(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 030 122 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
21.06.2023 Bulletin 2023/25

(21) Application number: **19944933.1**

(22) Date of filing: **09.09.2019**

(51) International Patent Classification (IPC):
F25B 49/02 *(2006.01)* ***F25B 1/00*** *(2006.01)*
F25B 49/00 *(2006.01)* ***F25B 41/30*** *(2021.01)*
F25B 1/10 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25B 49/02; F25B 1/10; F25B 41/30; F25B 49/005;
F25B 2309/06; F25B 2309/061; F25B 2400/0409; F25B 2400/16; F25B 2400/23; F25B 2500/19; F25B 2500/222; F25B 2500/24; F25B 2600/02; F25B 2600/05; F25B 2600/23; (Cont.)

(86) International application number:
PCT/JP2019/035407

(87) International publication number:
WO 2021/048905 (18.03.2021 Gazette 2021/11)

(54) OUTDOOR UNIT AND REFRIGERATION CYCLE APPARATUS

AUSSENEINHEIT UND KÜHLZYKLUSVORRICHTUNG

UNITÉ EXTÉRIEURE ET DISPOSITIF À CYCLE FRIGORIFIQUE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
20.07.2022 Bulletin 2022/29

(73) Proprietor: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventors:
- **ISHIKAWA, Tomotaka**
  Tokyo 100-8310 (JP)
- **ARII, Yusuke**
  Tokyo 100-8310 (JP)
- **HAYASAKA, Motoshi**
  Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
An der Frauenkirche 20
01067 Dresden (DE)

(56) References cited:
EP-A1- 3 348 939
WO-A1-2017/199391
WO-A1-2017/199391
WO-A1-2018/185841
JP-A- H05 288 438
JP-A- 2010 156 536
JP-A- 2011 226 704
JP-A- 2013 087 966
JP-A- 2013 164 242

Processed by Luminess, 75001 PARIS (FR)

(Cont. next page)

(52) Cooperative Patent Classification (CPC): (Cont.)
F25B 2600/2501; F25B 2600/2509; F25B 2700/195;
F25B 2700/21161; F25B 2700/21163

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an outdoor unit and a refrigeration cycle apparatus.

BACKGROUND ART

[0002] In a refrigeration cycle apparatus, excess or shortage of the amount of refrigerant causes degradation in the capability of a refrigeration apparatus and damage to constituting devices. WO 2017/199391 (PTL 1) discloses a refrigeration cycle apparatus which prevents a failure of a compressor by detecting shortage of refrigerant.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: WO 2017/199391

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] There is known a refrigeration cycle apparatus having an injection flow path which decompresses a portion of liquid refrigerant flowing out from a condenser, reduces its temperature, and returns it to a compressor. The refrigerant in the compressor can be cooled by the injection flow path. In addition to a common refrigeration apparatus, WO 2017/199391 (PTL 1) also discloses a refrigeration apparatus having an injection flow path, and the shortage of the refrigerant is detected before the compressor has a failure.

[0005] Generally, when refrigerant sealed in a refrigerant circuit becomes insufficient due to shortage of a filling amount, leak, or the like, the temperature of the discharged refrigerant from a compressor becomes higher than a target temperature, for example, causing a reduction in the efficiency of a refrigeration cycle apparatus. Accordingly, even at a stage where the shortage of the refrigerant does not lead to a failure of the compressor or the like, it is desirable to detect the shortage of the refrigerant progressing due to the leak of the refrigerant or the like, at as an early stage as possible.

[0006] An object of the present invention is to provide an outdoor unit and a refrigeration cycle apparatus capable of detecting shortage of refrigerant at an early stage.

SOLUTION TO PROBLEM

[0007] The present invention relates to an outdoor unit of a refrigeration cycle apparatus as defined in claim 1, the outdoor unit being connectable to a load device including an expansion device and an evaporator. The outdoor unit includes a refrigerant outlet port and a refrigerant inlet port for connecting to the load device, a first flow path, a compressor, a condenser, a second flow path, a first expansion valve, a receiver, a second expansion valve, and a controller. The first flow path, which is a flow path from the refrigerant inlet port to the refrigerant outlet port, is configured to form, together with the load device, a circulation flow path through which refrigerant circulates. The compressor and the condenser are disposed on the first flow path in order from the refrigerant inlet port toward the refrigerant outlet port. The second flow path is configured to branch from a portion of the first flow path between the condenser and the refrigerant outlet port, and to return, to the compressor, the refrigerant that has passed through the condenser. The first expansion valve, the receiver, and the second expansion valve are disposed on the second flow path in order from a branch point where the second flow path is branched from the first flow path. The controller is configured to control the compressor and the first and second expansion valves. The controller is configured to notify that the refrigerant is insufficient when a time period for which a degree of opening of the second expansion valve is at an upper limit exceeds a determination time period.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the outdoor unit and the refrigeration cycle apparatus including the same of the present invention, when the refrigerant becomes insufficient due to leak of the refrigerant or the like, shortage of the refrigerant can be detected at an early stage.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is an overall configuration diagram of a refrigeration cycle apparatus according to a first embodiment of the present invention.

Fig. 2 is a flowchart for illustrating control of a first expansion valve 71.

Fig. 3 is a flowchart for illustrating control of a second expansion valve 72.

Fig. 4 is a graph showing the relation between a degree of progress of shortage of refrigerant and degrees of opening of the expansion valves of an outdoor unit when leak of the refrigerant occurs.

Fig. 5 is an overall configuration diagram of a refrigeration cycle apparatus according to a second embodiment.

DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings. Although a plurality of embodiments will be de-

scribed below, it is originally intended from the time of filing the present application to combine features described in the embodiments as appropriate. It should be noted that identical or corresponding parts in the drawings will be designated by the same reference characters, and the description thereof will not be repeated.

First Embodiment

[0011] Fig. 1 is an overall configuration diagram of a refrigeration cycle apparatus according to a first embodiment. It should be noted that Fig. 1 functionally shows the connection relation and the arrangement configuration of devices in the refrigeration cycle apparatus, and does not necessarily show an arrangement in a physical space.

[0012] Referring to Fig. 1, a refrigeration cycle apparatus 1 includes an outdoor unit 2, a load device 3, and pipes 84 and 88. Outdoor unit 2 has a refrigerant outlet port PO2 and a refrigerant inlet port PI2 for connecting to load device 3. Load device 3 has a refrigerant outlet port PO3 and a refrigerant inlet port PI3 for connecting to outdoor unit 2. Pipe 84 connects refrigerant outlet port PO2 of outdoor unit 2 to refrigerant inlet port PI3 of load device 3. Pipe 88 connects refrigerant outlet port PO3 of load device 3 to refrigerant inlet port PI2 of outdoor unit 2.

[0013] Outdoor unit 2 of refrigeration cycle apparatus 1 is connectable to load device 3. Outdoor unit 2 includes a compressor 10 having a suction port G1, a discharge port G2, and an intermediate pressure port G3, a condenser 20, a fan 22, and pipes 80, 81, and 89.

[0014] Load device 3 includes an expansion valve 50 which is an expansion device, an evaporator 60, and pipes 85, 86, and 87. Evaporator 60 is configured to perform heat exchange between air and refrigerant. In refrigeration cycle apparatus 1, evaporator 60 evaporates the refrigerant by absorbing heat from the air in a space to be cooled. Expansion valve 50 is, for example, a temperature expansion valve controlled independently of outdoor unit 2. It should be noted that expansion valve 50 may be an electronic expansion valve which can decompress the refrigerant.

