



(11)

EP 4 556 818 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.05.2025 Bulletin 2025/21

(51) International Patent Classification (IPC):
F25B 41/22 ^(2021.01) **F25B 49/02** ^(2006.01)

(21) Application number: **24212649.8**

(52) Cooperative Patent Classification (CPC):
F25B 41/22; F25B 49/02; F25B 2600/2513;
F25B 2600/2515; F25B 2700/1933; F25B 2700/197;
F25B 2700/2117

(22) Date of filing: **13.11.2024**

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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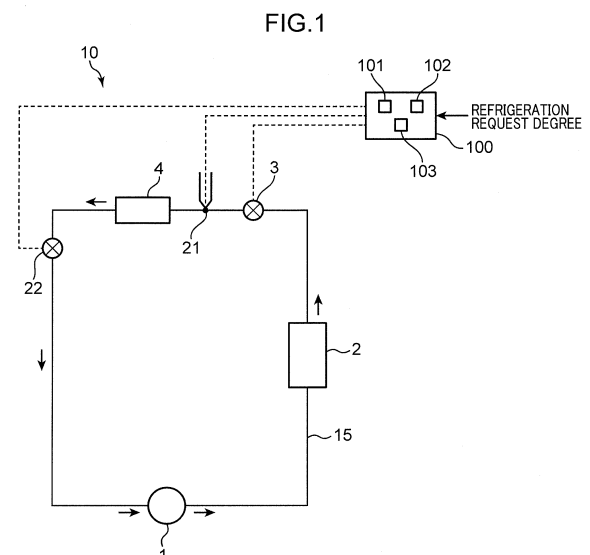
(30) Priority: **20.11.2023 JP 2023196739**

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(54) **REFRIGERATION DEVICE, ENVIRONMENT FORMING DEVICE, AND REFRIGERATION METHOD**

(57) A refrigeration device (10) includes: a refrigeration circuit (15) in which a compressor (1), a condenser (2), an expansion valve (3), an evaporator (4), and a flow rate adjustment valve (22) are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant; a valve control unit (103) that controls the expansion valve and the flow rate adjustment valve; and a target value changing unit (102) that changes a target value of an evaporation temperature or an evaporation pressure in the evaporator. The valve control unit controls a first one of the expansion valve and the flow rate adjustment valve based on the target value changed by the target value changing unit, and controls a second one of the expansion valve and the flow rate adjustment valve in accordance with a refrigeration request degree or a temperature of a cooling object.



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Description

Field of the Invention

[0001] The present invention relates to a refrigeration device, an environment forming device, and a refrigeration method.

Background Art

[0002] Conventionally, as disclosed in JP H2-97865 A, a refrigeration device in which a pressure regulating valve is provided on a downstream side of an evaporator in a refrigeration circuit is known. The pressure regulating valve is a spring-type pressure regulating valve. The pressure regulating valve can maintain a refrigerant pressure in the evaporator at a certain value or more. As a result, it is possible to suppress occurrence of freezing (frosting) at a fin portion of the evaporator.

[0003] The pressure regulating valve disclosed in JP H2-97865 A is of a spring type, and is provided to maintain the refrigerant pressure in the evaporator at a certain value or more. By providing such a spring-type pressure regulating valve on the downstream side of the evaporator, it is possible to suppress frost formation on the evaporator. On the other hand, since the refrigerant pressure in the evaporator is fixed to a certain value or more by the pressure regulating valve, there is a problem that the refrigeration device disclosed in JP H2-97865 A cannot operate flexibly. For example, when the temperature of a room air flowing into the evaporator is high, the problem of frost formation hardly occurs, so that it is not necessary to maintain the refrigerant pressure in the evaporator at a certain value or more.

Summary of the Invention

[0004] An object of the present invention is to enable more flexible operation while suppressing frost formation on the evaporator.

[0005] A refrigeration device according to one aspect of the present invention includes: a refrigeration circuit in which a compressor, a condenser, an expansion valve, an evaporator, and a flow rate adjustment valve are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant; a valve control unit configured to control the expansion valve and the flow rate adjustment valve; and a target value changing unit for changing a target value of an evaporation temperature or an evaporation pressure in the evaporator. The valve control unit is configured to control a first one of the expansion valve and the flow rate adjustment valve based on the target value changed by the target value changing unit, and to control a second one of the expansion valve and the flow rate adjustment valve in accordance with a refrigeration request degree or a temperature of a cooling object.

[0006] An environment forming device according to

one aspect of the present invention includes: an environment chamber; and the refrigeration device for cooling an inside of the environment chamber.

[0007] A refrigeration method according to one aspect of the present invention is a refrigeration method using a refrigeration device, the refrigeration device including a refrigeration circuit in which a compressor, a condenser, an expansion valve, an evaporator, and a flow rate adjustment valve are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant, and the refrigeration method includes: changing a target value of an evaporation temperature or an evaporation pressure in the evaporator; controlling a first one of the expansion valve and the flow rate adjustment valve based on the changed target value; receiving, by a reception unit of the refrigeration device, information indicating a refrigeration request degree or a temperature of a cooling object; and controlling a second one of the expansion valve and the flow rate adjustment valve in accordance with the refrigeration request degree or the temperature of the cooling object indicated by the information received by the reception unit.

Brief Description of the Drawings

[0008]

Fig. 1 is a diagram schematically illustrating a configuration of a refrigeration device according to a first embodiment.

Fig. 2 is a diagram schematically illustrating a control device including a controller of the refrigeration device.

Fig. 3 is a diagram for describing a relationship between an inside temperature and a target value of an evaporation temperature.

Fig. 4 is a diagram for describing a relationship between a refrigeration request degree and an opening degree of a flow rate adjustment valve.

Fig. 5 is a diagram for describing a control flow of the refrigeration device.

Fig. 6 is a diagram schematically illustrating a configuration of a refrigeration device according to a third embodiment.

Fig. 7 is a diagram schematically illustrating a configuration of a refrigeration device according to a variation of the third embodiment.

Fig. 8 is a diagram schematically illustrating a configuration of a refrigeration device according to a variation of the third embodiment.

Fig. 9 is a diagram schematically illustrating a configuration of a refrigeration device according to a fifth embodiment.

Fig. 10 is a diagram for describing a relationship between a refrigeration request degree and a target value of a suction pressure.

Fig. 11 is a diagram schematically illustrating an environment forming device according to a sixth

embodiment.

Fig. 12 is a diagram schematically illustrating a configuration of a refrigeration device according to another embodiment.

Description of Embodiments

[0009] Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

(First Embodiment)

[0010] As illustrated in Fig. 1, a refrigeration device 10 according to a first embodiment includes a refrigeration circuit 15 in which a refrigerant is sealed. The refrigerant may be a low boiling point refrigerant such as R-404A. Therefore, the evaporation temperature can be lowered to, for example, about -40°C.

[0011] The refrigeration circuit 15 is provided with a compressor 1, a condenser 2, an expansion valve 3, an evaporator 4, and a flow rate adjustment valve 22 in this order. When the compressor 1 operates, the refrigerant circulates in the refrigeration circuit 15, whereby a vapor compression type refrigeration cycle is performed. The refrigeration device 10 may be used for cooling an air inside a freezer or a refrigerator, or may be used for generating cooling water by a chiller. Alternatively, the refrigeration device 10 may be used for an environment forming device such as an environment testing device for providing an environment at a predetermined temperature or humidity. Alternatively, the refrigeration device 10 may be used in an air conditioner that adjusts the environment of a temperature and humidity in a room of, for example, a house. In the present embodiment, the refrigeration device 10 is used in a refrigerator-freezer.

[0012] The compressor 1 performs a compression step in a refrigeration cycle, and is configured to suction and compress a refrigerant. The compressor 1 includes a compression mechanism of, for example, a reciprocating type, a scroll type, or a screw type, and is configured to drive the compression mechanism by a motor at a constant rotation speed. Note that the compressor 1 may be configured such that a rotation speed of the motor can be adjusted by an inverter. The compressor 1 may include one unit compressor, but may alternatively include parallelly connected two unit compressors having different capacities.

[0013] The condenser 2 performs a condensation step in the refrigeration cycle, and is configured to exchange heat of a refrigerant discharged from the compressor 1 with a cooling medium such as air, water, or a refrigerant so as to condense the refrigerant.

[0014] The expansion valve 3 performs an expansion step in the refrigeration cycle, and is configured to expand the liquid refrigerant condensed in the condenser 2. The expansion valve 3 is constituted by, for example, an electronic expansion valve. Therefore, by adjusting the

opening degree of the valve, it is possible to change the evaporation temperature that is the temperature of the refrigerant flowing through the evaporator 4 in the refrigeration circuit 15, and is possible to change the evaporation pressure that is the pressure of the refrigerant in the evaporator 4.

[0015] The evaporator 4 performs an evaporation step in the refrigeration cycle, and is configured to exchange heat between air and the liquid refrigerant decompressed by the expansion valve 3 and to evaporate the liquid refrigerant. The evaporator 4 cools the air (a cooling object) supplied to the inside of the refrigerator-freezer (the room to be cooled). Note that, in a case where the refrigeration device 10 is provided in a chiller that generates cooling water, the evaporator 4 evaporates the liquid refrigerant so as to cool the cooling water (the cooling object).

[0016] The flow rate adjustment valve 22 is provided to adjust the flow rate of the refrigerant flowing through the evaporator 4. The flow rate adjustment valve 22 is constituted by, for example, an electronic expansion valve. When the opening degree of the flow rate adjustment valve 22 is adjusted, a low pressure in the refrigeration cycle and a pressure of the refrigerant flowing through the evaporator 4 also change.

[0017] The refrigeration circuit 15 is provided with an evaporation temperature detector 21. The evaporation temperature detector 21 is a detector for detecting the temperature of the refrigerant in the evaporator 4, that is, the evaporation temperature of the refrigerant in the evaporation step in the refrigeration cycle or a temperature corresponding to the evaporation temperature. Therefore, the evaporation temperature detector 21 may be disposed at a position between the expansion valve 3 and the evaporator 4 in the refrigeration circuit 15, or may be provided so as to detect the temperature of the refrigerant in the evaporator 4. The evaporation temperature detector 21 outputs a signal indicating the detected temperature.

[0018] The signal output from the evaporation temperature detector 21 is input to the controller 100. The controller 100 is configured with a microcomputer including: a central processing unit (CPU) that executes arithmetic processing; a read only memory (ROM) that stores a processing program, data, and the like; and a random access memory (RAM) that temporarily stores data, or may be configured with another device. By executing a processing program stored in the controller 100, the controller 100 can be made to function as a reception unit 101, a target value changing unit 102, and a valve control unit 103 as illustrated in Fig. 2.

[0019] The reception unit 101 is configured to repeatedly receive a refrigeration request degree at predetermined time intervals, and to temporarily store the received refrigeration request degree. The refrigeration request degree is generated by a generation unit 120, and the refrigeration request degree generated by the generation unit 120 is input to the reception unit 101. That

is, the reception unit 101 receives information indicating the refrigeration request degree. Note that, the illustrated example shows an example in which the generation unit 120 is configured separately from the controller 100, but the generation unit 120 to generate the refrigeration request degree may be one function provided by the controller 100.

[0020] For example, the generation unit 120 repeatedly receives, at predetermined time intervals, signals from a sensor 121 that detects a temperature of the cooling object (or an inside temperature of the refrigerator-freezer or the temperature of the room to be cooled), an input device 122 that inputs a set value of the temperature of the cooling object (or the inside temperature of the refrigerator-freezer or the temperature of the room to be cooled), and the like, and the generation unit 120 calculates the refrigeration request degree every time the signals are received. The refrigeration request degree is a dimensionless numerical value that indicates a refrigeration load in the refrigerator-freezer, which is the cooling object, and is calculated using, for example, a difference value between a detected value (the detected temperature by the sensor 121) of the temperature of the cooling object and the set value. Therefore, the refrigeration request degree is larger as the difference between the detected value of the temperature of the cooling object and the set value of the temperature of the cooling object is larger. Since the refrigeration request degree can change every moment, the generation unit 120 outputs the refrigeration request degree every predetermined time. The information output from the sensor 121 indicating the detected temperature is received by the reception unit 101.

