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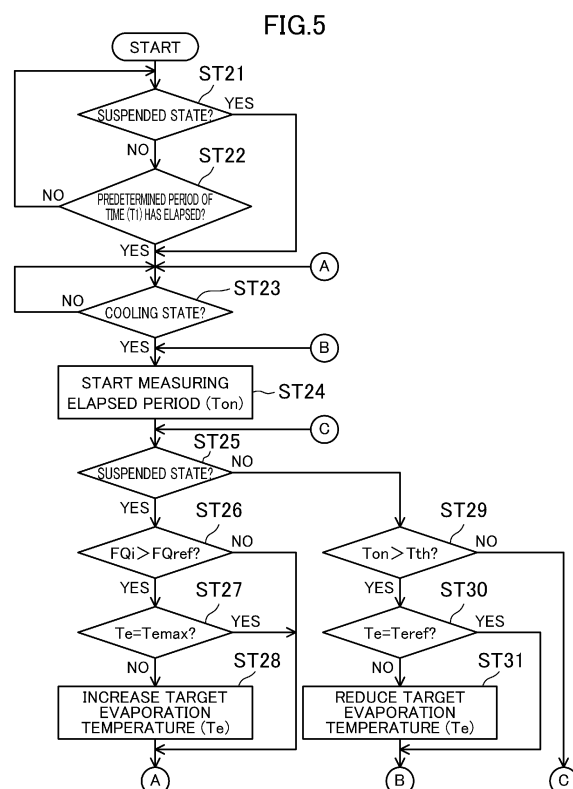
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(54) **REFRIGERATION DEVICE**

(57) The compressor control section (83) controls an operation frequency (FQ) of a compressor (21a) so that in a cooling mode, a temperature of a refrigerant sucked into the compressor (21a) is equal to a target evaporation temperature (T_e). A target temperature setting section (84) sets the target evaporation temperature (T_e) to be equal to a reference temperature (T_{ref}) lower than a set internal temperature (T_{set}) during a pull-down period (PD) for reducing the internal temperature (T_r), which has elapsed since the start of the cooling mode. The target temperature setting section (84) corrects the target evaporation temperature (T_e) so that if, after the pull-down period (PD) has elapsed, a frequency index value (FQi) dependent on the operation frequency (FQ) of the compressor (21a) during a period of time during which the utilization-side unit (12) is placed in the cooling state is above a predetermined reference value (FQref), the target evaporation temperature (T_e) is higher than the reference temperature (T_{ref}).



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration device.

BACKGROUND ART

[0002] A refrigeration device that circulates a refrigerant therethrough to perform a refrigeration cycle has been known in the art. Such a refrigeration device is widely used to cool the interior of a refrigerator or a freezer and to perform other operations. For example, Patent Document 1 discloses a refrigeration device including an outdoor unit and a cooling unit (a utilization-side unit). The outdoor unit includes a compressor and an outdoor heat exchanger. The cooling unit includes a utilization-side heat exchanger.

[0003] In the refrigeration device of Patent Document 1, the outdoor unit and the cooling unit are connected together to form a refrigerant circuit. In a cooling mode of the cooling apparatus, the cooling unit enters into either a thermo-on state (a state where inside air is cooled with the utilization-side heat exchanger) or a thermo-off state (a state where inside air is not cooled with the utilization-side heat exchanger), depending on the temperature of the inside air (internal temperature) detected by an internal temperature sensor. In the cooling apparatus, the cooling unit that has entered into the thermo-off state allows the compressor to stop, and the cooling unit that has entered into the thermo-on state allows the compressor to start.

CITATION LIST

PATENT DOCUMENTS

[0004] [Patent Document 1] Japanese Unexamined Patent Publication No. 2014-70830

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] In the refrigeration device of Patent Document 1, the operation frequency of the compressor may be controlled so that the temperature of a refrigerant sucked into the compressor (hereinafter referred to as the "suction temperature") is equal to a predetermined target evaporation temperature. In this case, the target evaporation temperature is set to be lower than a set internal temperature, with consideration given to pressure loss in a pipe between the liquid end of the utilization-side heat exchanger and a suction port of the compressor (specifically, the pipe length, the pipe diameter, the height difference, and other elements).

[0006] Upon the start of the cooling mode, the utiliza-

tion-side unit enters into a cooling state (a state where the utilization-side heat exchanger functions as an evaporator to cool inside air). Thus, the internal temperature gradually decreases. If a predetermined period of time (a period of time for reducing the internal temperature) has elapsed since the start of the cooling mode, the internal temperature becomes close to the set internal temperature. As a result, the internal cooling load decreases. That is to say, after the predetermined period of time has elapsed since the start of the cooling mode, the internal temperature is stable near the set internal temperature. Thus, the internal cooling load is considered to be relatively low. The period of time during which the internal temperature is stable near the set internal temperature and the internal cooling load is relatively low as above is hereinafter referred to as the "low internal load period."

[0007] The cooling capability required of the utilization-side unit is relatively low for the low internal load period in the cooling mode. Thus, the operation frequency of the compressor is preferably reduced to increase the coefficient of performance (COP) of the refrigeration device. However, the lower the target evaporation temperature is, the less likely the operation frequency of the compressor is to decrease for the low internal load period in the cooling mode. This makes it difficult to increase the coefficient of performance of the refrigeration device.

[0008] It is therefore an object of the present disclosure to provide a refrigeration device that can facilitate reducing the operation frequency of a compressor for a low internal load period in a cooling mode to increase the coefficient of performance.

SOLUTION TO THE PROBLEM

[0009] A refrigeration device according to a first aspect of the disclosure includes: a heat-source-side unit (11) including a compressor (21a) and a heat-source-side heat exchanger (23); and a utilization-side unit (12) including a utilization-side heat exchanger (51) and provided in an internal space. The heat-source-side unit (11) and the utilization-side unit (12) are connected together to form a refrigerant circuit (15) through which a refrigerant circulates. During a cooling mode in which the heat-source-side heat exchanger (23) functions as a condenser, if an internal temperature (T_r) is above a set internal temperature range including a set internal temperature (T_{set}), the utilization-side unit (12) is placed in a cooling state where a refrigerant is passed through the utilization-side heat exchanger (51) to allow the utilization-side heat exchanger (51) to function as an evaporator. If the internal temperature (T_r) is below the set internal temperature range, the utilization-side unit (12) is placed in a suspended state where flow of a refrigerant through the utilization-side heat exchanger (51) is interrupted so that cooling of the internal space is suspended. The refrigeration device further includes: a compressor control section (83) configured to control an operation frequency (FQ) of the compressor (21a) so that in the cooling mode,

a temperature of a refrigerant sucked into the compressor (21a) is equal to a target evaporation temperature (T_e); and a target temperature setting section (84) configured to set the target evaporation temperature (T_e) to be equal to the reference temperature (T_{ref}) lower than the set internal temperature (T_{set}) during a pull-down period (PD) for reducing the internal temperature (T_r), which has elapsed since the start of the cooling mode, the target temperature setting section (84) being configured to correct the target evaporation temperature (T_e) so that if, after the pull-down period (PD) has elapsed, a frequency index value (FQ_i) dependent on the operation frequency (FQ) of the compressor (21a) during a cooling duration during which the utilization-side unit (12) is placed in the cooling state is above a predetermined reference value (FQ_{ref}), the target evaporation temperature (T_e) is higher than the reference temperature (T_{ref}).

[0010] According to the first aspect, the target evaporation temperature (T_e) is set to be equal to the reference temperature (T_{ref}) between the time when the cooling mode starts and the time when the pull-down period (PD) has elapsed since the start of the cooling mode. This allows the utilization-side unit (12) to have sufficiently high cooling capability during the pull-down period (PD). Thus, inside air can be appropriately cooled during the pull-down period (PD).

[0011] In the first aspect, if the pull-down period (PD) has elapsed since the start of the cooling mode, the internal temperature (T_r) becomes close to the set internal temperature (T_{set}). Thus, the internal cooling load decreases. That is to say, after the pull-down period (PD) has elapsed since the start of the cooling mode, the internal temperature (T_r) is stable near the set internal temperature (T_{set}). Thus, the internal cooling load is considered to be relatively low. The period during which the internal temperature (T_r) is stable near the set internal temperature (T_{set}) and the internal cooling load is relatively low is hereinafter referred to as the "low internal load period."

[0012] In the first aspect, if, after the pull-down period (PD) has elapsed, the frequency index value (FQ_i) during the cooling duration (the period of time during which the utilization-side unit (12) is in the cooling state) is above the reference value (FQ_{ref}), the target evaporation temperature (T_e) is corrected to be higher than the reference temperature (T_{ref}). Thus, if the compressor (21a) is driven at relatively high operation frequencies during the low internal load period after the pull-down period (PD) has elapsed, increasing the target evaporation temperature (T_e) can facilitate reducing the operation frequency (FQ) of the compressor (21a).

[0013] The second aspect of the disclosure is an embodiment of the first aspect. In the second aspect, the frequency index value (FQ_i) corresponds to an average (FQ_{ave}) of operation frequencies (FQ) of the compressor (21a) during the cooling duration.

[0014] According to the second aspect, if, after the pull-down period (PD) has elapsed, the average (FQ_{ave}) of

the operation frequencies (FQ) of the compressor (21a) during the cooling duration is above the predetermined reference value (FQ_{ref}), the target evaporation temperature (T_e) is corrected to be higher than the reference temperature (T_{ref}). Thus, if the compressor (21a) is driven at relatively high operation frequencies during the low internal load period after the pull-down period (PD) has elapsed, increasing the target evaporation temperature (T_e) can facilitate reducing the operation frequency (FQ) of the compressor (21a).

[0015] A third aspect of the disclosure is an embodiment of the first aspect. In the third aspect, the frequency index value (FQ_i) corresponds to an operation frequency (FQ) of the compressor (21a) obtained when the utilization-side unit (12) shifts from the cooling state to the suspended state.

[0016] According to the third aspect, if, after the pull-down period (PD) has elapsed, the operation frequency (FQ) of the compressor (21a) at a time when the utilization-side unit (12) shifts from the cooling state to the suspended state is above the predetermined reference value (FQ_{ref}), the target evaporation temperature (T_e) is corrected to be higher than the reference temperature (T_{ref}). Thus, if the compressor (21a) is driven at relatively high operation frequencies during the low internal load period after the pull-down period (PD) has elapsed, increasing the target evaporation temperature (T_e) can facilitate reducing the operation frequency (FQ) of the compressor (21a).

[0017] A fourth aspect of the disclosure is an embodiment of any one of the first through third aspects. In the fourth aspect, the target temperature setting section (84) corrects the target evaporation temperature (T_e) to prevent the target evaporation temperature (T_e) from exceeding a predetermined upper-limit temperature (T_{max}).

[0018] According to the fourth aspect, correcting the target evaporation temperature (T_e) to prevent the target evaporation temperature (T_e) from exceeding the upper-limit temperature (T_{max}) can prevent the target evaporation temperature (T_e) from becoming too high.

[0019] A fifth aspect of the disclosure is an embodiment of any one of the first through fourth aspects. In the fifth aspect, the target temperature setting section (84) corrects the target evaporation temperature (T_e) so that if the target evaporation temperature (T_e) is higher than the reference temperature (T_{ref}), and the cooling duration is longer than a predetermined duration threshold (T_{th}), the target evaporation temperature (T_e) decreases to be closer to, or equal to, the reference temperature (T_{ref}).

[0020] During the low internal load period after a lapse of the pull-down period (PD), the opening/closing of a door and other factors may cause outside heat to enter the internal space. This may increase the internal cooling load. An increase in the internal cooling load as above triggers an increase in the cooling duration (the period of time during which the utilization-side unit (12) is in the

cooling state).

[0021] According to the fifth aspect, if the cooling duration (the period of time during which the utilization-side unit (12) is in the cooling state) is longer than the duration threshold (T_{th}), the target evaporation temperature (T_e) is reduced. This can increase the cooling capability of the utilization-side unit (12) when the internal cooling load is high during the low internal load period after a lapse of the pull-down period (PD).

[0022] A sixth aspect of the disclosure is an embodiment of any one of the first through fifth aspects. In the sixth aspect, the target temperature setting section (84) sets the target evaporation temperature (T_e) to be equal to the reference temperature (T_{ref}) after an end of the cooling mode and before start of a defrosting mode in which the utilization-side heat exchanger (51) functions as a condenser and the heat-source-side heat exchanger (23) functions as an evaporator.

[0023] The sixth aspect allows the utilization-side unit (12) to have sufficiently high heat dissipation capability (specifically, allows the utilization-side heat exchanger (51) to have sufficiently high heat dissipation capability) in the defrosting mode.

[0024] A seventh aspect of the disclosure is an embodiment of any one of the first through sixth aspects. In the seventh aspect, the pull-down period (PD) corresponds to a shorter one of a period of time from a time when the cooling mode starts to a time when the utilization-side unit (12) shifts from the cooling state to the suspended state or a period of time from the time when the cooling mode starts to a time when a predetermined period of time (T₁) has elapsed since the start of the cooling mode.

[0025] According to the seventh aspect, if the utilization-side unit (12) shifts from the cooling state to the suspended state after the start of the cooling mode, the internal temperature (T_r) can be considered to be close to the set internal temperature (T_{set}). In addition, also if a sufficient period of time (i.e., the predetermined period of time (T₁)) has elapsed since the start of the cooling mode, the internal temperature (T_r) can be considered to be close to the set internal temperature (T_{set}).

ADVANTAGES OF THE INVENTION

[0026] According to the first through third aspects of the disclosure, if a compressor (21a) is driven at relatively high operation frequencies during a low internal load period after a pull-down period (PD) has elapsed, increasing a target evaporation temperature (T_e) can facilitate reducing the operation frequency (FQ) of the compressor (21a). This can increase the coefficient of performance (COP) of a refrigeration device during the low internal load period in the cooling mode.

[0027] The fourth aspect of the disclosure can prevent the target evaporation temperature (T_e) from becoming too high. This can prevent an increase in the target evaporation temperature (T_e) from causing lack of the cooling

capability of the utilization-side unit (12).

[0028] According to the fifth aspect of the disclosure, the cooling capability of the utilization-side unit (12) can be increased when the internal cooling load is high during the low internal load period after a lapse of the pull-down period (PD). This allows the internal temperature (T_r) to be rapidly closer to the set internal temperature (T_{set}).

[0029] The sixth aspect of the disclosure allows the utilization-side unit (12) to have sufficiently high heat dissipation capability in the defrosting mode. Thus, the utilization-side heat exchanger (51) can be appropriately defrosted in the defrosting mode.