[0015] Compressor 10 compresses the refrigerant suctioned from pipe 89, and discharges the compressed refrigerant to pipe 80. Compressor 10 can arbitrarily change a drive frequency by inverter control. Further, compressor 10 is provided with intermediate pressure port G3, and allows the refrigerant from intermediate pressure port G3 to flow into an intermediate portion of a compression process. Compressor 10 is configured to adjust a rotation speed according to a control signal from a controller 100. By adjusting the rotation speed of compressor 10, a circulation amount of the refrigerant is adjusted, and the capability of refrigeration cycle apparatus 1 can be adjusted. As compressor 10, various types of compressors can be adopted, and for example, a compressor of scroll type, rotary type, screw type, or the like can be adopted.

[0016] Condenser 20 is configured such that the high-temperature, high-pressure gas refrigerant discharged from compressor 10 performs heat exchange with outside air (heat dissipation). By this heat exchange, the gas refrigerant is condensed and transforms into a liquid phase. The refrigerant discharged from compressor 10 to pipe 80 is condensed and liquefied in condenser 20, and flows into pipe 81. Fan 22 for blowing the outside air is attached to condenser 20 in order to increase the efficiency of heat exchange. Fan 22 supplies condenser 20 with the outside air with which the refrigerant performs heat exchange in condenser 20. By adjusting the number of revolutions of fan 22, a refrigerant pressure on a discharge side of compressor 10 (a high pressure-side pressure) can be adjusted.

[0017] Outdoor unit 2 includes a first flow path F1 from refrigerant inlet port PI2 to refrigerant outlet port PO2 via compressor 10 and condenser 20. First flow path F1 forms, together with a flow path on which expansion valve 50 and evaporator 60 of load device 3 are disposed, a circulation flow path through which the refrigerant circulates. Hereinafter, this circulation flow path will also be referred to as a "main refrigerant circuit" of a refrigeration cycle.

[0018] Outdoor unit 2 further includes a second flow path F2 including pipes 91, 92, 93, and 94 configured to cause the refrigerant to flow from a portion of the circulation flow path between an outlet of condenser 20 and refrigerant outlet port PO2 to intermediate pressure port G3 of compressor 10. Hereinafter, second flow path F2 that branches from the main refrigerant circuit and delivers the refrigerant to compressor 10 will also be referred to as an "injection flow path".

[0019] Outdoor unit 2 further includes a first expansion valve 71, a receiver 73, a second expansion valve 72, and a flow rate limiting device 70 disposed on second flow path F2. Receiver 73 stores liquid refrigerant. First expansion valve 71 is disposed between pipes 91 and 92, pipe 91 branching from the main refrigerant circuit, and pipe 92 connected to an inlet of receiver 73. Pipe 93 connects a gas exhaust outlet of receiver 73 to pipe 94 to exhaust a refrigerant gas within receiver 73. Flow rate limiting device 70 is disposed between pipes 93 and 94 to limit the flow rate of the refrigerant gas. As flow rate limiting device 70, a capillary tube can be used, for example.

[0020] Pipe 91 is a pipe that branches from the main refrigerant circuit and causes the refrigerant to flow into receiver 73. First expansion valve 71 is an electronic expansion valve which can decrease the pressure of the refrigerant at a high pressure portion of the main refrigerant circuit to an intermediate pressure. Receiver 73 is a container in which the refrigerant decompressed and having two phases is separated into a gas phase and a liquid phase, and which can store the refrigerant and adjust the circulation amount of the refrigerant in the main refrigerant circuit. Pipe 93 connected to an upper portion of receiver 73 and pipe 94 connected to a lower portion

of receiver 73 are pipes for taking out the refrigerant separated into gas refrigerant and liquid refrigerant within receiver 73, in a separated state. Second expansion valve 72 is provided on pipe 94. Second expansion valve 72 adjusts the amount of the liquid refrigerant to be exhausted from pipe 94, and thereby can adjust the amount of the refrigerant in receiver 73.

[0021] By providing receiver 73 on the injection flow path as described above, it becomes easy to ensure a subcool in pipe 81 which is a liquid pipe. This is because, since receiver 73 generally includes the gas refrigerant therein and the temperature of the refrigerant reaches a saturation temperature, it is not possible to ensure a subcool if receiver 73 is disposed on pipe 81.

[0022] Outdoor unit 2 further includes pressure sensors 110, 111, and 112, temperature sensors 120 and 121, and controller 100 configured to control compressor 10, first expansion valve 71, and second expansion valve 72.

[0023] Pressure sensor 110 detects a pressure PL at the suction port portion of compressor 10, and outputs a detection value thereof to controller 100. Pressure sensor 111 detects a pressure PH of the discharged refrigerant from compressor 10, and outputs a detection value thereof to controller 100. Pressure sensor 112 detects a pressure P1 of the refrigerant flowing out from condenser 20, and outputs a detection value thereof to controller 100.

[0024] Temperature sensor 120 detects a temperature TH of the discharged refrigerant from compressor 10, and outputs a detection value thereof to controller 100. Temperature sensor 121 detects a temperature T1 of the refrigerant in pipe 81 at the outlet of condenser 20, and outputs a detection value thereof to controller 100.

[0025] In the present embodiment, second flow path F2 controls temperature TH of the discharged refrigerant from compressor 10 by causing the refrigerant decompressed and having a lower temperature to flow into compressor 10. In addition, the amount of the refrigerant in the main refrigerant circuit can be adjusted by receiver 73 placed on second flow path F2.

[0026] Controller 100 includes a CPU (Central Processing Unit) 102, a memory 104 (a ROM (Read Only Memory) and a RAM (Random Access Memory)), input/output buffers (not shown) for inputting/outputting various signals, and the like. CPU 102 expands programs stored in the ROM onto the RAM or the like and executes the programs. The programs stored in the ROM are programs describing processing procedures of controller 100. According to these programs, controller 100 performs control of the devices in outdoor unit 2. This control can be processed not only by software but also by dedicated hardware (electronic circuitry).

[0027] Controller 100 feedback-controls first expansion valve 71 such that temperature TH of the discharged refrigerant from compressor 10 matches a target temperature.

[0028] Fig. 2 is a flowchart for illustrating control of first expansion valve 71. When temperature TH of the discharged refrigerant from compressor 10 is higher than the target temperature (YES in S21), controller 100 increases a degree of opening of first expansion valve 71 (S22). Thereby, the refrigerant flowing into intermediate pressure port G3 via receiver 73 increases, and thus temperature TH decreases.

[0029] On the other hand, when temperature TH of the discharged refrigerant from compressor 10 is lower than the target temperature (NO in S21 and YES in S23), controller 100 decreases the degree of opening of first expansion valve 71 (S24). Thereby, the refrigerant flowing into intermediate pressure port G3 via receiver 73 decreases, and thus temperature TH increases.

[0030] When temperature TH is equal to the target temperature (NO in S21 and NO in S23), controller 100 maintains the degree of opening of first expansion valve 71 in the present state.