[0021] The target value changing unit 102 is configured to store a target value of the evaporation temperature. The target value changing unit 102 is configured to change the stored target value in accordance with the refrigeration request degree received by the reception unit 101 and the temperature of the cooling object (or the inside temperature of the refrigerator-freezer or the temperature of the room to be cooled), which is the detected temperature by the sensor 121. In a case where the target value of the evaporation temperature is assumed as a first value when a received refrigeration request degree is a first refrigeration request degree, the target value changing unit 102 changes, when a received refrigeration request degree is a second refrigeration request degree smaller than the first refrigeration request degree, the target value of the evaporation temperature to a second value lower than the first value. Furthermore, in a low temperature region to be described later, in a case where the target value of the evaporation temperature is assumed as a first value when the temperature of the cooling object is a first temperature, the target value changing unit 102 changes, when the temperature of the cooling object is a second temperature lower than the first temperature, the target value of the evaporation temperature to a second value lower than the first value.

Furthermore, in a high temperature region to be described later, the target value changing unit 102 sets the target value of the evaporation temperature to the same value regardless of the temperature of the cooling object. The changed target value and the set target value are stored in the target value changing unit 102.

[0022] As illustrated in Fig. 3, the target value of the evaporation temperature includes a low temperature region and a high temperature region, in the low temperature region, the target value of the evaporation temperature changing in accordance with the temperature of the cooling object (or the inside temperature of the refrigerator-freezer or the temperature of the room to be cooled), and in the high temperature region, the target value of the evaporation temperature being constant regardless of the temperature of the cooling object. A threshold temperature TS, which is a boundary between the low temperature region and the high temperature region, is set to, for example, a temperature equal to or higher than 0°C and equal to or lower than 60°C, a temperature equal to or higher than 10°C and equal to or lower than 50°C, or a temperature equal to or higher than 20°C and equal to or lower than 40°C. In the low temperature region, the target value of the evaporation temperature is set to be lower as the temperature of the cooling object is lower. On the other hand, in the high temperature region, the target value of the evaporation temperature is set to be the same value regardless of the temperature of the cooling object.

[0023] However, the target value of the evaporation temperature does not need to be set as described above. For example, the target value of the evaporation temperature may be set to be higher as the temperature of the cooling object is higher, over the entire possible temperature range of the temperature of the cooling object. Specifically, in the low temperature region (the region where the inside temperature or the temperature of the room to be cooled is lower than the threshold temperature TS), the target value of the evaporation temperature may change, as shown in Fig. 3, linearly in accordance with a change in the temperature of the cooling object (the inside temperature or the temperature of the room to be cooled). However, alternatively, the target value of the evaporation temperature may change in a curved manner, or may change in a stepping manner (stepwise). Furthermore, it is not necessary to set such that the target value of the evaporation temperature changes differently between the low temperature region and the high temperature region as shown in Fig. 3. For example, the target value of the evaporation temperature may change in accordance with a change in the temperature of the cooling object over the entire region of the temperature of the cooling object. In this case, the target value of the evaporation temperature may change linearly, may change in a curved manner, or may change in a stepping manner (stepwise). At this time, in a case where the target value of the evaporation temperature is assumed as a first value when the temperature of the cooling object

is a first temperature, the target value changing unit 102 changes, when the temperature of the cooling object is a second temperature lower than the first temperature, the target value of the evaporation temperature to a second value lower than the first value. Note that, when the refrigeration device 10 is configured as a chiller, the temperature of the cooling object is the temperature of cooling water introduced to the evaporator 4.

[0024] The target value of the evaporation temperature may have a latitude with respect to the temperature of the cooling object (or the inside temperature or the temperature of the room to be cooled). For example, the target value of the evaporation temperature may be changed not only in accordance with the temperature of the cooling object but also in accordance with the refrigeration request degree. Specifically, when the temperature of the cooling object is a certain temperature, the target value of the evaporation temperature may be further changed in accordance with the refrigeration request degree. In that case, the setting is performed such that the target value of the evaporation temperature is higher as the refrigeration request degree is larger and such that the target value of the evaporation temperature is lower as the refrigeration request degree is smaller. The upper limit value and the lower limit value of the target value of the evaporation temperature in that case may include a low temperature region in which the upper limit value and the lower limit value change in accordance with the temperature of the cooling object and a region that is a temperature region higher than the low temperature region and in which the upper limit value and the lower limit value are constant regardless of the temperature of the cooling object, but are not limited thereto. The setting may be performed such that, over the entire possible temperature range of the temperature of the cooling object, the upper limit value and the lower limit value of the target value of the evaporation temperature are higher as the temperature of the cooling object is higher.

[0025] The valve control unit 103 is configured to control the expansion valve 3 based on the target value of the evaporation temperature changed by the target value changing unit 102, and to control the flow rate adjustment valve 22 in accordance with the refrigeration request degree.

[0026] The control of the expansion valve 3 is performed every time the target value of the evaporation temperature is adjusted. The target value changing unit 102 sets the target value of the evaporation temperature to a value corresponding to the temperature of the cooling object (for example, the inside temperature or the temperature of the room to be cooled), which is the detected temperature by the sensor 121. The valve control unit 103 controls the expansion valve 3 such that the detected temperature by the evaporation temperature detector 21 becomes close to the target value of the evaporation temperature set by the target value changing unit 102. The opening degree of the expansion valve 3 becomes smaller when the target value of the evaporation tem-

perature is lower, and becomes larger when the target value of the evaporation temperature is higher.

[0027] Every time the reception unit 101 receives the refrigeration request degree, the valve control unit 103 adjusts the opening degree of the flow rate adjustment valve 22 in accordance with the received refrigeration request degree. That is, the controller 100 stores information indicating a relationship in which the opening degree of the flow rate adjustment valve 22 is assigned to the refrigeration request degree, and the valve control unit 103 controls the flow rate adjustment valve 22 by using the information.

[0028] Note that the controller 100 may not store the information indicating the relationship in which the opening degree of the flow rate adjustment valve 22 is assigned to the refrigeration request degree, and may store the information indicating the relationship in which the suction pressure is assigned to the refrigeration request degree. In this case, the valve control unit 103 controls the flow rate adjustment valve 22 by using this information. However, also in this case, it is the same that the flow rate adjustment valve 22 is controlled based on the refrigeration request degree. For example, when the refrigeration request degree is larger, the suction pressure is set to a higher value. In this case, the flow rate adjustment valve 22 is controlled such that the opening degree of the flow rate adjustment valve 22 becomes larger. When the refrigeration request degree is smaller, the suction pressure is set to a lower value. In this case, the flow rate adjustment valve 22 is controlled such that the opening degree of the flow rate adjustment valve 22 becomes smaller.

[0029] As illustrated in Fig. 4, the flow rate adjustment valve 22 is controlled such that the opening degree becomes larger when the refrigeration request degree is larger and such that the opening degree becomes smaller when the refrigeration request degree is smaller. Note that the flow rate adjustment valve 22 may maintain the opening degree constant in one of or both of the following ranges: a range where the refrigeration request degree is equal to or greater than a predetermined value; and a range where the refrigeration request degree is equal to or less than a predetermined value.

[0030] When the temperature of the cooling object (for example, the inside temperature or the temperature of the room to be cooled) is lower than the threshold temperature TS, the target value of the evaporation temperature is set to a lower value as the temperature of the cooling object is lower. Therefore, the valve control unit 103 controls the expansion valve 3 such that the opening degree of expansion valve 3 is smaller as the temperature of the cooling object is lower. At this time, the valve control unit 103 performs control such that the flow rate adjustment valve 22 has an opening degree based on the refrigeration request degree. That is, the flow rate adjustment valve 22 is controlled not based on the evaporation temperature (the evaporation pressure). Furthermore, when the temperature of the cooling object is lower than

the threshold temperature TS, the target value of the evaporation temperature is set to a higher value as the temperature of the cooling object is higher (see Fig. 3). Therefore, the valve control unit 103 controls the expansion valve 3 such that the opening degree of expansion valve 3 is larger as the temperature of the cooling object is higher. Also in this case, the valve control unit 103 performs control such that the flow rate adjustment valve 22 has an opening degree based on the refrigeration request degree.

[0031] On the other hand, when the temperature of the cooling object (for example, the inside temperature or the temperature of the room to be cooled) is higher than the threshold temperature TS, the target value of the evaporation temperature is set to a constant value regardless of the temperature of the cooling object. Therefore, the valve control unit 103 controls the expansion valve 3 such that the set target value of the evaporation temperature is achieved. Also in this case, the valve control unit 103 adjusts the opening degree of the flow rate adjustment valve 22 based on the refrigeration request degree. That is, the flow rate adjustment valve 22 is controlled such that the opening degree is smaller as the refrigeration request degree is smaller and such that the opening degree is larger as the refrigeration request degree is larger. Therefore, the refrigeration capacity can be varied while the evaporation temperature is maintained at a high value.

[0032] Here, a description will be given to a refrigeration method using the refrigeration device 10 having the above configuration.

[0033] When a target temperature of the inside temperature or the temperature of the room to be cooled is set and an operation of the refrigeration device 10 is started, the controller 100 receives the refrigeration request degree generated by the generation unit 120 and the detected temperature by the sensor 121 (the temperature of the cooling object) as illustrated in Fig. 5 (steps ST11 and ST12). The refrigeration request degree and the detected temperature by the sensor 121 are repeatedly received by the controller 100 every predetermined time.

[0034] Subsequently, the target value changing unit 102 of the controller 100 changes the target value of the evaporation temperature in accordance with the refrigeration request degree and the detected temperature by the sensor 121 received by the reception unit 101 (step ST13).

[0035] At this time, in the case where the detected temperature by the sensor 121 is in the low temperature region, which is equal to or lower than the preset threshold temperature TS, the target value changing unit 102 sets the target value of the evaporation temperature to a lower target value as the received detected temperature is lower, and sets the target value of the evaporation temperature to a higher target value as the received detected temperature by the sensor 121 is higher. That is, in the case of the low temperature region, even when the refrigeration request degree is the same, the target

value of the evaporation temperature is set to a lower value as the detected temperature is lower.

[0036] Furthermore, in the case where the detected temperature by the sensor 121 is in a high temperature region, which is higher than the preset threshold temperature TS, the target value changing unit 102 sets the target value of the evaporation temperature to a constant value regardless of the detected temperature by the sensor 121.

[0037] Subsequently, the valve control unit 103 controls the expansion valve 3 based on the target value of the evaporation temperature changed by the target value changing unit 102, and controls the flow rate adjustment valve 22 in accordance with the refrigeration request degree (step ST14).

[0038] Specifically, the valve control unit 103 sets the opening degree of the flow rate adjustment valve 22 to a predetermined opening degree in accordance with the refrigeration request degree (for example, to a maximum opening degree when the refrigeration request degree is 100%); and in this state, the valve control unit 103 controls the expansion valve 3 such that the detected temperature by the evaporation temperature detector 21 becomes close to the target value of the evaporation temperature set by the target value changing unit 102. At this time, the opening degree of the expansion valve 3 is smaller as the target value of the evaporation temperature is lower, and the opening degree of the expansion valve 3 is larger as the target value of the evaporation temperature is higher.

[0039] Then, when the refrigeration request degree received by the reception unit 101 changes from the refrigeration request degree received last time, the valve control unit 103 adjusts the opening degree of the flow rate adjustment valve 22 in accordance with the change amount of the refrigeration request degree. Accordingly, the evaporation temperature changes; therefore, the valve control unit 103 further adjusts the opening degree of the expansion valve 3 such that the evaporation temperature becomes close to the target value.