[0030] According to the seventh aspect of the disclosure, if a shorter one of the period of time from a time when the cooling mode starts to a time when the utilization-side unit (12) shifts from the cooling state to the suspended state and a period of time from the time when the cooling mode starts to a time when a predetermined period of time (T₁) has elapsed since the start of the cooling mode is defined as the pull-down period (PD), the internal temperature (T_r) can be reduced to a temperature close to the set internal temperature (T_{set}) during the pull-down period (DP).

BRIEF DESCRIPTION OF THE DRAWINGS

[0031]

[FIG. 1] FIG. 1 is a piping system diagram showing an exemplary configuration for a refrigeration device according to an embodiment.

[FIG. 2] FIG. 2 is a flowchart showing operations of the refrigeration device.

[FIG. 3] FIG. 3 is a piping system diagram showing the flow of a refrigerant in a cooling mode.

[FIG. 4] FIG. 4 is a piping system diagram showing the flow of a refrigerant in a defrosting mode.

[FIG. 5] FIG. 5 is a flowchart for explaining operations of a target temperature setting section in the cooling mode.

[FIG. 6] FIG. 6 is a graph for explaining a frequency index value.

[FIG. 7] FIG. 7 is a graph for explaining how the internal temperature changes.

[FIG. 8] FIG. 8 is a graph for explaining how the operation frequency of a compressor of a refrigeration device according to a comparative example changes.

[FIG. 9] FIG. 9 is a graph for explaining how the operation frequency of a compressor of the refrigeration device according to the embodiment changes.

DETAILED DESCRIPTION

[0032] Embodiments will now be described in detail with reference to the drawings. Note that like reference characters denote the same or equivalent components in the drawings, and the description thereof will not be

repeated.

(Refrigeration Device)

[0033] FIG. 1 shows an exemplary configuration for a refrigeration device (10) according to an embodiment. The refrigeration device (10) includes a heat-source-side unit (11) provided outside a refrigerator, a freezer, or any other similar device, an utilization-side unit (12) provided inside the device, and a controller (80). The heat-source-side unit (11) includes a heat-source-side circuit (16) and a heat-source-side fan (17). The utilization-side unit (12) includes a utilization-side circuit (18) and a utilization-side fan (19). In this refrigeration device (10), the heat-source-side circuit (16) of the heat-source-side unit (11) and the utilization-side circuit (18) of the utilization-side units (12) are connected together through a liquid interconnecting pipe (13) and a gas interconnecting pipe (14) to form a refrigerant circuit (15) that circulates a refrigerant therethrough to perform a vapor compression refrigeration cycle. Specifically, a liquid stop valve (V1) and a gas stop valve (V2) are provided at the liquid and gas ends of the heat-source-side circuit (16), respectively, and are connected to one end of the liquid interconnecting pipe (13) and one end of the gas interconnecting pipe (14), respectively. The liquid interconnecting pipe (13) and the gas interconnecting pipe (14) are connected to the liquid and gas ends of the utilization-side circuit (18), respectively.

<Heat-Source-Side Circuit>

[0034] The heat-source-side circuit (16) includes first and second compressors (21a, 21b), a four-way valve (22), a heat-source-side heat exchanger (23), a supercooling heat exchanger (24), a supercooling expansion valve (31), an intermediate expansion valve (32), an intermediate open/close valve (33), an intermediate check valve (34), a receiver (35), a heat-source-side expansion valve (36), first, second, and third check valves (CV1, CV2, CV3), first and second oil separators (OSa, OSb), first and second discharge check valves (CVa, CVb), first and second capillary tubes (CTa, CTb), and an oil return check valve (CVc).

[0035] The heat-source-side circuit (16) further includes a discharge refrigerant pipe (41), a suction refrigerant pipe (42), a heat-source-side liquid refrigerant pipe (43), an injection pipe (44), first and second connection pipes (45, 46), and an oil return pipe (47).

<<Compressors>>

[0036] The first compressor (21a) is configured to compress, and discharge, a refrigerant sucked thereinto. The first compressor (21a) has a suction port, an intermediate port, and a discharge port. The suction port communicates with a compression chamber (i.e., a compression chamber in a low pressure phase) during a suction stroke

of the first compressor (21a). The intermediate port communicates with a compression chamber (i.e., a compression chamber in an intermediate pressure phase) in the middle of a compression stroke of the first compressor (21a). The discharge port communicates with a compression chamber (i.e., a compression chamber in a high pressure phase) during a discharge stroke of the first compressor (21a). The first compressor (21a) is configured as, for example, a scroll compressor including a compression chamber defined between a fixed scroll and an orbiting scroll, which mesh with each other. The second compressor (21b) has a configuration similar to that for the first compressor (21a).

[0037] Note that the first compressor (21a) has a variable operation frequency (capacity). Specifically, changing the output frequency of an inverter (not shown) triggers a change in the rotational speed of an electric motor provided inside the first compressor (21a). This causes the operation frequency of the first compressor (21a) to vary. On the other hand, the second compressor (21b) has a fixed operation frequency (capacity). Specifically, the second compressor (21b) includes therein an electric motor rotating at a constant rotational speed, and has a constant operation frequency.

<<Four-Way Valve>>

[0038] The four-way valve (22) is switchable between a first state (indicated by the solid curves shown in FIG. 1) and a second state (indicated by the dashed curves shown in FIG. 1). In the first state, a first port communicates with a third port, and a second port communicates with a fourth port. In the second state, the first port communicates with the fourth port, and the second port communicates with the third port.

[0039] The first port of the four-way valve (22) is connected to the discharge ports of the first and second compressors (21a, 21b) through the discharge refrigerant pipe (41). The second port of the four-way valve (22) is connected to the suction ports of the first and second compressors (21a, 21b) through the suction refrigerant pipe (42). The third port of the four-way valve (22) is connected to the gas end of the heat-source-side heat exchanger (23). The fourth port of the four-way valve (22) is connected to the gas stop valve (V2).

<<Discharge Refrigerant Pipe>>

[0040] The discharge refrigerant pipe (41) includes first and second discharge pipes (41a, 41b) one end of each of which is connected to the discharge port of an associated one of the first and second compressors (21a, 21b), and a main discharge pipe (41c) connecting the other end of each of the first and second discharge pipes (41a, 41b) to the first port of the four-way valve (22).

<<Suction Refrigerant Pipe>>

[0041] The suction refrigerant pipe (42) includes first and second suction pipe (42a, 42b) one end of each of which is connected to the suction port of an associated one of the first and second compressors (21a, 21b), and a main suction pipe (42c) connecting the other end of each of the first and second suction pipes (42a, 42b) to the second port of the four-way valve (22).

<<Heat-Source-Side Heat Exchanger>>

[0042] The heat-source-side heat exchanger (23) has its liquid end connected to one end of the heat-source-side liquid refrigerant pipe (43), and has its gas end connected to the third port of the four-way valve (22). The heat-source-side fan (17) is disposed near the heat-source-side heat exchanger (23). The heat-source-side heat exchanger (23) is configured to exchange heat between a refrigerant and heat-source-side air (i.e., outside air) transferred by the heat-source-side fan (17). The heat-source-side heat exchanger (23) is configured as, for example, a cross-fin, fin-and-tube heat exchanger.

<<Heat-Source-Side Liquid Refrigerant Pipe>>

[0043] The heat-source-side liquid refrigerant pipe (43) has two ends respectively connected to the heat-source-side heat exchanger (23) and the liquid stop valve (VI). In this example, the heat-source-side liquid refrigerant pipe (43) includes a first heat-source-side liquid pipe (43a) connecting the liquid end of the heat-source-side heat exchanger (23) to the receiver (35), a second heat-source-side liquid pipe (43b) connecting the receiver (35) to the supercooling heat exchanger (24), and a third heat-source-side liquid pipe (43c) connecting the supercooling heat exchanger (24) to the liquid stop valve (VI).

<<Injection Pipe>>

[0044] The injection pipe (44) connects a first intermediate portion (Q1) of the heat-source-side liquid refrigerant pipe (43) to the intermediate ports of the first and second compressors (21a, 21b). In this example, the injection pipe (44) includes a first main injection pipe (44m) connecting the first intermediate portion (Q1) of the heat-source-side liquid refrigerant pipe (43) to the supercooling heat exchanger (24), a second main injection pipe (44n) one end of which is connected to the supercooling heat exchanger (24), and first and second injection branch pipes (44a, 44b) each connecting the other end of the second main injection pipe (44n) to the intermediate port of an associated one of the first and second compressors (21a, 21b).

<<Subcooling Heat Exchanger>>

[0045] The supercooling heat exchanger (24) is con-

nected to the heat-source-side liquid refrigerant pipe (43) and the injection pipe (44), and is configured to exchange heat between a refrigerant flowing through the heat-source-side liquid refrigerant pipe (43) and a refrigerant flowing through the injection pipe (44). In this example, the supercooling heat exchanger (24) has first channels (24a) connected between the second heat-source-side liquid pipe (43b) and the third heat-source-side liquid pipe (43c), and second channels (24b) connected between the first main injection pipe (44m) and the second main injection pipe (44n), and is configured to exchange heat between a refrigerant flowing through the first channels (24a) and a refrigerant flowing through the second channels (24b). The supercooling heat exchanger (24) is configured as, for example, a plate heat exchanger.

<<Subcooling Expansion Valve>>

[0046] The supercooling expansion valve (31) is provided on a portion of the injection pipe (44) between the first intermediate portion (Q1) of the heat-source-side liquid refrigerant pipe (43) and the supercooling heat exchanger (24) (in this example, on the first main injection pipe (44m)). The supercooling expansion valve (31) has an adjustable degree of opening. The supercooling expansion valve (31) is configured as, for example, an electronic expansion valve (motor-operated valve).

<<Intermediate Expansion Valve>>

[0047] The intermediate expansion valve (32) is provided on a portion of the injection pipe (44) between the supercooling heat exchanger (24) and the intermediate port of the first compressor (21a) (in this example, on the first injection branch pipe (44a)). The intermediate expansion valve (32) also has an adjustable degree of opening. The intermediate expansion valve (32) is configured as, for example, an electronic expansion valve (a motor-operated valve).

<<Intermediate Open/Close Valve and Intermediate Check Valve>>

[0048] The intermediate open/close valve (33) and the intermediate check valve (34) are provided on a portion of the injection pipe (44) between the supercooling heat exchanger (24) and the intermediate port of the second compressor (21b) (in this example, on the second injection branch pipe (44b)). The intermediate open/close valve (33) and the intermediate check valve (34) are arranged on the second injection branch pipe (44b) in this order from the inlet toward the outlet of the second injection branch pipe (44b).

[0049] The intermediate open/close valve (33) is switchable between an open state and a closed state. The intermediate open/close valve (33) is configured as, for example, a solenoid valve. The intermediate check valve (34) allows a refrigerant to flow from the inlet toward

the outlet of the second injection branch pipe (44b), but disallows a refrigerant to flow in the reverse direction.

<<Receiver>>

[0050] The receiver (35) is connected to a portion of the heat-source-side liquid refrigerant pipe (43) between the heat-source-side heat exchanger (23) and the super-cooling heat exchanger (24), and is capable of temporarily storing a refrigerant condensed in the condenser (specifically, the heat-source-side heat exchanger (23) or a utilization-side heat exchanger (51), which will be described below). In this example, the receiver (35) has its inlet and outlet respectively connected to the first and second heat-source-side liquid pipes (43a, 43b).

<<First Connection Pipe>>

[0051] The first connection pipe (45) connects second and third intermediate portions (Q2, Q3) of the heat-source-side liquid refrigerant pipe (43) together. The second intermediate portion (Q2) is a portion of the heat-source-side liquid refrigerant pipe (43) between the first intermediate portion (Q1) and the liquid stop valve (VI), and the third intermediate portion (Q3) is a portion of the heat-source-side liquid refrigerant pipe (43) between the liquid end of the heat-source-side heat exchanger (23) and the receiver (35).

<<Second Connection Pipe>>

[0052] The second connection pipe (46) connects fourth and fifth intermediate portions (Q4, Q5) of the heat-source-side liquid refrigerant pipe (43) together. The fourth intermediate portion (Q4) is a portion of the heat-source-side liquid refrigerant pipe (43) between the first intermediate portion (Q1) and the second intermediate portion (Q2), and the fifth intermediate portion (Q5) is a portion of the heat-source-side liquid refrigerant pipe (43) between the liquid end of the heat-source-side heat exchanger (23) and the third intermediate portion (Q3).

<<Heat-Source-Side Expansion Valve>>

[0053] The heat-source-side expansion valve (36) is provided on the second connection pipe (46). The heat-source-side expansion valve (36) has an adjustable degree of opening. The heat-source-side expansion valve (36) is configured as, for example, an electronic expansion valve (motor-operated valve).

<<First Check Valve>>

[0054] The first check valve (CV1) is provided between the third and fifth intermediate portions (Q3, Q5) of the heat-source-side liquid refrigerant pipe (43), and is configured to allow a refrigerant to flow from the fifth intermediate portion (Q5) toward the third intermediate portion (Q3) and to disallow a refrigerant to flow in the reverse direction.

tion (Q3) and to disallow a refrigerant to flow in the reverse direction.

<<Second Check Valve>>

[0055] The second check valve (CV2) is provided between the second and fourth intermediate portions (Q2, Q4) of the heat-source-side liquid refrigerant pipe (43), and is configured to allow a refrigerant to flow from the fourth intermediate portion (Q4) toward the second intermediate portion (Q2) and to disallow a refrigerant to flow in the reverse direction.

<<Third Check Valve>>

[0056] The third check valve (CV3) is provided on the first connection pipe (45), and is configured to allow a refrigerant to flow from the second intermediate portion (Q2) toward the third intermediate portion (Q3) of the heat-source-side liquid refrigerant pipe (43) and to disallow a refrigerant to flow in the reverse direction.

<<First Oil Separator and First Discharge Check Valve>>

[0057] The first oil separator (OSa) and the first discharge check valve (CVa) are provided on a portion of the discharge refrigerant pipe (41) between the first compressor (21a) and the first port of the four-way valve (22) (specifically, on the first discharge pipe (41a)). The first oil separator (OSa) and the first discharge check valve (CVa) are arranged on the first discharge pipe (41a) in this order from the inlet toward the outlet of the first discharge pipe (41a). The first oil separator (OSa) is capable of separating refrigerating machine oil from a refrigerant discharged from the first compressor (21a) and storing therein the refrigerating machine oil. The first discharge check valve (CVa) allows a refrigerant to flow from the inlet toward the outlet of the first discharge pipe (41a), but disallows a refrigerant to flow in the reverse direction.