[0031] Thus, controller 100 controls the degree of opening of first expansion valve 71 such that temperature TH of the discharged refrigerant from compressor 10 approaches the target temperature.

[0032] Further, in a normal operation, controller 100 feedback-controls second expansion valve 72 such that temperature T1 of the refrigerant at the outlet of condenser 20 matches a target temperature, in order to ensure a subcool SC of the refrigerant at the outlet of condenser 20. On this occasion, in the first embodiment, detection of shortage of the refrigerant is also performed simultaneously.

[0033] Fig. 3 is a flowchart for illustrating control of second expansion valve 72. In steps S31 and S33, controller 100 calculates subcool SC of the refrigerant at the outlet portion of condenser 20 based on temperature T1 and a pressure in condenser 20 (approximated by PH). Specifically, controller 100 calculates subcool SC by subtracting temperature T1 from the saturation temperature of the refrigerant corresponding to pressure PH. It should be noted that a conversion table for obtaining the saturation temperature of the refrigerant corresponding to each pressure is stored beforehand in memory 104 of controller 100. Then, controller 100 compares calculated subcool SC with a target value. This target value is 5 K (kelvin), for example. When subcool SC is larger than the target value (YES in S31), controller 100 decreases a degree of opening of second expansion valve 72 (S32). Thereby, the amount of the liquid refrigerant to be exhausted from receiver 73 decreases and the amount of the liquid refrigerant within receiver 73 increases, and thus the amount of the refrigerant circulating through the main refrigerant circuit decreases. Accordingly, temperature T1 of the refrigerant increases, and thus subcool SC decreases.

[0034] On the other hand, when subcool SC of the refrigerant at the outlet of condenser 20 is smaller than the target value (NO in S31 and YES in S33), in step S34, controller 100 determines whether or not the degree of opening of second expansion valve 72 is full open. Here, full open means that the degree of opening of second

expansion valve 72 has an upper limit value.

[0035] When the degree of opening of second expansion valve 72 is not full open (NO in S34), controller 100 increases the degree of opening of second expansion valve 72 (S35). Thereby, the amount of the liquid refrigerant to be exhausted from receiver 73 increases and the amount of the liquid refrigerant stored in receiver 73 decreases, and thus the amount of the refrigerant circulating through the main refrigerant circuit increases. Accordingly, temperature T1 of the refrigerant decreases, and thus subcool SC increases.

[0036] On the other hand, when the degree of opening of second expansion valve 72 is full open (YES in S34), in step S36, controller 100 determines whether or not the state where second expansion valve 72 is fully opened continues for a determination time period.

[0037] When the state where second expansion valve 72 is fully opened does not continue for the determination time period (NO in S36), controller 100 maintains the degree of opening of second expansion valve 72 in the state of full open.

[0038] On the other hand, when the state where second expansion valve 72 is fully opened continues for the determination time period (YES in S36), in step S37, controller 100 causes a notification device 101 to output an alarm indicating that the refrigerant is insufficient. Notification device 101 is, for example, a display device such as a liquid crystal display, an alarm lamp, or the like, and may be a device that transmits an alarm signal to an external device via a communication line.

[0039] After performing the processing in any of steps S32, S35, and S37, controller 100 advances the processing to step S38. Further, when subcool SC of the refrigerant at the outlet of condenser 20 is equal to the target value (NO in S31 and NO in S33), controller 100 advances the processing to step S38 while maintaining the present degree of opening. In these cases, the processing is temporarily returned to a main routine, and then the processing in the flowchart of Fig. 3 is performed repeatedly at fixed time intervals.

[0040] Fig. 4 is a graph showing the relation between a degree of progress of shortage of the refrigerant and the degrees of opening of the expansion valves of the outdoor unit when leak of the refrigerant occurs. The degree of shortage of the refrigerant increases as the degree of progress increases from D0 to D3.

[0041] When the degree of progress is D0 to D1, the amount of the refrigerant is not insufficient yet, and the liquid refrigerant is present in receiver 73. At this stage, the temperature of the discharged refrigerant from compressor 10 is controlled properly by increasing the degree of opening of second expansion valve 72 to full open. However, subcool SC of the refrigerant at the outlet portion of condenser 20 gradually decreases, and subcool SC is zero when the degree of progress is D1.

[0042] When the degree of progress is D1 to D2, the temperature of the discharged refrigerant from compressor 10 is still controlled properly, although subcool SC of the refrigerant at the outlet portion of condenser 20 is zero. However, the amount of the liquid refrigerant in receiver 73 decreases, and the liquid refrigerant is not present in receiver 73 when the degree of progress is D2. At this stage, the degree of opening of second expansion valve 72 is full open.

[0043] When the degree of progress is D2 to D3, subcool SC of the refrigerant at the outlet portion of condenser 20 is zero, and the liquid refrigerant is not present in receiver 73. At this stage, the degree of opening of first expansion valve 71 is increased to increase the amount of the refrigerant flowing into the injection flow path. However, temperature TH of the discharged refrigerant from compressor 10 becomes higher than that in an optimum state. Then, when the degree of progress is D3, the degree of opening of first expansion valve 71 is full open.

[0044] As shown in Fig. 4, in a process in which shortage of the refrigerant occurs, both first expansion valve 71 and second expansion valve 72 are fully opened. Since second expansion valve 72 is fully opened at an earlier stage, the shortage of the refrigerant can be detected at an earlier stage when the shortage of the refrigerant is determined based on the degree of opening of second expansion valve 72. In the present embodiment, it is determined that the refrigerant is insufficient when a time period for which the degree of opening of second expansion valve 72 is full open reaches the determination time period. Accordingly, a user can be notified of the shortage of the refrigerant at an early stage.

Second Embodiment

[0045] The first embodiment has described the case that uses the refrigerant for which subcool SC can be calculated from temperature T1 and pressure PH, that is, the refrigerant used with the pressure in the condenser being less than a critical pressure. In recent years, adoption of natural refrigerant having a low global warming potential has been considered, and refrigerant used with a pressure in the condenser being more than or equal to the critical pressure, such as CO_2, may be adopted. A second embodiment will describe detection of shortage of refrigerant in a case where such refrigerant is adopted.

[0046] Fig. 5 is an overall configuration diagram of a refrigeration cycle apparatus according to the second embodiment. It should be noted that Fig. 5 functionally shows the connection relation and the arrangement configuration of devices in the refrigeration cycle apparatus, and does not necessarily show an arrangement in a physical space.

[0047] Referring to Fig. 5, a refrigeration cycle apparatus 1A includes an outdoor unit 2A, load device 3, and pipes 84 and 88. Since load device 3 and pipes 84 and 88 are the same as those in the first embodiment, the description thereof will not be repeated.

[0048] Outdoor unit 2A includes a temperature sensor 123 instead of pressure sensor 112, and a controller 100A instead of controller 100, in the configuration of

outdoor unit 2 shown in Fig. 1. Since other components of outdoor unit 2A are the same as those of outdoor unit 2, the description thereof will not be repeated.

[0049] Temperature sensor 123 detects an outside air temperature TA, which is an ambient temperature of outdoor unit 2A, and outputs a detection value thereof to controller 100A.

