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

(11) EP 3 869 120 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.08.2021 Bulletin 2021/34

(21) Application number: **21156006.5**

(22) Date of filing: **09.02.2021**

(51) Int Cl.:
F25B 1/00 *(2006.01)* ***F25B 41/31*** *(2021.01)*
F25B 41/39 *(2021.01)* ***F25B 40/00*** *(2006.01)*
F25B 9/00 *(2006.01)* ***F25B 41/22*** *(2021.01)*

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **21.02.2020 JP 2020028697**

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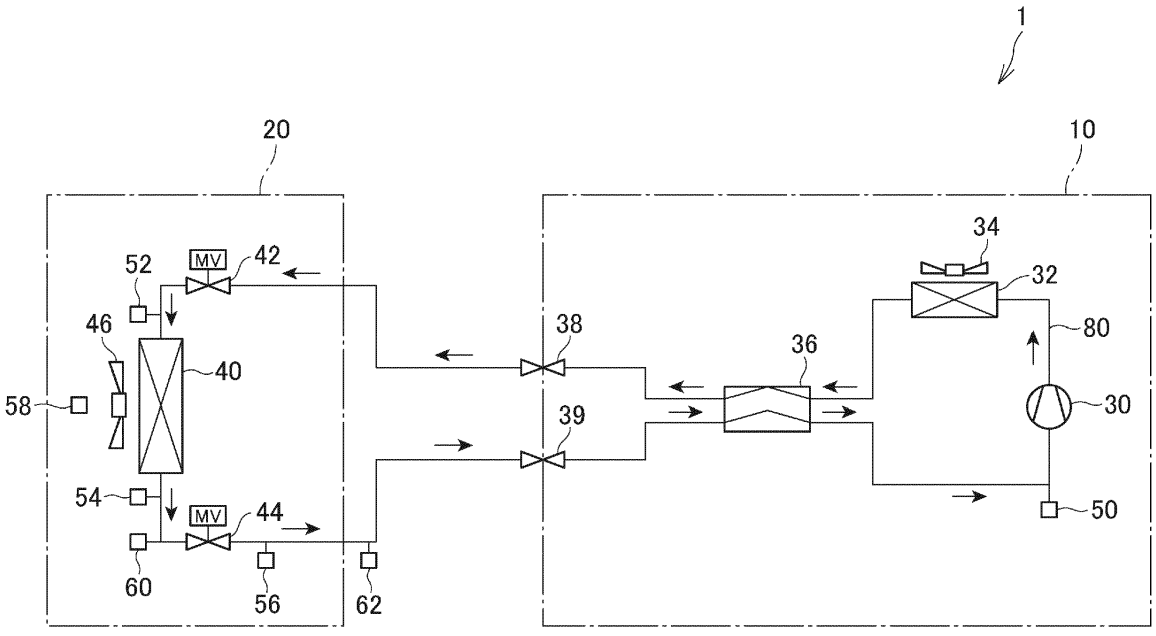
(54) REFRIGERATION APPARATUS

(57) To provide a refrigeration apparatus capable of regulating a refrigerant amount while achieving downsizing and weight reduction. A refrigeration apparatus 1 includes: a refrigerator 10 including a compressor 30 and a heat exchanger configured to perform heat exchange of a refrigerant discharged from the compressor 30; a cooling apparatus including an evaporator 40 and an inlet expansion valve 42 disposed at an inlet of the evaporator 40; and a refrigerant regulating valve disposed at an outlet of the evaporator 40, the refrigerant regulating valve being configured to regulate a refrigerant flow rate.

FIG.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a refrigeration apparatus.

Description of the Related Art

[0002] There are known conventional refrigeration apparatuses for cooling cold storage or freezing showcases in stores such as supermarkets and convenience stores. Such a refrigeration apparatus includes a compressor, a condenser, an expansion valve, and an evaporator that are connected through a refrigerant pipe to constitute a refrigeration cycle.

[0003] A known conventional refrigeration apparatus is provided with a refrigerant amount regulating tank that regulates the amount of refrigerant flowing through the refrigeration cycle by storing a surplus refrigerant that is generated by fluctuations in a refrigeration load (e.g., refer to Japanese Patent Laid-Open No. 2017-122524).

[0004] However, in the conventional refrigeration apparatus, the refrigerant amount regulating tank may increase the size or weight.

[0005] It is an object of the present invention to provide a refrigeration apparatus capable of regulating a refrigerant amount while achieving downsizing and weight reduction.

SUMMARY OF THE INVENTION

[0006] The present invention provides a refrigeration apparatus including: a refrigerator including a compressor and a heat exchanger configured to perform heat exchange of a refrigerant discharged from the compressor; a cooling apparatus including an evaporator and an inlet expansion valve disposed at an inlet of the evaporator; and a refrigerant regulating valve disposed at an outlet of the evaporator, the refrigerant regulating valve being configured to regulate a refrigerant flow rate.

[0007] With this configuration, a surplus refrigerant is stored inside the evaporator by regulating the refrigerant flow rate by the refrigerant regulating valve.

[0008] Thus, it is possible to regulate the refrigerant amount without providing a refrigerant amount regulating unit that regulates the refrigerant flow rate by storing the refrigerant, such as a refrigerant amount regulating tank, and achieve downsizing and weight reduction of the refrigerator.

[0009] According to the present invention, it is possible to regulate the refrigerant amount while achieving downsizing and weight reduction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a diagram showing a schematic configuration of a refrigerant circuit of a refrigeration apparatus according to an embodiment of the present invention;

Fig. 2 is a diagram showing a schematic configuration of the refrigeration apparatus;

Fig. 3 is a flowchart showing operation of the refrigeration apparatus; and

Fig. 4 is a diagram showing a schematic configuration of a refrigerant circuit of a refrigeration apparatus according to a modified example of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] A first invention provides a refrigeration apparatus including: a refrigerator including a compressor and a heat exchanger configured to perform heat exchange of a refrigerant discharged from the compressor; a cooling apparatus including an evaporator and an inlet expansion valve disposed at an inlet of the evaporator; and a refrigerant regulating valve disposed at an outlet of the evaporator, the refrigerant regulating valve being configured to regulate a refrigerant flow rate.

[0012] With this configuration, a surplus refrigerant is stored inside the evaporator by regulating the refrigerant flow rate by the refrigerant regulating valve.

[0013] Thus, the refrigeration apparatus can regulate the refrigerant amount without providing a refrigerant amount regulating unit that regulates the refrigerant flow rate by storing the refrigerant, such as a refrigerant amount regulating tank. That is, the refrigeration apparatus can eliminate the necessity of the refrigerant amount regulating tank and achieve downsizing and weight reduction of the refrigeration apparatus.

[0014] In a second invention, the refrigeration apparatus further includes an internal heat exchanger configured to exchange heat between the refrigerant discharged from the compressor and the refrigerant jetted from the refrigerant regulating valve.