<<Second Oil Separator and Second Discharge Check Valve>>

[0058] The second oil separator (OSb) is provided on a portion of the discharge refrigerant pipe (41) between the second compressor (21b) and the first port of the four-way valve (22) (specifically, on the second discharge pipe (41b)). The second oil separator (OSb) and the second discharge check valve (CVb) are arranged on the second discharge pipe (41b) in this order from the inlet toward the outlet of the second discharge pipe (41b). The second oil separator (OSb) is capable of separating refrigerating machine oil from a refrigerant discharged from the second compressor (21b) and storing therein the refrigerating machine oil. The second discharge check valve (CVb) allows a refrigerant to flow from the inlet toward the outlet of the second discharge pipe (41b), but disallows a refrigerant to flow in the reverse direction.

<<Oil Return Pipe>>

[0059] The oil return pipe (47) is used to supply the refrigerating machine oil stored in the first and second oil separators (OSa, OSb) to the injection pipe (44). In this example, the oil return pipe (47) includes first and second oil return sub-pipes (47a, 47b) one end of each of which is connected to an associated one of the first and second oil separators (OSa, OSb), and a main oil return pipe (47c) connecting the other ends of the first and second oil return sub-pipes (47a, 47b) to an intermediate portion of the injection pipe (44) (specifically, an intermediate portion (Q6) of the second main injection pipe (44n)).

<<First Capillary Tube>>

[0060] The first capillary tube (CTa) is provided on a portion of the oil return pipe (47) between the first oil separator (OSa) and the intermediate portion (Q6) of the injection pipe (44) (specifically, on the first oil return sub-pipe (47a)).

<<Second Capillary Tube and Oil Return Check Valve>>

[0061] The second capillary tube (CTb) and the oil return check valve (CVc) are provided on a portion of the oil return pipe (47) between the second oil separator (OSb) and the intermediate portion (Q6) of the injection pipe (44) (specifically, on the second oil return sub-pipe (47b)). The oil return check valve (CVc) and the second capillary tube (CTb) are arranged on the second oil return sub-pipe (47b) in this order from the inlet toward the outlet of the second oil return sub-pipe (47b). The oil return check valve (CVc) allows a refrigerant to flow from the inlet toward the outlet of the second oil return sub-pipe (47b), but disallows a refrigerant to flow in the reverse direction.

<Utilization-Side Circuit>

[0062] The utilization-side circuit (18) includes a utilization-side heat exchanger (51), a utilization-side open/close valve (52), a utilization-side expansion valve (53), and a utilization-side check valve (54). The utilization-side circuit (18) is provided with a utilization-side liquid refrigerant pipe (61), a utilization-side gaseous refrigerant pipe (62), and a bypass pipe (63).

<<Utilization-Side Heat Exchanger>>

[0063] The utilization-side heat exchanger (51) has its liquid end connected to the liquid interconnecting pipe (13) through the utilization-side liquid refrigerant pipe (61), and has its gas end connected to the gas interconnecting pipe (14) through the utilization-side gaseous refrigerant pipe (62). The utilization-side fan (19) is disposed near the utilization-side heat exchanger (51). The utilization-side heat exchanger (51) is configured to ex-

change heat between a refrigerant and utilization-side air (i.e., inside air) transferred by the utilization-side fan (19). The utilization-side heat exchanger (51) is configured as, for example, a cross-fin, fin-and-tube heat exchanger.

<<Utilization-Side Liquid Refrigerant Pipe and Utilization-Side Gaseous Refrigerant Pipe>>

[0064] One end of the utilization-side liquid refrigerant pipe (61) is connected to the liquid interconnecting pipe (13), and the other end thereof is connected to the liquid end of the utilization-side heat exchanger (51). One end of the utilization-side gaseous refrigerant pipe (62) is connected to the gas end of the utilization-side heat exchanger (51), and the other end thereof is connected to the gas interconnecting pipe (14).

<<Utilization-Side Open/Close Valve and Utilization-Side Expansion Valve>>

[0065] The utilization-side open/close valve (52) and the utilization-side expansion valve (53) are provided on the utilization-side liquid refrigerant pipe (61). The utilization-side open/close valve (52) and the utilization-side expansion valve (53) are arranged on the utilization-side liquid refrigerant pipe (61) in this order from the one end toward the other end of the utilization-side liquid refrigerant pipe (61).

[0066] The utilization-side open/close valve (52) is switchable between an open state and a closed state. The utilization-side open/close valve (52) is configured as, for example, a solenoid valve. The utilization-side expansion valve (53) has an adjustable degree of opening. In this example, the utilization-side expansion valve (53) is configured as an externally equalized thermostatic expansion valve. Specifically, the utilization-side expansion valve (53) includes a feeler bulb (53a) provided on the utilization-side gaseous refrigerant pipe (62), and an equalizer (not shown) connected to an intermediate portion of the utilization-side gaseous refrigerant pipe (62), and has its degree of opening adjusted in accordance with the temperature of the feeler bulb (53a) and the pressure of a refrigerant in the equalizer.

<<Bypass Pipe>>

[0067] One end of the bypass pipe (63) is connected to an intermediate portion of the utilization-side liquid refrigerant pipe (61) between the utilization-side expansion valve (53) and the utilization-side heat exchanger (51). The other end of the bypass pipe (63) is connected to an intermediate portion of the utilization-side liquid refrigerant pipe (61) between the liquid interconnecting pipe (13) and the utilization-side open/close valve (52).

<<Utilization-Side Check Valve>>

[0068] The utilization-side check valve (54) is provided on the bypass pipe (63). The utilization-side check valve (54) allows a refrigerant to flow from the utilization-side heat exchanger (51) toward the liquid interconnecting pipe (13), but disallows a refrigerant to flow in the reverse direction.

<Various Sensors>

[0069] The refrigeration device (10) is provided with various sensors such as a suction temperature sensor (71), a suction pressure sensor (72), and an internal temperature sensor (76).

<<Suction Temperature Sensor>>

[0070] The suction temperature sensor (71) is configured to sense the temperature of a refrigerant sucked into the first and second compressors (21a, 21b) (hereinafter referred to as the "suction temperature"). In this example, the suction temperature sensor (71) is installed on the main suction pipe (42c) to sense the refrigerant temperature at its installation location as the suction temperature.

<<Suction Pressure Sensor>>

[0071] The suction pressure sensor (72) is configured to sense the pressure of a refrigerant sucked into the first and second compressors (21a, 21b) (hereinafter referred to as the "suction pressure"). In this example, the suction pressure sensor (72) is installed on the main suction pipe (42c) to sense the refrigerant pressure at its installation location as the suction pressure.

<<Internal Temperature Sensor>>

[0072] The internal temperature sensor (76) is configured to sense the temperature of inside air (hereinafter referred to as the "internal temperature (Tr)"). In this example, the internal temperature sensor (76) is installed on a portion of the utilization-side unit (12) downstream of the air flow from the utilization-side fan (19) to sense the air temperature at its installation location as the internal temperature (Tr).

<Controller>

[0073] The controller (80) controls components of the refrigeration device (10), based on values sensed by the various sensors, to control operations of the refrigeration device (10). In this example, the controller (80) includes a main controller (81) included in the heat-source-side unit (11), and a utilization-side controller (86) included in the utilization-side unit (12).

<<Main Controller>>

[0074] The main controller (81) controls components of the heat-source-side unit (11). In this example, the main controller (81) includes an operation control section (82), a compressor control section (83), and a target temperature setting section (84). The operation control section (82) controls the heat-source-side fan (17), the various valves (in this example, the four-way valve (22), the supercooling expansion valve (31), the intermediate expansion valve (32), and the intermediate open/close valve (33)), and other components included in the heat-source-side unit (11). The compressor control section (83) controls the first and second compressors (21a, 21b). The target temperature setting section (84) sets a target evaporation temperature (Te) described below.

<<Utilization-Side Controller>>

[0075] The utilization-side controller (86) controls components of the utilization-side unit (12) (in this example, the utilization-side fan (19) and the utilization-side open/close valve (52)).

[0076] The utilization-side controller (86) determines whether or not the refrigeration device (10) should start operating. If the utilization-side controller (86) determines that the refrigeration device (10) should start operating, the utilization-side controller (86) allows a cooling mode (for cooling inside air) to start, and transmits an operation start signal to the main controller (81). The utilization-side controller (86) further determines whether or not the refrigeration device (10) should finish operating. If the utilization-side controller (86) determines that the refrigeration device (10) should finish operating, the utilization-side controller (86) allows the cooling mode to end, and transmits an operation end signal to the main controller (81). For example, the utilization-side controller (86) determines whether or not the refrigeration device (10) should start operating and whether or not the refrigerating apparatus (10) should finish operating, in response to user's operations (operations for instructing the refrigerating apparatus (10) to start operating and to finish operating).

[0077] The utilization-side controller (86) determines whether or not a defrosting mode (an operation for defrosting the utilization-side heat exchanger (51)) should be started during a period of time during which an operation is performed in the cooling mode. If the utilization-side controller (86) determines that the defrosting mode should be started, the utilization-side controller (86) allows the defrosting mode to start, and transmits a defrosting start signal to the main controller (81). The utilization-side controller (86) determines whether or not the defrosting mode should be ended during a period of time during which the operation is performed in the defrosting mode. If the utilization-side controller (86) determines that the defrosting mode should be ended, the utilization-side controller (86) allows the defrosting mode to end,

allows the cooling mode to start, and transmits a defrosting end signal to the main controller (81). For example, if a predetermined period (a cooling mode period) has elapsed since the start of the cooling mode, the utilization-side controller (86) determines that the defrosting mode should be started. If a predetermined period (a defrosting mode period) has elapsed since the start of the defrosting mode, the utilization-side controller (86) determines that the defrosting mode should be ended.

<Operation of Refrigeration Device>

[0078] Next, operations of the refrigeration device (10) will be described with reference to FIG. 2.

<<Step (ST10)>>

[0079] The target temperature setting section (84) that has received the operation start signal from the utilization-side controller (86) sets the target evaporation temperature (T_e) to be equal to a predetermined reference temperature (T_{ref}). Note that the target evaporation temperature (T_e) is a target temperature set for the temperature of a refrigerant sucked into the first and second compressors (21a, 21b). The reference temperature (T_{ref}) is set to be lower than a set internal temperature (T_{set}). The set internal temperature (T_{set}) is a target temperature set for the internal temperature (T_r). The reference temperature (T_{ref}) is preferably set with consideration given to pressure loss in a pipe between the liquid end of the utilization-side heat exchanger (51) and the suction ports of the first and second compressors (21a, 21b) (specifically, the pipe length, the pipe diameter, the height difference, and other elements). Specifically, the reference temperature (T_{ref}) is set to be a temperature obtained by subtracting a predetermined temperature (e.g., a temperature falling within the range from 10°C to 17°C) from the set internal temperature (T_{set}).

<<Step (ST11): Cooling Mode>>

[0080] Next, the main controller (81) and the utilization-side controller (86) control components of the refrigeration device (10) so that the refrigeration device (10) operates in the cooling mode. In the cooling mode, a refrigeration cycle is performed to cool inside air. In this refrigeration cycle, the heat-source-side heat exchanger (23), the supercooling heat exchanger (24), and the utilization-side heat exchanger (51) of the refrigerant circuit (15) serve as a condenser, a supercooler, and an evaporator, respectively. How a refrigerant flows through the refrigerant circuit (15) during the cooling mode and how the target temperature setting section (84) operates in the cooling mode will be described in detail below.

[0081] The operation control section (82) that has received the operation start signal (or the defrosting end signal) from the utilization-side controller (86) places the four-way valve (22) in a first state, and places the heat-

source-side fan (17) in a driven state. The operation control section (82) adjusts the degree of opening of the supercooling expansion valve (31) so that the degree of supercooling of a refrigerant in the supercooling heat exchanger (24) (specifically, the degree of supercooling of a refrigerant at the outlets of the first channels (24a) of the supercooling heat exchanger (24)) is equal to a predetermined target degree of supercooling, and adjusts the degree of opening of the intermediate expansion valve (32) so that the degree of superheat of a refrigerant discharged from the first compressor (21a) is equal to a predetermined target degree of superheat. The operation control section (82) places the intermediate open/close valve (33) in an open state, and places the heat-source-side expansion valve (36) in a fully-closed state.

[0082] The compressor control section (83) that has received the operation start signal (or the defrosting end signal) from the utilization-side controller (86) places the first and second compressors (21a, 21b) in a driven state. Then, if the pressure of a refrigerant sensed by the suction pressure sensor (72) (i.e., the suction pressure) is above a predetermined low pressure range, the compressor control section (83) places the first and second compressors (21a, 21b) in a driven state. If the suction pressure is below the low pressure range, the compressor control section (83) places the first and second compressors (21a, 21b) at rest. The low pressure range will be described in detail below.

[0083] The compressor control section (83) controls the operation frequency (FQ) of the first compressor (21a) so that the temperature of a refrigerant sensed by the suction temperature sensor (71) (i.e., the suction temperature) is equal to the target evaporation temperature (T_e) set by the target temperature setting section (84). Specifically, if the suction temperature is higher than the target evaporation temperature (T_e), the compressor control section (83) increases the operation frequency (FQ) of the first compressor (21a). This reduces the suction temperature to allow the suction temperature to be closer to the target evaporation temperature (T_e). On the other hand, if the suction temperature is lower than the target evaporation temperature (T_e), the compressor control section (83) reduces the operation frequency (FQ) of the first compressor (21a). This increases the suction temperature to allow the suction temperature to be closer to the target evaporation temperature (T_e).

[0084] If the utilization-side controller (86) determines that the refrigeration device (10) should start operating (or should finish operating in the defrosting mode), the utilization-side controller (86) places the utilization-side fan (19) in a driven state. If the temperature of air sensed by the internal temperature sensor (76) (i.e., the internal temperature (T_r)) is above a set internal temperature range including the set internal temperature (T_{set}) (e.g., the temperature range including the set internal temperature (T_{set}) as a median value), the utilization-side controller (86) places the utilization-side open/close valve (52) in an open state to circulate a refrigerant through

the utilization-side heat exchanger (51). Thus, the utilization-side heat exchanger (51) functions as an evaporator. On the other hand, if the internal temperature (T_r) is below the set internal temperature range, the utilization-side controller (86) places the utilization-side open/close valve (52) in a closed state to interrupt the flow of a refrigerant in the utilization-side heat exchanger (51).