[0050] Controller 100A includes CPU 102, memory 104, input/output buffers (not shown) for inputting/outputting various signals, and the like. CPU 102 expands programs stored in the ROM onto the RAM or the like and executes the programs. The programs stored in the ROM are programs describing processing procedures of controller 100A. According to these programs, controller 100A performs control of the devices in outdoor unit 2A. This control can be processed not only by software but also by dedicated hardware (electronic circuitry).

[0051] Controller 100A feedback-controls first expansion valve 71 such that temperature TH of the discharged refrigerant from compressor 10 matches a target temperature. Since the control of first expansion valve 71 is the same as the control in the first embodiment shown in Fig. 2, the description thereof will not be repeated.

[0052] Further, in a normal operation, controller 100A feedback-controls second expansion valve 72 such that temperature T1 of the refrigerant at the outlet of condenser 20 matches a target temperature, in order to ensure subcool SC of the refrigerant at the outlet of condenser 20. On this occasion, in the second embodiment, detection of shortage of the refrigerant is also performed simultaneously.

[0053] It should be noted that, in the present specification, for ease of description, a device which cools the refrigerant such as CO_2 in a supercritical state will also be referred to as condenser 20. Further, in the present specification, for ease of description, an amount of decrease from a reference temperature of the refrigerant in the supercritical state will also be referred to as a subcool. In the second embodiment, the reference temperature is set to TA+α, where TA is the temperature of the outside air measured by temperature sensor 123, and the amount of decrease has a target value of 5 K (kelvin), for example.

[0054] Also in the second embodiment, shortage of the refrigerant can be detected at an early stage by the processing of the flowchart shown in Fig. 3, by calculating subcool SC as a difference between temperature TA+α and temperature T1.

[0055] In the case where the pressure in condenser 20 may exceed the critical pressure as in the second embodiment, if receiver 73 is provided at an intermediate pressure portion, it becomes possible to store the intermediate pressure liquid refrigerant within receiver 73 even when the pressure at the high pressure portion of the main refrigerant circuit is high and the refrigerant is in the supercritical state. Thus, the design pressure of the container of receiver 73 can be set to be lower than that of the high pressure portion, and cost reduction by thinning the container can also be achieved.

[0056] The outdoor units and the refrigeration cycle apparatuses of the first and second embodiments described above will be summarized with reference to the drawings again.

[0057] The present invention relates to outdoor unit 2 of refrigeration cycle apparatus 1 and outdoor unit 2A of refrigeration cycle apparatus 1A, each outdoor unit being connectable to load device 3 including expansion valve 50, which is an expansion device, and evaporator 60. Outdoor unit 2 shown in Fig. 1 and outdoor unit 2A shown in Fig. 5 include refrigerant outlet port PO2 and refrigerant inlet port PI2 for connecting to load device 3, first flow path F1, compressor 10, condenser 20, second flow path F2, first expansion valve 71, receiver 73, second expansion valve 72, and controller 100 or 100A. First flow path F1, which is a flow path from refrigerant inlet port PI2 to refrigerant outlet port PO2, is configured to form, together with load device 3, a circulation flow path through which refrigerant circulates. Compressor 10 and condenser 20 are disposed on first flow path F1 in order from refrigerant inlet port PI2 toward refrigerant outlet port PO2. Second flow path F2 is configured to branch from a portion of first flow path F1 between condenser 20 and refrigerant outlet port PO2, and to return, to compressor 10, the refrigerant that has passed through condenser 20. First expansion valve 71, receiver 73, and second expansion valve 72 are disposed on second flow path F2 in order from a branch point where second flow path F2 is branched from first flow path F1. Controllers 100 and 100A are configured to control compressor 10 and first and second expansion valves 71 and 72. Controllers 100 and 100A are configured to notify that the refrigerant is insufficient when a time period for which a degree of opening of second expansion valve 72 is at an upper limit exceeds a determination time period.

[0058] By detecting shortage of the refrigerant as described above, the shortage of the refrigerant can be detected at an early stage in the configuration in which receiver 73 is disposed on the injection flow path, and degradation in the capability of the refrigeration cycle apparatus and continued leak of the refrigerant can be prevented.

[0059] Preferably, outdoor unit 2 shown in Fig. 1 and outdoor unit 2A shown in Fig. 5 further include first temperature sensor 121 configured to detect temperature T1 at a refrigerant outlet portion of condenser 20 on first flow path F1. Controllers 100 and 100A are configured to control the degree of opening of second expansion valve 72 according to an output of first temperature sensor 121.

[0060] More preferably, outdoor unit 2 shown in Fig. 1 further includes pressure sensor 111 configured to detect pressure PH of the refrigerant at the refrigerant outlet portion of condenser 20 on first flow path F1. When the time period for which the degree of opening of second expansion valve 72 is at the upper limit exceeds the determination time period, and subcool SC of the refrigerant calculated based on the output of first temperature sen-

sor 121 and an output of pressure sensor 111 is not equal to a target value, controller 100 determines that the refrigerant is insufficient.

[0061] More preferably, the refrigerant used in the configuration shown in Fig. 1 is refrigerant used with a pressure in condenser 20 being less than a critical pressure.

[0062] More preferably, outdoor unit 2A shown in Fig. 5 further includes second temperature sensor 123 configured to detect temperature TA of outside air to be supplied to condenser 20. When the time period for which the degree of opening of second expansion valve 72 is at the upper limit exceeds the determination time period, and a difference between a detection temperature of first temperature sensor 121 and a detection temperature of second temperature sensor 123 is smaller than a determination value, controller 100A determines that the refrigerant is insufficient.

[0063] More preferably, the refrigerant used in the configuration shown in Fig. 5 is carbon dioxide used with a pressure in condenser 20 being more than or equal to the critical pressure.

[0064] In another aspect, the present invention relates to a refrigeration cycle apparatus including the outdoor unit according to any one of the above descriptions, and the load device.

[0065] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the scope of the claims, rather than the description of the embodiments described above, and is intended to include any modifications within the scope and meaning equivalent to the scope of the claims.

REFERENCE SIGNS LIST

[0066] 1, 1A: refrigeration cycle apparatus; 2, 2A: outdoor unit; 3: load device; 10: compressor; 20: condenser; 22: fan; 50: expansion valve; 60: evaporator; 70: flow rate limiting device; 71: first expansion valve; 72: second expansion valve; 73: receiver; 80, 81, 84, 85, 88, 89, 91, 92, 93, 94: pipe; 100, 100A: controller; 101: notification device; 104: memory; 110, 111, 112: pressure sensor; 120, 121, 123: temperature sensor; F1, F2: flow path; G1: suction port; G2: discharge port; G3: intermediate pressure port; PI2, PI3: refrigerant inlet port; PO2, PO3: refrigerant outlet port.

Claims

1. An outdoor unit (2) of a refrigeration cycle apparatus, the outdoor unit (2) being connectable to a load device (3) including an expansion device (50) and an evaporator (60), the outdoor unit comprising:

   a refrigerant outlet port and a refrigerant inlet port for connecting to the load device;
   a first flow path (F1), which is a flow path from the refrigerant inlet port to the refrigerant outlet port, the first flow path being configured to form, together with the load device, a circulation flow path through which refrigerant circulates;
   a compressor (10) and a condenser (20) disposed on the first flow path (F1) in order from the refrigerant inlet port (PI2) toward the refrigerant outlet port (PO2);
   a second flow path (F2) configured to branch from a portion of the first flow path (F1) between the condenser (20) and the refrigerant outlet port (PO2), and to return, to the compressor (10), the refrigerant that has passed through the condenser (10);
   a first expansion valve (71), a receiver (73), and a second expansion valve (72) disposed on the second flow path (F2) in order from a branch point where the second flow path (F2) is branched from the first flow path (F1); and
   a controller (100) configured to control the compressor (10) and the first and second expansion valves (71, 72), the controller (100) being configured to notify that the refrigerant is insufficient when a time period for which a degree of opening of the second expansion valve (72) is at an upper limit exceeds a determination time period.