[0040] For example, when the refrigeration request degree becomes smaller than the previous value, the valve control unit 103 make the opening degree of the flow rate adjustment valve 22 smaller. Accordingly, the evaporation temperature increases; therefore, the valve control unit 103 decreases the opening degree of the expansion valve 3 in accordance with the change in the evaporation temperature. As a result, the evaporation temperature becomes close to the target value. At this time, since the opening degrees of the expansion valve 3 and the flow rate adjustment valve 22 decrease, the flow rate of evaporator 4 is reduced, and the refrigeration capacity therefore decreases.

[0041] At this time, in the low temperature region, which is equal to or lower than the threshold temperature TS, the target value of the evaporation temperature is adjusted to a lower value as the detected temperature is lower. Therefore, even when the temperature of the cool-

ing object is low and the temperature of the air returning to the evaporator 4 is low, the refrigerant can be easily evaporated. Furthermore, since both the expansion valve 3 and the flow rate adjustment valve 22 are throttled, the flow rate of the refrigerant flowing through the evaporator 4 is reduced, thereby contributing to reduction in power of the compressor 1.

[0042] On the other hand, when the refrigeration request degree remains high, the opening degree of the flow rate adjustment valve 22 is maintained large. Furthermore, since the target value of the evaporation temperature is also maintained at a high value, the opening degree of the expansion valve 3 is maintained large. Therefore, the flow rate of the refrigerant flowing through evaporator 4 is secured in a state where the evaporation temperature is high, so that a state where a large refrigeration capacity is exerted is maintained. As a result, it is possible to exert a refrigeration capacity corresponding to a high refrigeration request degree.

[0043] Furthermore, when the refrigeration request degree becomes larger than the previous value, the valve control unit 103 further makes the opening degree of the flow rate adjustment valve 22 larger. Accordingly, the evaporation temperature decreases; therefore, the valve control unit 103 increases the opening degree of the expansion valve 3 in accordance with the change in the evaporation temperature. As a result, the evaporation temperature becomes close to the target value. At this time, since the opening degrees of the expansion valve 3 and the flow rate adjustment valve 22 increase, the flow rate of evaporator 4 is increased, and the refrigeration capacity therefore increases.

[0044] As described above, in the present embodiment, the valve control unit 103 controls the expansion valve 3 based on the target value of the evaporation temperature in the evaporator 4. At this time, the evaporation temperature (or the evaporation pressure) in the evaporator 4 tends to become higher as the flow rate adjustment valve 22 is throttled such that the opening degree of the flow rate adjustment valve 22 becomes smaller. Therefore, the evaporation temperature (or the evaporation pressure) can be made higher as compared with a refrigeration circuit in which the flow rate adjustment valve 22 is not provided. As a result, for example, even when the temperature of the cooling object is lower, it is possible to bring the evaporator 4 into a state where frost is not formed or a state where frost is hardly formed. In other words, the refrigeration device 10 can be controlled such that the temperature of the cooling object becomes lower. In the refrigeration circuit 15, a pressure reduction degree corresponding to a differential pressure between the high pressure and the low pressure of the refrigeration circuit 15 obtained by the compressor 1 is obtained by the expansion valve 3 and the flow rate adjustment valve 22.

[0045] Furthermore, since the target value of the evaporation temperature can be changed by the target value changing unit 102, it is possible to perform more flexible

operation as compared with a case where the target value of the evaporation temperature is fixed. For example, when the target value of the evaporation temperature is changed to a higher value, the expansion valve 3 is controlled such that the opening degree of the expansion valve 3 becomes larger. At this time, since the flow rate adjustment valve 22 is controlled in accordance with the refrigeration request degree, the evaporation temperature changes in accordance with a change amount of the opening degree of the flow rate adjustment valve 22. Therefore, the opening degree of the expansion valve 3 is further adjusted in accordance with the changed evaporation temperature, so that the evaporation temperature is suppressed from changing. Therefore, the expansion valve 3 and the flow rate adjustment valve 22 enable a desired refrigeration capacity to be exerted in accordance with the refrigeration request degree while adjusting the evaporation temperature to the target value. As a result, it is possible to increase a variable range of the refrigeration capacity while suppressing frost formation, and to contribute to continuous operation and energy saving of the device. Furthermore, the refrigeration device 10 may be configured as an air conditioner capable of adjusting humidity. In this case, control can be performed at an evaporation temperature (the refrigerant temperature in the evaporator 4) suitable for a dew-point temperature. Therefore, it is possible to perform a temperature and humidity operation covering a wide range. In addition, since it is possible to change a sensible heat ratio by the evaporation temperature, a desired dehumidifying capacity can be exerted, and it is possible to contribute also to energy saving.

[0046] The valve control unit 103 is configured to control the flow rate adjustment valve 22 in accordance with the refrigeration request degree; however, alternatively, the valve control unit 103 may be configured to control the flow rate adjustment valve 22 in accordance with the temperature of the cooling object. For example, when the temperature of the cooling object (or the inside temperature or the temperature of the room to be cooled) is lower than a freezing point, the valve control unit 103 may increase the opening degree of the flow rate adjustment valve 22 so that the evaporation temperature becomes lower than the freezing point. Furthermore, when the temperature of the cooling object is higher than a freezing point, the valve control unit 103 may control the flow rate adjustment valve 22 so that the opening degree becomes smaller, in order to make the evaporation temperature higher than the freezing point. In this case, the evaporation pressure in the evaporator 4 becomes higher, and the evaporation temperature accordingly increases; therefore, frost formation can be prevented. Note that, depending on the temperature of the cooling object, the opening degree of the flow rate adjustment valve 22 can be performed in a manner exactly opposite to the above case.

(Second Embodiment)

[0047] In the first embodiment, the valve control unit 103 controls the expansion valve 3 based on the target value of the evaporation temperature, and controls the flow rate adjustment valve 22 in accordance with the refrigeration request degree. In contrast, in a second embodiment, the valve control unit 103 is configured to control the flow rate adjustment valve 22 based on the target value of the evaporation temperature changed by the target value changing unit 102, and to control the expansion valve 3 in accordance with the refrigeration request degree.

[0048] In step ST14, the valve control unit 103 sets the opening degree of the expansion valve 3 to a predetermined opening degree in accordance with the refrigeration request degree (for example, to a maximum opening degree when the refrigeration request degree is 100%). Furthermore, in that state, the valve control unit 103 controls the flow rate adjustment valve 22 such that the detected temperature by the evaporation temperature detector 21 becomes close to the target value of the evaporation temperature set by the target value changing unit 102. At this time, when the target value of the evaporation temperature is lower than the current evaporation temperature, the opening degree of the flow rate adjustment valve 22 becomes larger, and when the target value of the evaporation temperature is higher than the current evaporation temperature, the opening degree of the flow rate adjustment valve 22 becomes smaller.

[0049] Then, when the refrigeration request degree received by the reception unit 101 changes from the refrigeration request degree received last time, the valve control unit 103 adjusts the opening degree of the expansion valve 3 in accordance with the change amount of the refrigeration request degree. Accordingly, the evaporation temperature changes; therefore, the valve control unit 103 further adjusts the opening degree of the flow rate adjustment valve 22 such that the evaporation temperature becomes close to the target value.

[0050] For example, when the refrigeration request degree becomes smaller than the previous value, the valve control unit 103 further decreases the opening degree of the expansion valve 3. Accordingly, the evaporation temperature decreases. When the target value of the evaporation temperature does not change, the valve control unit 103 decreases the opening degree of the flow rate adjustment valve 22 in accordance with the change in the evaporation temperature. As a result, the evaporation temperature becomes close to the target value. At this time, since the opening degrees of the expansion valve 3 and the flow rate adjustment valve 22 decrease, the flow rate of the evaporator 4 is reduced, and the refrigeration capacity therefore decreases.

[0051] On the other hand, when the refrigeration request degree remains high, the opening degree of the expansion valve 3 is maintained large. Furthermore, since the target value of the evaporation temperature

is also maintained at a high value, the opening degree of the flow rate adjustment valve 22 is maintained large. Therefore, the flow rate of the refrigerant flowing through evaporator 4 is secured in a state where the evaporation temperature is high, so that a state where a large refrigeration capacity is exerted is maintained. As a result, it is possible to exert a refrigeration capacity corresponding to a high refrigeration request degree.

[0052] Furthermore, when the refrigeration request degree becomes larger than the previous value, the valve control unit 103 further increases the opening degree of the expansion valve 3. Accordingly, the evaporation temperature increases; therefore, the valve control unit 103 increases the opening degree of the flow rate adjustment valve 22 in accordance with the change in the evaporation temperature. As a result, the evaporation temperature becomes close to the target value. Therefore, the flow rate of the refrigerant flowing through the evaporator 4 increases, so that a higher refrigeration capacity can be exerted.

[0053] In the present embodiment, for example, when the target value of the evaporation temperature is changed to a higher value, the flow rate adjustment valve 22 is controlled such that the opening degree of the flow rate adjustment valve 22 becomes smaller. At this time, since the expansion valve 3 is controlled in accordance with the refrigeration request degree, the evaporation temperature changes in accordance with a change amount of the opening degree of the expansion valve 3. Therefore, the opening degree of the flow rate adjustment valve 22 is further adjusted in accordance with the changed evaporation temperature, so that the change in the evaporation temperature is suppressed. Therefore, the expansion valve 3 and the flow rate adjustment valve 22 enable a desired refrigeration capacity to be exerted in accordance with the refrigeration request degree while adjusting the evaporation temperature to the target value. As a result, it is possible to increase a variable range of the refrigeration capacity while suppressing frost formation, and to contribute to continuous operation and energy saving of the device. Furthermore, the refrigeration device 10 may be configured as an air conditioner capable of adjusting humidity. In this case, control can be performed at an evaporation temperature (the refrigerant temperature in the evaporator 4) suitable for a dew-point temperature, so that it is possible to perform a temperature and humidity operation covering a wide range. In addition, since it is possible to change a sensible heat ratio by the evaporation temperature, a desired dehumidifying capacity can be exerted, and it is possible to contribute also to energy saving.

[0054] The valve control unit 103 may be configured to control the expansion valve 3 in accordance with the temperature of the cooling object, instead of controlling the expansion valve 3 in accordance with the refrigeration request degree. When the valve control unit 103 controls the expansion valve 3 in accordance with the temperature of the cooling object, the expansion valve 3

is controlled such that the opening degree of the expansion valve 3 becomes larger when the temperature of the cooling object is high, and the opening degree becomes smaller when the temperature of the cooling object is low. That is, the expansion valve 3 is controlled such that the opening degree of the expansion valve 3 becomes larger when the temperature of the cooling object is high, so that the evaporation temperature in the evaporator 4 increases. On the other hand, the expansion valve 3 is controlled such that the opening degree of the expansion valve 3 becomes smaller when the temperature of the cooling object is low, so that the evaporation temperature in the evaporator 4 becomes lower. Therefore, the cooling object can be efficiently cooled.

[0055] Although descriptions of the other configurations, operations, and effects are omitted, the description of the first embodiment can be applied to the second embodiment.

(Third Embodiment)

[0056] In the first embodiment and the second embodiment, the target value changing unit 102 is configured to change the target value of the evaporation temperature. In contrast, in the third embodiment, the target value changing unit 102 is configured to change the target value of the evaporation pressure.

[0057] In the third embodiment, as illustrated in Fig. 6, an evaporation pressure detector 33 is provided instead of the evaporation temperature detector 21. The evaporation pressure detector 33 is disposed at a position between the expansion valve 3 and the evaporator 4 in the refrigeration circuit 15, and detects an evaporation pressure of the refrigerant in the evaporator 4.