[0085] As can be seen, if the internal temperature (T_r) is above the set internal temperature range in the cooling mode, the utilization-side unit (12) enters into a cooling state where a refrigerant is circulated through the utilization-side heat exchanger (51) to allow the utilization-side heat exchanger (51) to function as an evaporator. If the internal temperature (T_r) is below the set internal temperature range, the utilization-side unit (12) enters into a suspended state where the flow of a refrigerant in the utilization-side heat exchanger (51) is interrupted to suspend the cooling of inside air.

[0086] In the utilization-side unit (12), the degree of opening of the utilization-side expansion valve (53) varies in accordance with the temperature of the feeler bulb (53a) and the refrigerant pressure in the equalizer (not shown) so that the degree of superheat of a refrigerant at the outlet of the utilization-side heat exchanger (51) is equal to a predetermined degree of superheat.

<<Step (ST12)>>

[0087] The utilization-side controller (86) determines whether or not the defrosting mode should be started during the cooling mode period (the period during which an operation is performed in the cooling mode). If the utilization-side controller (86) determines that the defrosting mode should be started, the utilization-side controller (86) transmits the defrosting start signal to the main controller (81). Next, the process proceeds to step (ST13).

<<Step (ST13)>>

[0088] The target temperature setting section (84) that has received the defrosting start signal from the utilization-side controller (86) sets the target evaporation temperature (T_e) to be equal to the reference temperature (T_{ref}). That is to say, the target temperature setting section (84) sets the target evaporation temperature (T_e) to be equal to the reference temperature (T_{ref}) after the cooling mode has ended and before the defrosting mode is started.

<<Step (ST14): Defrosting Mode>>

[0089] Next, the main controller (81) and the utilization-side controller (86) control components of the refrigeration device (10) so that the refrigeration device (10) operates in the defrosting mode. In the defrosting mode, the refrigerant circuit (15) performs a refrigeration cycle

to defrost the utilization-side heat exchanger (51). In this refrigeration cycle, the utilization-side heat exchanger (51) and the heat-source-side heat exchanger (23) serve as a condenser and an evaporator, respectively. How a refrigerant flows through the refrigerant circuit (15) during the defrosting mode will be described in detail below.

[0090] The operation control section (82) that has received the defrosting start signal from the utilization-side controller (86) places the four-way valve (22) in the second state, and places the heat-source-side fan (17) in the driven state. The operation control section (82) further places the supercooling expansion valve (31) and the intermediate expansion valve (32) in the fully-closed state, places the intermediate open/close valve (33) in the closed state, and adjusts the degree of opening of the heat-source-side expansion valve (36) so that the degree of superheat of a refrigerant at the outlet of the heat-source-side heat exchanger (23) is equal to a predetermined target degree of superheat.

[0091] The compressor control section (83) that has received the defrosting start signal from the utilization-side controller (86) places the first and second compressors (21a, 21b) in the driven state. As in the cooling mode, the compressor control section (83) controls the operation frequency (FQ) of the first compressor (21a) so that the temperature of a refrigerant sensed by the suction temperature sensor (71) (i.e., the suction temperature) is equal to the target evaporation temperature (T_e) set by the target temperature setting section (84).

[0092] If the utilization-side controller (86) determines that the defrosting mode should be started, the utilization-side controller (86) places the utilization-side fan (19) at rest. The utilization-side controller (86) places the utilization-side open/close valve (52) in the open state to circulate a refrigerant through the utilization-side heat exchanger (51). Thus, the utilization-side heat exchanger (51) functions as a condenser. Specifically, the utilization-side unit (12) circulates a refrigerant through the utilization-side heat exchanger (51), and is thus placed in a heat dissipation state where the utilization-side heat exchanger (51) functions as a condenser. In the utilization-side unit (12), the utilization-side expansion valve (53) is placed in the open state.

<<Step (ST15)>>

[0093] Next, the utilization-side controller (86) determines whether or not the defrosting mode should be ended during the defrosting mode period (the period during which an operation is performed in a defrosting mode). If the utilization-side controller (86) determines that the defrosting mode should be ended, the utilization-side controller (86) transmits the defrosting end signal to the main controller (81). Next, the process proceeds to step (ST11).

<Refrigerant Flow in Cooling Mode>

[0094] Next, how a refrigerant flows in the refrigerant circuit (15) during the cooling mode will be described with reference to FIG. 3. In the cooling mode, the four-way valve (22) is placed in the first state, in which the discharge ports of the first and second compressors (21a, 21b) communicate with the gas end of the heat-source-side heat exchanger (23), and the suction ports of the first and second compressors (21a, 21b) communicate with the gas interconnecting pipe (14).

[0095] A refrigerant discharged from the first and second compressors (21a, 21b) passes through the first and second oil separators (OSa, OSb) and the first and second discharge check valves (CVa, CVb) in the discharge refrigerant pipe (41), then flows through the four-way valve (22) into the heat-source-side heat exchanger (23), dissipates heat to the heat-source-side air (i.e., outside air) in the heat-source-side heat exchanger (23), and condenses. The refrigerant (high-pressure refrigerant) that has flowed out of the heat-source-side heat exchanger (23) passes through the first check valve (CV1) in the first heat-source-side liquid pipe (43a), then passes through the receiver (35) and the second heat-source-side liquid pipe (43b) in this order, flows into the first channels (24a) of the supercooling heat exchanger (24), and is supercooled by having its heat absorbed by a refrigerant (intermediate-pressure refrigerant) flowing through the second channels (24b) of the supercooling heat exchanger (24). The refrigerant that has flowed out of the first channels (24a) of the supercooling heat exchanger (24) flows into the third heat-source-side liquid pipe (43c). Then, part of the refrigerant flows into the first main injection pipe (44m). The remaining part passes through the second check valve (CV2) in the third heat-source-side liquid pipe (43c), and then flows through the liquid stop valve (VI) into the liquid interconnecting pipe (13).

[0096] The refrigerant that has flowed into the first main injection pipe (44m) is decompressed in the supercooling expansion valve (31), flows into the second channels (24b) of the supercooling heat exchanger (24), and absorbs heat from the refrigerant (high-pressure refrigerant) flowing through the first channels (24a) of the supercooling heat exchanger (24). The refrigerant that has flowed out of the second channels (24b) of the supercooling heat exchanger (24) passes through the second main injection pipe (44n). Then, part of the refrigerant flows into the first injection branch pipe (44a). The remaining part flows into the second injection branch pipe (44b). The refrigerant that has flowed into the first injection branch pipe (44a) is decompressed in the intermediate expansion valve (32), and flows into the intermediate port of the first compressor (21a). The refrigerant that has flowed into the second injection branch pipe (44b) passes through the intermediate open/close valve (33) and the intermediate check valve (34) in this order, and then flows into the intermediate port of the second compressor (21b). The refrigerant that has flowed through

the intermediate ports into the first and second compressors (21a, 21b) is mixed with a refrigerant in the first and second compressors (21a, 21b) (specifically, a refrigerant in the compression chamber). That is to say, the refrigerant in the first and second compressors (21a, 21b) is compressed while being cooled.

[0097] On the other hand, the refrigerant that has flowed into the liquid interconnecting pipe (13) passes through the open utilization-side open/close valve (52) in the utilization-side liquid refrigerant pipe (61) of the utilization-side unit (12), and is then decompressed in the utilization-side expansion valve (53). The decompressed refrigerant flows into the utilization-side heat exchanger (51), and absorbs heat from the utilization-side air (i.e., inside air) in the utilization-side heat exchanger (51) to evaporate. Thus, the utilization-side air is cooled. The refrigerant that has flowed out of the utilization-side heat exchanger (51) passes through the utilization-side gaseous refrigerant pipe (62), the gas interconnecting pipe (14), and the gas stop valve (V2), the four-way valve (22), and the suction refrigerant pipe (42) of the heat-source-side unit (11) in this order, and is sucked into the suction ports of the first and second compressors (21a, 21b).

[0098] The first and second oil separators (OSa, OSb) separate refrigerating machine oil from the refrigerant (i.e., the refrigerant discharged from the first and second compressors (21a, 21b)), and store therein the refrigerating machine oil. The refrigerating machine oil stored in the first oil separator (OSa) passes through the first capillary tube (CTa) in the first oil return sub-pipe (47a), and then flows into the main oil return pipe (47c). The refrigerating machine oil stored in the second oil separator (OSb) passes through the oil return check valve (CVc) and the second capillary tube (CTb) in this order in the second oil return sub-pipe (47b), and then flows into the main oil return pipe (47c). The refrigerating machine oil that has flowed into the main oil return pipe (47c) flows into the second main injection pipe (44n) to join with a refrigerant flowing through the second main injection pipe (44n).

<Refrigerant Flow in Defrosting Mode>

[0099] Next, how a refrigerant flows through the refrigerant circuit (15) during the defrosting mode will be described with reference to FIG. 4. In the defrosting mode, the four-way valve (22) is placed in the second state, in which the discharge ports of the first and second compressors (21a, 21b) communicate with the gas interconnecting pipe (14), and the suction ports of the first and second compressors (21a, 21b) communicate with the gas end of the heat-source-side heat exchanger (23).

[0100] The refrigerant discharged from the first and second compressors (21a, 21b) passes through the first and second oil separators (OSa, OSb) and the first and second discharge check valves (CVa, CVb) in the discharge refrigerant pipe (41), then passes through the

four-way valve (22) and the gas stop valve (V2) in this order, and flows into the gas interconnecting pipe (14). The refrigerant that has flowed into the gas interconnecting pipe (14) passes through the utilization-side gaseous refrigerant pipe (62) of the utilization-side unit (12), flows into the utilization-side heat exchanger (51), and dissipates heat in the utilization-side heat exchanger (51) to condense. Thus, frost formed on the utilization-side heat exchanger (51) is heated to melt. Part of the refrigerant that has flowed out of the utilization-side heat exchanger (51) passes through the open utilization-side expansion valve (53) and the open utilization-side open/close valve (52) in this order in the utilization-side liquid refrigerant pipe (61). The remaining part passes through the utilization-side check valve (54) in the bypass pipe (63). The refrigerant that has passed through the open utilization-side open/close valve (52) in the utilization-side liquid refrigerant pipe (61) joins with the refrigerant that has passed through the utilization-side check valve (54) in the bypass pipe (63), and flows into the liquid interconnecting pipe (13).

[0101] The refrigerant that has passed through the liquid interconnecting pipe (13) passes through the liquid stop valve (VI) of the heat-source-side unit (11), and flows into the third heat-source-side liquid pipe (43c). The refrigerant that has flowed into the third heat-source-side liquid pipe (43c) flows into the first connection pipe (45) at the second intermediate portion (Q2), passes through the third check valve (CV3) in the first connection pipe (45), and flows into the intermediate portion (third intermediate portion (Q3)) of the first heat-source-side liquid pipe (43a). The refrigerant that has flowed into the intermediate portion of the first heat-source-side liquid pipe (43a) passes through the receiver (35), the second heat-source-side liquid pipe (43b), the first channels (24a) of the supercooling heat exchanger (24) in this order, and flows into the third heat-source-side liquid pipe (43c). The refrigerant that has flowed into the third heat-source-side liquid pipe (43c) flows into the second connection pipe (46) at the fourth intermediate portion (Q4), is decompressed in the heat-source-side expansion valve (36), and flows into the intermediate portion (fifth intermediate portion (Q5)) of the first heat-source-side liquid pipe (43a). The refrigerant that has flowed into the intermediate portion of the first heat-source-side liquid pipe (43a) flows into the heat-source-side heat exchanger (23), and absorbs heat from the heat-source-side air (i.e., outside air) in the heat-source-side heat exchanger (23) to evaporate. The refrigerant that has flowed out of the heat-source-side heat exchanger (23) passes through the four-way valve (22) and the suction refrigerant pipe (42) in this order, and is sucked into the suction ports of the first and second compressors (21a, 21b).

<Operation of Target Temperature Setting Section in Cooling Mode>

[0102] Next, how the target temperature setting sec-

tion (84) operates in the cooling mode will be described with reference to FIG. 5.

<<Step (ST21)>>

[0103] First, the target temperature setting section (84) determines whether or not the utilization-side unit (12) is in a suspended state. In this example, if the utilization-side unit (12) shifts from the cooling state to the suspended state in the cooling mode, the pressure of the refrigerant sucked into the first and second compressors (21a, 21b) (i.e., the suction pressure) decreases to below the low pressure range. If the utilization-side unit (12) shifts from the suspended state to the cooling state in the cooling mode, the suction pressure increases to above the low pressure range. Specifically, a lower limit of the low pressure range is set to be equal to the suction pressure obtained when the utilization-side unit (12) is considered to have shifted from the cooling state to the suspended state, and an upper limit thereof is set to be equal to the suction pressure obtained when the utilization-side unit (12) is considered to have shifted from the suspended state to the cooling state. If the suction pressure is above the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) is in the cooling state. If the suction pressure is below the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) is in the suspended state. Specifically, if the suction pressure decreases to below the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) has shifted from the cooling state to the suspended state. If the suction pressure increases to above the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) has shifted from the suspended state to the cooling state. If a determination is made that the utilization-side unit (12) is in the suspended state, the process proceeds to step (ST23). If not, the process proceeds to step (ST22).

<<Step (ST22)>>

[0104] If, in step (ST21), a determination is not made that the utilization-side unit (12) is in the suspended state (i.e., if the utilization-side unit (12) is in the cooling state), the target temperature setting section (84) determines whether or not a predetermined period of time (T1) has elapsed since the start of the cooling mode. Note that the predetermined period of time (T1) is set to be equal to a period of time that it is estimated to take from the start of the cooling mode to a time when the internal temperature (Tr) decreases to a temperature near the set internal temperature (Tset) (e.g., 24 hours). If a determination is made that the predetermined period of time (T1) has elapsed, the process proceeds to step (ST23). If not, the process proceeds to step (ST21).

[0105] As can be seen, the target temperature setting

section (84) determines, in steps (ST21, ST22), whether or not a period of time required to reduce the internal temperature (T_r) (hereinafter referred to as the "pull-down period (PD)") has elapsed since the start of the cooling mode. Specifically, in this example, the pull-down period (PD) corresponds to a shorter one of a period of time from a time when the cooling mode is started to a time when the utilization-side unit (12) has shifted from the cooling state to the suspended state or a period of time from the time when the cooling mode is started to a time when the predetermined period of time (T_1) has elapsed since the start of the cooling mode. If a determination is made that the pull-down period (PD) has elapsed since the start of the cooling mode, the process proceeds to step (ST23).

<<Step (ST23)>>

[0106] Next, the target temperature setting section (84) determines whether or not the utilization-side unit (12) is in the cooling state. In this example, if the suction pressure is above the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) is in the cooling state. If the suction pressure is below the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) is in the suspended state. Specifically, if the suction pressure decreases to below the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) has shifted from the cooling state to the suspended state. If the suction pressure increases to above the low pressure range, the target temperature setting section (84) determines that the utilization-side unit (12) has shifted from the suspended state to the cooling state. If a determination is made that the utilization-side unit (12) is in the cooling state, the process proceeds to step (ST24).