2. The outdoor unit (2, 2A) according to claim 1, further comprising a first temperature sensor (121) configured to detect a temperature of the refrigerant at a refrigerant outlet portion of the condenser (20) on the first flow path (F1), wherein
   the controller (100, 100A) is configured to control the degree of opening of the second expansion valve (72) according to an output of the first temperature sensor (121).

3. The outdoor unit (2) according to claim 2, further comprising a pressure sensor (111) configured to detect a pressure of the refrigerant at the refrigerant outlet portion of the condenser (20) on the first flow path (F1), wherein
   when the time period for which the degree of opening of the second expansion valve (72) is at the upper limit exceeds the determination time period, and a subcool of the refrigerant calculated based on the output of the first temperature sensor (121) and an output of the pressure sensor (111) is not equal to a target value, the controller (100) determines that the refrigerant is insufficient.

4. The outdoor unit according to claim 3, wherein the refrigerant is refrigerant used with a pressure in the condenser (20) being less than a critical pressure.

5. The outdoor unit (2A) according to claim 2, further comprising a second temperature sensor (123) configured to detect a temperature of outside air to be

supplied to the condenser (20), wherein
when the time period for which the degree of opening of the second expansion valve (72) is at the upper limit exceeds the determination time period, and a difference between a detection temperature of the first temperature sensor (121) and a detection temperature of the second temperature sensor (123) is smaller than a determination value, the controller (100A) determines that the refrigerant is insufficient.

6. The outdoor unit according to claim 5, wherein the refrigerant is carbon dioxide used with a pressure in the condenser (20) being more than or equal to a critical pressure.

7. A refrigeration cycle apparatus comprising:

the outdoor unit (2, 2A) according to any one of claims 1 to 6; and
the load device (3).

Patentansprüche

1. Außeneinheit (2) einer Kältekreislaufvorrichtung, wobei die Außeneinheit (2) mit einer Lasteinrichtung (3) verbunden werden kann, die eine Expansionseinrichtung (50) und einen Verdampfer (60) aufweist, wobei die Außeneinheit umfasst:

eine Kältemittelauslassöffnung und eine Kältemitteleinlassöffnung zum Verbinden mit der Lasteinrichtung;
einen ersten Strömungsweg (F1), der ein Strömungsweg von der Kältemitteleinlassöffnung zur Kältemittelauslassöffnung ist, wobei der erste Strömungsweg eingerichtet ist, zusammen mit der Lasteinrichtung einen Zirkulationsströmungsweg zu bilden, durch den Kältemittel zirkuliert;
einen Verdichter (10) und einen Kondensator (20), die auf dem ersten Strömungsweg (F1) in der Reihenfolge von der Kältemitteleinlassöffnung (PI2) zur Kältemittelauslassöffnung (PO2) angeordnet sind;
einen zweiten Strömungsweg (F2), der eingerichtet ist, von einem Abschnitt des ersten Strömungswegs (F1) zwischen dem Kondensator (20) und der Kältemittelauslassöffnung (PO2) abzuzweigen und das Kältemittel, das den Kondensator (10) durchlaufen hat, zum Verdichter (10) zurückzuführen;
ein erstes Expansionsventil (71), einen Sammler (73) und ein zweites Expansionsventil (72), die auf dem zweiten Strömungsweg (F2) in der Reihenfolge von einem Verzweigungspunkt aus, an dem der zweite Strömungsweg (F2) von dem ersten Strömungsweg (F1) abgezweigt wird, angeordnet sind; und
eine Steuereinheit (100), die eingerichtet ist, den Verdichter (10) und das erste und das zweite Expansionsventil (71, 72) zu steuern, wobei die Steuereinheit (100) eingerichtet ist, zu melden, dass das Kältemittel unzureichend ist, wenn eine Zeitspanne, für die ein Öffnungsgrad des zweiten Expansionsventils (72) an einer oberen Grenze liegt, eine Bestimmungszeitspanne überschreitet.

2. Außeneinheit (2, 2A) nach Anspruch 1, ferner umfassend einen ersten Temperatursensor (121), der eingerichtet ist, eine Temperatur des Kältemittels an einem Kältemittelauslassabschnitt des Kondensators (20) auf dem ersten Strömungsweg (F1) zu erfassen, wobei
die Steuereinheit (100, 100A) eingerichtet ist, den Öffnungsgrad des zweiten Expansionsventils (72) gemäß einer Ausgabe des ersten Temperatursensors (121) zu steuern.

3. Außeneinheit (2) nach Anspruch 2, ferner umfassend einen Drucksensor (111), der eingerichtet ist, einen Druck des Kältemittels an dem Kältemittelauslassabschnitt des Kondensators (20) auf dem ersten Strömungsweg (F1) zu erfassen, wobei
wenn die Zeitspanne, für die der Öffnungsgrad des zweiten Expansionsventils (72) an der oberen Grenze liegt, die Bestimmungszeitspanne überschreitet, und eine Unterkühlung des Kältemittels, die auf der Grundlage der Ausgabe des ersten Temperatursensors (121) und einer Ausgabe des Drucksensors (111) berechnet wird, nicht gleich einem Zielwert ist, die Steuereinheit (100) bestimmt, dass das Kältemittel unzureichend ist.

4. Außeneinheit nach Anspruch 3, wobei das Kältemittel ein Kältemittel ist, das mit einem Druck im Kondensator (20) verwendet wird, der unter einem kritischen Druck liegt.

5. Außeneinheit (2A) nach Anspruch 2, ferner umfassend einen zweiten Temperatursensor (123), der eingerichtet ist, eine Temperatur von Außenluft zu erfassen, die dem Kondensator (20) zugeführt werden soll, wobei
wenn die Zeitspanne, für die der Öffnungsgrad des zweiten Expansionsventils (72) an der oberen Grenze liegt, die Bestimmungszeitspanne überschreitet, und eine Differenz zwischen einer Erfassungstemperatur des ersten Temperatursensors (121) und einer Erfassungstemperatur des zweiten Temperatursensors (123) kleiner als ein Bestimmungswert ist, die Steuereinheit (100A) bestimmt, dass das Kältemittel unzureichend ist.

6. Außeneinheit nach Anspruch 5, wobei das Kältemit-

tel Kohlenstoffdioxid ist, das mit einem Druck im Kondensator (20) verwendet wird, der größer oder gleich einem kritischen Druck ist.

7. Kältekreislaufvorrichtung, umfassend:

die Außeneinheit (2, 2A) nach einem der Ansprüche 1 bis 6; und
die Lasteinrichtung (3).