[0015] With this configuration, the internal heat exchanger reliably takes a superheat degree from the refrigerant jetted from the refrigerant regulating valve, and the refrigerant is fed to the compressor. Thus, liquid back and liquid compression of the refrigerant in the compressor are prevented.

[0016] In a third invention, the refrigeration apparatus further includes a control unit configured to adjust an opening degree of the inlet expansion valve and an opening degree of the refrigerant regulating valve, and the control unit stores the refrigerant in the evaporator by reducing the opening degree of the refrigerant regulating valve.

[0017] With this configuration, the refrigeration apparatus adjusts the opening degree of the inlet expansion valve and the opening degree of the refrigerant regulating valve according to the refrigerant temperature of the evaporator.

[0018] Thus, when the refrigerant temperature of the evaporator drops below a predetermined value, it is possible to return the refrigerant temperature of the evaporator to a desired temperature by adjusting the opening degree of the inlet expansion valve and the opening degree of the refrigerant regulating valve.

[0019] In a fourth invention, the refrigeration apparatus further includes a temperature sensor configured to detect a refrigerant temperature at the inlet and the outlet of the evaporator, the control unit acquires a detection value of the temperature sensor and acquires a superheat degree of the refrigerant in the evaporator on the basis of the detection value, and the control unit reduces the opening degree of the refrigerant regulating valve when the superheat degree is equal to or higher than a predetermined value.

[0020] With this configuration, the control device opens or closes the refrigerant regulating valve according to the superheat degree of the evaporator.

[0021] Thus, an excessive reduction in the refrigerant temperature of the evaporator is prevented, which reduces frost formation on the evaporator.

[0022] In a fifth invention, the control unit acquires a temperature inside the cooling apparatus and a detection value of the temperature sensor and controls driving of the compressor on the basis of the temperature inside the cooling apparatus and the detection value, and the control unit reduces the opening degree of the refrigerant regulating valve when a driving frequency of the compressor is a minimum value.

[0023] With this configuration, the opening degree of the refrigerant regulating valve is adjusted in a state where the driving of the compressor is sufficiently suppressed.

[0024] Thus, in addition to inside temperature regulation performed by the compressor, an inside temperature can be regulated also by the refrigerant regulating valve.

[0025] In a sixth invention, the control unit acquires a refrigerant temperature of the compressor and a refrigerant temperature of the refrigerant regulating valve and stops driving of the compressor when a difference between the refrigerant temperature of the compressor and the refrigerant temperature of the refrigerant regulating valve is equal to or less than a predetermined value.

[0026] This prevents the refrigerant containing wet vapor from being taken into the compressor.

[0027] Thus, the occurrence of so-called liquid back and liquid compression in the refrigeration apparatus is prevented.

[0028] Hereinbelow, an embodiment of the present invention will be described with reference to the drawings.

[0029] Fig. 1 is a diagram showing a schematic configuration of a refrigerant circuit of a refrigeration apparatus 1 according to the embodiment of the present invention.

[0030] As shown in Fig. 1, the refrigeration apparatus 1 includes a refrigerator 10 which performs compression and heat exchange of a refrigerant and a showcase 20 which is cooled with the refrigerant fed from the refrigerator 10, the refrigerator 10 and the showcase 20 constituting a refrigeration cycle. The showcase 20 is, for example, a cooling apparatus that is installed in a facility such as a convenience store or a supermarket and cools chilled or frozen products displayed inside thereof. In the refrigeration apparatus 1 of the present embodiment, the refrigerator 10 and the showcase 20 are integrally provided.

[0031] The refrigeration apparatus 1 of the present embodiment uses, as the refrigerant, carbon dioxide which brings a refrigerant pressure at the high-pressure side (high-pressure side pressure) equal to or higher than a critical pressure (supercritical). Although carbon dioxide is used as the refrigerant in the present embodiment, the refrigerant is not limited thereto, and various refrigerants may also be used.

[0032] The refrigerator 10 includes a compressor 30 which compresses the refrigerant to a required pressure and discharges the refrigerant. A refrigerant pipe 80 is connected to a discharge port of the compressor 30, and a gas cooler 32 is connected to the compressor 30 through the refrigerant pipe 80.

[0033] The gas cooler 32 functions as a heat exchanger that cools the refrigerant fed from the compressor 30 by heat exchange with outside air by operating an air blowing fan 34 included in the refrigerator 10. Note that when a condensable refrigerant is used as the refrigerant in the refrigeration apparatus 1, the gas cooler 32 functions as a condenser.

[0034] The refrigerator 10 includes an internal heat exchanger 36. A refrigerant pipe 80 extending from the outlet side of the gas cooler 32 and a refrigerant pipe 80 connected to a suction port of the compressor 30 are housed in the internal heat exchanger 36. The internal heat exchanger 36 increases the temperature of the refrigerant sucked into the compressor 30 by exchanging heat between these two refrigerant pipes 80, thereby improving the operation efficiency of the refrigeration apparatus 1 and preventing the occurrence of liquid back and liquid compression. Hereinbelow, the temperature of the refrigerant sucked into the compressor 30 is referred to as a suction temperature.

[0035] An outlet service valve 38 for feeding the refrigerant to the showcase 20 is connected to the refrigerant pipe 80 at the outlet side of the gas cooler 32 at a position located downstream of a part housed in the internal heat exchanger 36.

[0036] On the other hand, an inlet service valve 39 for returning the refrigerant from the showcase 20 is connected to the refrigerant pipe 80 connected to the suction port of the compressor 30 at a position located upstream of a part housed in the internal heat exchanger 36. The

inlet service valve 39 is connected to the suction port of the compressor 30 through the refrigerant pipe 80.

[0037] The showcase 20 includes an evaporator 40, an inlet expansion valve 42, an outlet regulating valve 44, and an air blowing fan 46. An inlet of the evaporator 40 is connected to the outlet service valve 38 through a refrigerant pipe 80. The refrigerant pipe 80 connecting the evaporator 40 and the outlet service valve 38 is provided with the inlet expansion valve 42. The inlet expansion valve 42 of the present embodiment is an electronic expansion valve that controls the refrigerant flow rate and controls the evaporation temperature of the refrigerant by opening and closing a valve through driving of a motor, that is, a so-called motor-operated valve. The opening degree of the inlet expansion valve 42 is steplessly adjustable, and the evaporation temperature of the refrigerant in the inlet expansion valve 42, that is, the refrigerant temperature at the inlet of the evaporator 40 can be regulated by adjusting the opening degree of the inlet expansion valve 42.

[0038] The evaporator 40 exchanges heat between the refrigerant fed through the refrigerant pipe 80 and air inside the showcase 20, thereby cooling the inside of the showcase 20.

[0039] Air (cold air) cooled by the evaporator 40 is circulated by the air blowing fan 46.

