2 of the present invention. As illustrated in Fig. 5, a heat source side unit 100A of a refrigeration apparatus 50A according to the present embodiment includes a heat source unit 300 and an outdoor heat exchange unit 400 that are connected to each other with refrigerant pipes. The heat source unit 300 is provided indoors on the inside of a machine chamber 2, whereas the outdoor heat exchange unit 400 is provided outdoors on the outside of the chamber 1 and the machine chamber 2. The machine chamber 2 may be provided with a ventilation device (not illustrated). The refrigeration apparatus 50A includes a machine chamber refrigerant leakage detecting unit 12 provided on the inside of the machine chamber 2, in addition to the refrigerant leakage detecting unit 11 provided on the inside of the chamber 1. For example, the machine chamber refrigerant leakage detecting unit 12 may be a refrigerant leakage detecting device configured to detect refrigerant leaking from a refrigerant circuit 60A. The refrigeration apparatus 50A is configured to reduce the leakage amount of the refrigerant by having the refrigerant retained in a refrigerant tank 103A when the refrigerant is leaking on the inside of either the chamber 1 or the machine chamber 2. In the following sections, to make it easier to understand the present embodiment, explanations that are a duplicate of the explanations in Embodiment 1 will be omitted.

<The heat source unit>

[0040] The heat source unit 300 includes the compressor 101, a check valve 105, a liquid receptor 303, a controller 110A, a storage unit 120A, the alarm device 130, the suction side pressure sensor 111, and the discharge side pressure sensor 112. The check valve 105 is provided between the discharge side of the compressor 101 and the condenser 102 in the refrigerant circuit 60A. The check valve 105 is configured to prevent the refrigerant from flowing backward from the condenser 102 to the compressor 101. The liquid receptor 303 is configured to store the refrigerant and to cause liquid refrigerant to

flow out. The controller 110A is configured to control the entirety of the heat source side unit 100A. The controller 110A is structured to include an analog circuit, a digital circuit, a CPU, or a set made up of at least two selected from among these. For example, the controller 110A is configured to control the heat source side unit 100A, by using a detection result obtained by the refrigerant leakage detecting unit 11 and a detection result obtained by the machine chamber refrigerant leakage detecting unit 12. Alternatively, the controller 110A may be configured to control the entirety of the refrigeration apparatus 50A. The storage unit 120A is structured to include a non-volatile memory, for example. The storage unit 120A stores data, a program, and other information used for controlling the heat source side unit 100A. The alarm device 130 is configured to issue an alarm by receiving an instruction from the controller 110A. The alarm device 130 may be, for example, a lamp configured to issue an alarm with light, a buzzer configured to issue an alarm with sound, or other devices.

<The outdoor heat exchange unit>

[0041] The outdoor heat exchange unit 400 includes the condenser 102, the refrigerant tank 103A, and a valve device 104A. The refrigerant tank 103A is a container configured to store the refrigerant condensed by the condenser 102. When the refrigerant tank 103A also has a function of storing the refrigerant and causing liquid refrigerant to flow out, the liquid receptor 303 in the heat source unit 300 may be omitted. The valve device 104A is configured to control the passing of the refrigerant flowing out of the refrigerant tank 103A by opening and closing. For example, the valve device 104A may be structured by using a solenoid valve or other elements.

[0042] The refrigerant circuit 60A is structured by connecting together, with refrigerant pipes, the heat source side unit 100A and the load side unit 200. The refrigerant circuit 60A is structured by connecting together, with refrigerant pipes, at least the compressor 101, the check valve 105, the condenser 102, the refrigerant tank 103A, the valve device 104A, the liquid receptor 303, the pressure reducing device 201, and the evaporator 202.

<An operation of the heat source side unit>

[0043] Next, an example of an operation of the heat source side unit 100A according to the present embodiment will be explained. In the present embodiment, the controller 110A obtains the detection result from the refrigerant leakage detecting unit 11 and the detection result from the machine chamber refrigerant leakage detecting unit 12 and further determines whether or not the refrigerant is leaking by using the detection result from the refrigerant leakage detecting unit 11 and the detection result from the machine chamber refrigerant leakage detecting unit 12. When it is determined that the refrigerant is leaking, similarly to Embodiment 1, the valve de-

vice 104A is brought into the closed state, while the low pressure threshold pressure value of the compressor 101 is set to the second low pressure threshold pressure value B (MPa), and the refrigerant is retained in the refrigerant tank 103A.