Revendications

1. Unité extérieure (2) d'un appareil à cycle de réfrigération, l'unité extérieure (2) pouvant être connectée à un dispositif de charge (3) comprenant un dispositif d'expansion (50) et un évaporateur (60), l'unité extérieure comprenant :

un orifice de sortie de réfrigérant et un orifice d'entrée de réfrigérant pour la connexion au dispositif de charge ;
un premier trajet d'écoulement (F1), qui est un trajet d'écoulement allant de l'orifice d'entrée de réfrigérant à l'orifice de sortie de réfrigérant, le premier trajet d'écoulement étant configuré pour former, avec le dispositif de charge, un trajet d'écoulement de circulation à travers lequel le réfrigérant circule ;
un compresseur (10) et un condenseur (20) disposés sur le premier trajet d'écoulement (F1) dans l'ordre à partir de l'orifice d'entrée de réfrigérant (PI2) vers l'orifice de sortie de réfrigérant (PO2) ;
un second trajet d'écoulement (F2) configuré se ramifier à partir d'une partie du premier trajet d'écoulement (F1) entre le condenseur (20) et l'orifice de sortie de réfrigérant (PO2), et pour renvoyer au compresseur (10) le réfrigérant qui a traversé le condenseur (10) ;
un premier détendeur (71), un récepteur (73) et un second détendeur (72) disposés sur le second trajet d'écoulement (F2) dans l'ordre à partir d'un point de ramification où le second trajet d'écoulement (F2) est ramifié à partir du premier trajet d'écoulement (F1) ; et
un dispositif de commande (100) configuré pour commander le compresseur (10) et les premier et second détendeurs (71, 72), le dispositif de commande (100) étant configuré pour fournir une notification concernant une pénurie de réfrigérant lorsqu'une période de temps pendant laquelle le degré d'ouverture du second détendeur (72) se trouve à une limite supérieure dépasse une période de temps de détermination.

2. Unité extérieure (2, 2A) selon la revendication 1, comprenant en outre un premier capteur de température (121) configuré pour détecter une température du réfrigérant au niveau d'une partie de sortie de réfrigérant du condenseur (20) sur le premier trajet d'écoulement (F1), dans laquelle
le dispositif de commande (100, 100A) est configuré pour commander le degré d'ouverture du second détendeur (72) en fonction d'une sortie du premier capteur de température (121).

3. Unité extérieure (2) selon la revendication 2, comprenant en outre un capteur de pression (111) configuré pour détecter une pression du réfrigérant au niveau de la partie de sortie de réfrigérant du condenseur (20) sur le premier trajet d'écoulement (F1), dans laquelle
lorsque la période pendant laquelle le degré d'ouverture du second détendeur (72) se trouve à la limite supérieure dépasse la période de détermination, et qu'un sous-refroidissement du réfrigérant calculé sur la base de la sortie du premier capteur de température (121) et d'une sortie du capteur de pression (111) n'est pas égal à une valeur cible, le dispositif de commande (100) détermine que le réfrigérant est insuffisant.

4. Unité extérieure selon la revendication 3, dans laquelle le réfrigérant est un réfrigérant utilisé avec une pression dans le condenseur (20) inférieure à une pression critique.

5. Unité extérieure (2A) selon la revendication 2, comprenant en outre un second capteur de température (123) configuré pour détecter une température de l'air extérieur à fournir au condenseur (20), dans laquelle
lorsque la période pendant laquelle le degré d'ouverture du second détendeur (72) se trouve à la limite supérieure dépasse la période de détermination, et qu'une différence entre une température de détection du premier capteur de température (121) et une température de détection du second capteur de température (123) est inférieure à une valeur de détermination, le dispositif de commande (100A) détermine que le réfrigérant est insuffisant.

6. Unité extérieure selon la revendication 5, dans laquelle le réfrigérant est du dioxyde de carbone utilisé avec une pression dans le condenseur (20) supérieure ou égale à une pression critique.

7. Appareil à cycle de réfrigération comprenant :

l'unité intérieure (2, 2A) selon l'une quelconque des revendications 1 à 6 ; et
le dispositif de charge (3).

FIG.1

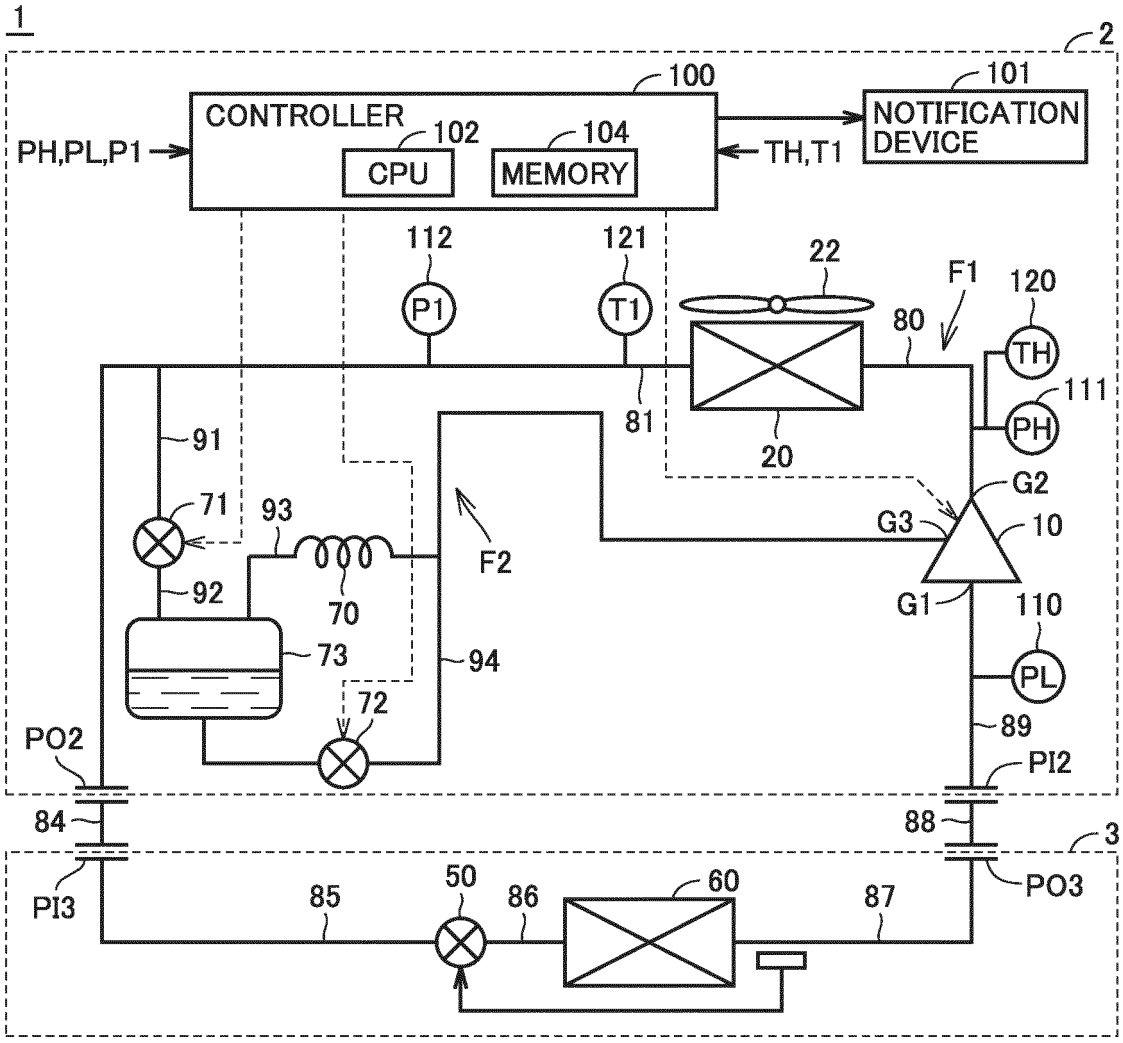

1
2
100
CONTROLLER
102
CPU
104
MEMORY
101
NOTIFICATION DEVICE
PH,PL,P1
TH,T1
112
P1
121
T1
22
F1
120
TH
80
111
PH
81
20
91
71
93
F2
G2
G3
10
92
70
G1
110
73
94
PL
72
89
PO2
PI2
84
88
3
PI3
85
50
86
60
87
PO3