<<Step (ST24)>>

[0107] Next, the target temperature setting section (84) starts measuring a period of time (T_{on}) that has elapsed since the utilization-side unit (12) determined in step (ST23) that the utilization-side unit (12) was in the cooling state. That is to say, the target temperature setting section (84) measures the length of time during which the utilization-side unit (12) is in the cooling state (hereinafter referred to as the "cooling duration"). In this example, the cooling duration corresponds to a period of time from a time when the utilization-side unit (12) shifts from the suspended state to the cooling state to a time when the utilization-side unit (12) subsequently shifts from the cooling state to the suspended state, or a period of time from a time when the pull-down period (PD) ends to a time when the utilization-side unit (12) subsequently shifts from the cooling state to the suspended state.

<<Step (ST25)>>

[0108] Next, the target temperature setting section (84) determines whether or not the utilization-side unit (12) is in the suspended state. If the utilization-side unit (12) is in the suspended state, the process proceeds to step (ST26). If not, the process proceeds to step (ST29).

<<Step (ST26)>>

[0109] Next, the target temperature setting section (84) determines whether or not a frequency index value (FQ_i) during the cooling duration (i.e., the period of time during which the utilization-side unit (12) is in the cooling state) is above a predetermined reference value (FQ_{ref}).

[0110] Note that the frequency index value (FQ_i) depends on the operation frequency (FQ) of the first compressor (21a) during the cooling duration. For example, as shown in FIG. 6, the frequency index value (FQ_i) may correspond to the average (FQ_{ave}) of the operation frequencies (FQ) of the first compressor (21a) during the cooling duration. Alternatively, the frequency index value (FQ_i) may correspond to the operation frequency (FQ) of the first compressor (21a) obtained when the utilization-side unit (12) shifts from the cooling state to the suspended state.

[0111] The reference value (FQ_{ref}) is a value based on which a determination is made whether or not the operation frequency of the first compressor (21a) is relatively high. For example, the reference value (FQ_{ref}) is set to correspond to 60% of a maximum value (FQ_{max}) of the operation frequency (FQ) of the first compressor (21a).

[0112] If a determination is made that the frequency index value (FQ_i) is above the reference value (FQ_{ref}), the process proceeds to step (ST27). If not, the process proceeds to step (ST23).

<<Step (ST27)>>

[0113] Next, the target temperature setting section (84) determines whether or not the present target evaporation temperature (T_e) is equal to a predetermined upper-limit temperature (T_{emax}). In this example, the upper-limit temperature (T_{emax}) is set to be equal to the target evaporation temperature (T_e) at which the utilization-side unit (12) may be considered to have cooling capability high enough to appropriately cool inside air in the cooling mode. Specifically, the upper-limit temperature (T_{emax}) is set to be equal to a temperature obtained by adding a predetermined temperature (e.g., 3°C) to the reference temperature (T_{eref}). If a determination is made that the present target evaporation temperature (T_e) is equal to the upper-limit temperature (T_{emax}), the process proceeds to step (ST23). If not, the process proceeds to step (ST28).

<<Step (ST28)>>

[0114] Next, the target temperature setting section (84) corrects the target evaporation temperature (Te) so that the target evaporation temperature (Te) increases. Specifically, the target temperature setting section (84) increases the target evaporation temperature (Te) by a predetermined temperature (e.g., 1°C). Next, the process proceeds to step (ST23).

<<Step (ST29)>>

[0115] On the other hand, if a determination is not made, in step (ST25), that the utilization-side unit (12) is in the suspended state (i.e., if the utilization-side unit (12) in the cooling state), the target temperature setting section (84) determines whether or not the period of time (Ton) is above a predetermined duration threshold (Tth). In this example, the duration threshold (Tth) is set to be equal to a period of time (e.g., one hour) corresponding to a cooling duration (the length of time during which the utilization-side unit (12) is in the cooling state) required when the internal cooling load may be considered to have increased after the pull-down period (PD) has elapsed. If the period of time (Ton) is above the duration threshold (Tth), the process proceeds to step (ST30). If not, the process proceeds to step (ST25).

<<Step (ST30)>>

[0116] Next, the target temperature setting section (84) determines whether or not the target evaporation temperature (Te) is equal to the reference temperature (Teref). If a determination is made that the target evaporation temperature (Te) is equal to the reference temperature (Teref), the process proceeds to step (ST24). If not, the process proceeds to step (ST31).

<<Step (ST31)>>

[0117] Next, the target temperature setting section (84) corrects the target evaporation temperature (Te) so that the target evaporation temperature (Te) decreases to be closer to, or equal to, the reference temperature (Teref). Specifically, the target temperature setting section (84) reduces the target evaporation temperature (Te) by a predetermined temperature (e.g., 1°C). Next, the process proceeds to step (ST24). In other words, the period of time (Ton) is set to be zero, and measurement of the period of time (Ton) is restarted.

<Change in Internal Temperature>

[0118] Next, how the internal temperature (Tr) changes will be described with reference to FIG. 7.

[0119] At a time (t0), the refrigeration device (10) starts operating to start operating in the cooling mode. Thus, the utilization-side unit (12) is in the cooling state. This

allows the cooling of inside air to start. Thus, the internal temperature (Tr) gradually decreases.

[0120] At a time (t1), the internal temperature (Tr) is below the set internal temperature range, and the utilization-side unit (12) shifts from the cooling state to the suspended state. That is to say, the utilization-side unit (12) performs a thermo-off operation. This allows the pull-down period (PD) to end. Specifically, in the example shown in FIG. 7, the pull-down period (PD) is a period of time from a time when the cooling mode starts to a time when the utilization-side unit (12) shifts from the cooling state to the suspended state. When the utilization-side unit (12) shifts from the cooling state to the suspended state, the cooling of the inside air is suspended. Thus, the internal temperature (Tr) gradually increases.

[0121] At a time (t2), the internal temperature (Tr) is above the set internal temperature range, and the utilization-side unit (12) shifts from the suspended state to the cooling state. That is to say, the utilization-side unit (12) performs a thermo-on operation. This allows the cooling of the inside air to restart. Thus, the internal temperature (Tr) gradually decreases.

[0122] At a time (t3), the internal temperature (Tr) is below the set internal temperature range, and the utilization-side unit (12) shifts from the cooling state to the suspended state. This allows the cooling of the inside air to be suspended. Thus, the internal temperature (Tr) gradually increases.

[0123] The utilization-side unit (12) alternately and repeatedly performs the thermo-off operation (an operation to shift from the cooling state to the suspended state) and the thermo-on operation (an operation to shift from the suspended state to the cooling state) during a period of time from the time (t3) to the time (t4). This can stabilize the internal temperature (Tr) near the set internal temperature (Tset).

[0124] At a time (t4), the cooling mode ends, and the defrosting mode is started. Thus, the utilization-side unit (12) enters into the heat dissipation state. Thus, the defrosting of the utilization-side heat exchanger (51) is started. The heat dissipation of the utilization-side heat exchanger (51) causes the internal temperature (Tr) to gradually increase.

[0125] At a time (t5), the defrosting mode ends, and the cooling mode is restarted. Thus, the utilization-side unit (12) enters into the cooling state. This allows the cooling of the inside air to restart. Thus, the internal temperature (Tr) gradually decreases.

[0126] As can be seen, upon the start of the cooling mode, the utilization-side unit (12) enters into the cooling state. Thus, the internal temperature (Tr) gradually decreases. If the pull-down period (PD) has elapsed since the start of the cooling mode, the internal temperature (Tr) becomes close to the set internal temperature (Tset). Thus, the internal cooling load decreases. That is to say, after the pull-down period (PD) has elapsed since the start of the cooling mode (during the period of time from the time (t1) to the time (t4) in FIG. 7), the internal tem-

perature (T_r) is stable near the set internal temperature (T_{set}). Thus, the internal cooling load is considered to be relatively low. The period during which the internal temperature (T_r) is stable near the set internal temperature (T_{set}) and the internal cooling load is relatively low is hereinafter referred to as the "low internal load period."

<Change in Operation Frequency of Compressor>

[0127] Next, how the operation frequency (FQ) of the first compressor (21a) changes during the period of time during which an operation is performed in the cooling mode will be described with reference to FIGS. 8 and 9. FIG. 8 shows how the internal temperature (T_r) and the operation frequency (FQ) change if the target evaporation temperature (T_e) is always the reference temperature (T_{eref}) during the period of time during which the operation is performed in the cooling mode (i.e., in a comparative example of the refrigeration device (10)). FIG. 9 shows how the internal temperature (T_r) and the operation frequency (FQ) change if the target evaporation temperature (T_e) is corrected in accordance with the frequency index value (FQi) during the period of time during which the operation is performed in the cooling mode (i.e., in the refrigeration device (10) according to this embodiment).

[0128] In FIGS. 8 and 9, the cooling mode is started at the time (t_0), and the cooling mode ends at the time (t_1). For convenience of description, FIGS. 8 and 9 do not show how the internal temperature (T_r) and the operation frequency (FQ) change during the period of time (suspension duration) from a time when the utilization-side unit (12) shifts from the cooling state to the suspended state to a time when the utilization-side unit (12) subsequently shifts from the suspended state to the cooling state.

<<Change in refrigeration device of Comparative Example>>

[0129] As shown in FIG. 8, in the refrigeration device (10) of a comparative example, the target evaporation temperature (T_e) is a fixed value (the reference temperature (T_{eref})) during the period of time from the time (t_1) to the time (t_2). The operation frequency (FQ) of the first compressor (21a) is close to the maximum value (FQmax) of the operation frequency (FQ) during the pull-down period (PD), and gradually decreases after the pull-down period (PD) has elapsed.

<<Change in refrigeration device of Embodiment>>

[0130] On the other hand, as shown in FIG. 9, in the refrigeration device (10) of this embodiment, the target evaporation temperature (T_e) is corrected during the period of time from the time (t_1) to the time (t_2). In the example shown in FIG. 9, the reference value (FQref) is set to correspond to 60% of the maximum value (FQmax) of

the operation frequency (FQ) of the first compressor (21a). The target temperature setting section (84) is configured to increase the target evaporation temperature (T_e) by 1°C if a determination is made that the frequency index value (FQi) is above the reference value (FQref).

[0131] Specifically, at a time (t_{11}), the target temperature setting section (84) determines that the frequency index value (FQi) during the period of time from the time (t_1) to the time (t_{11}) (e.g., the average (FQave) of the operation frequencies (FQi) of the first compressor (21a) during the period of time from the time (t_1) to the time (t_{11})) is above the reference value (FQref). Thus, the target temperature setting section (84) increases the target evaporation temperature (T_e) by 1°C. Next, at a time (t_{12}), the target temperature setting section (84) determines that the frequency index value (FQi) during the period of time from the time (t_{11}) to the time (t_{12}) is above the reference value (FQref). Thus, the target temperature setting section (84) increases the target evaporation temperature (T_e) by 1°C. Next, at a time (t_{13}), the target temperature setting section (84) determines that the frequency index value (FQi) during the period of time from the time (t_{12}) to the time (t_{13}) is above the reference value (FQref). Thus, the target temperature setting section (84) increases the target evaporation temperature (T_e) by 1°C.

[0132] In the refrigeration device (10) according to this embodiment, if the target temperature setting section (84) corrects the target evaporation temperature (T_e) so that the target evaporation temperature (T_e) increases, the compressor control section (83) reduces the operation frequency (FQ) of the first compressor (21a) so that the temperature of a refrigerant sucked into the first compressor (21a) increases. Specifically, correcting the target evaporation temperature (T_e) at the times (t_{11} , t_{12} , t_{13}) so that the target evaporation temperature (T_e) increases can facilitate reducing the operation frequency (FQ) of the first compressor (21a) during the low internal load period (the period of time from the time (t_1) to the time (t_2) in FIG. 9) in the cooling mode, as compared with a case where the target evaporation temperature (T_e) is a fixed value.

[0133] Reducing the operation frequency (FQ) of the first compressor (21a) triggers a reduction in the cooling capability of the utilization-side unit (12). This increases the period of time during which the utilization-side unit (12) is in the cooling state (the cooling duration), and also increases the period of time during which the first compressor (21a) is placed in the driven state. In general, if a compressor is driven at low operation frequencies for a long time, the compressor tends to have higher operating efficiency than if a compressor is driven at high operation frequencies for a short time. Thus, reducing the operation frequency (FQ) of the first compressor (21a) during the low internal load period in the cooling mode can improve the operating efficiency of the first compressor (21a) to increase the coefficient of performance (COP) of the refrigeration device (10).

<Advantages of Embodiment>

[0134] As can be seen from the foregoing description, the target temperature setting section (84) sets the target evaporation temperature (T_e) to be equal to the reference temperature (T_{ref}) between the time when the cooling mode starts and the time when the pull-down period (PD) has elapsed since the start of the cooling mode (step (ST10)). This allows the utilization-side unit (12) to have sufficiently high cooling capability during the pull-down period (PD). Thus, the inside air can be appropriately cooled during the pull-down period (PD).

[0135] If, after the pull-down period (PD) has elapsed, the frequency index value (FQ_i) during the cooling duration (the period of time during which the utilization-side unit (12) is in the cooling state) is above the reference value (FQ_{ref}), the target temperature setting section (84) corrects the target evaporation temperature so that the target evaporation temperature (T_e) is higher than the reference temperature (T_{ref}) (steps (ST21-ST28)). Thus, if the first compressor (21a) is driven at relatively high operation frequencies during the low internal load period after the pull-down period (PD) has elapsed, increasing the target evaporation temperature (T_e) can facilitate reducing the operation frequency (FQ) of the first compressor (21a). This can increase the coefficient of performance (COP) of the refrigeration device (10) during the low internal load period in the cooling mode.

[0136] An increase in the target evaporation temperature (T_e) during the low internal load period in the cooling mode reduces the cooling capability of the utilization-side unit (12). This can reduce the amount of frost formed on the utilization-side heat exchanger (51). This can shorten the defrosting mode period (the period of time during which an operation is performed in the defrosting mode), and can reduce the power consumed in the defrosting mode.