[0044] As explained above, according to the present embodiment, the compressor 101 is provided on the inside of the machine chamber 2. The machine chamber refrigerant leakage detecting unit 12 is provided on the inside of the machine chamber 2 and is configured to detect refrigerant leaking from the refrigerant circuit 60A. The controller 110A is configured to obtain the detection result from the refrigerant leakage detecting unit 11 and the detection result from the machine chamber refrigerant leakage detecting unit 12 to judge whether or not the refrigerant is leaking. Further, when it is determined that the refrigerant is leaking, the refrigerant is retained in the refrigerant tank 103A. Consequently, the possibility of having either the chamber 1 or the machine chamber 2 filled with the refrigerant is reduced.

[0045] Further, the refrigerant circuit 60A of the refrigeration apparatus 50A according to the present embodiment includes the check valve 105 configured to prevent the refrigerant from flowing backward from the condenser 102 to the compressor 101. Accordingly, it is possible to lower the possibility of having the retained refrigerant flowing backward and flowing into the machine chamber 2 or the chamber 1.

<Modification Example 3>

[0046] Fig. 6 is a diagram for explaining Modification Example 3 of the present invention obtained by modifying the example in Fig. 5. In comparison to the example in Embodiment 2 illustrated in Fig. 5, an outdoor heat exchange unit 400A of a refrigeration apparatus 50B according to Modification Example 3 illustrated in Fig. 6 is configured so that a valve device 104B is connected in parallel to a refrigerant tank 103B. In Modification Example 3, while the valve device 104B is in an open state, the refrigerant condensed by the condenser 102 is branched into refrigerant stored in the refrigerant tank 103B and refrigerant flowing to the valve device 104B.

[0047] In the example in Embodiment 2 illustrated in Fig. 5, while the valve device 104A is in the open state, the refrigerant condensed by the condenser 102 goes through the refrigerant tank 103A and flows into the valve device 104A. In contrast to the example in Embodiment 2, Modification Example 3 is configured so that, as illustrated in Fig. 6, while the valve device 104B is in the open state, the refrigerant condensed by the condenser 102 directly flows into the valve device 104B. Consequently, pressure loss in a refrigerant circuit 60B is improved.

[0048] The present invention is not limited to the embodiments described above. It is possible to modify the present invention in various manners within the scope of the invention. In other words, the configurations described in the embodiments above may be modified as

appropriate. Further, at least a part of the configurations may be replaced with another configuration. In addition, some of the constituent elements of which the positional arrangements are not particularly specified do not necessarily have to be placed in the positions disclosed in the embodiments and may be provided in any position that can realize the functions thereof.

[0049] For example, in Embodiment 1 and Embodiment 2 described above, the example is explained in which the refrigerant leakage detecting unit 11 is structured separately from the load side unit 200. However, the refrigerant leakage detecting unit 11 may be incorporated into the load side unit 200 to be integrally formed with the load side unit 200. Further, in Embodiment 2, the example is explained in which the machine chamber refrigerant leakage detecting unit 12 is structured separately from the heat source unit 300. However, the machine chamber refrigerant leakage detecting unit 12 may be incorporated into the heat source unit 300 to be integrally formed with the heat source unit 300.

[0050] Further, for example, the refrigerant leakage detecting unit 11 and the machine chamber refrigerant leakage detecting unit 12 each do not necessarily have to be a refrigerant leakage detecting device configured to detect leakage of the refrigerant. For example, the refrigerant leakage detecting unit 11 and the machine chamber refrigerant leakage detecting unit 12 may each be structured to include a temperature sensor configured to detect temperatures in various locations in the refrigerant circuit, a pressure sensor configured to detect pressure levels in various locations in the refrigerant circuit, and a controller configured to judge whether or not the refrigerant is leaking by using detection results from the temperature sensor and detection results from the pressure sensor.

[0051] Further, for example, it is also acceptable to apply the check valve 105 in Embodiment 2 to the refrigerant circuit 60 in Embodiment 1. In other words, the check valve 105 may be provided on the refrigerant discharge side of the compressor 101 in the refrigerant circuit 60 illustrated in Fig. 1.