FIG.2

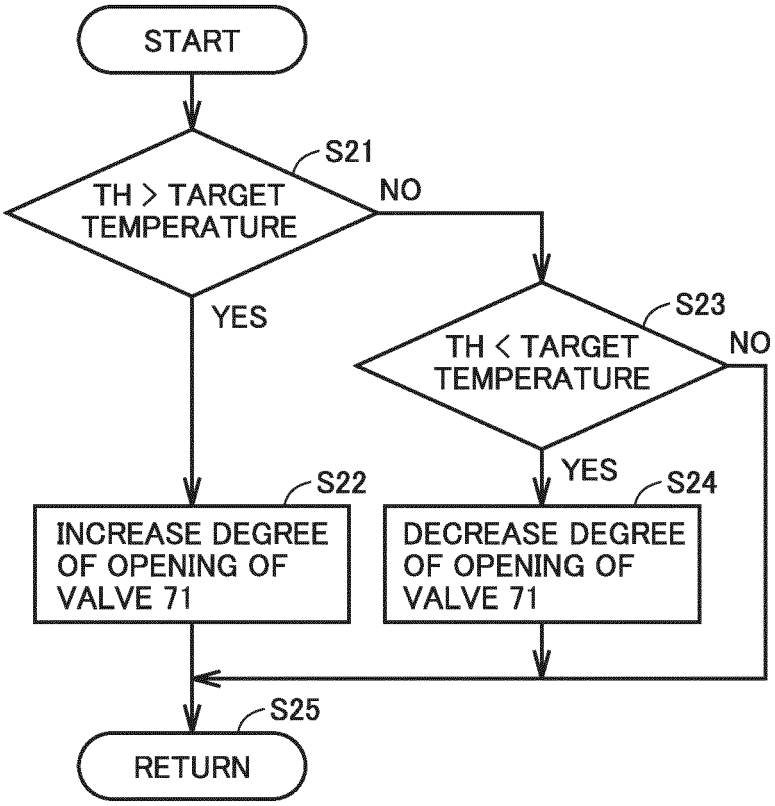

START
S21
TH > TARGET TEMPERATURE
NO
YES
S23
TH < TARGET TEMPERATURE
NO
YES
S22
INCREASE DEGREE OF OPENING OF VALVE 71
S24
DECREASE DEGREE OF OPENING OF VALVE 71
S25
RETURN

FIG.3

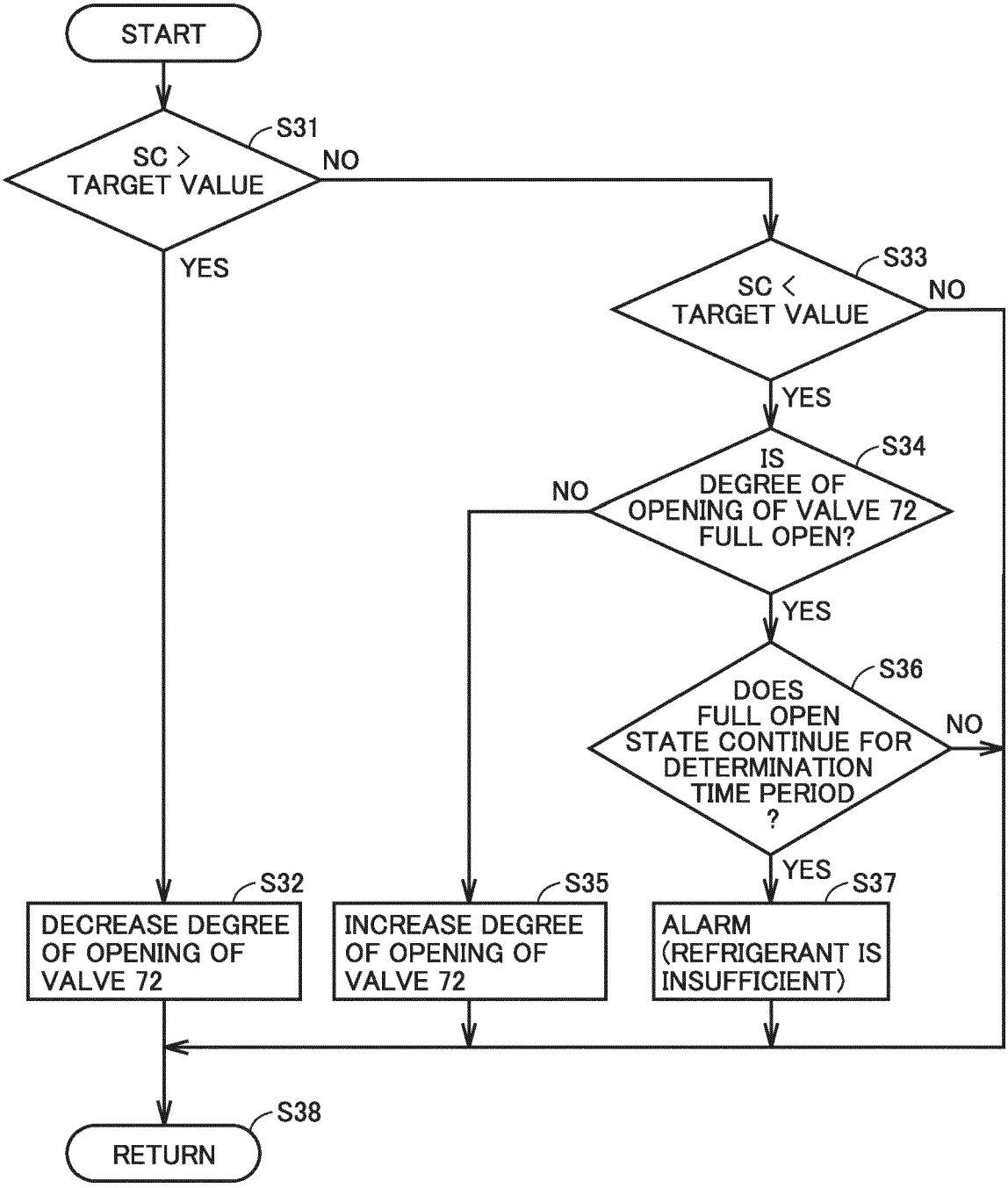

START
S31
SC > TARGET VALUE
NO
YES
S33
SC < TARGET VALUE
NO
YES
S34
IS DEGREE OF OPENING OF VALVE 72 FULL OPEN?
NO
YES
S36
DOES FULL OPEN STATE CONTINUE FOR DETERMINATION TIME PERIOD ?
NO
YES
S32
DECREASE DEGREE OF OPENING OF VALVE 72
S35
INCREASE DEGREE OF OPENING OF VALVE 72
S37
ALARM (REFRIGERANT IS INSUFFICIENT)
S38
RETURN

