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

(11) EP 4 033 178 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
**29.05.2024 Bulletin 2024/22**

(21) Application number: **20871109.3**

(22) Date of filing: **17.07.2020**

(51) International Patent Classification (IPC):
***F25B 13/00*** *(2006.01)* ***F25B 1/10*** *(2006.01)*
***F25B 41/22*** *(2021.01)* ***F25B 47/02*** *(2006.01)*
***F25B 49/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
**F25B 13/00; F25B 1/10; F25B 41/22; F25B 49/02;**
F25B 41/20; F25B 47/025; F25B 2313/0234;
F25B 2400/075; F25B 2600/2509;
F25B 2700/21152; F25B 2700/21163

(86) International application number:
**PCT/JP2020/027906**

(87) International publication number:
**WO 2021/065156 (08.04.2021 Gazette 2021/14)**

(54) **REFRIGERATION DEVICE**

KÜHLVORRICHTUNG

DISPOSITIF DE RÉFRIGÉRATION

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

(30) Priority: **30.09.2019 JP 2019180679**
**30.09.2019 JP 2019180683**

(43) Date of publication of application:
**27.07.2022 Bulletin 2022/30**

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## Description

TECHNICAL FIELD

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

BACKGROUND ART

**[0002]** A refrigeration apparatus provided with a refrigerant circuit has been known. JP 2015 48983 A discloses a refrigeration apparatus having a refrigerant circuit. The refrigerant circuit includes a compressor, an air heat exchanger (heat source heat exchanger), an expansion valve, an internal heat exchanger (utilization heat exchanger), and a subcooler (subcooling heat exchanger). The refrigerant circuit performs a first refrigeration cycle and a second refrigeration cycle. In the first refrigeration cycle, the heat source heat exchanger serves as a radiator, and the utilization heat exchanger serves as an evaporator. In the second refrigeration cycle, the heat source heat exchanger serves as an evaporator, and the utilization heat exchanger serves as a radiator.

**[0003]** The refrigeration apparatus performs the first refrigeration cycle in a cooling operation. When the utilization heat exchanger is frosted in the cooling operation, the refrigeration apparatus performs a defrosting operation. In the defrosting operation, the second refrigeration cycle is performed, and the utilization heat exchanger serves as a radiator. This operation allows the refrigerant to melt frost on the surface of the utilization heat exchanger.

**[0004]** Further examples of previously known refrigeration apparatuses are derivable from JP 2015 068571 A. The document JP 2010 236712 A discloses a refrigeration apparatus according to the preamble of independent claim 1.

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

**[0005]** When the refrigeration apparatus described above is performing the first refrigeration cycle, the refrigerant that has dissipated heat in the heat source heat exchanger is cooled in the subcooling heat exchanger, and then evaporates in the utilization heat exchanger. When the first refrigeration cycle is switched to the second refrigeration cycle, the refrigerant having a relatively high temperature flows into the subcooling heat exchanger from the utilization heat exchanger. This increases thermal stress on the subcooling heat exchanger, which may cause cracks in the subcooling heat exchanger.

**[0006]** An object of the present invention is to keep thermal stress on a subcooling heat exchanger from increasing when switching from a first refrigeration cycle to a second refrigeration cycle.

SOLUTION TO THE PROBLEM

**[0007]** This object is solved by means of a refrigeration apparatus according to independent claim 1. Distinct embodiments of the invention are defined in the dependent claims.

**[0008]** A first aspect is directed to a refrigeration apparatus including a heat source unit (10) and a utilization unit (50) having a utilization heat exchanger (54). The heat source unit includes: a heat source circuit (11) including a compression element (20), a heat source heat exchanger (14), a subcooling heat exchanger (40), and a switching mechanism (24), the heat source unit being connected to a utilization unit (50) having a utilization heat exchanger (54) to constitute a refrigerant circuit (2) that performs a refrigeration cycle, wherein

the switching mechanism (24) is configured to switch the refrigeration cycle between a first refrigeration cycle in which the heat source heat exchanger (14) serves as a radiator and the utilization heat exchanger (54) serves as an evaporator and a second refrigeration cycle in which the utilization heat exchanger (54) serves as a radiator and the heat source heat exchanger (14) serves as an evaporator,
the subcooling heat exchanger (40) has a first channel (40a) connected to a middle portion of a liquid pipe (32, 33) through which a liquid refrigerant in the heat source circuit (11) flows, and a second channel (40b) through which a heating medium for cooling the refrigerant in the first channel (40a) flows, and
the heat source unit (10)further comprises a regulation mechanism including an expansion valve (26) connected to an upstream side of the second channel (40b) and a control unit (101) configured to control an opening degree of the expansion valve (26), so that the cooling capability is reduced in a first operation of reducing a capability of the second channel (40b) of cooling the refrigerant in the first channel (40a) before switching from the first refrigeration cycle to the second refrigeration cycle.

**[0009]** In the first aspect, the first operation reduces the cooling capability of the second channel (40b). As a result, the temperature of the refrigerant in the first channel (40a) rises. This can keep the thermal stress on the subcooling heat exchanger (40) from increasing even if a relatively high-temperature refrigerant flows into the first channel (40a) from the utilization heat exchanger (54) in the second refrigeration cycle. Further, control of the opening degree of the expansion valve (26) can reduce the cooling capability of the second channel (40b).

**[0010]** In a second aspect, the switching mechanism (24) is configured to switch the refrigeration cycle to the second refrigeration cycle when a temperature of the refrigerant flowing through the first channel (40a) exceeds a predetermined value in the first operation.