[0040] An outlet of the evaporator 40 is connected to the inlet service valve 39 through a refrigerant pipe 80. The refrigerant pipe 80 connecting the evaporator 40 and the inlet service valve 39 is provided with the outlet regulating valve 44.

[0041] The outlet regulating valve 44 is a motor-operated valve that is substantially identical to the inlet expansion valve 42 and functions as the refrigerant regulating valve that regulates the refrigerant flow rate. The outlet regulating valve 44 controls the refrigerant flow rate by opening and closing a valve through driving of a motor. The opening degree of the outlet regulating valve 44 is steplessly adjustable, and the superheat degree of the refrigerant in the evaporator 40, that is, a refrigerant temperature difference between the inlet and the outlet of the evaporator 40 can be regulated by adjusting the opening degree of the outlet regulating valve 44.

[0042] The refrigerant pipe 80 located at the suction side of the compressor 30 is provided with a suction temperature sensor 50 which detects the temperature of the refrigerant sucked into the compressor 30.

[0043] The refrigerant pipe 80 connected to the inlet of the evaporator 40 is provided with an inlet temperature sensor 52, and the refrigerant pipe 80 connected to the outlet of the evaporator 40 is provided with an outlet temperature sensor 54. More specifically, the inlet temperature sensor 52 is disposed between the inlet expansion valve 42 and the inlet of the evaporator 40, and the outlet temperature sensor 54 is disposed between the outlet of the evaporator 40 and the outlet regulating valve 44.

[0044] The inlet temperature sensor 52 detects the refrigerant temperature at the inlet of the evaporator 40, and the outlet temperature sensor 54 detects the refrigerant temperature at the outlet of the evaporator 40.

[0045] The refrigerant pipe 80 connected to an outlet of the outlet regulating valve 44 is provided with a regulating valve outlet temperature sensor 56. More specifically, the regulating valve outlet temperature sensor 56 is disposed between the outlet of the outlet regulating valve 44 and an inlet of the inlet service valve 39.

[0046] The regulating valve outlet temperature sensor 56 detects the refrigerant temperature at the outlet of the outlet regulating valve 44.

[0047] Furthermore, the showcase 20 is provided with an inside temperature sensor 58 which detects the temperature inside the showcase 20. Hereinbelow, the temperature inside the showcase 20 is referred to as the inside temperature.

[0048] Furthermore, the refrigerant pipe 80 connected to the inlet of the outlet regulating valve 44 is provided with a regulating valve inlet pressure sensor 60, and the refrigerant pipe 80 connected to the outlet of the outlet regulating valve 44 is provided with a regulating valve outlet pressure sensor 62. More specifically, the regulating valve inlet pressure sensor 60 is disposed between the outlet of the evaporator 40 and the inlet of the outlet regulating valve 44 as with the outlet temperature sensor 54, and the regulating valve outlet pressure sensor 62 is disposed between the outlet of the outlet regulating valve 44 and the inlet of the inlet service valve 39 as with the regulating valve outlet temperature sensor 56.

[0049] The regulating valve inlet pressure sensor 60 detects the refrigerant pressure at the inlet of the evaporator 40, and the regulating valve outlet pressure sensor 62 detects the refrigerant pressure at the outlet of the evaporator 40.

[0050] Next, a control configuration of the present embodiment will be described.

[0051] Fig. 2 is a diagram showing a schematic configuration of the refrigeration apparatus 1 in the present embodiment.

[0052] As shown in Fig. 2, in the present embodiment, the refrigeration apparatus 1 includes a control device 70 which performs centralized control of the refrigeration apparatus 1. The control device 70 includes a computer including a processor, such as a CPU or an MPU, and a memory device, such as a ROM or a RAM, and functions as the control unit that controls each part of the refrigeration apparatus 1.

[0053] The control device 70 includes a storage unit 72 which stores various data items related to operation of the refrigeration apparatus 1 such as various setting conditions related to a method for controlling the operation of the refrigeration apparatus 1 and the relationship between the pressure and the saturation temperature of the refrigerant.

[0054] The control device 70 is capable of acquiring detection values detected by the suction temperature sensor 50, the inlet temperature sensor 52, the outlet temperature sensor 54, the regulating valve outlet tem-

perature sensor 56, the inside temperature sensor 58, the regulating valve inlet pressure sensor 60, and the regulating valve outlet pressure sensor 62. The control device 70 controls the driving frequency of the compressor 30, the rotation speed of each of the air blowing fans 34, 46, the opening degree of the inlet expansion valve 42, and the opening degree of the outlet regulating valve 44 on the basis of the detection values acquired from these sensors and the setting conditions stored in the storage unit 72.

[0055] The control device 70 of the present embodiment acquires detections values of the inlet temperature sensor 52 and the outlet temperature sensor 54 and obtains the superheat degree of the refrigerant in the evaporator 40 from these detection values.

[0056] The control device 70 controls the driving frequency of the compressor 30 and the opening degree of the inlet expansion valve 42 so that the superheat degree becomes a predetermined value stored in the storage unit 72.

[0057] Furthermore, the control device 70 acquires an actual temperature inside the showcase 20 by inputting a detection value of the inside temperature sensor 58 and determines whether the cooling capacity of the refrigeration apparatus 1 exceeds the refrigeration load thereof. When it is determined that the driving frequency of the compressor 30 is a minimum value and the cooling capacity of the refrigeration apparatus 1 exceeds the refrigeration load of the refrigeration apparatus 1, the control device 70 performs a refrigerant amount regulating operation.

[0058] The refrigerant amount regulating operation is an operation of storing a surplus refrigerant inside the evaporator 40 when the cooling capacity of the refrigeration apparatus 1 exceeds the refrigeration load thereof. Specifically, the opening degree of the outlet regulating valve 44 is reduced to reduce an outflow rate of the refrigerant flowing out of the evaporator 40, and the opening degree of the inlet expansion valve 42 is increased to increase an inflow rate of the refrigerant flowing into the evaporator 40. Accordingly, the surplus refrigerant is stored inside the evaporator 40.

[0059] Furthermore, in the refrigerant amount regulating operation, the control device 70 controls the opening degree of the inlet expansion valve 42 so that the evaporation temperature of the refrigerant in the inlet expansion valve 42 becomes a predetermined value.

[0060] Furthermore, the control device 70 controls the opening degree of the outlet regulating valve 44 so that the superheat degree of the refrigerant in the evaporator 40 becomes the predetermined value.

[0061] In this manner, the control device 70 regulates the refrigerant temperature so that the superheat degree of the refrigerant in the evaporator 40 becomes the predetermined value stored in the storage unit 72.

[0062] Note that, in the present embodiment, the control device 70 sets the opening degree of the outlet regulating valve 44 to full open except when the refrigerant amount regulating operation is performed, that is, when the refrigeration apparatus 1 performs a normal cooling operation.