[0137] The target temperature setting section (84) corrects the target evaporation temperature (T_e) to prevent the target evaporation temperature (T_e) from being above the upper-limit temperature (T_{max}) (step (ST27)). An excessively high target evaporation temperature (T_e) may cause the utilization-side unit (12) to have insufficient cooling capability. This may prevent inside air from being appropriately cooled. Thus, correcting the target evaporation temperature (T_e) to prevent the target evaporation temperature (T_e) from being above the upper-limit temperature (T_{max}) can prevent the target evaporation temperature (T_e) from becoming too high. This can prevent an increase in the target evaporation temperature (T_e) from causing lack of the cooling capability of the utilization-side unit (12). Thus, the inside air can be appropriately cooled in the cooling mode.

[0138] If the target evaporation temperature (T_e) is higher than the reference temperature (T_{ref}), and the cooling duration (the period of time during which the utilization-side unit (12) is in the cooling state) is longer than the duration threshold (T_{th}), the target temperature set-

ting section (84) corrects the target evaporation temperature (T_e) so that the target evaporation temperature (T_e) decreases to be closer to, or equal to, the reference temperature (T_{ref}) (steps (ST29-ST31)). During the low internal load period after a lapse of the pull-down period (PD), the opening/closing of a door and other factors may cause outside heat to enter the internal space. This may increase the internal cooling load. An increase in the internal cooling load as above triggers an increase in the cooling duration (the period of time during which the utilization-side unit (12) is in the cooling state). Thus, if, when the cooling duration is longer than the duration threshold (T_{th}), the target evaporation temperature (T_e) is reduced, the cooling capability of the utilization-side unit (12) can be increased when the internal cooling load is high during the low internal load period after a lapse of the pull-down period (PD). This allows the internal temperature (T_r) to be rapidly closer to the set internal temperature (T_{set}).

[0139] The target temperature setting section (84) sets the target evaporation temperature (T_e) at the reference temperature (T_{ref}) after the end of the cooling mode and before the start of the defrosting mode (step (ST13)). This allows the utilization-side unit (12) to have sufficiently high heat dissipation capability (specifically, allows the utilization-side heat exchanger (51) to have sufficiently high heat dissipation capability) in the defrosting mode. Thus, the utilization-side heat exchanger (51) can be appropriately defrosted in the defrosting mode.

[0140] The pull-down period (PD) corresponds to a shorter one of a period of time from a time when the cooling mode starts to a time when the utilization-side unit (12) shifts from the cooling state to the suspended state or a period of time from the time when the cooling mode starts to a time when the predetermined period of time (T_1) has elapsed since the start of the cooling mode. Note that if the utilization-side unit (12) shifts from the cooling state to the suspended state after the start of the cooling mode, the internal temperature (T_r) can be considered to be close to the set internal temperature (T_{set}). In addition, also if a sufficient period of time (i.e., the predetermined period of time (T_1)) has elapsed since the start of the cooling mode, the internal temperature (T_r) can be considered to be close to the set internal temperature (T_{set}). Thus, if a shorter one of the period of time from the time when the cooling mode starts to the time when the utilization-side unit (12) shifts from the cooling state to the suspended state or a period of time from the time when the cooling mode starts to the time when the predetermined period of time (T_1) has elapsed since the start of the cooling mode is defined as the pull-down period (PD), the internal temperature (T_r) can be reduced to a temperature close to the set internal temperature (T_{set}) during the pull-down period (DP).

(Other Embodiments)

[0141] In the foregoing description, a shorter one of

the period of time from the time when the cooling mode starts to the time when the utilization-side unit (12) shifts from the cooling state to the suspended state and the period of time from the time when the cooling mode starts to the time when the predetermined period of time (T1) has elapsed since the start of the cooling mode, for example, is defined as the pull-down period (PD). However, the pull-down period (PD) may be the period of time from the time when the cooling mode starts to the time when the utilization-side unit (12) shifts from the cooling state to the suspended state. In other words, step (ST22) shown in FIG. 5 may be omitted. Alternatively, the pull-down period (PD) may be the period of time from the time when the cooling mode starts to the time when the predetermined period of time (T1) has elapsed since the start of the cooling mode. In other words, step (ST21) shown in FIG. 5 may be omitted.

[0142] Note that the foregoing description of the embodiment is a merely preferred example in nature, and is not intended to limit the scope, application, or uses of the present disclosure.

INDUSTRIAL APPLICABILITY

[0143] As can be seen from the foregoing description, the above-mentioned refrigeration device is useful as a refrigeration device which cools inside air.

DESCRIPTION OF REFERENCE CHARACTERS

[0144]

10	Refrigeration Device	
11	Heat-Source-Side Unit	
12	Utilization-Side Unit	
15	Refrigerant Circuit	
21a	First Compressor (Compressor)	
21b	Second Compressor	
22	Four-Way Valve	
23	Heat-Source-Side Heat Exchanger	
24	Supercooling Heat Exchanger	
51	Utilization-Side Heat Exchanger	
52	Utilization-Side Open/Close valve	
53	Utilization-Side Expansion Valve	
71	Suction Temperature Sensor	
72	Suction Pressure Sensor	
76	Internal Temperature Sensor	
80	Controller	
81	Main Controller	
82	Operation Control Section	
83	Compressor Control Section	
84	Target Temperature Setting Section	
86	Utilization-Side Controller	

Claims

1. A refrigeration device comprising:

a heat-source-side unit (11) including a compressor (21a) and a heat-source-side heat exchanger (23); and
a utilization-side unit (12) including a utilization-side heat exchanger (51) and provided in an internal space, wherein
the heat-source-side unit (11) and the utilization-side unit (12) are connected together to form a refrigerant circuit (15) through which a refrigerant circulates,
during a cooling mode in which the heat-source-side heat exchanger (23) functions as a condenser,

if an internal temperature (Tr) is above a set internal temperature range including a set internal temperature (Tset), the utilization-side unit (12) is placed in a cooling state where a refrigerant is passed through the utilization-side heat exchanger (51) to allow the utilization-side heat exchanger (51) to function as an evaporator, and
if the internal temperature (Tr) is below the set internal temperature range, the utilization-side unit (12) is placed in a suspended state where flow of a refrigerant through the utilization-side heat exchanger (51) is interrupted so that cooling of the internal space is suspended, and

the refrigeration device further includes:

a compressor control section (83) configured to control an operation frequency (FQ) of the compressor (21a) so that in the cooling mode, a temperature of a refrigerant sucked into the compressor (21a) is equal to a target evaporation temperature (Te); and
a target temperature setting section (84) configured to set the target evaporation temperature (Te) to be equal to the reference temperature (Teref) lower than the set internal temperature (Tset) during a pull-down period (PD) for reducing the internal temperature (Tr), which has elapsed since the start of the cooling mode, the target temperature setting section (84) being configured to correct the target evaporation temperature (Te) so that if, after the pull-down period (PD) has elapsed, a frequency index value (FQi) dependent on the operation frequency (FQ) of the compressor (21a) during a cooling duration during which the utilization-side unit (12) is placed in the cooling state is above a predetermined reference value (FQref), the target evaporation temperature (Te) is higher than the reference

temperature (T_{ref}).

2. The refrigeration device of claim 1, wherein
the frequency index value (FQ_i) corresponds to an
average (FQ_{ave}) of operation frequencies (FQ) of 5
the compressor (21a) during the cooling duration.

3. The refrigeration device of claim 1, wherein
the frequency index value (FQ_i) corresponds to an
operation frequency (FQ) of the compressor (21a) 10
obtained when the utilization-side unit (12) shifts
from the cooling state to the suspended state.

4. The refrigeration device of any one of claims 1 to 3,
wherein 15
the target temperature setting section (84) corrects
the target evaporation temperature (T_e) to prevent
the target evaporation temperature (T_e) from ex-
ceeding a predetermined upper-limit temperature 20
(T_{max}).

5. The refrigeration device of any one of claims 1 to 4,
wherein
the target temperature setting section (84) corrects 25
the target evaporation temperature (T_e) so that if the
target evaporation temperature (T_e) is higher than
the reference temperature (T_{ref}), and the cooling
duration is longer than a predetermined duration
threshold (T_{th}), the target evaporation temperature 30
(T_e) decreases to be closer to, or equal to, the re-
ference temperature (T_{ref}).

6. The refrigeration device of any one of claims 1 to 5,
wherein
the target temperature setting section (84) sets the 35
target evaporation temperature (T_e) to be equal to
the reference temperature (T_{ref}) after an end of the
cooling mode and before start of a defrosting mode
in which the utilization-side heat exchanger (51)
functions as a condenser and the heat-source-side 40
heat exchanger (23) functions as an evaporator.

7. The refrigeration device of any one of claims 1 to 6,
wherein
the pull-down period (PD) corresponds to a shorter 45
one of a period of time from a time when the cooling
mode starts to a time when the utilization-side unit
(12) shifts from the cooling state to the suspended
state or a period of time from the time when the cool-
ing mode starts to a time when a predetermined pe- 50
riod of time (T_1) has elapsed since the start of the
cooling mode.