[0052] Further, for example, in Embodiment 1 and Embodiment 2 described above, the example is explained in which the refrigeration apparatus is configured so that the one load side unit is connected to the one heat source side unit. However, the refrigeration apparatus may be configured to include a plurality of load side units connected in parallel to a single heat source side unit. The plurality of load side units may be provided on the inside of a single chamber. Alternatively, one or more load side units may be provided on the inside of each of a plurality of chambers. When there are two or more chambers in each of which at least one load side unit is installed, it is a good idea to provide the refrigerant leakage detecting unit in each of the plurality of chambers, so that it is judged whether or not the refrigerant is leaking with respect to each of the plurality of chambers.

Reference Signs List

[0053]

1 chamber 2 machine chamber 11 refrigerant leakage detecting unit 12 machine chamber refrigerant leakage detecting unit 50 refrigeration apparatus 50A refrigeration apparatus 50B refrigeration apparatus 60 refrigerant circuit 60A refrigerant circuit 60B refrigerant circuit 100 heat source side unit 100A heat source side unit 101 compressor 102 condenser 103 refrigerant tank 103A refrigerant tank 103B refrigerant tank 104 valve device 104A valve device 104B valve device 105 check valve 110 controller 110A controller 111 suction side pressure sensor 112 discharge side pressure sensor 120 storage unit 120A storage unit 130 alarm device 200 load side unit 201 pressure reducing device 202 evaporator 300 heat source unit 303 liquid receptor 400 outdoor heat exchange unit 400A outdoor heat exchange unit A first low pressure threshold pressure value B second low pressure threshold pressure value P1 suction pressure value.

Claims

1. A refrigeration apparatus comprising:
 - a refrigerant circuit including a compressor configured to compress refrigerant, a condenser configured to condense the refrigerant compressed by the compressor, a refrigerant tank configured to store the refrigerant condensed by the condenser, and a valve device configured to control passing of the refrigerant flowing out of the refrigerant tank;
 - a refrigerant leakage detecting unit configured to detect the refrigerant leaking from the refrigerant circuit; and
 - a controller configured to obtain a detection result from the refrigerant leakage detecting unit and, when determining that the refrigerant is leaking, to bring the valve device into a closed state to retain, in the refrigerant tank, the refrigerant being compressed by the compressor and condensed by the condenser.
2. The refrigeration apparatus of claim 1, wherein the compressor is configured to be controlled to stop operating when a suction pressure on a suction side of the compressor becomes equal to or smaller than a low pressure threshold pressure value determined in advance, and the controller is configured to control the compressor by, when determining that the refrigerant is leaking,

setting the low pressure threshold pressure value to a second low pressure threshold pressure value that is smaller than a first low pressure threshold pressure value to which the low pressure threshold pressure value is set when the controller determines that the refrigerant is not leaking.

3. The refrigeration apparatus of claim 2, wherein the second low pressure threshold pressure value is equal to or larger than 0 MPa in gauge pressure.
4. The refrigeration apparatus of any one of claims 1 to 3, wherein the refrigerant circuit further includes an evaporator provided inside a chamber and configured to evaporate the refrigerant, and the refrigerant leakage detecting unit is installed inside the chamber.
5. The refrigeration apparatus of any one of claims 1 to 4, comprising:
 - a heat source unit including the compressor and the controller.
6. The refrigeration apparatus of any one of claims 1 to 5, wherein the refrigerant tank and the valve device are installed outdoors.
7. The refrigeration apparatus of any one of claim 1 to 6, wherein the compressor and the condenser are installed outdoors.
8. The refrigeration apparatus of any one of claims 1 to 6, wherein the compressor is installed inside a machine chamber, the refrigeration apparatus further comprises a machine chamber refrigerant leakage detecting unit that is installed inside the machine chamber and is configured to detect the refrigerant leaking from the refrigerant circuit, and the controller is configured to determine whether or not the refrigerant is leaking by obtaining the detection result from the refrigerant leakage detecting unit and a detection result from the machine chamber refrigerant leakage detecting unit.
9. The refrigeration apparatus of any one of claims 1 to 8, wherein the refrigerant circuit further includes a check valve configured to prevent the refrigerant from flowing backward from the condenser to the compressor.
10. The refrigeration apparatus of any one of claims 1 to 9, further comprising:

an alarm device configured to issue an alarm,
wherein
the controller is configured to cause the alarm
device to issue the alarm when the refrigerant
leaks.