[0063] Furthermore, the control device 70 acquires detection values of the suction temperature sensor 50 and the regulating valve outlet temperature sensor 56 and stops the operation of the compressor 30 when the difference between the acquired detection values is equal to or less than a predetermined value.

[0064] This prevents the occurrence of so-called liquid back in the compressor 30.

[0065] Next, operation of the present embodiment will be described.

[0066] Fig. 3 is a flowchart illustrating the operation of the refrigeration apparatus 1.

[0067] In the normal cooling operation of the refrigeration apparatus 1, the control device 70 drives the compressor 30 which constitutes a part of the refrigeration cycle, and the refrigerant is discharged from the compressor 30. The discharged refrigerant is cooled by the gas cooler 32 and then fed out to the showcase 20 through the refrigerant pipe 80. The refrigerant is decompressed by the inlet expansion valve 42 and supplied to the evaporator 40. The refrigerant evaporated in the evaporator 40 cools the inside of the showcase 20 and returns to the compressor 30.

[0068] In the normal cooling operation of the refrigeration apparatus 1, the control device 70 acquires detection values of the inlet temperature sensor 52 and the outlet temperature sensor 54 and obtains the superheat degree of the refrigerant in the evaporator 40 from these detection values.

[0069] The control device 70 controls the driving frequency of the compressor 30 and the opening degree of the inlet expansion valve 42 so that the superheat degree becomes the predetermined value stored in the storage unit 72, thereby regulating the superheat degree to be obtained. In this manner, the control device 70 regulates the inside temperature of the showcase 20 to a set predetermined value.

[0070] Note that, as described above, in the normal cooling operation of the refrigeration apparatus 1, the outlet regulating valve 44 is fully open.

[0071] In the normal cooling operation of the refrigeration apparatus 1, the control device 70 determines whether the inside temperature is equal to or lower than the predetermined value (step ST1). When it is determined that the inside temperature is equal to or lower than the predetermined value, that is, when the cooling capacity of the refrigeration apparatus 1 exceeds the refrigeration load of the refrigeration apparatus (step ST1: YES), the control device 70 reduces the driving frequency of the compressor 30 (step ST2).

[0072] After reducing the driving frequency of the compressor 30, the control device 70 again determines whether the inside temperature is equal to or lower than the predetermined value (step ST3). When it is determined that the inside temperature is not equal to or lower

than the predetermined value (step ST3: NO), the control device 70 stops the reduction of the driving frequency of the compressor 30 (step ST11) and returns the refrigeration apparatus 1 to the normal cooling operation.

[0073] When it is determined that the inside temperature is equal to or lower than the predetermined value (step ST3: YES), the control device 70 determines whether the driving frequency of the compressor 30 is the minimum value (step ST4).

[0074] When it is determined that the driving frequency of the compressor 30 is not the minimum value (step ST4: NO), the control device 70 again reduces the driving frequency of the compressor 30 (step ST2) and again determines whether the inside temperature is equal to or lower than the predetermined value (step ST3).

[0075] When it is determined that the driving frequency of the compressor 30 is a minimum driving frequency which is the minimum value (step ST4: YES), the control device 70 determines whether a predetermined time has passed after the compressor 30 reaching the minimum driving frequency (step ST5). When it is determined that the predetermined time has not passed (step ST5: NO), the control device 70 again performs the determination of step ST5 after a predetermined interval.

[0076] When it is determined that the predetermined time has passed (step ST5: YES), the control device 70 again determines whether the inside temperature is equal to or lower than the predetermined value (step ST6).

[0077] When it is determined that the inside temperature is not equal to or lower than the predetermined value (step ST6: NO), the control device 70 stops the reduction of the driving frequency of the compressor 30 (step ST11) and returns the refrigeration apparatus 1 to the normal cooling operation.

[0078] When it is determined that the inside temperature is equal to or lower than the predetermined value (step ST6: YES), the control device 70 performs the refrigerant amount regulating operation.

[0079] Specifically, the opening degree of the outlet regulating valve 44 is reduced to reduce the outflow rate of the refrigerant flowing out of the evaporator 40, and the opening degree of the inlet expansion valve 42 is increased to increase the inflow rate of the refrigerant flowing into the evaporator 40 (step ST7). Accordingly, the surplus refrigerant is stored inside the evaporator 40.

[0080] As described above, in addition to storing the surplus refrigerant inside the evaporator 40, the control device 70 controls the opening degree of the inlet expansion valve 42 so that the evaporation temperature of the refrigerant in the inlet expansion valve 42 becomes the predetermined value. Furthermore, the control device 70 controls the opening degree of the outlet regulating valve 44 so that the superheat degree of the refrigerant in the evaporator 40 becomes the predetermined value.

[0081] In this manner, the control device 70 regulates the refrigerant temperature so that the superheat degree of the refrigerant in the evaporator 40 becomes the predetermined value stored in the storage unit 72.

[0082] The control device 70 acquires detection values of the suction temperature sensor 50 and the regulating valve outlet temperature sensor 56 while adjusting the opening degree of the outlet regulating valve 44 and the opening degree of the inlet expansion valve 42 in this manner. That is, the control device 70 acquires the suction temperature and the refrigerant temperature at the outlet of the outlet regulating valve 44. Then, the control device 70 determines whether the difference between these temperature values is equal to or less than the predetermined value (step ST8). When it is determined that the difference between the suction temperature and the refrigerant temperature at the outlet of the outlet regulating valve 44 is equal to or less than the predetermined value (step ST8: YES), the control device 70 stops the operation of the compressor 30 (step ST9). This prevents the occurrent of liquid back in the compressor 30.

[0083] When it is determined that the difference between the suction temperature and the refrigerant temperature at the outlet of the outlet regulating valve 44 is not equal to or less than the predetermined value (step ST8: NO), the control device 70 again acquires the saturation temperature from a detection value of the regulating valve inlet pressure sensor 60 and acquires the refrigerant temperature in the evaporator 40 from detection values of the inlet temperature sensor 52 and the outlet temperature sensor 54. Then, the control device 70 determines whether the superheat degree of the refrigerant in the evaporator 40 has become the predetermined value (step ST10).

[0084] When it is determined that the superheat degree of the refrigerant in the evaporator 40 has not become the predetermined value (step ST10: NO), the control device 70 again adjusts the opening degree of the outlet regulating valve 44 and the opening degree of the inlet expansion valve 42 so that the superheat degree becomes the predetermined value (step ST7).

[0085] When it is determined that the superheat degree of the refrigerant in the evaporator 40 has become the predetermined value (step ST10: YES), the control device 70 returns the refrigeration apparatus 1 to the normal cooling operation.