55

FIG.1

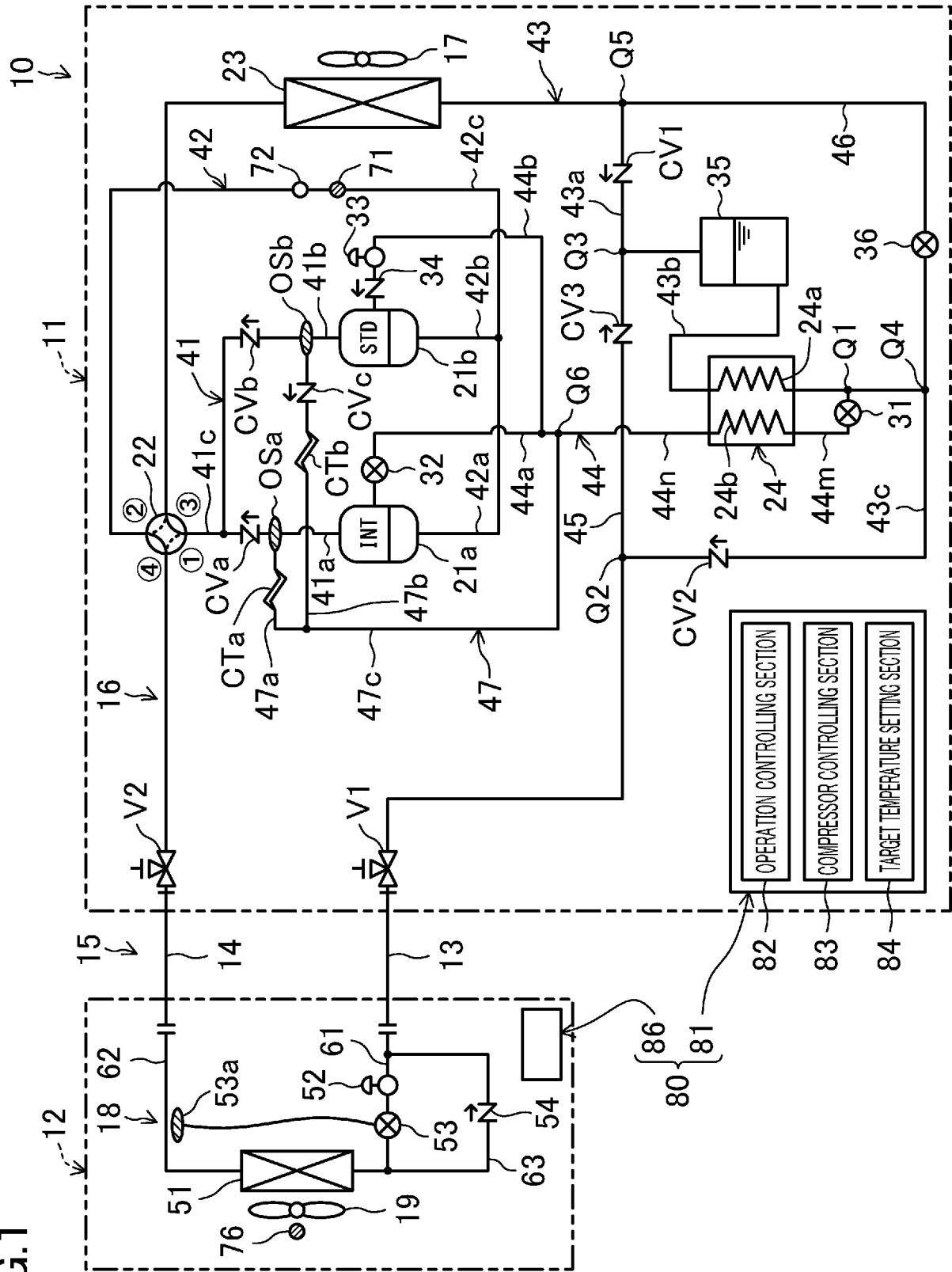


FIG.2

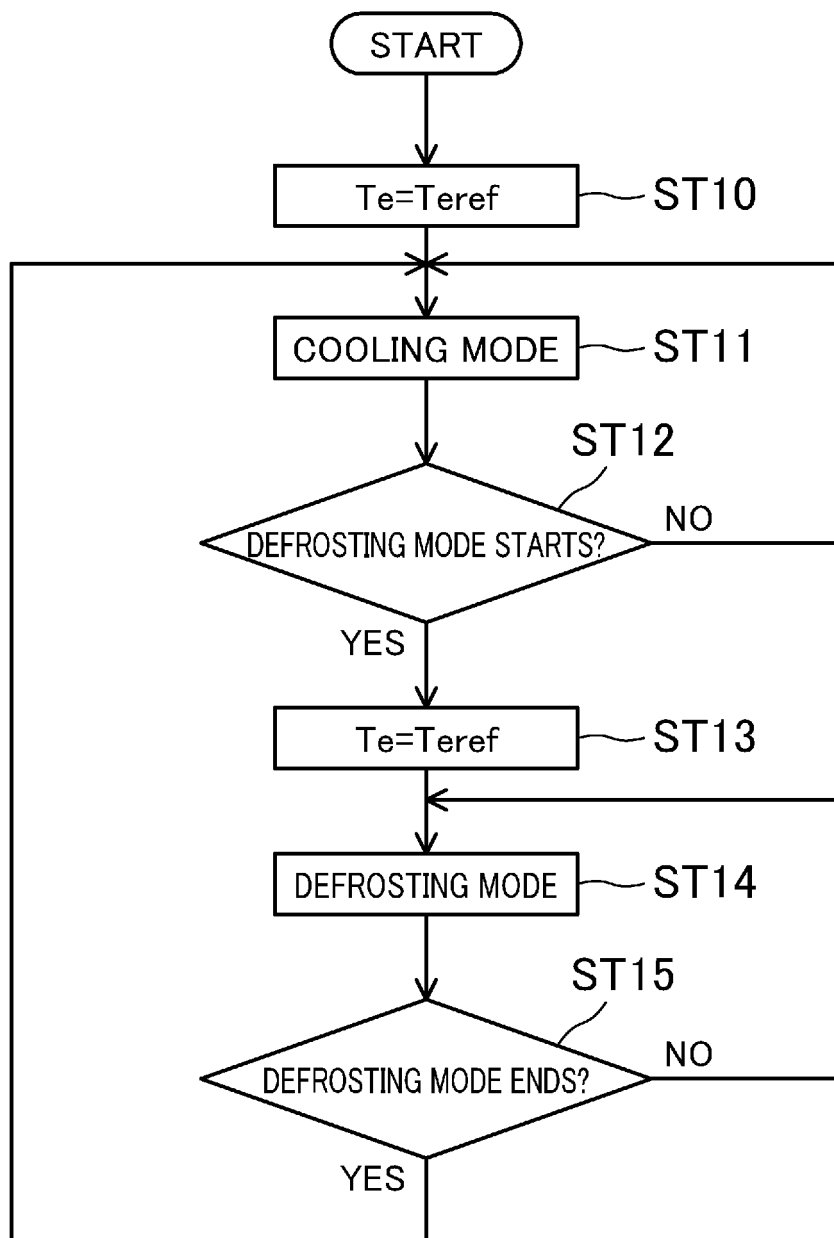


FIG.3

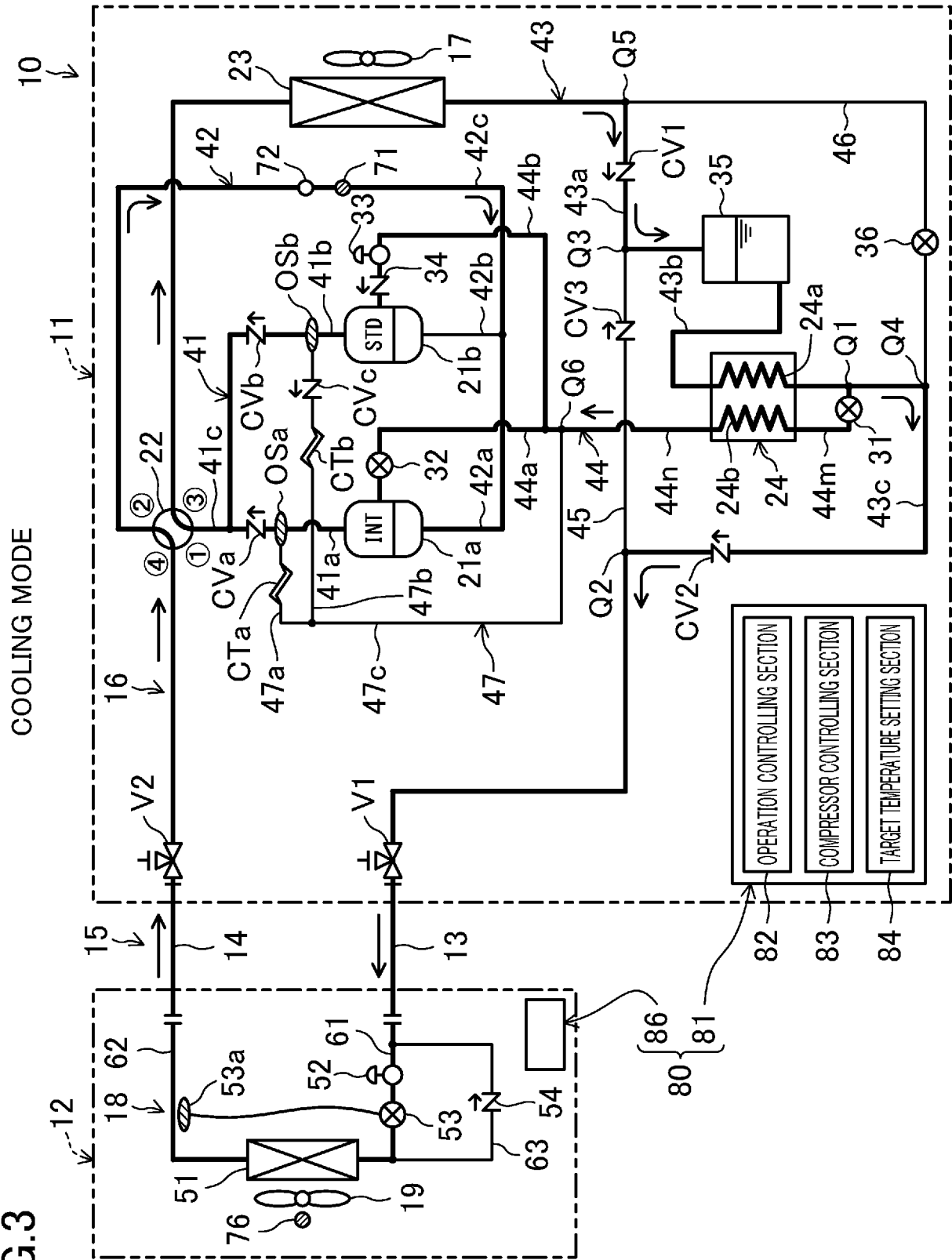


FIG. 4

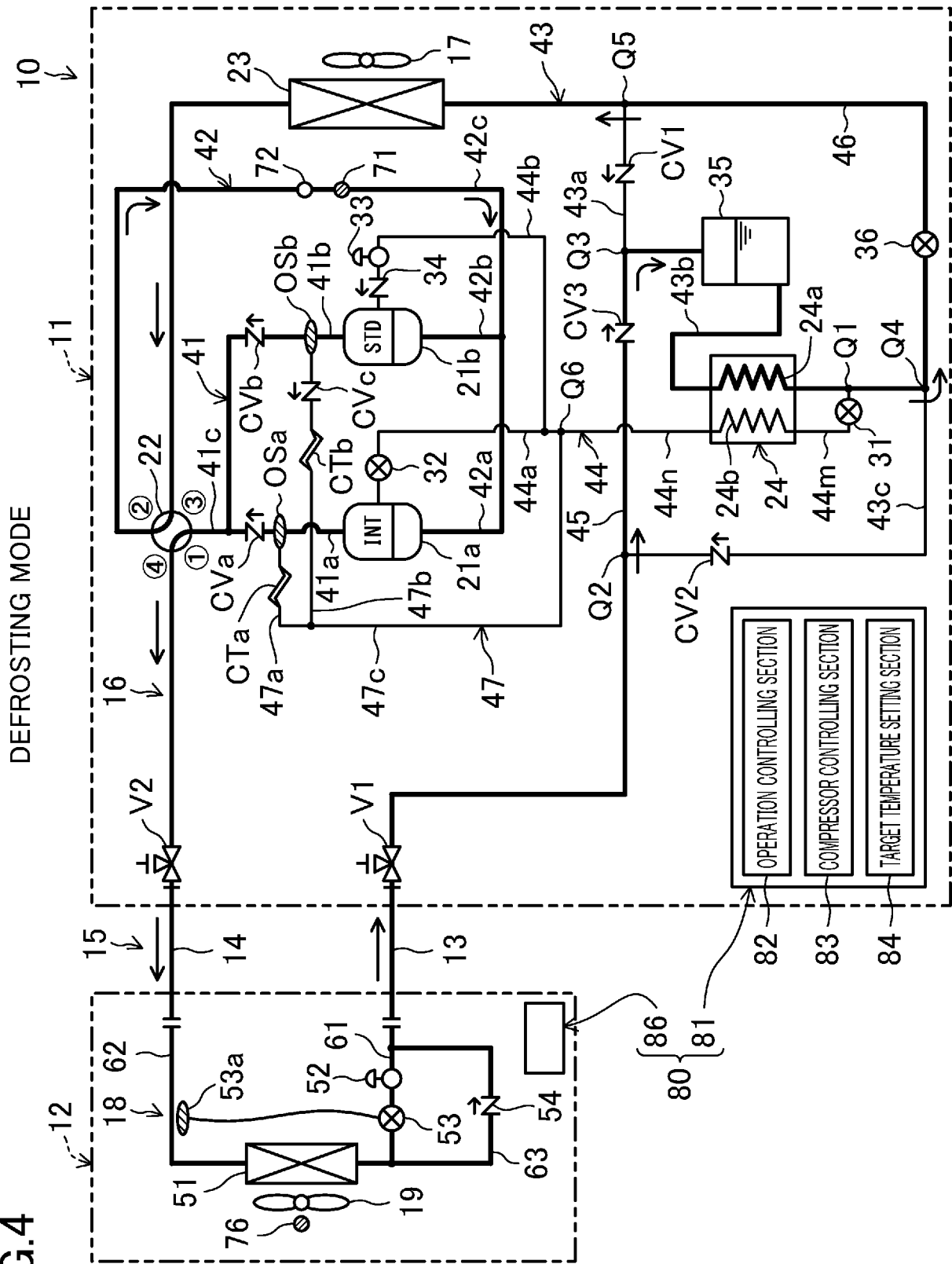


FIG.5

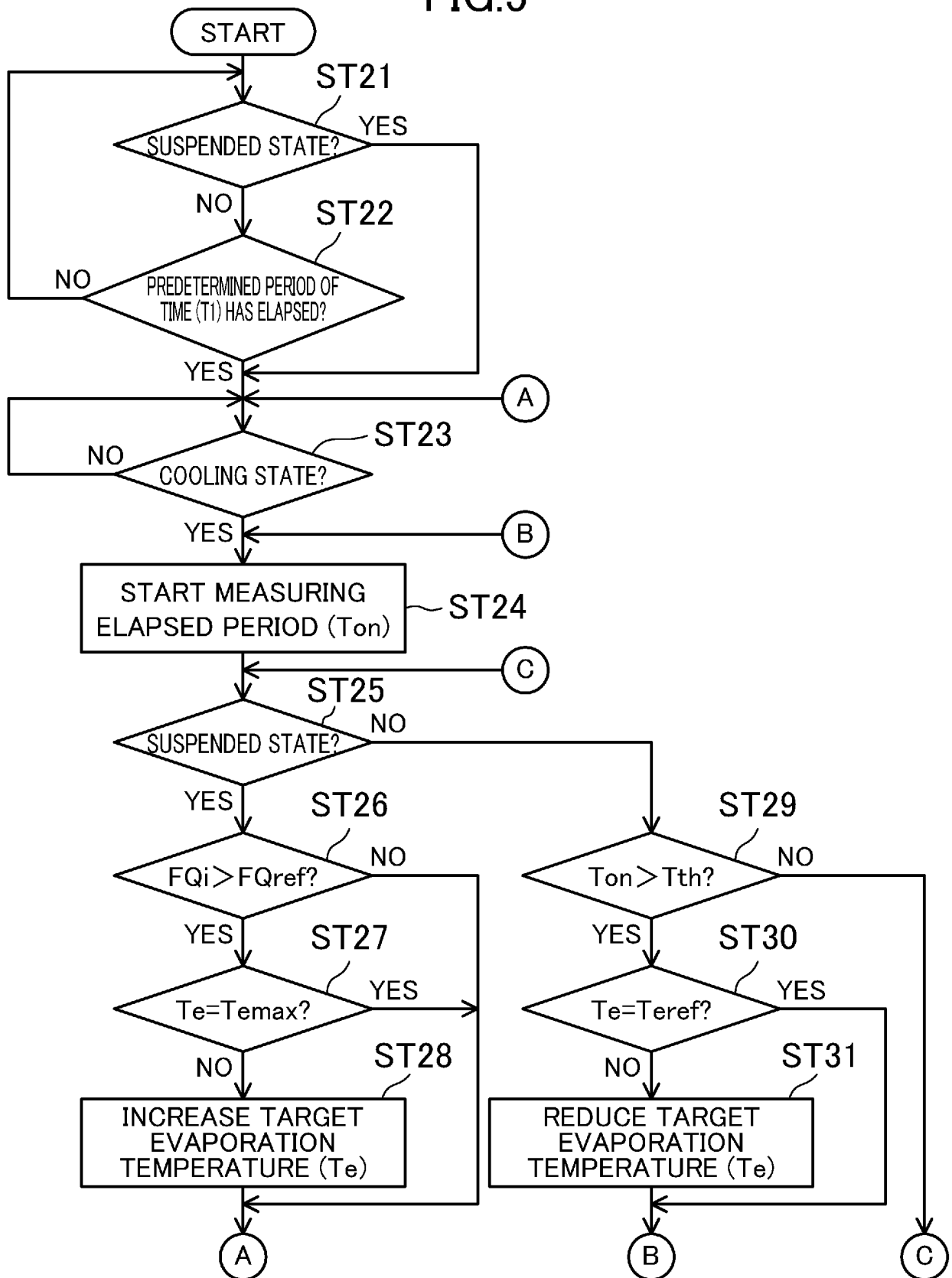


FIG.6

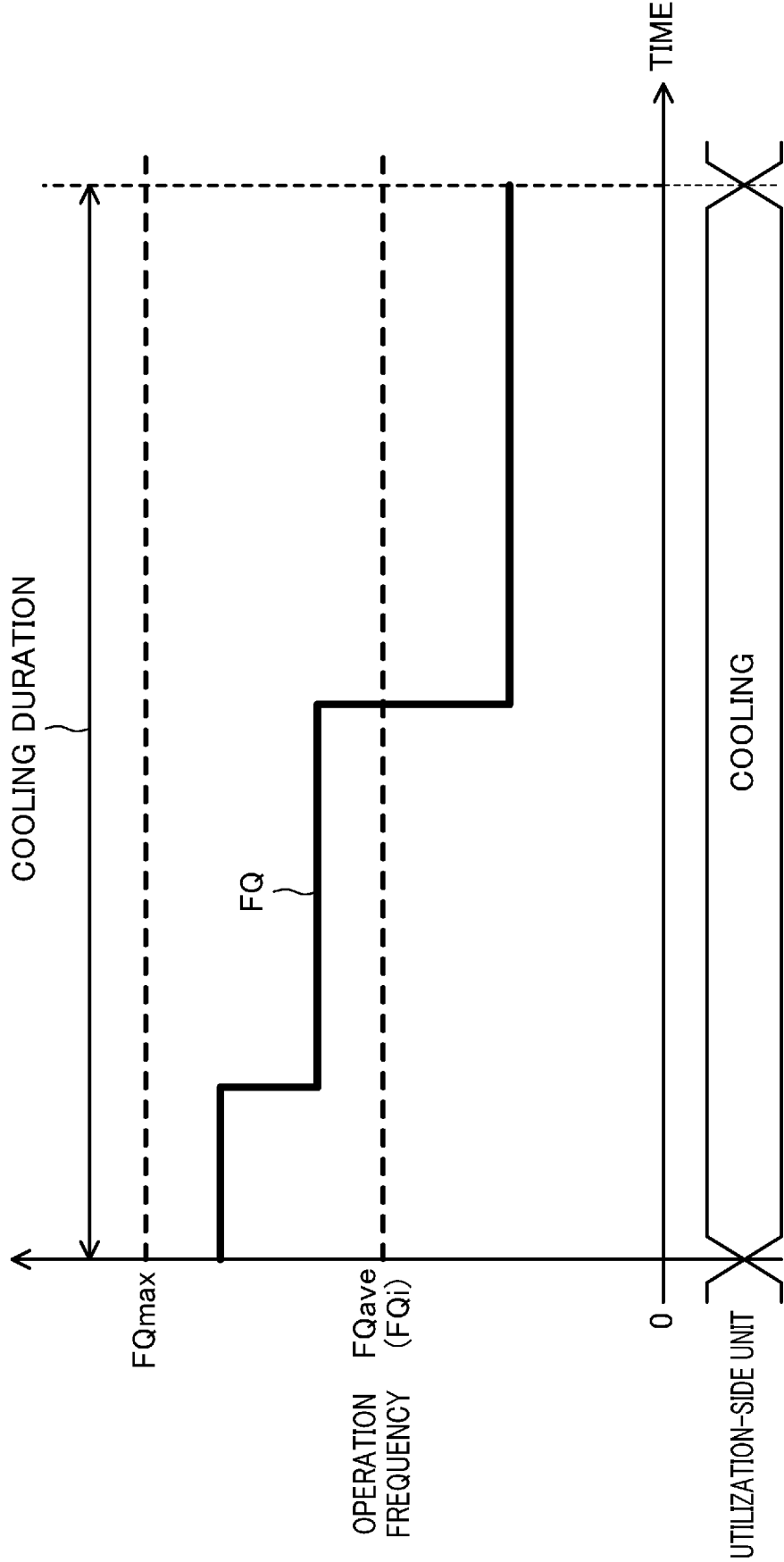


FIG.7

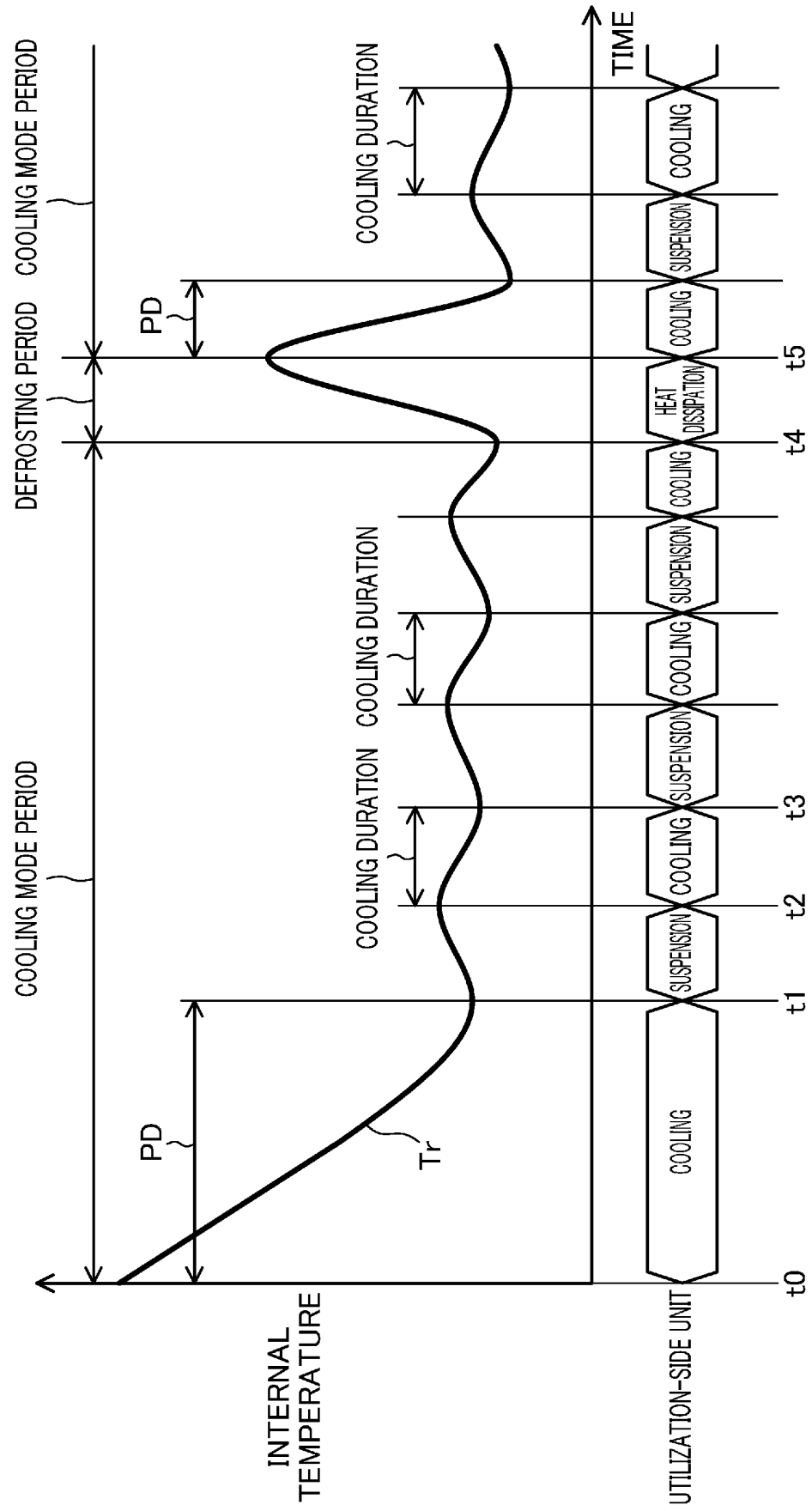


FIG.8

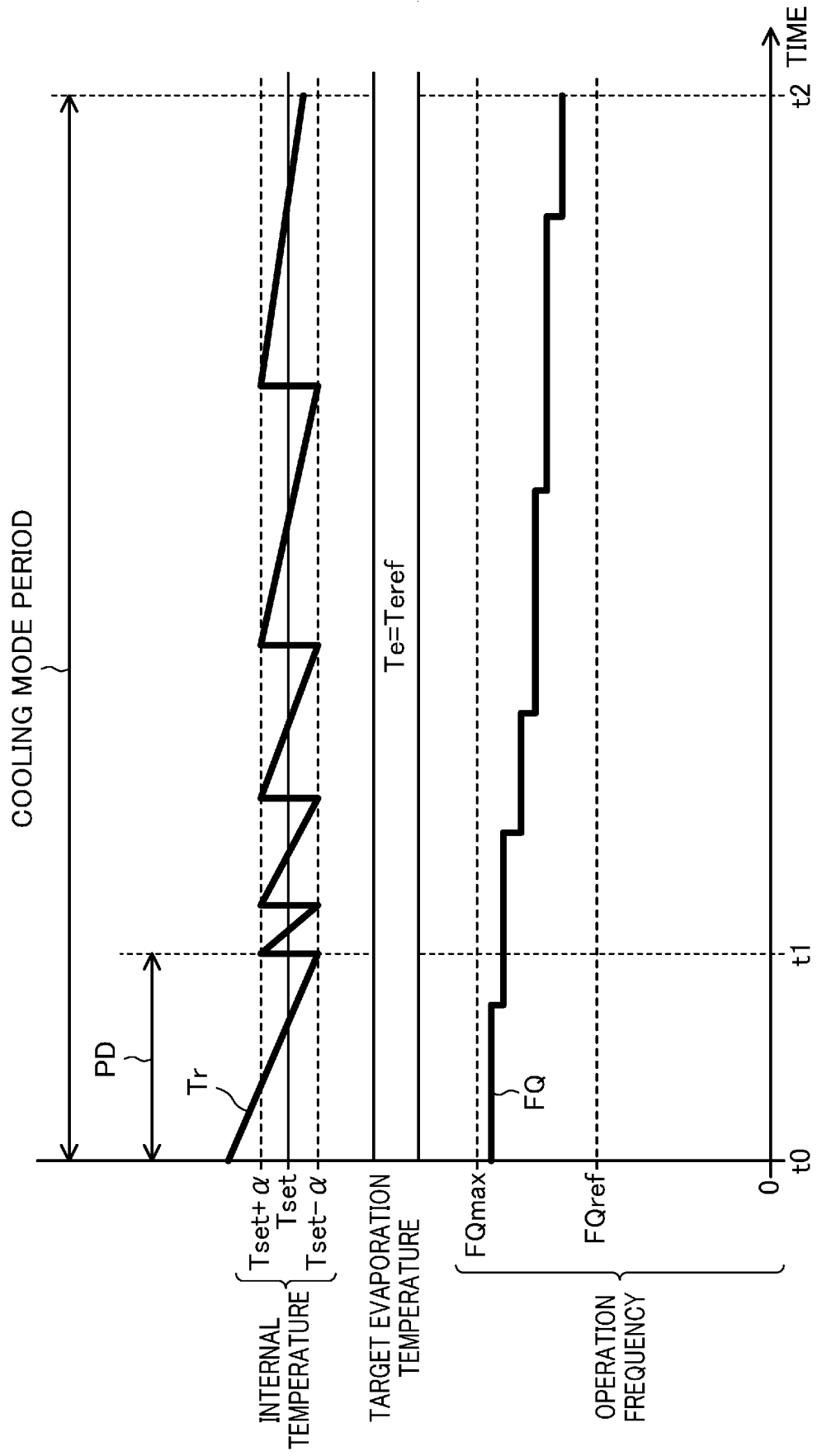
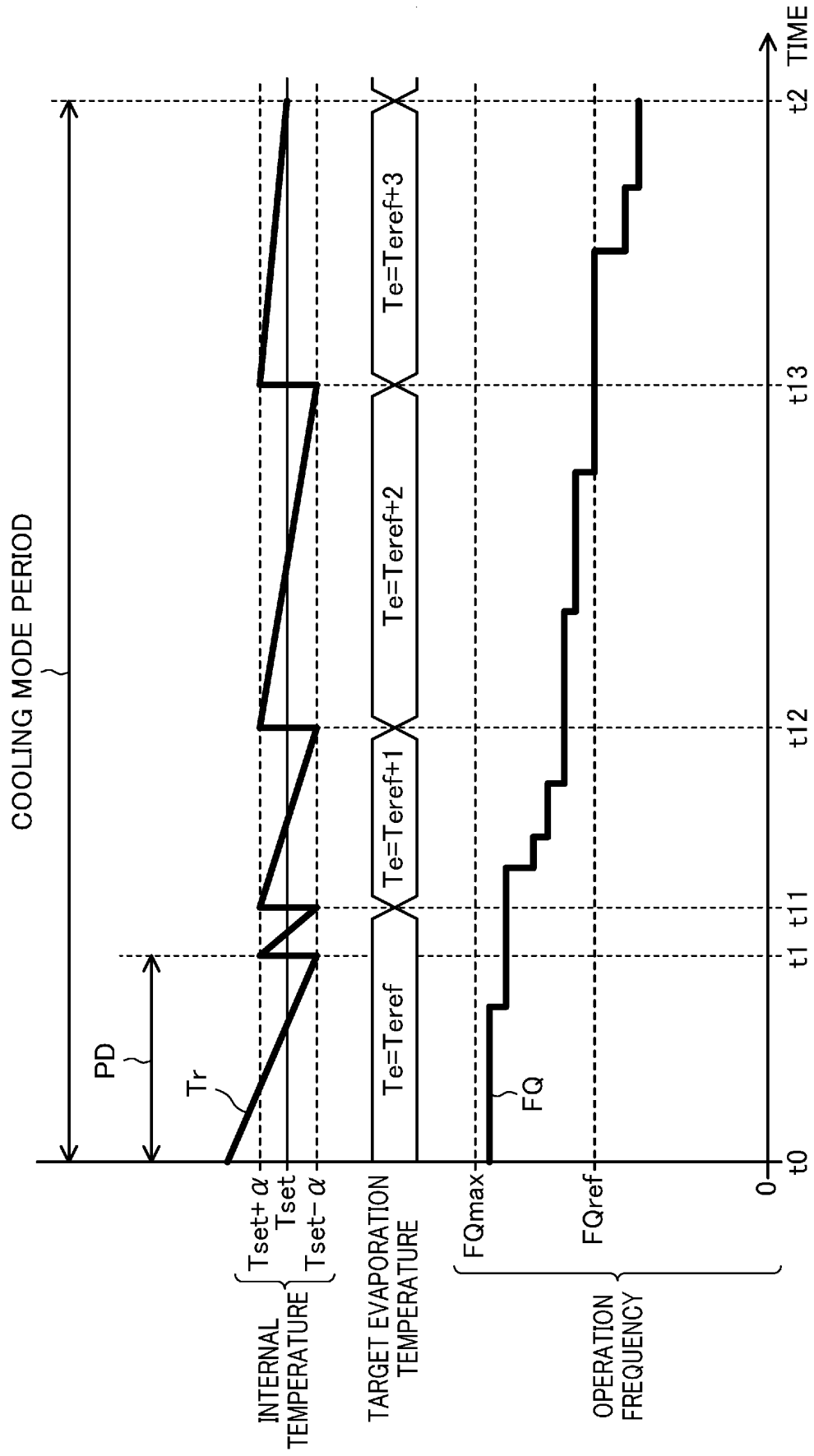


FIG.9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/003624

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F25D11/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B1/00, F25D11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-175203 A (Hitachi Appliances, Inc.), 12 August 2010 (12.08.2010), paragraphs [0021], [0035] to [0036]; fig. 1 to 5 (Family: none)	1-7
A	JP 2007-225155 A (Mitsubishi Electric Corp.), 06 September 2007 (06.09.2007), paragraph [0015] (Family: none)	1-7
A	WO 2014/103028 A1 (Mitsubishi Electric Corp.), 03 July 2014 (03.07.2014), paragraph [0069] & US 2015/0292777 A1 paragraphs [0121] to [0123] & EP 2940395 A1	1-7

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

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"&"

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Date of the actual completion of the international search
14 October 2016 (14.10.16)Date of mailing of the international search report
01 November 2016 (01.11.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/003624

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-304344 A (Toshiba Corp.), 05 November 1999 (05.11.1999), paragraph [0055] (Family: none)	6
A	JP 2008-70015 A (Toshiba Corp.), 27 March 2008 (27.03.2008), paragraph [0055] & CN 101144671 A	7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2014070830 A [0004]