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FIG. 1

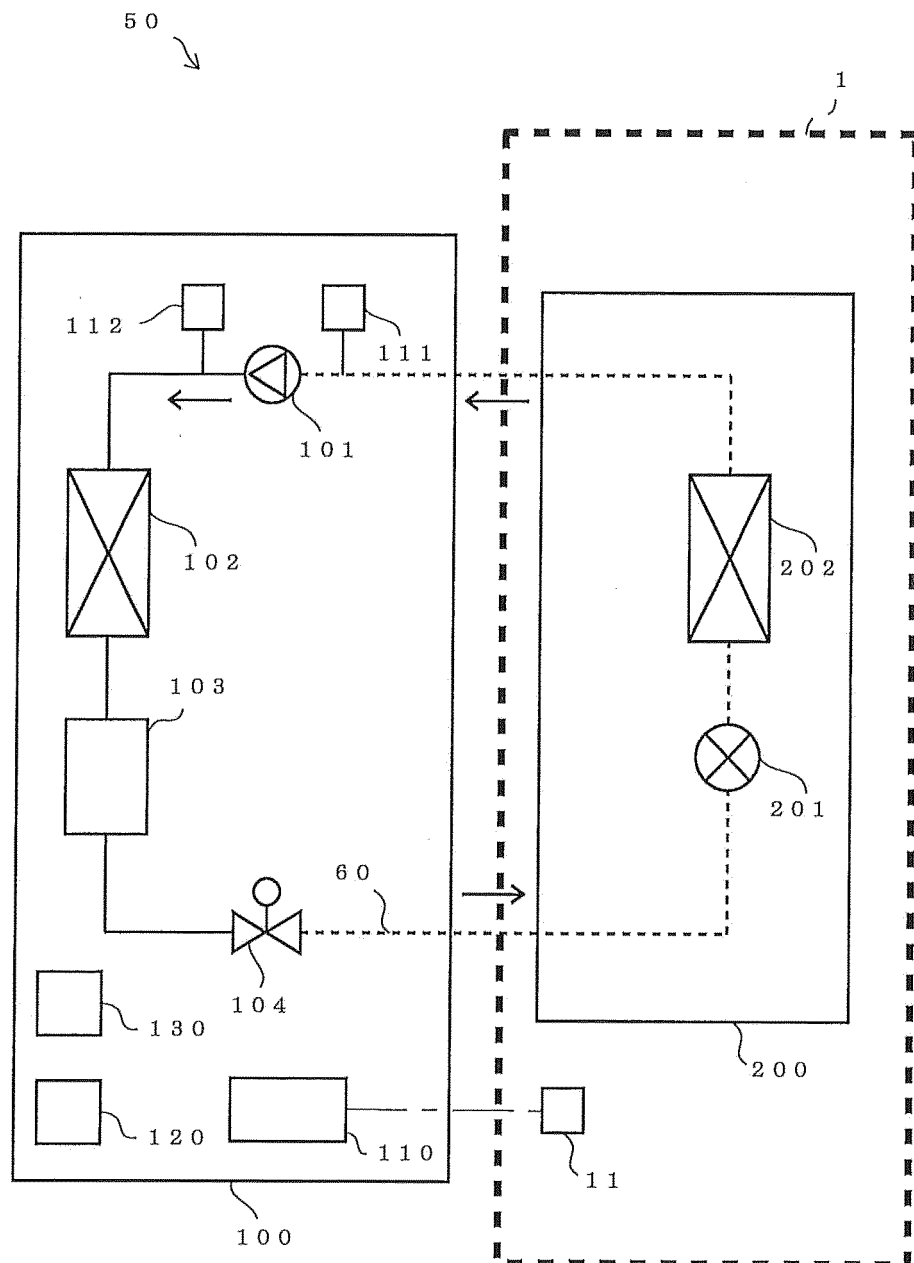


FIG. 2

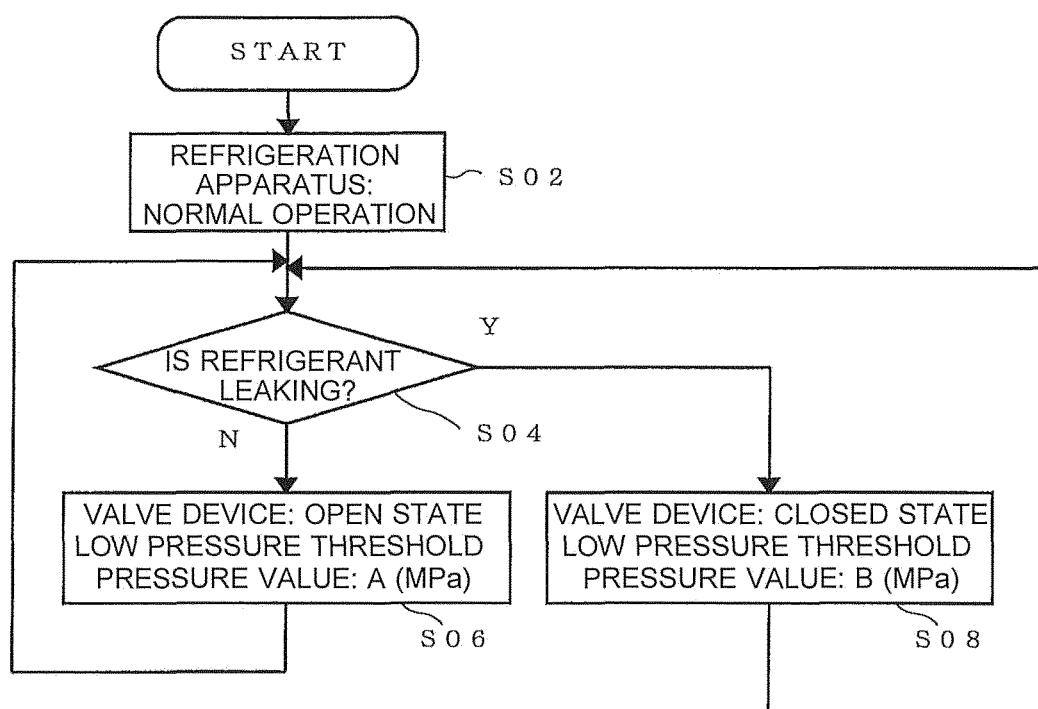


FIG. 3

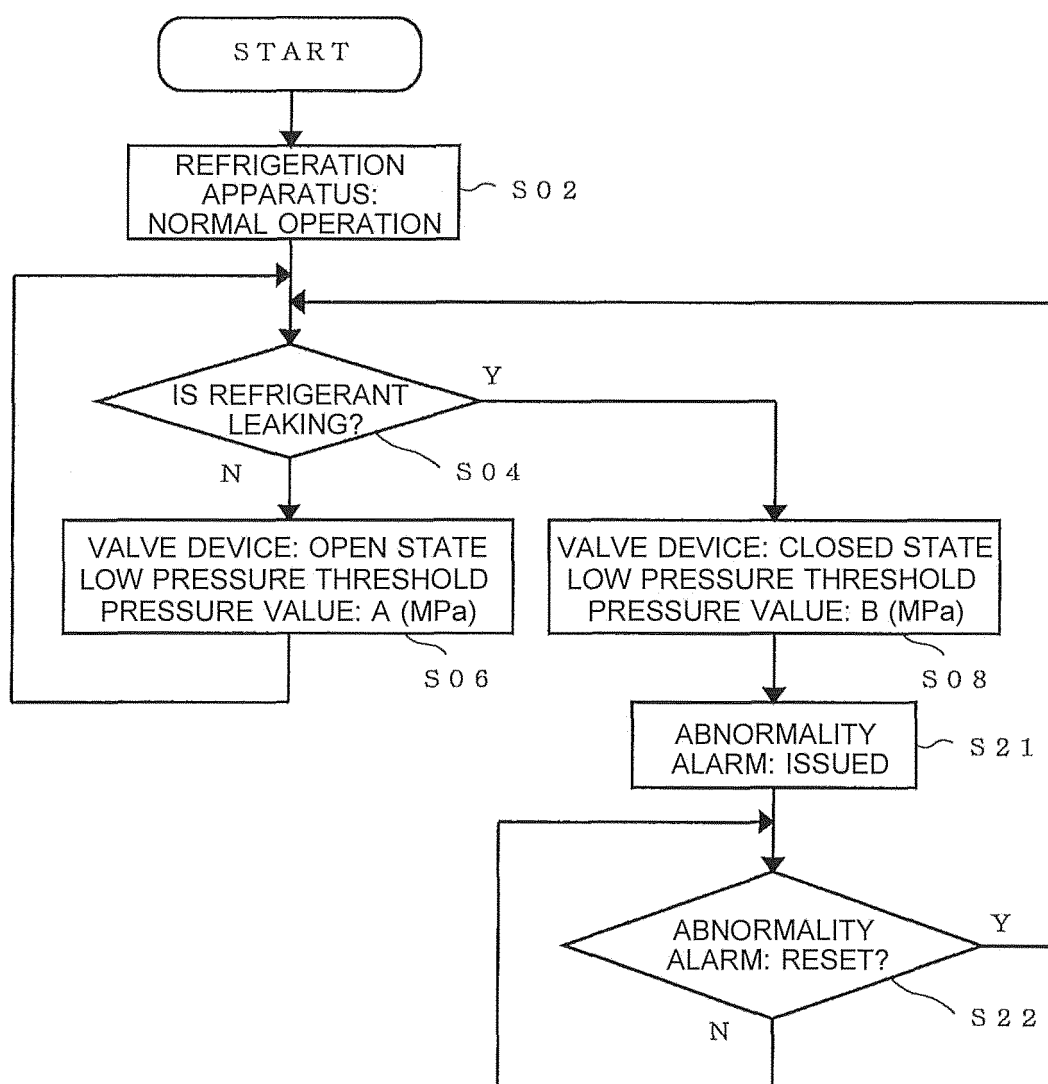


FIG. 4

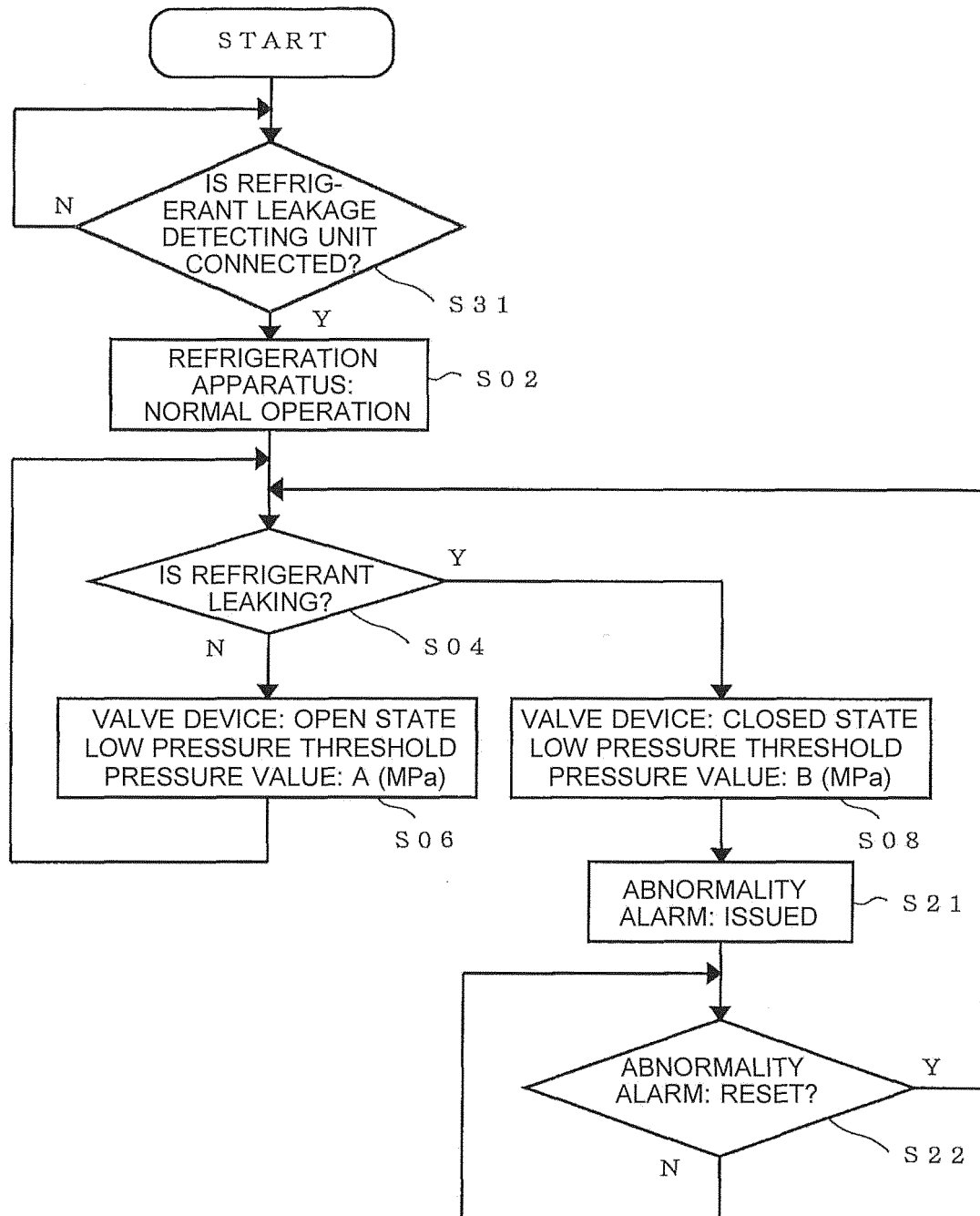


FIG. 5