FIG.4

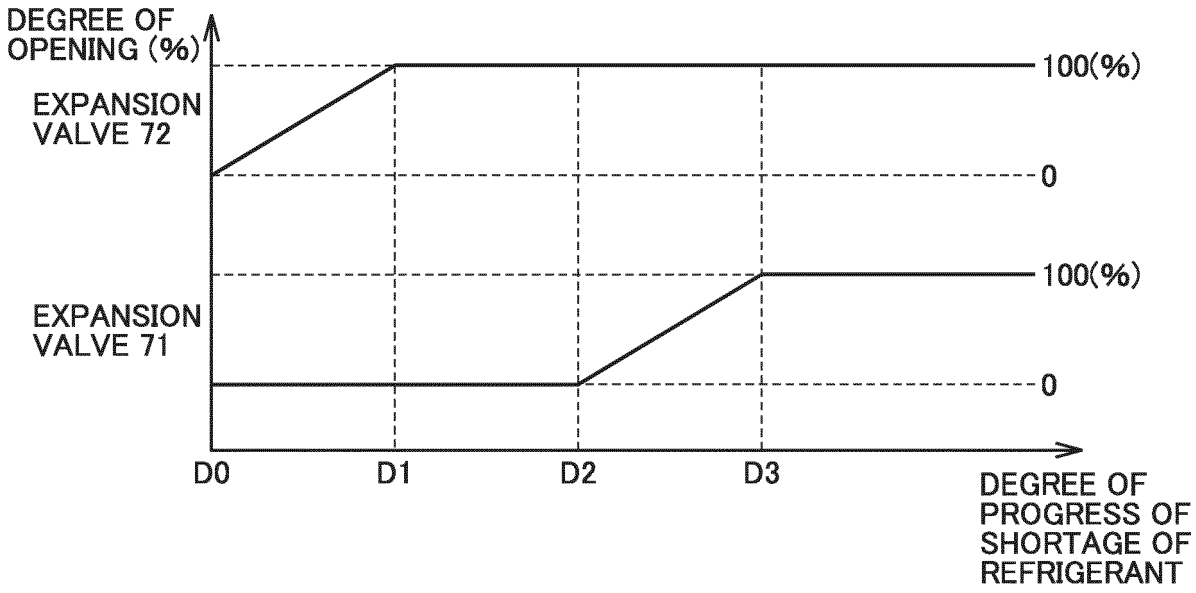
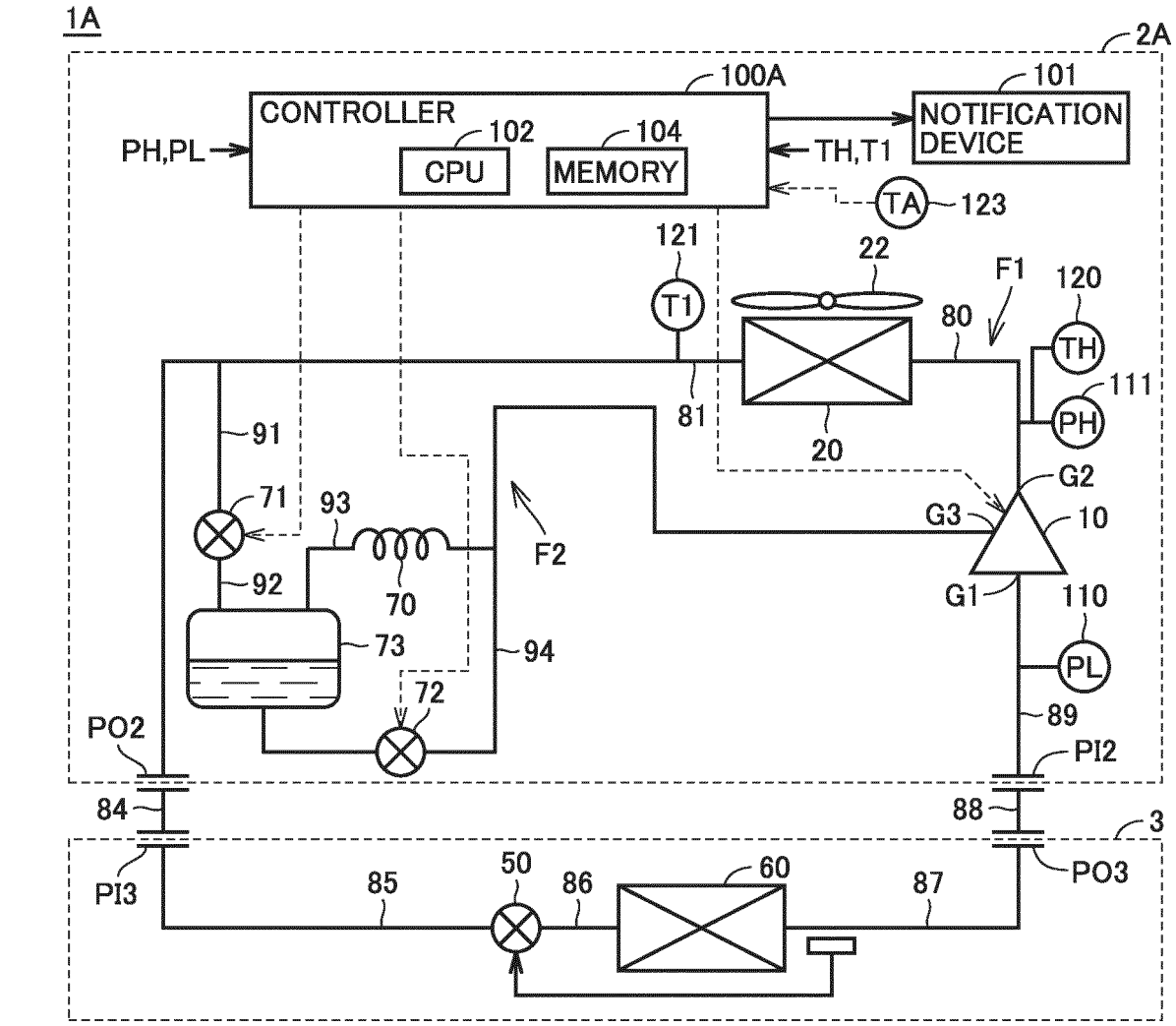

DEGREE OF OPENING (%)
EXPANSION VALVE 72
100(%)
0
EXPANSION VALVE 71
100(%)
0
D0
D1
D2
D3
DEGREE OF PROGRESS OF SHORTAGE OF REFRIGERANT

FIG.5


1A
2A
100A
CONTROLLER
102
CPU
104
MEMORY
101
NOTIFICATION DEVICE
PH,PL
TH,T1
TA
123
121
T1
22
F1
120
TH
80
111
PH
91
81
20
G2
71
93
G3
10
F2
92
70
G1
110
73
94
PL
72
89
PO2
PI2
84
88
3
PI3
85
50
86
60
87
PO3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2017199391 A **[0002] [0003] [0004]**