[0058] As illustrated in Fig. 7, instead of the evaporation pressure detector 33, an evaporation pressure detector 32 may be provided to be disposed at a position between the evaporator 4 and the flow rate adjustment valve 22 in the refrigeration circuit 15. Furthermore, both the evaporation pressure detector 33 (see Fig. 6) and the evaporation pressure detector 32 may be provided, or the evaporation temperature detector 21 (see Fig. 1) and the evaporation pressure detector 32 may be provided. In the refrigeration circuit 15, at a position between the expansion valve 3 and the flow rate adjustment valve 22, there is a pressure difference corresponding to a pressure loss in the evaporator 4; however, by taking such a pressure difference into consideration, it is possible to detect the refrigerant pressure (the evaporation pressure) in the evaporator 4 by using the evaporation pressure detector 32.

[0059] In the case where the evaporation pressure detector 33 or the evaporation pressure detector 32 is provided, the target value of the evaporation temperature shown in Fig. 3 can be alternatively read as the target value of the evaporation pressure. The target value of the evaporation pressure is assumed as a first value when the temperature of the cooling object (or the inside tem-

perature of the refrigerator-freezer or the temperature of the room to be cooled) is a first temperature, and, on the other hand, the target value changing unit 102 changes, when the temperature of the cooling object (or the inside temperature of the refrigerator-freezer or the temperature of the room to be cooled) is a second temperature lower than the first temperature, the target value of the evaporation pressure to a second value lower than the first value. Furthermore, the target value of the evaporation pressure may have a latitude, and the target value changing unit 102 may be configured to change the target value of the evaporation pressure in accordance with the received refrigeration request degree.

[0060] In this case, the valve control unit 103 is configured to control the expansion valve 3 based on the target value of the evaporation pressure changed by the target value changing unit 102, and to control the flow rate adjustment valve 22 in accordance with the refrigeration request degree. Alternatively, the valve control unit 103 may be configured to control the flow rate adjustment valve 22 based on the target value of the evaporation pressure changed by the target value changing unit 102, and, to control the expansion valve 3 in accordance with the refrigeration request degree. Note that the controller 100 may calculate a temperature corresponding to the pressure detected by the evaporation pressure detector 32, and may use the calculated temperature as the evaporation temperature.

[0061] Furthermore, as illustrated in Fig. 8, a temperature detector 34 may be used instead of the evaporation pressure detector 32. The temperature detector 34 is disposed in a bypass flow path 16 connected to the refrigeration circuit 15. In this case, one end of the bypass flow path 16 is connected to the refrigeration circuit 15 between the condenser 2 and the expansion valve 3, and the other end is connected to the refrigeration circuit 15 between the evaporator 4 and the flow rate adjustment valve 22. The bypass flow path 16 is provided with an electronic expansion valve 11, and the temperature detector 34 is disposed on the downstream side of the electronic expansion valve 11 and at a position where the temperature in the evaporation step is detected. In the bypass flow path 16, since the temperature on the downstream side of the electronic expansion valve 11 is an evaporation temperature corresponding to an outlet pressure of the evaporator 4, it is possible to measure the evaporation temperature in consideration of the pressure loss of the evaporator 4.

[0062] Although descriptions of the other configurations, operations, and effects are omitted, the descriptions of the first and second embodiments can be applied to the third embodiment.

(Fourth Embodiment)

[0063] In the first embodiment, the valve control unit 103 constantly controls the flow rate adjustment valve 22 in accordance with the refrigeration request degree. In

contrast, in a fourth embodiment, the valve control unit 103 has a first control mode in which the valve control unit 103 controls the flow rate adjustment valve 22 in accordance with the refrigeration request degree and a second control mode in which the valve control unit 103 maintains the flow rate adjustment valve 22 to be fully opened. The first control mode is performed when the temperature of the cooling object (or the inside temperature or the temperature of the room to be cooled) is equal to or higher than a predetermined temperature, and is switched to the second control mode when the temperature of the cooling object falls below the predetermined temperature. That is, in the second control mode, since the flow rate adjustment valve 22 is maintained fully opened, the evaporation temperature becomes lower as compared with the first control mode. Therefore, the second control mode is performed when the temperature of the cooling object is made to be a low temperature, for example, equal to or lower than a freezing point, or is performed when the refrigeration capacity is desired to be increased. On the other hand, similarly to the first embodiment, the first control mode is performed when suppressing frost formation. The predetermined temperature for switching between the first control mode and the second control mode is set to a value lower than 10°C, for example, 0°C or 5°C. However, the second control mode may be performed not only when the temperature of the cooling object is lower than the predetermined temperature, but also when the temperature of the cooling object is equal to or higher than the predetermined temperature and frost formation hardly occurs on the evaporator 4. For example, the second control mode is performed in a case where it is desired to rapidly change the temperature of the cooling object from a high temperature to a low temperature, or in a case where, in a temperature and humidity operation, it is desired to exert a dehumidifying capacity so as to lower the humidity.

[0064] In the first control mode, the control described in step ST14 of the first embodiment is performed. On the other hand, in the second control mode, the flow rate adjustment valve 22 is maintained fully opened. Therefore, in the second control mode, the control of the flow rate adjustment valve 22 based on the refrigeration request degree is not performed. However, in the second control mode, the expansion valve 3 is controlled such that the detected temperature by the evaporation temperature detector 21 becomes equal to the target value of the evaporation temperature.

[0065] In the first control mode, the expansion valve 3 may be controlled similarly to the second embodiment, instead of controlling the flow rate adjustment valve 22 (step ST14). Alternatively, similarly to the third embodiment, the target value changing unit 102 may be configured to change the target value of the evaporation pressure, and the valve control unit 103 may be configured to control the expansion valve 3 or the flow rate adjustment valve 22 based on the target value of the evaporation pressure changed by the target value changing unit 102,

and to control the flow rate adjustment valve 22 or the expansion valve 3 in accordance with the refrigeration request degree. In this case, it is also possible to use the evaporation pressure detector 33 illustrated in Fig. 6, the evaporation pressure detector 32 illustrated in Fig. 7, or the temperature detector 34 illustrated in Fig. 8.

[0066] Although descriptions of the other configurations, operations, and effects are omitted, the descriptions of the first to third embodiments can be applied to the fourth embodiment.

(Fifth Embodiment)

[0067] In the first embodiment, the opening degree of the flow rate adjustment valve 22 is assigned to the refrigeration request degree; however, in the fifth embodiment, the target value of the suction pressure is assigned to the refrigeration request degree, and the flow rate adjustment valve 22 is controlled such that the suction pressure becomes equal to the target value. Here, the same components as those in the first to fourth embodiments are denoted by the same reference numerals, and detailed descriptions thereof will be omitted.

[0068] As illustrated in Fig. 9, in the fifth embodiment, a pressure detector 31 for detecting the suction pressure of the compressor 1 is provided.

[0069] As illustrated in Fig. 10, in the valve control unit 103, there is used information indicating a relationship in which the target value of the suction pressure is assigned to the refrigeration request degree. That is, the target value of the suction pressure is higher as the refrigeration request degree is higher, and the target value of the suction pressure is lower as the refrigeration request degree is lower. A maximum value and a minimum value of the target value of the suction pressure are set based on the specification of the compressor 1.

[0070] That is, the opening degree of the expansion valve 3 is smaller as the target value of the evaporation temperature is lower. When the refrigeration request degree is lower, the opening degree of the flow rate adjustment valve 22 is smaller. Therefore, the suction pressure of the compressor 1 becomes lower. However, the target value of the suction pressure assigned to the lowest value of the refrigeration request degree, in other words, the minimum value of the target value is set based on a specification of the compressor 1. Therefore, even when the refrigeration request degree is the lowest, the compressor 1 can be stably operated.

[0071] The valve control unit 103 controls the flow rate adjustment valve 22 such that the detected pressure by the pressure detector 31 becomes equal to the target value of the suction pressure set in accordance with the refrigeration request degree. That is, also in the present embodiment, the valve control unit 103 controls the flow rate adjustment valve 22 in accordance with the refrigeration request degree.

[0072] Therefore, according to the present embodiment, the expansion valve 3 is controlled such that the

evaporation temperature in the evaporator 4 becomes equal to the target value, and, on the other hand, the flow rate adjustment valve 22 is controlled such that the detection value by the pressure detector 31 becomes equal to the target suction pressure value set in accordance with the refrigeration request degree. Therefore, not only the evaporation temperature is adjusted to the target value, but also the suction pressure is adjusted to the target value. Therefore, when the evaporation temperature is adjusted to the target value, it is possible to prevent the suction pressure from excessively increasing or decreasing. Accordingly, this contributes to stable operation of the compressor 1.

[0073] However, in the present embodiment, the flow rate adjustment valve 22 may be controlled such that the evaporation temperature in the evaporator 4 becomes equal to the target value, and, on the other hand, the expansion valve 3 may be controlled such that the detection value by the pressure detector 31 becomes equal to the target suction pressure value set in accordance with the refrigeration request degree. Although descriptions of the other configurations, operations, and effects are omitted, the descriptions of the first to fourth embodiments can be applied to the fifth embodiment.

(Sixth Embodiment)

[0074] Fig. 11 illustrates a sixth embodiment. Here, the same components as those in the first to fifth embodiments are denoted by the same reference numerals, and detailed descriptions thereof will be omitted.

[0075] The sixth embodiment is an example in which the refrigeration device 10 is applied to an environment forming device 50 such as an environment testing device. As illustrated in Fig. 11, the environment forming device 50 includes an environment chamber 51, and is configured to adjust the inside of the environment chamber 51 to a predetermined temperature environment. The environment forming device 50 further includes an air conditioning chamber 52 for generating air whose temperature is adjusted, and the evaporator 4 of the refrigeration device 10 is disposed in the air conditioning chamber 52.

[0076] In the air conditioning chamber 52, there are disposed, on the downstream side of the evaporator 4: a heater 54 for heating air; and a blower 55 for blowing out air whose temperature is adjusted, to the environment chamber 51. In the environment chamber 51, there is disposed a sensor 121 for detecting a temperature of a cooling object (a chamber air temperature of the environment chamber 51). The input device 122 is used to input a set temperature of the temperature in the environment chamber 51. The environment forming device 50 can set a wide range of temperatures such as a minus temperature region, a normal temperature region, or a high temperature region, and may have a program operation function that changes a plurality of temperatures stepwise or continuously.

[0077] Note that the environment forming device 50

may be configured to obtain not only a predetermined temperature environment but also a predetermined humidity environment. In this case, a humidifier (not illustrated) is provided. In this case, the evaporator 4 can also function as a dehumidifier.

[0078] The generation unit 120 calculates the refrigeration request degree by using the detected temperature by the sensor 121 and the set temperature indicated by the signal output from the input device 122.

[0079] The heater 54 is output-controlled based on the detected temperature by the sensor 121 and the set temperature indicated by the signal output from the input device 122. That is, the predetermined refrigeration capacity is exerted by the control of the expansion valve 3 and the flow rate adjustment valve 22 of the refrigeration device 10, but the detected temperature by the sensor 121 becomes lower than the set temperature in some cases; therefore, a chamber air temperature of the environment chamber 51 is finely adjusted by the heater 54. Therefore, when it is possible to suppress the refrigeration device 10 from excessively cooling, it is possible not only to suppress electric power consumed by the refrigeration device 10 but also suppress electric power consumed by the heater 54. In this respect, by adjusting the target value of the evaporation temperature to a low value when the refrigeration request degree is small, it is possible to reduce an amount of the circulating refrigerant by using the expansion valve 3 and the flow rate adjustment valve 22, so that the refrigeration capacity can be reduced. Therefore, the electric power of the heater 54 can also be suppressed, so that further energy saving can be achieved. Furthermore, since the target value of the evaporation temperature is changed by the target value changing unit 102, the evaporation temperature can be set higher than a freezing point. In addition, since the flow rate of the refrigerant flowing through the evaporator 4 can be adjusted by using the flow rate adjustment valve 22, energy saving can be achieved while suppressing frost formation. In particular, in the case of continuous operation in which the humidity is adjusted, it is possible to greatly contribute to the effect. As described above, since the target value changing unit 102 controls the flow rate adjustment valve 22 while changing the target value of the evaporation temperature, it is possible to achieve both followability to the set temperature and energy saving after the temperature reaches the set temperature, and the present embodiment is particularly preferable when a program operation is performed.