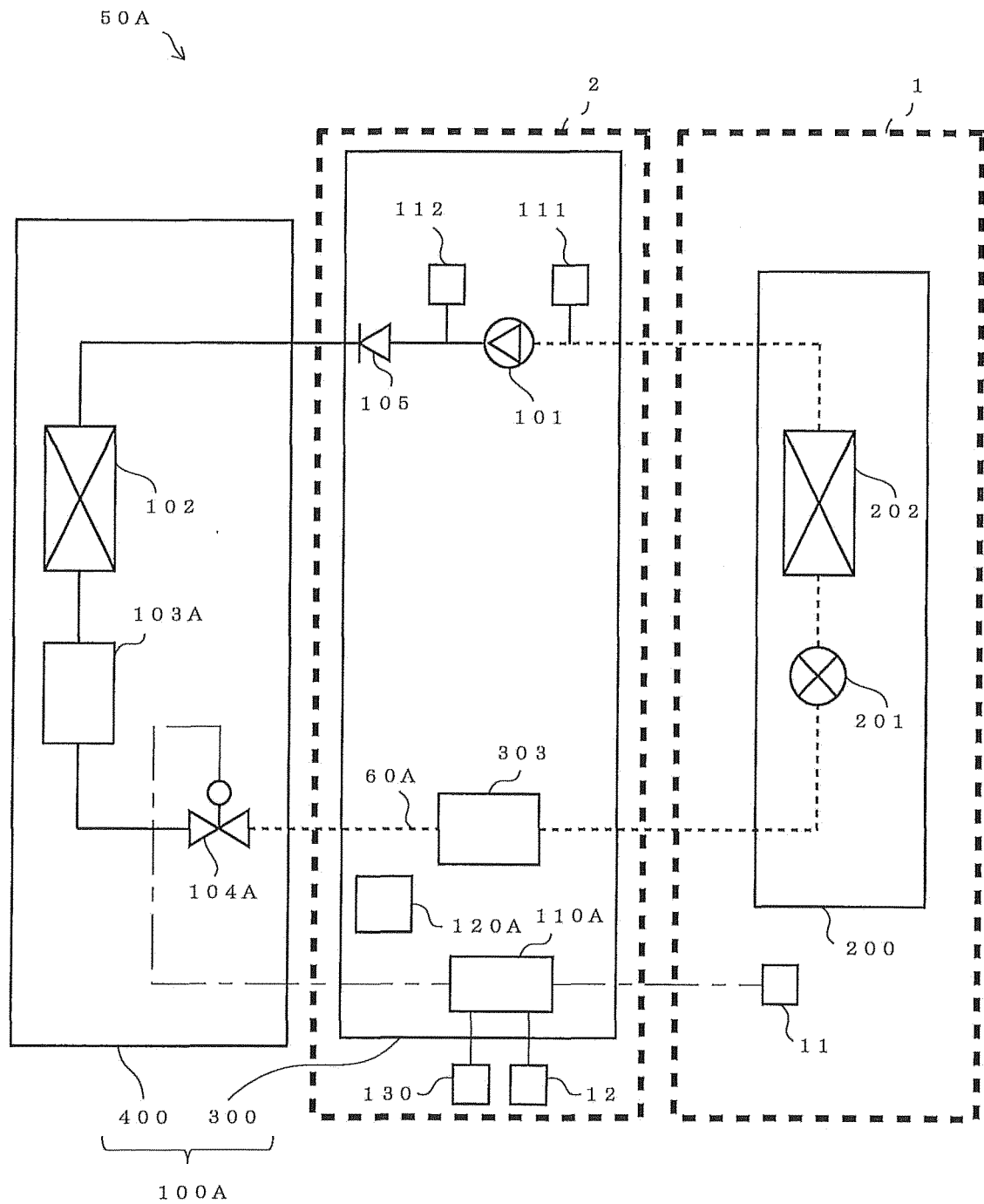
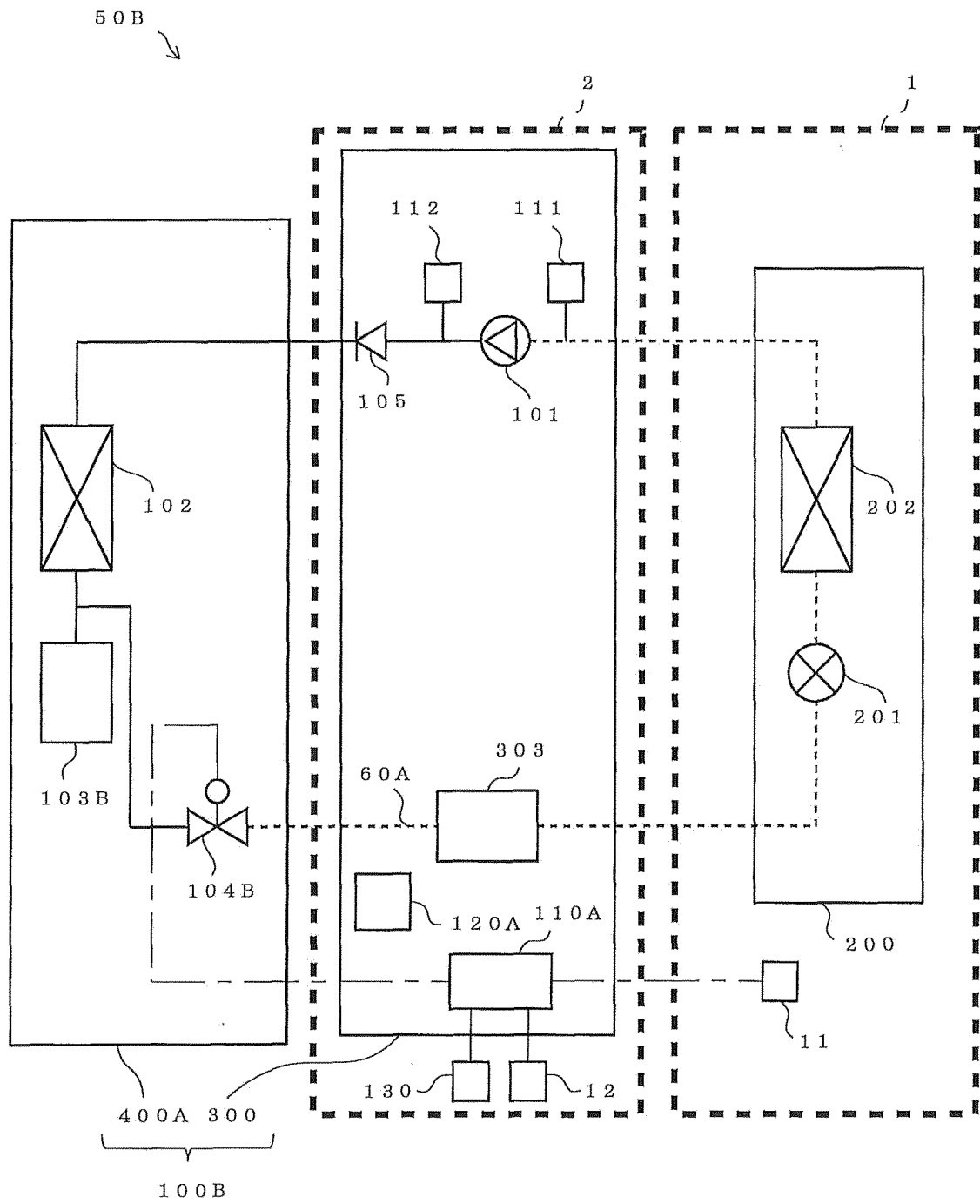


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/062419

A. CLASSIFICATION OF SUBJECT MATTER

F25B49/02(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)

F25B49/02

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	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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.
Y	JP 05-118720 A (Hitachi, Ltd.), 14 May 1993 (14.05.1993), paragraphs [0015] to [0018]; fig. 1, 3 (Family: none)	1-10
Y	JP 2002-228281 A (Sanyo Electric Co., Ltd.), 14 August 2002 (14.08.2002), paragraphs [0019] to [0026], [0030] to [0034]; fig. 1 (Family: none)	1-10
Y	JP 09-318141 A (Mitsubishi Electric Corp.), 12 December 1997 (12.12.1997), paragraphs [0002] to [0005], [0019] to [0030]; fig. 1 to 5 (Family: none)	2-10

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

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Date of the actual completion of the international search

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