[0086] The refrigeration apparatus 1 can store the surplus refrigerant inside the evaporator 40 by performing the refrigerant amount regulating operation in this manner. Thus, the refrigeration apparatus 1 can regulate the refrigerant amount without providing a refrigerant amount regulating tank (receiver tank). That is, the refrigeration apparatus 1 can eliminate the necessity of the refrigerant amount regulating tank and achieve downsizing and weight reduction of the refrigerator 10.

[0087] Furthermore, the refrigerant jetted from the outlet regulating valve 44 exchanges heat with the refrigerant discharged from the compressor 30 in the internal heat exchanger 36. The internal heat exchanger 36 reliably takes a superheat degree from the refrigerant jetted from the outlet regulating valve 44, and the refrigerant is

fed to the compressor 30. Thus, liquid back and liquid compression of the refrigerant in the compressor 30 are prevented.

[0088] Furthermore, in the refrigerant amount regulating operation, the opening degree of the inlet expansion valve 42 and the opening degree of the outlet regulating valve 44 are controlled, thereby regulating the refrigerant temperature so that the superheat degree of the refrigerant in the evaporator 40 becomes the predetermined value stored in the storage unit 72.

[0089] This prevents an excessive reduction in the refrigerant temperature in the evaporator 40. Thus, frost formation on the evaporator 40 is reduced, which suppresses execution of a so-called defrosting operation. That is, it is possible to prevent a rise in the inside temperature of the showcase 20 caused by executing the defrosting operation.

[0090] As described above, according to the present embodiment, the refrigeration apparatus 1 includes the refrigerator 10 which includes the compressor 30 and the gas cooler 32, the showcase 20 which includes the evaporator 40 and the inlet expansion valve 42 disposed at the inlet of the evaporator 40, and the outlet regulating valve 44 disposed at the outlet of the evaporator 40.

[0091] With this configuration, it is possible to store the surplus refrigerant inside the evaporator 40 by regulating the refrigerant flow rate by opening or closing the outlet regulating valve 44.

[0092] Thus, the refrigeration apparatus 1 can regulate the refrigerant amount without providing a refrigerant amount regulating unit such as a refrigerant amount regulating tank (receiver tank). That is, the refrigeration apparatus 1 can eliminate the necessity of the refrigerant amount regulating tank and achieve downsizing and weight reduction of the refrigerator 10.

[0093] According to the present embodiment, the refrigerant jetted from the outlet regulating valve 44 exchanges heat with the refrigerant discharged from the compressor 30 at the internal heat exchanger 36. The internal heat exchanger 36 reliably takes a superheat degree from the refrigerant jetted from the outlet regulating valve 44, and the refrigerant is fed to the compressor 30. Thus, liquid back and liquid compression of the refrigerant in the compressor 30 are prevented.

[0094] According to the present embodiment, the refrigeration apparatus 1 includes the inlet temperature sensor 52 and the outlet temperature sensor 54 which detect the refrigerant temperature in the evaporator 40 and the regulating valve inlet pressure sensor 60 which detects the refrigerant pressure. The control device 70 acquires detection values of the inlet temperature sensor 52 and the outlet temperature sensor 54 and adjusts the opening degree of the inlet expansion valve 42 and the opening degree of the outlet regulating valve 44 on the basis of the detection values.

[0095] In this manner, the refrigeration apparatus 1 adjusts the opening degree of the inlet expansion valve 42 and the opening degree of the outlet regulating valve 44 according to the refrigerant temperature of the evaporator 40.

[0096] Thus, when the refrigerant temperature of the evaporator 40 drops below the predetermined value, it is possible to return the refrigerant temperature of the evaporator 40 to a desired temperature by adjusting the opening degree of the inlet expansion valve 42 and the opening degree of the outlet regulating valve 44.

[0097] According to the present embodiment, the control device 70 acquires detection values of the inlet temperature sensor 52 and the outlet temperature sensor 54 and acquires the superheat degree of the refrigerant of the evaporator 40 on the basis of the detection values. Then, the control device 70 adjusts the opening degree of the outlet regulating valve 44 when the superheat degree is equal to or higher than the predetermined value.

[0098] In this manner, the control device 70 opens or closes the outlet regulating valve 44 according to the superheat degree of the evaporator 40.

[0099] Thus, an excessive reduction in the refrigerant temperature of the evaporator 40 is prevented, which reduces frost formation on the evaporator 40.

[0100] According to the present embodiment, the control device 70 acquires the inside temperature of the showcase 20 and detection values of the inlet temperature sensor 52, the outlet temperature sensor 54, and the regulating valve inlet pressure sensor 60, and controls driving of the compressor 30 on the basis of the inside temperature and the detection values. The control device 70 adjusts the opening degree of the outlet regulating valve 44 when the driving frequency of the compressor 30 is the minimum value.

[0101] With this configuration, the opening degree of the outlet regulating valve 44 is adjusted in a state where the driving of the compressor 30 is sufficiently suppressed.

[0102] Thus, in addition to the inside temperature regulation performed by the compressor 30, the inside temperature can be regulated also by the outlet regulating valve 44.

[0103] According to the present embodiment, the control device 70 acquires the refrigerant temperature of the compressor 30 and the refrigerant temperature of the outlet regulating valve 44 and stops the driving of the compressor 30 when the difference between the refrigerant temperature of the compressor 30 and the refrigerant temperature of the outlet regulating valve 44 is equal to or less than the predetermined value.

[0104] This prevents the refrigerant containing wet vapor from being taken into the compressor 30.

[0105] Thus, the occurrence of so-called liquid back and liquid compression in the refrigeration apparatus 1 is prevented.

[0106] The above embodiment describes, as an example, one aspect of the present invention, and any modifications and applications can be made without departing from the gist of the present invention.

[0107] Although, in the above embodiment, the refrig-

eration apparatus 1 has a configuration in which one showcase 20 is connected to one refrigerator 10, the present invention is not limited thereto. For example, as shown in Fig. 4, two or more showcases may be provided. Note that the sensors are not illustrated in Fig. 4.

[0108] Although, in the above embodiment, the internal heat exchanger 36 is provided, the present invention is not limited thereto. For example, an accumulator may be provided.

[0109] Although, in the refrigeration apparatus 1 of the present embodiment, the refrigerator 10 and the showcase 20 are integrally provided, the present invention is not limited thereto. For example, the refrigerator 10 and the showcase 20 may be separately installed.

[0110] As described above, the refrigeration apparatus according to the present invention is suitably usable as a refrigeration apparatus aimed at downsizing and weight reduction as a whole.