[0080] Although descriptions of the other configurations, operations, and effects are omitted, the descriptions of the first to fifth embodiments can be applied to the sixth embodiment.

(Other Embodiments)

[0081] It should be understood that the embodiments disclosed this time are illustrative in all respects and are not restrictive. The present invention is not limited to the

above embodiments, and various modifications, improvements, and the like can be made without departing from the gist of the present invention. For example, as illustrated in Fig. 12, a bypass flow path 18 bypassing the flow rate adjustment valve 22 may be provided in the refrigeration circuit 15, and an electromagnetic valve 36 may be provided in the bypass flow path 18.

[0082] In the above embodiment, one expansion valve 3 and one flow rate adjustment valve 22 are provided, but a plurality of expansion valves 3 and a plurality of flow rate adjustment valves 22 may be provided.

[0083] Here, the embodiments will be outlined.

(1) A refrigeration device according to the embodiment includes: a refrigeration circuit in which a compressor, a condenser, an expansion valve, an evaporator, and a flow rate adjustment valve are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant; a valve control unit configured to control the expansion valve and the flow rate adjustment valve; and a target value changing unit for changing a target value of an evaporation temperature or an evaporation pressure in the evaporator. The valve control unit is configured to control a first one of the expansion valve and the flow rate adjustment valve based on the target value changed by the target value changing unit, and to control a second one of the expansion valve and the flow rate adjustment valve in accordance with a refrigeration request degree or a temperature of a cooling object.

[0084] In the refrigeration device, the valve control unit controls one of the expansion valve and the flow rate adjustment valve based on the target value of the evaporation temperature or the evaporation pressure in the evaporator. At this time, the evaporation temperature or the evaporation pressure in the evaporator tends to become higher as the flow rate adjustment valve is throttled so as to decrease the opening degree of the flow rate adjustment valve. Therefore, the evaporation temperature (or the evaporation pressure) can be made higher as compared with a refrigeration circuit in which the flow rate adjustment valve is not provided. As a result, for example, even when control is performed such that the temperature of the cooling object becomes lower, it is possible to bring the evaporator into a state where frost is not formed or a state where frost is hardly formed. In other words, it is possible to control the refrigeration device such that the temperature of the cooling object becomes lower in a state where frost is hardly formed. In the refrigeration circuit, a pressure reduction degree corresponding to a differential pressure between the high pressure and the low pressure of the refrigeration circuit obtained by the compressor is obtained by the expansion valve and the flow rate adjustment valve.

[0085] Furthermore, since the target value of the evaporation temperature or the evaporation pressure can be

changed by the target value changing unit, it is possible to perform more flexible operation as compared with a case where the target value of the evaporation pressure or the evaporation temperature is fixed. For example, in the case of a configuration in which the expansion valve is controlled based on the evaporation temperature or the evaporation pressure, for example, when the target value of the evaporation temperature or the evaporation pressure is changed to a higher value, the opening degree of the expansion valve is controlled to become larger. On the other hand, since the flow rate adjustment valve is controlled in accordance with the refrigeration request degree or the temperature of the cooling object, the evaporation temperature or the evaporation pressure changes in accordance with a change amount of the opening degree of the flow rate adjustment valve. Therefore, the opening degree of the expansion valve is further adjusted in accordance with the changed evaporation temperature or evaporation pressure, so that the change in the evaporation temperature or the evaporation pressure is suppressed. Therefore, the expansion valve and the flow rate adjustment valve enable a desired refrigeration capacity to be exerted in accordance with the refrigeration request degree or the temperature of the cooling object while adjusting the evaporation temperature or the evaporation pressure to the target value.

[0086] On the other hand, for example, in the case of a configuration in which the flow rate adjustment valve is controlled based on the evaporation temperature or the evaporation pressure, for example, when the target value of the evaporation temperature or the evaporation pressure is changed to a higher value, the opening degree of the flow rate adjustment valve is controlled to become smaller. At this time, since the expansion valve is controlled in accordance with the refrigeration request degree or the temperature of the cooling object, the evaporation temperature or the evaporation pressure changes in accordance with a change amount of the opening degree of the expansion valve. Therefore, the opening degree of the flow rate adjustment valve is further adjusted in accordance with the changed evaporation temperature or evaporation pressure, so that the change in the evaporation temperature or the evaporation pressure is suppressed. Therefore, the expansion valve and the flow rate adjustment valve enable a desired refrigeration capacity to be exerted in accordance with the refrigeration request degree or the temperature of the cooling object while adjusting the evaporation temperature or the evaporation pressure to the target value. In addition, the sensible heat ratio can be changed by the evaporation temperature (the temperature of the evaporator); therefore, for example, when the humidity of the cooling object air is adjusted, a desired dehumidifying capacity can be exerted.

[0087] (2) The target value changing unit may be configured to set the target value to a first target value when the temperature of the cooling object is a first temperature, and to set the target value to a second target value

lower than the first target value when the temperature of the cooling object is a second temperature lower than the first temperature.

[0088] In this aspect, when the temperature of the cooling object is the second temperature lower than the first temperature, the target value of the evaporation temperature or the evaporation pressure is set to the second target value lower than the first target value. As a result, when the temperature of the cooling object is the second temperature (the lower temperature), one of the expansion valve and the flow rate adjustment valve is controlled such that the opening degree becomes smaller when the expansion valve is controlled and the opening degree becomes larger when the flow rate adjustment valve is controlled. In addition, the other of the expansion valve and the flow rate adjustment valve is controlled in accordance with the refrigeration request degree or the temperature of the cooling object. Therefore, the evaporation temperature or the evaporation pressure in the evaporator is adjusted in accordance with the temperature of the cooling object, and the refrigeration capacity is exerted in accordance with the refrigeration request degree or the temperature of the cooling object. For example, when the temperature of the cooling object is higher, the target value of the evaporation temperature or the evaporation pressure is set to a higher value, so that it is possible to perform the operation in which the refrigeration capacity is lowered as compared with the control in which the target value of the evaporation temperature or the evaporation pressure is constant. On the other hand, when the temperature of the cooling object is lower, the target value of the evaporation temperature or the evaporation pressure is set to a lower value, so that the refrigeration capacity can be appropriately exerted.

[0089] (3) The valve control unit may have a control mode for controlling, in a state where the flow rate adjustment valve is fully opened, the expansion valve such that the evaporation temperature or the evaporation pressure becomes equal to the target value changed by the target value changing unit.

[0090] In this aspect, the valve control unit has the control mode for controlling the expansion valve in the state where the flow rate adjustment valve is fully opened; therefore, it is possible to perform control other than the control in which the flow rate adjustment valve is controlled in accordance with the refrigeration request degree or the temperature of the cooling object. Therefore, it is possible to perform a more flexible operation as a refrigeration device.

[0091] (4) The refrigeration device may include a pressure detector configured to detect a suction pressure of the compressor. In this case, the valve control unit may be configured to control the second one of the expansion valve and the flow rate adjustment valve such that a detection value detected by the pressure detector is equal to a target suction pressure value that is set in accordance with the refrigeration request degree.

[0092] In this aspect, the first one of the expansion

valve and the flow rate adjustment valve is controlled such that the evaporation temperature or the evaporation pressure in the evaporator is equal to the target value, and, on the other hand, the second one of the expansion valve and the flow rate adjustment valve is controlled such that the detection value by the pressure detector is equal to the target suction pressure value set in accordance with the refrigeration request degree. Therefore, not only the evaporation temperature is adjusted to the target value, but also the suction pressure is adjusted to the target value. That is, the refrigeration capacity is adjusted by adjusting the suction pressure; therefore, the refrigeration capacity can be made variable with respect to the adjusted evaporation temperature. In addition, when the evaporation temperature is adjusted to the target value, it is possible to prevent the suction pressure from excessively decreasing. Accordingly, this contributes to stable operation of the compressor.

[0093] (5) The refrigeration device may include a reception unit configured to receive information indicating the refrigeration request degree or the temperature of the cooling object.

[0094] (6) The environment forming device according to the embodiment includes: an environment chamber; and the refrigeration device for cooling an inside of the environment chamber.

[0095] (7) A refrigeration method according to the embodiment is a refrigeration method using a refrigeration device, the refrigeration device including: a refrigeration circuit in which a compressor, a condenser, an expansion valve, an evaporator, and a flow rate adjustment valve are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant, and the refrigeration method includes: changing a target value of an evaporation temperature or an evaporation pressure in the evaporator; controlling a first one of the expansion valve and the flow rate adjustment valve based on the changed target value; receiving, by a reception unit of the refrigeration device, information indicating a refrigeration request degree or a temperature of a cooling object; and controlling a second one of the expansion valve and the flow rate adjustment valve in accordance with the refrigeration request degree or the temperature of the cooling object indicated by the information received by the reception unit.

[0096] As described above, according to the above embodiments, it is possible to perform more flexible operation while suppressing frost formation on the evaporator.

[0097] This application is based on Japanese Patent Application No. 2023-196739 filed with the Japan Patent Office on November 20, 2023, the contents of which are incorporated herein by reference.

Claims

1. A refrigeration device (10) comprising:

- a refrigeration circuit (15) in which a compressor (1), a condenser (2), an expansion valve (3), an evaporator (4), and a flow rate adjustment valve (22) are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant; a valve control unit (103) configured to control the expansion valve (3) and the flow rate adjustment valve (22); and a target value changing unit (102) for changing a target value of an evaporation temperature or an evaporation pressure in the evaporator (4), wherein the valve control unit (103) is configured to control a first one of the expansion valve (3) and the flow rate adjustment valve (22) based on the target value changed by the target value changing unit (102), and to control a second one of the expansion valve (3) and the flow rate adjustment valve (22) in accordance with a refrigeration request degree or a temperature of a cooling object.
2. The refrigeration device (10) according to claim 1, wherein the target value changing unit (102) is configured to set the target value to a first target value when the temperature of the cooling object is a first temperature, and to set the target value to a second target value lower than the first target value when the temperature of the cooling object is a second temperature lower than the first temperature.
 3. The refrigeration device (10) according to claim 1 or 2, wherein the valve control unit (103) has a control mode for controlling, in a state where the flow rate adjustment valve (22) is fully opened, the expansion valve (3) such that the evaporation temperature or the evaporation pressure becomes equal to the target value changed by the target value changing unit (102).
 4. The refrigeration device (10) according to any one of claims 1 to 3, further comprising a pressure detector (31) configured to detect a suction pressure of the compressor (1), wherein the valve control unit (103) is configured to control the second one of the expansion valve (3) and the flow rate adjustment valve (22) such that a detection value detected by the pressure detector (31) is equal to a target suction pressure value that is set in accordance with the refrigeration request degree.
 5. The refrigeration device (10) according to any one of claims 1 to 4, further comprising a reception unit (101) configured to receive information indicating the refrigeration request degree or the temperature of the cooling object.
 6. An environment forming device (50) comprising:

an environment chamber (51); and the refrigeration device (10) according to any one of claims 1 to 5 for cooling an inside of the environment chamber (51).

7. A refrigeration method using a refrigeration device (10), the refrigeration device (10) including a refrigeration circuit (15) in which a compressor (1), a condenser (2), an expansion valve (3), an evaporator (4), and a flow rate adjustment valve (22) are disposed in this order, the refrigeration circuit being configured to circulate a refrigerant, the refrigeration method comprising:

changing a target value of an evaporation temperature or an evaporation pressure in the evaporator (4);
controlling a first one of the expansion valve (3) and the flow rate adjustment valve (22), based on the changed target value;
receiving, by a reception unit (101) of the refrigeration device (10), information indicating a refrigeration request degree or a temperature of a cooling object; and
controlling a second one of the expansion valve (3) and the flow rate adjustment valve (22) in accordance with the refrigeration request degree or the temperature of the cooling object indicated by the information received by the reception unit (101).

FIG.1

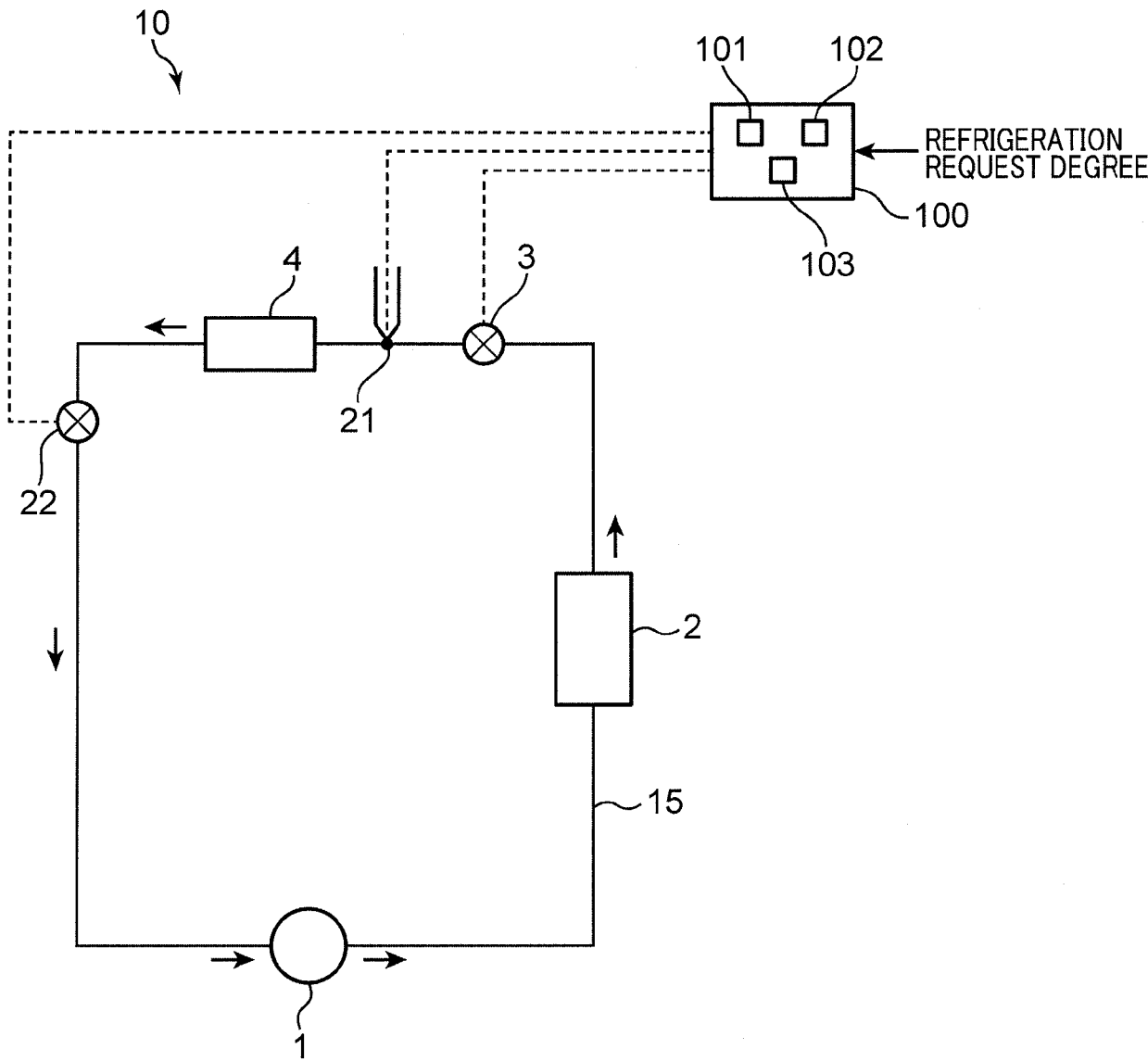


FIG.2

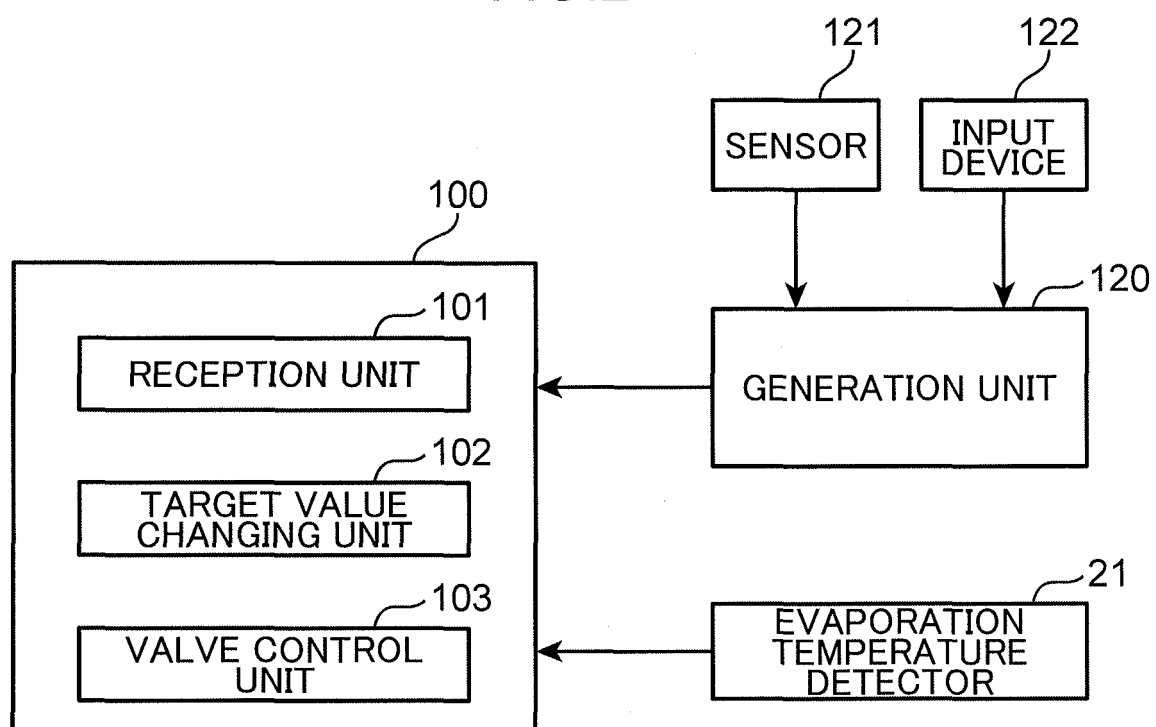


FIG.3

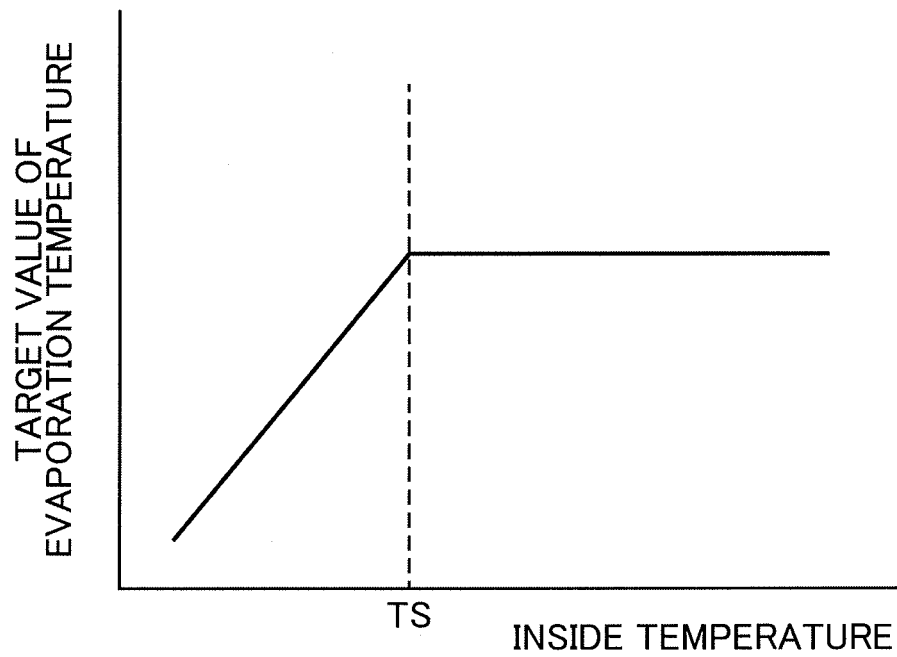


FIG.4

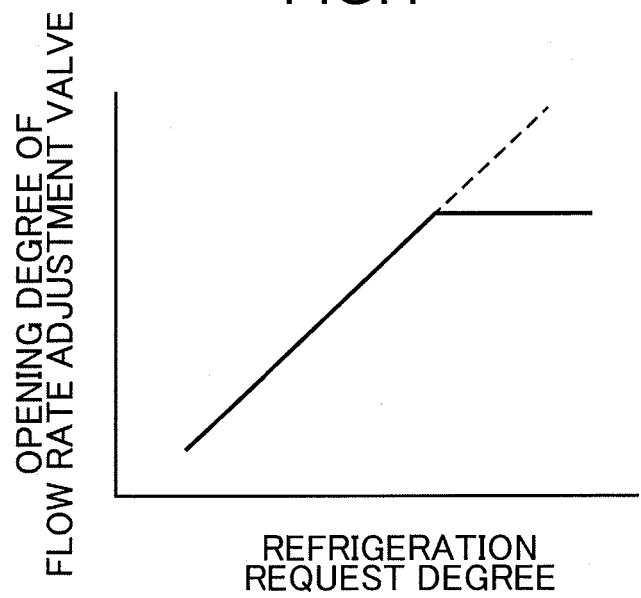


FIG.5

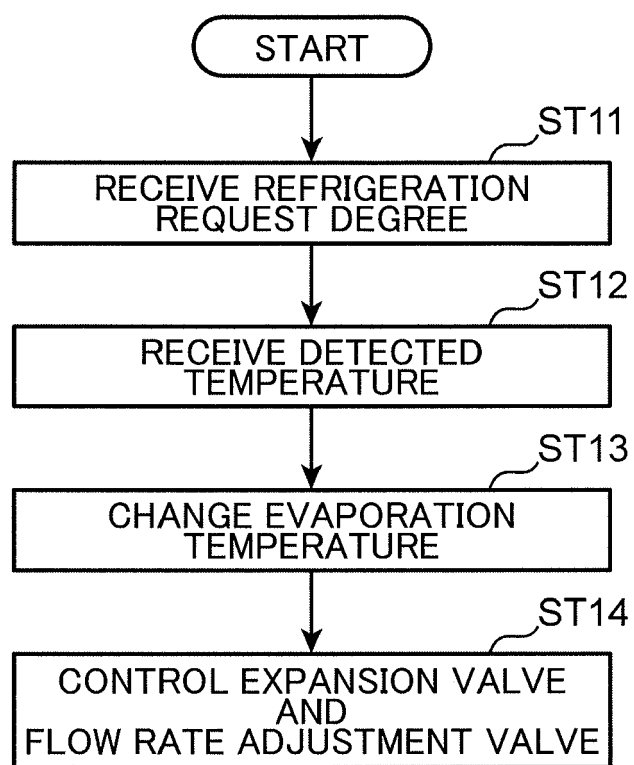


FIG.6

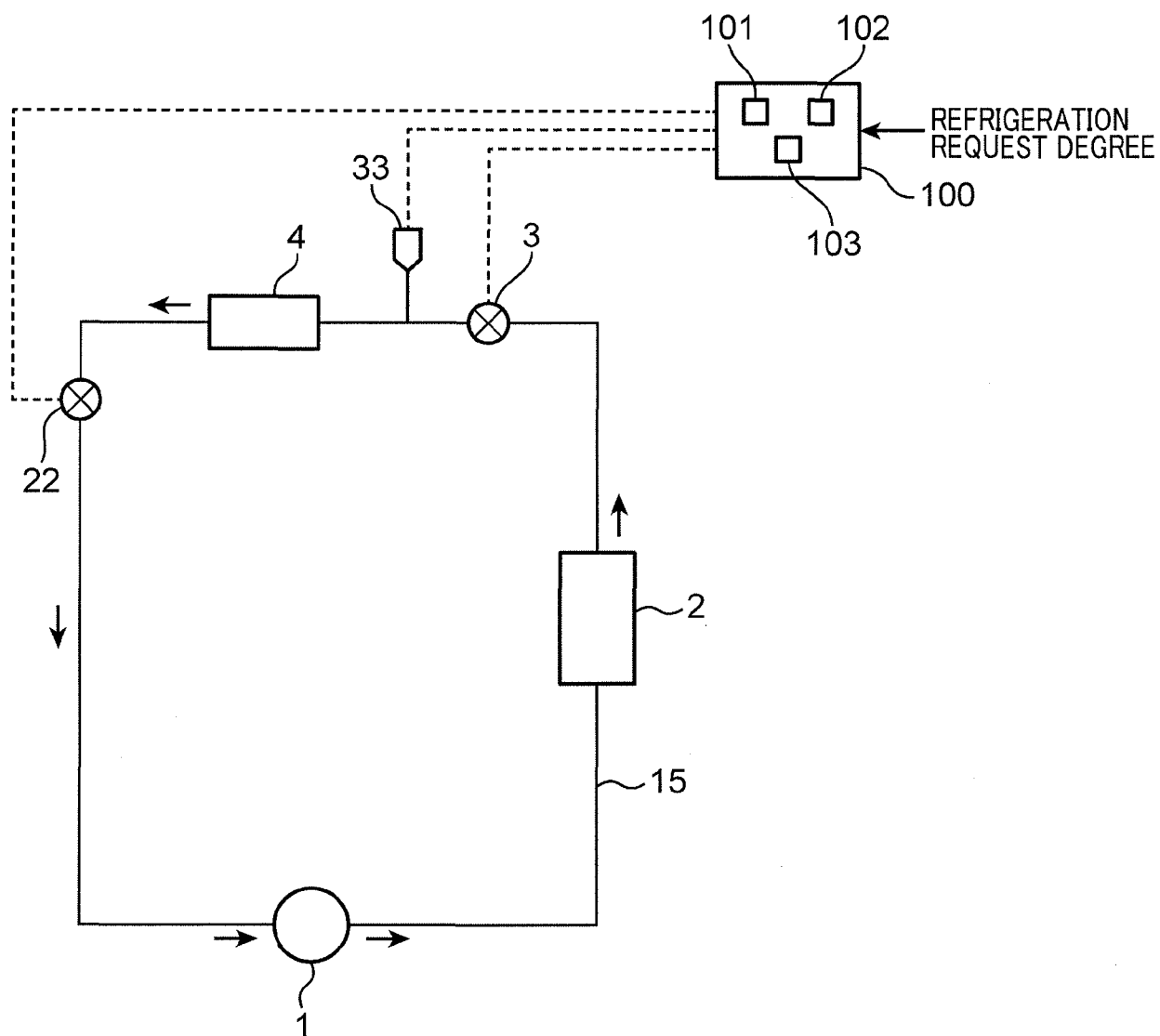