Reference Signs List

[0111]

1	refrigeration apparatus
10	refrigerator
20	showcase (cooling apparatus)
30	compressor
32	gas cooler (heat exchanger)
36	internal heat exchanger
40	evaporator
42	inlet expansion valve
44	outlet regulating valve (refrigerant regulating valve)
46	air blowing fan
50	suction temperature sensor (temperature sensor)
52	inlet temperature sensor (temperature sensor)
54	outlet temperature sensor (temperature sensor)
56	regulating valve outlet temperature sensor (temperature sensor)
58	inside temperature sensor (temperature sensor)
60	regulating valve inlet pressure sensor (pressure sensor)
62	regulating valve outlet pressure sensor (pressure sensor)
70	control device (control unit)
80	refrigerant pipe

Claims

1. A refrigeration apparatus comprising:

a refrigerator (10) including a compressor (30) and a heat exchanger (34) configured to perform heat exchange of a refrigerant discharged from the compressor; and
a cooling apparatus (20) including an evaporator (40) and an inlet expansion valve (42) disposed at an inlet of the evaporator, **characterized by** comprising
a refrigerant regulating valve (44) disposed at an outlet of the evaporator, the refrigerant regulating valve being configured to regulate a refrigerant flow rate.

2. The refrigeration apparatus according to claim 1, further comprising an internal heat exchanger (36) configured to exchange heat between the refrigerant discharged from the compressor and the refrigerant jetted from the refrigerant regulating valve.

3. The refrigeration apparatus according to claim 1, further comprising a control unit (70) configured to adjust an opening degree of the inlet expansion valve and an opening degree of the refrigerant regulating valve, wherein the control unit stores the refrigerant in the evaporator by reducing the opening degree of the refrigerant regulating valve.

4. The refrigeration apparatus according to claim 3, further comprising a temperature sensor configured to detect a refrigerant temperature at the inlet and the outlet of the evaporator, wherein
the control unit acquires a detection value of the temperature sensor and acquires a superheat degree of the refrigerant in the evaporator on the basis of the detection value, and
the control unit reduces the opening degree of the refrigerant regulating valve when the superheat degree is equal to or higher than a predetermined value.

5. The refrigeration apparatus according to claim 4, wherein
the control unit acquires a temperature inside the cooling apparatus and a detection value of the temperature sensor and controls driving of the compressor on the basis of the temperature inside the cooling apparatus and the detection value, and
the control unit reduces the opening degree of the refrigerant regulating valve when a driving frequency of the compressor is a minimum value.

6. The refrigeration apparatus according to any one of claims 3 to 5, wherein the control unit acquires a refrigerant temperature of the compressor and a refrigerant temperature of the refrigerant regulating valve and stops driving of the compressor when a difference between the refrigerant temperature of the compressor and the refrigerant temperature of the refrigerant regulating valve is equal to or less than a predetermined value.