FIG.7

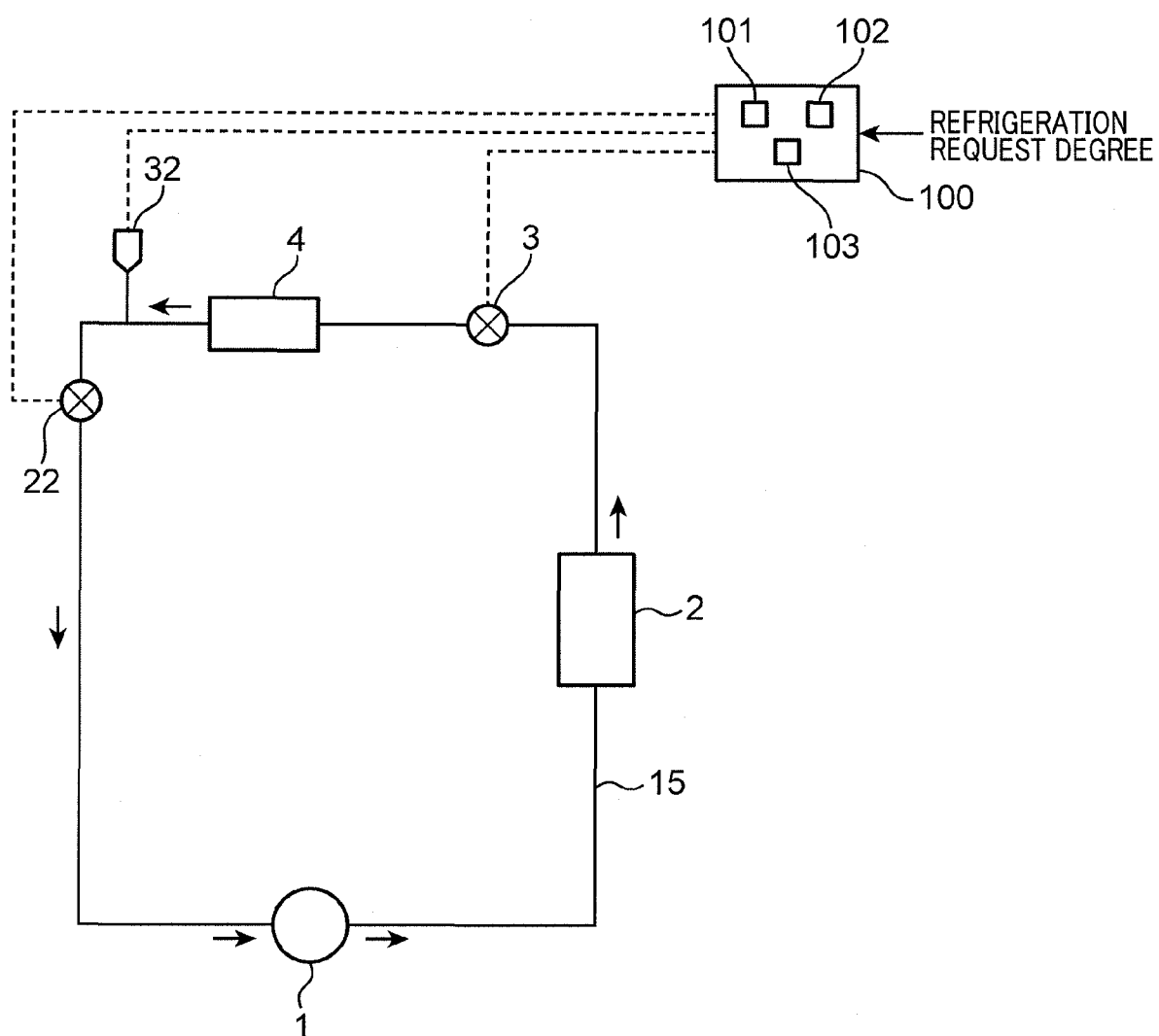


FIG.8

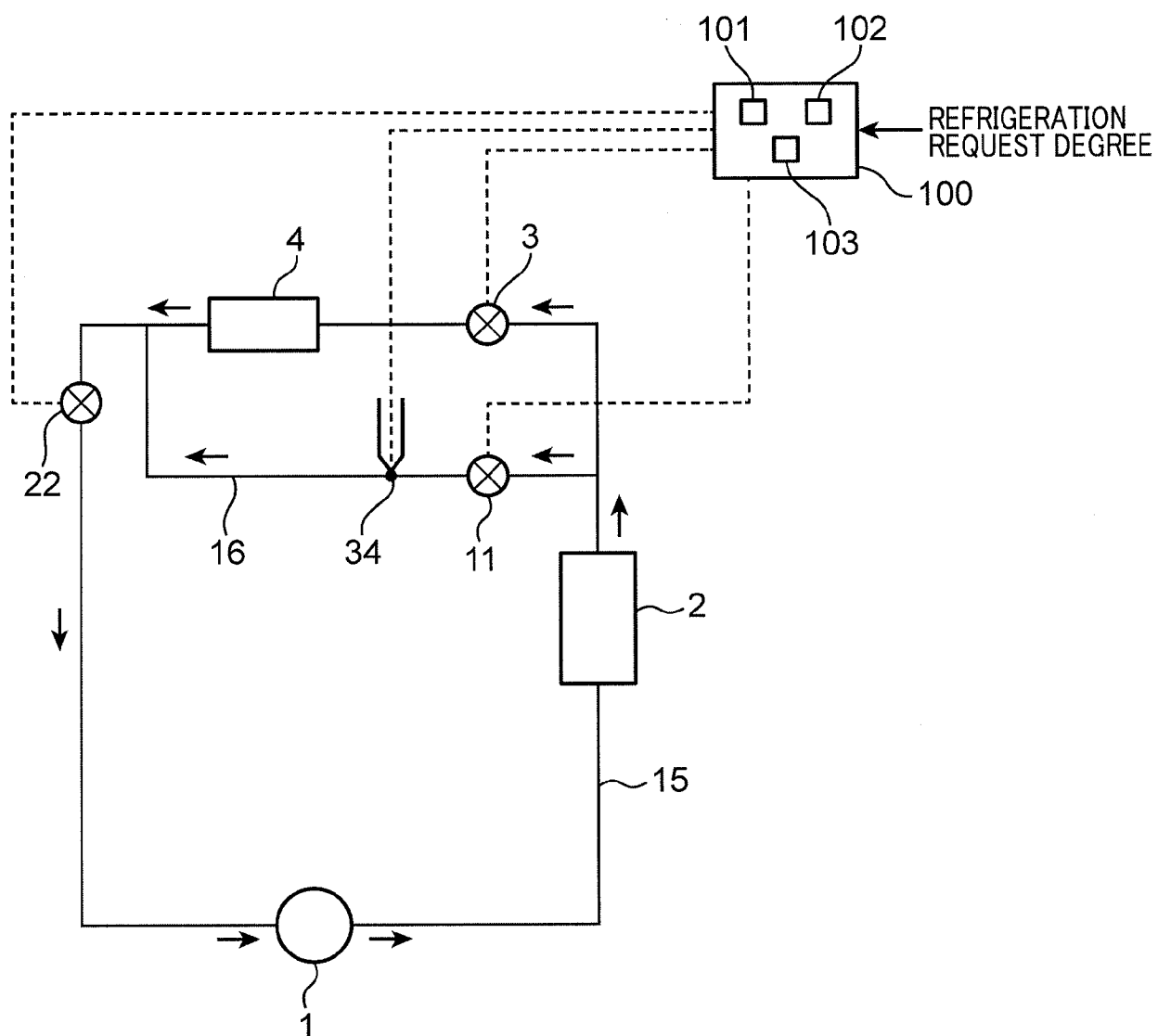


FIG.9

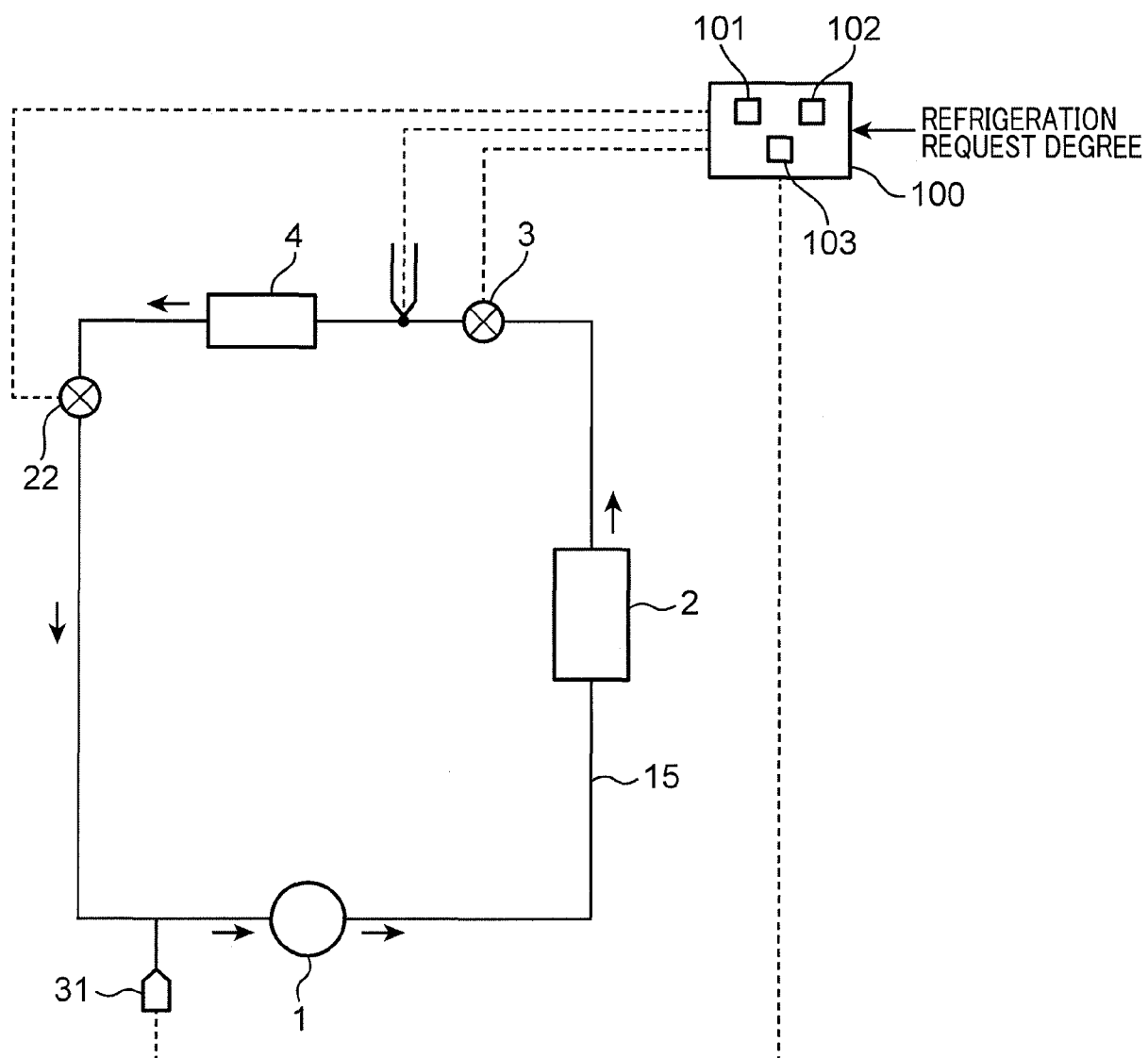


FIG.10

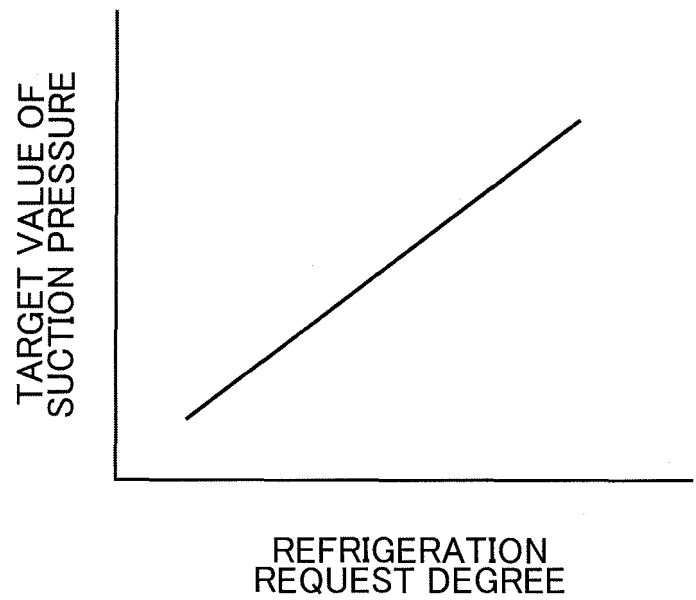


FIG.11

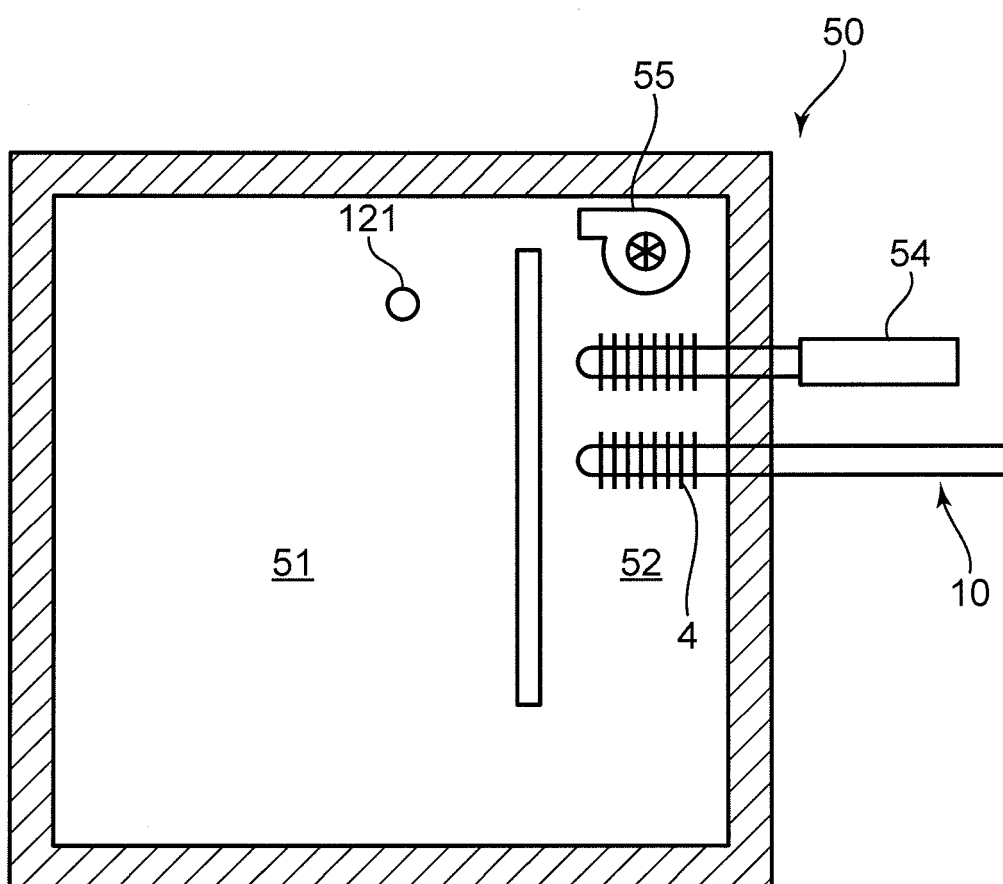
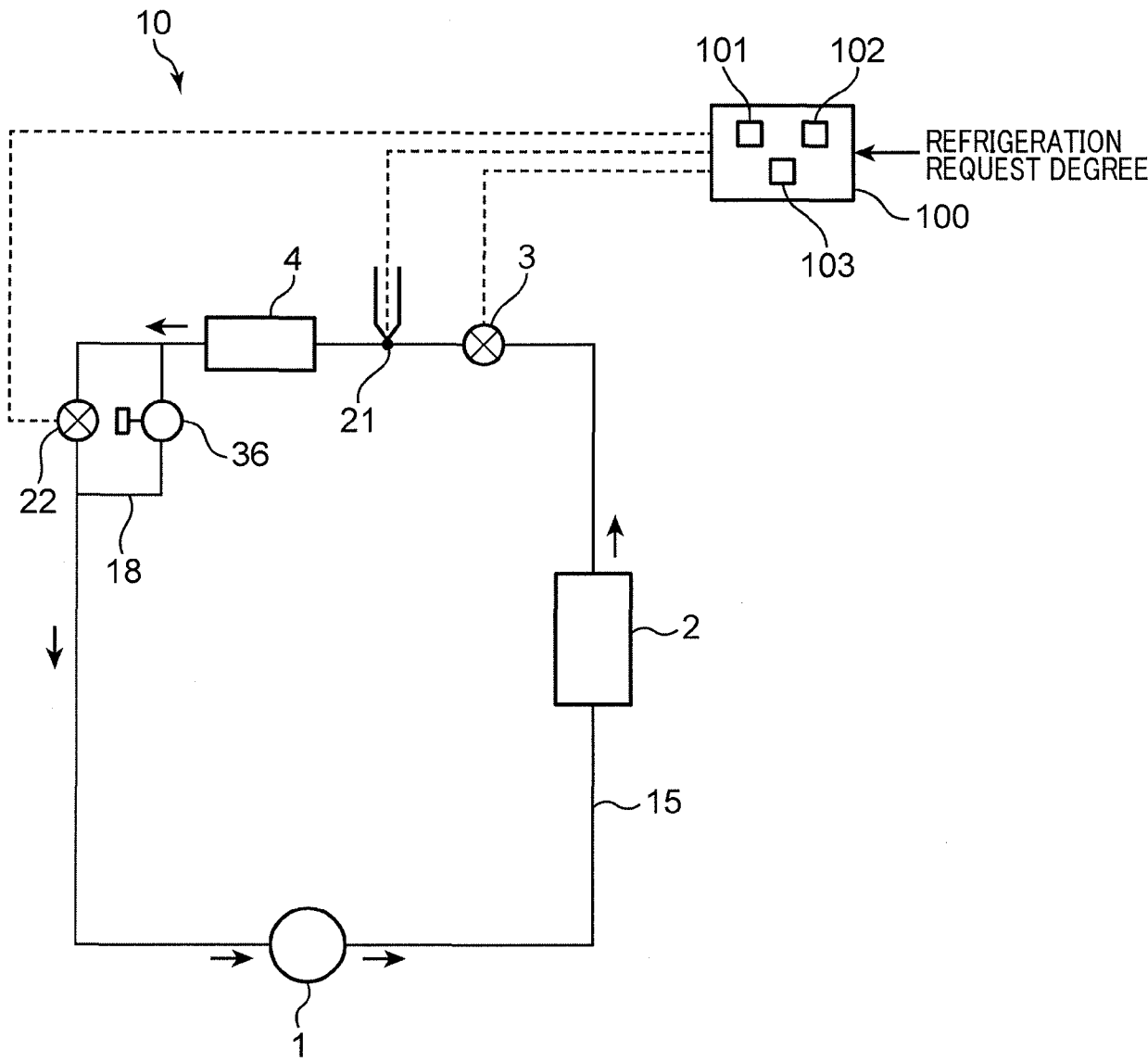


FIG.12





EUROPEAN SEARCH REPORT

Application Number

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			TECHNICAL FIELDS SEARCHED (IPC)
			F25B
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Place of search Munich		Date of completion of the search 17 March 2025	Examiner Szilagyi, Barnabas
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