FIG.1

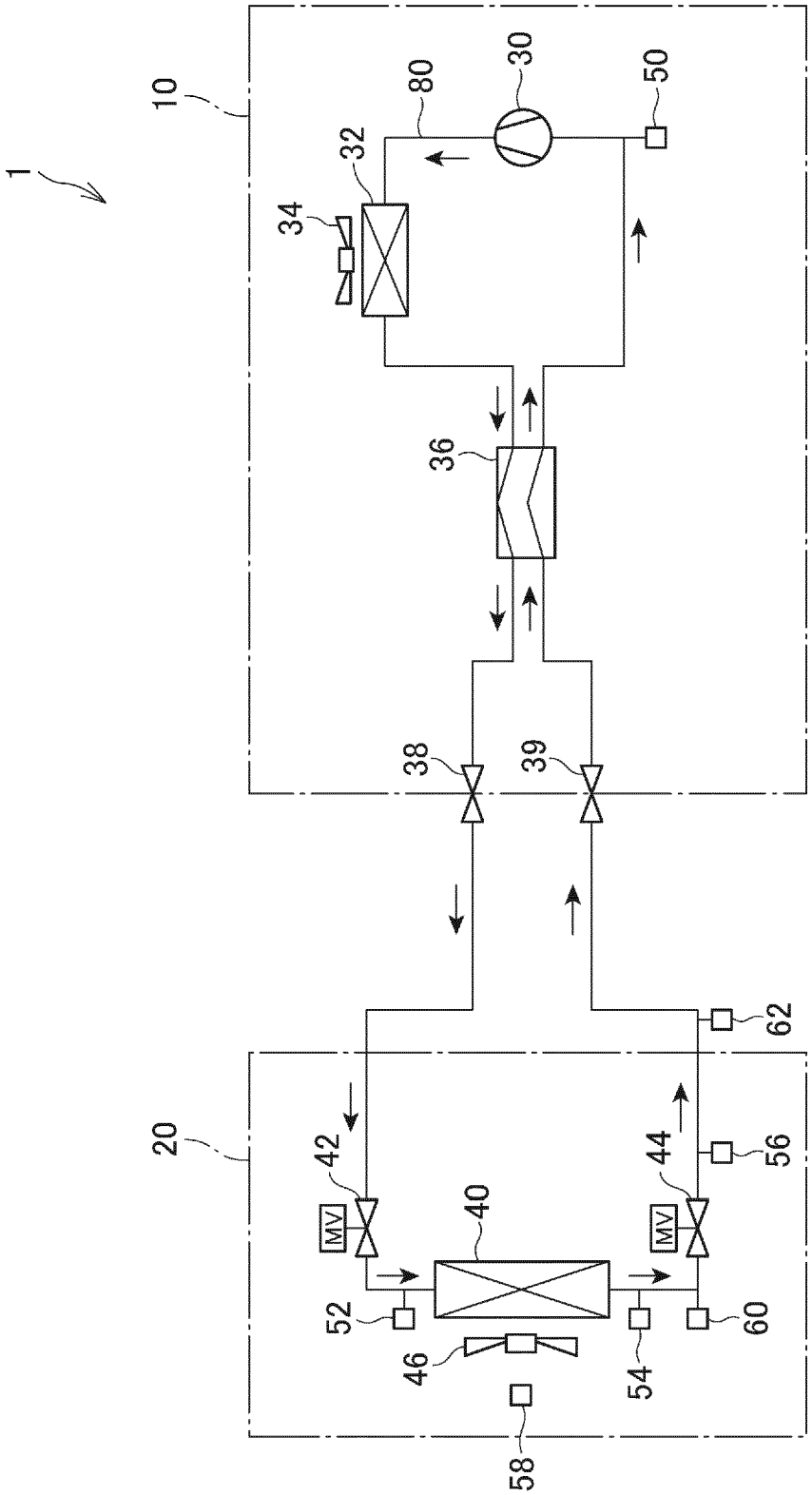


FIG.2

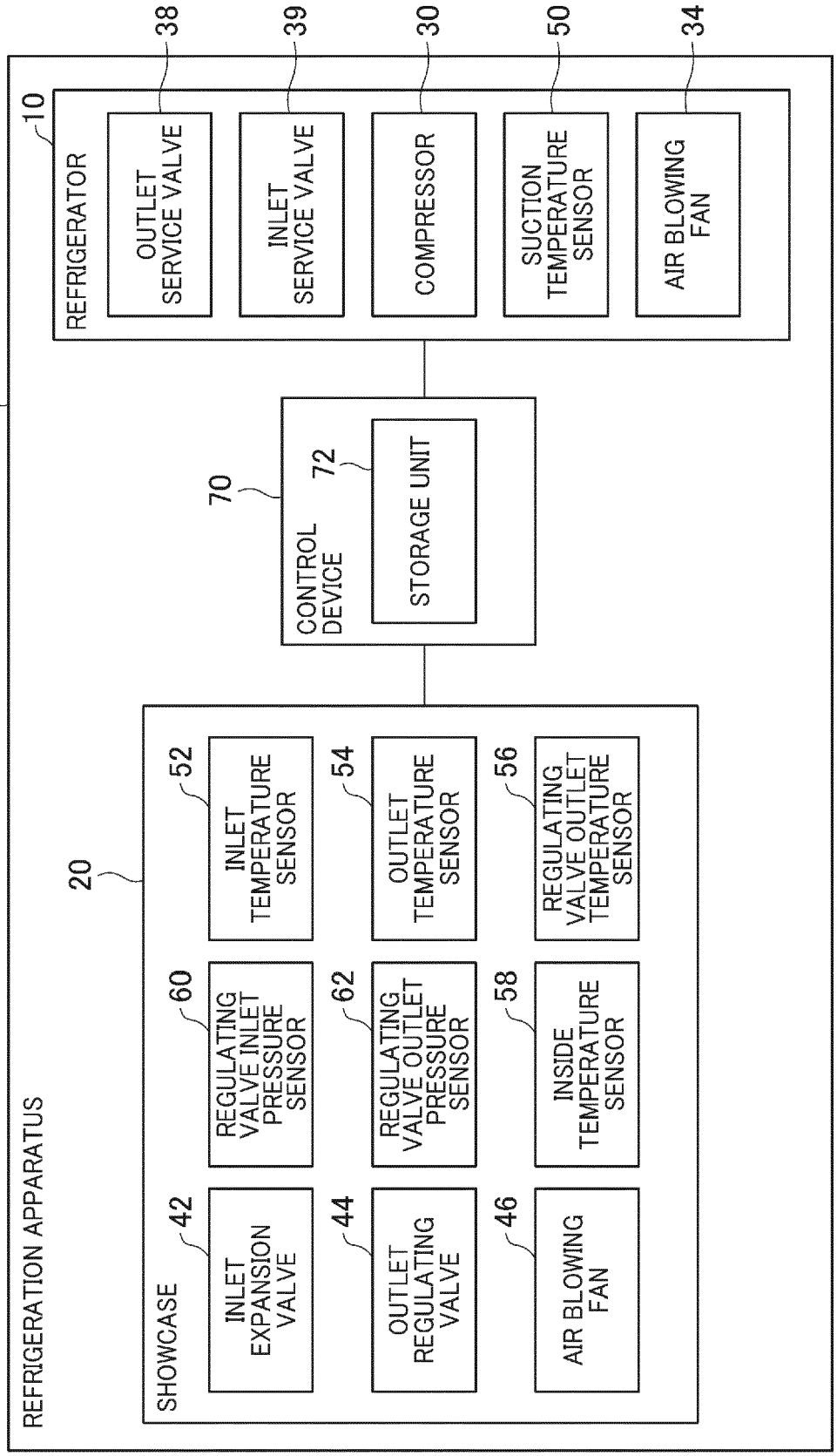

1
REFRIGERATION APPARATUS
10
REFRIGERATOR
38
OUTLET SERVICE VALVE
39
INLET SERVICE VALVE
30
COMPRESSOR
50
SUCTION TEMPERATURE SENSOR
34
AIR BLOWING FAN
70
CONTROL DEVICE
72
STORAGE UNIT
20
SHOWCASE
42
INLET EXPANSION VALVE
44
OUTLET REGULATING VALVE
46
AIR BLOWING FAN
60
REGULATING VALVE INLET PRESSURE SENSOR
62
REGULATING VALVE OUTLET PRESSURE SENSOR
58
INSIDE TEMPERATURE SENSOR
52
INLET TEMPERATURE SENSOR
54
OUTLET TEMPERATURE SENSOR
56
REGULATING VALVE OUTLET TEMPERATURE SENSOR

FIG.3

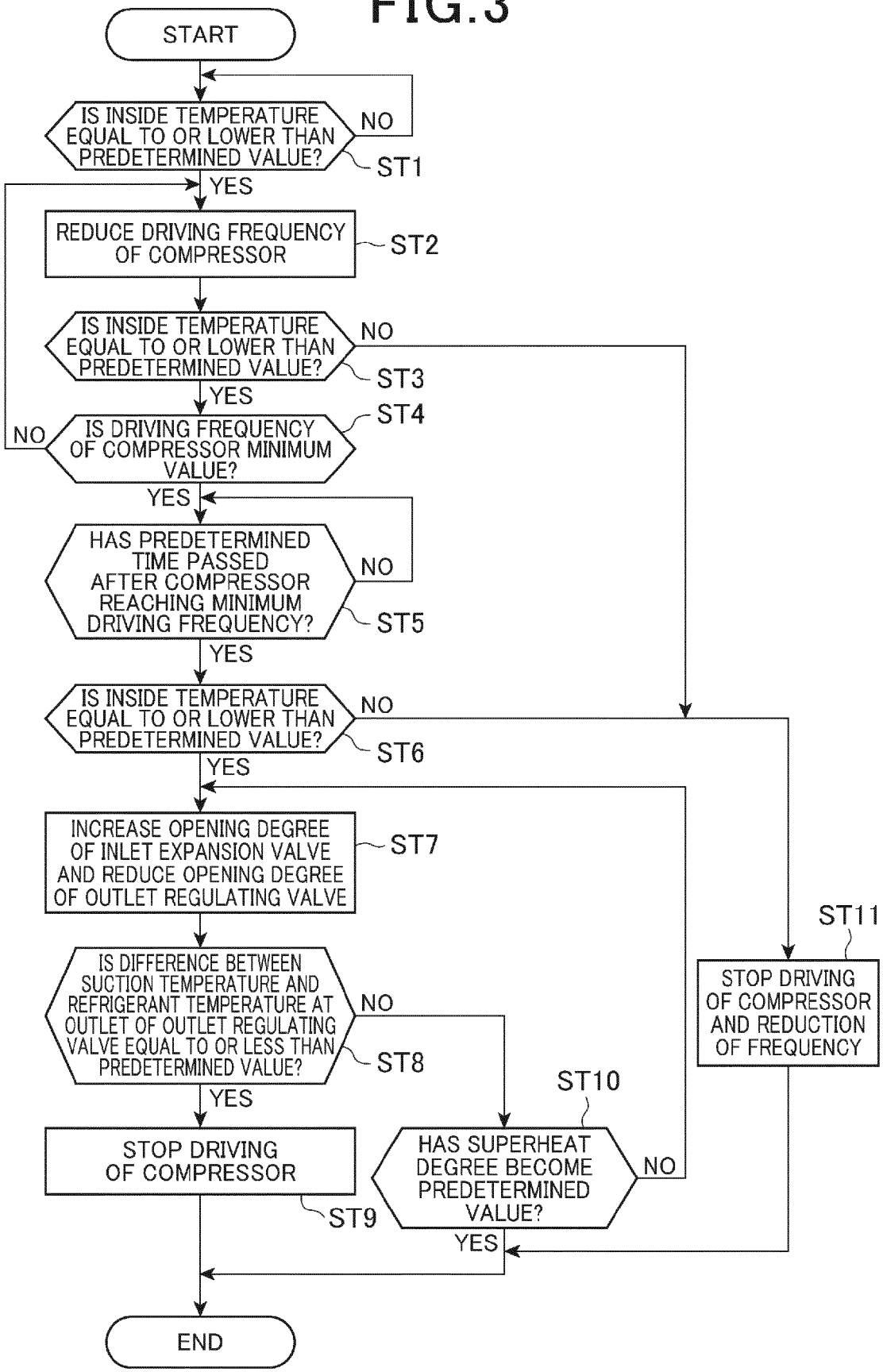
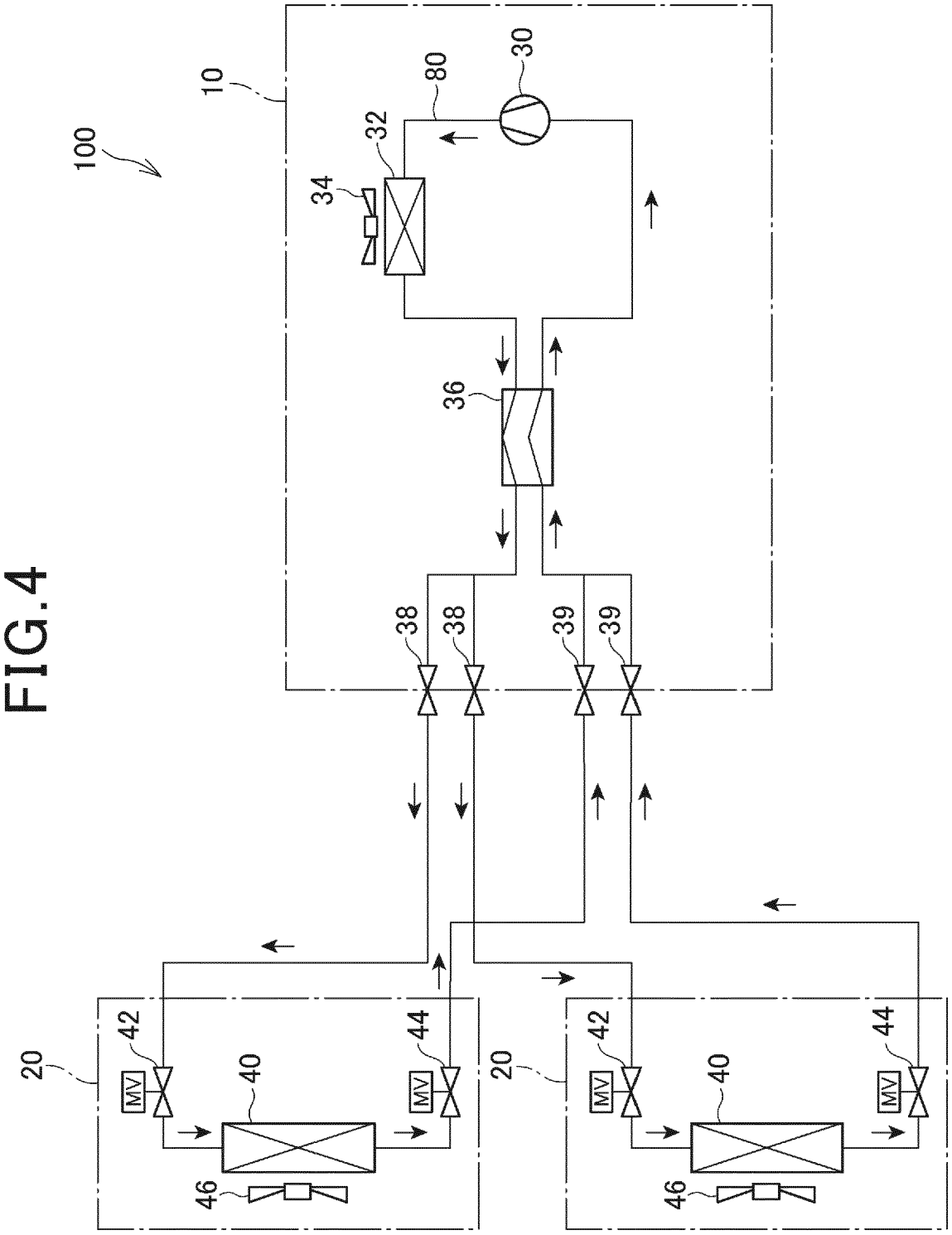

START
IS INSIDE TEMPERATURE EQUAL TO OR LOWER THAN PREDETERMINED VALUE?
NO
ST1
YES
REDUCE DRIVING FREQUENCY OF COMPRESSOR
ST2
IS INSIDE TEMPERATURE EQUAL TO OR LOWER THAN PREDETERMINED VALUE?
NO
ST3
YES
IS DRIVING FREQUENCY OF COMPRESSOR MINIMUM VALUE?
ST4
NO
YES
HAS PREDETERMINED TIME PASSED AFTER COMPRESSOR REACHING MINIMUM DRIVING FREQUENCY?
NO
ST5
YES
IS INSIDE TEMPERATURE EQUAL TO OR LOWER THAN PREDETERMINED VALUE?
NO
ST6
YES
INCREASE OPENING DEGREE OF INLET EXPANSION VALVE AND REDUCE OPENING DEGREE OF OUTLET REGULATING VALVE
ST7
IS DIFFERENCE BETWEEN SUCTION TEMPERATURE AND REFRIGERANT TEMPERATURE AT OUTLET OF OUTLET REGULATING VALVE EQUAL TO OR LESS THAN PREDETERMINED VALUE?
NO
ST8
YES
STOP DRIVING OF COMPRESSOR
ST9
HAS SUPERHEAT DEGREE BECOME PREDETERMINED VALUE?
ST10
NO
YES
STOP DRIVING OF COMPRESSOR AND REDUCTION OF FREQUENCY
ST11
END

FIG.4


100
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MV
MV
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42
40
44
MV
MV
46

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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 6006

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Y	* page 3, line 15 - line 26; figure 1 *	2	
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F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 June 2021	Gasper, Ralf

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