**[0011]** In the second aspect, the first refrigeration cycle is switched to the second refrigeration cycle when the temperature of the refrigerant in the first channel (40a) exceeds the predetermined value in the first operation.

**[0012]** In a third aspect, the heat source circuit (11) includes: an injection circuit (60) having one end branched from the liquid pipe (32, 33) and the other end communicating with an intermediate pressure portion or a suction portion of the compression element (20), and including the second channel (40b) through which a refrigerant as the heating medium flows; and the expansion valve (26) connected to the upstream side of the second channel (40b) in the injection circuit (60).

**[0013]** In the third aspect, the refrigerant in the second channel (40b) can be introduced into the compression element (20) via the injection circuit (60).

**[0014]** In a fourth aspect, the control unit (101) performs first control in the first operation to reduce the opening degree of the expansion valve (26) so that a flow rate of the refrigerant in the second channel (40b) decreases.

**[0015]** In the fourth aspect, the first control reduces the flow rate of the refrigerant flowing into the second channel (40b). This can reduce the cooling capability of the second channel (40b).

**[0016]** In a fifth aspect, the control unit (101) performs second control in the first operation to increase the opening degree of the expansion valve (26) so that a pressure of the refrigerant in the second channel (40b) rises.

**[0017]** In the fifth aspect, the second control raises the pressure of the refrigerant flowing into the second channel (40b). This can reduce the cooling capability of the second channel (40b).

**[0018]** In a sixth aspect, the control unit (101) performs, in the first operation, first control to reduce the opening degree of the expansion valve (26) so that a flow rate of the refrigerant in the second channel (40b) decreases when a condition indicating that a discharge temperature, which is a temperature of the refrigerant discharged from the compression element (20), is low is met, and second control to increase the opening degree of the expansion valve (26) so that a pressure of the refrigerant in the second channel (40b) rises when a condition indicating that the discharge temperature of the compression element (20) is high is met.

**[0019]** In the sixth aspect, the first control is performed when the discharge temperature is low. The second control is performed when the discharge temperature is high. The second control can lower the temperature of the refrigerant discharged from the compression element (20).

**[0020]** In a seventh aspect, the heat source circuit (11) includes a flow rate regulating valve (28, 29) connected to a downstream side of the second channel (40b) in the injection circuit (60). The second control performed in the first operation regulates an opening degree of the flow rate regulating valve (28, 29) so that a discharge temperature, which is a temperature of the refrigerant discharged from the compression element (20), approaches a predetermined value.

**[0021]** In the seventh aspect, the amount of refrigerant introduced into the compression element (20) can be controlled by regulating the opening degree of the flow rate regulating valve (28, 29). This can control the discharge temperature of the compression element (20).

**[0022]** An eighth aspect is an embodiment of any one of the first to seventh aspects. In the eighth aspect, the heat source unit further includes:

a subcooling heat exchanger (40) having the first channel (40a) and the second channel (40b);
a bypass channel (70) configured to allow at least part of the refrigerant that has dissipated heat in the utilization heat exchanger (54) to bypass the first channel (40a) in the second refrigeration cycle; and
a channel switching mechanism (180) configured to regulate the refrigerant flowing through the first channel (40a) and allow the refrigerant to flow through the bypass channel (70) in the second refrigeration cycle.

**[0023]** In the eighth aspect, the flow rate of the refrigerant flowing through the first channel can be reduced in the second refrigeration cycle. This can keep the thermal stress on the subcooling heat exchanger (40) from increasing.

**[0024]** A ninth aspect is an embodiment of any one of the first to eighth aspects. In the ninth aspect, the compression element (20) is a two-stage compression element having a first compression section (22, 23) and a second compression section (21), and is configured to compress the refrigerant in the first compression section (22, 23) and then compress the refrigerant again in the second compression section (21) in the first refrigeration cycle.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0025]**

FIG. 1 is a piping system diagram of a refrigeration apparatus according to an embodiment.
FIG. 2 is a block diagram illustrating a relationship among a controller, various sensors, and components of a refrigerant circuit.
FIG. 3 is a view corresponding to FIG. 1, illustrating the flow of a refrigerant during a cooling operation.
FIG. 4 is a view corresponding to FIG. 1, illustrating the flow of a refrigerant during a defrosting operation.
FIG. 5 is a flowchart of a first operation.
FIG. 6 is a piping system diagram of a refrigeration apparatus according to a first variation.
FIG. 7 is a view corresponding to FIG. 5, illustrating a first operation according to the first variation.
FIG. 8 is a piping system diagram of a refrigeration apparatus according to a second variation.
FIG. 9 is a piping system diagram of a refrigeration apparatus according to a third variation.
FIG. 10 is a view corresponding to FIG. 9, illustrating

the flow of a refrigerant during a cooling operation.

FIG. 11 is a view corresponding to FIG. 9, illustrating the flow of a refrigerant during a defrosting operation.

FIG. 12 is an enlarged piping system diagram of a subcooling heat exchanger and its peripheral components of a refrigeration apparatus according to a fourth variation.

FIG. 13 is a view corresponding to FIG. 12, illustrating the flow of a refrigerant during a cooling operation.

FIG. 14 is a view corresponding to FIG. 12, illustrating the flow of a refrigerant during a defrosting operation.

FIG. 15 is a piping system diagram of a refrigeration apparatus according to a fifth variation.

FIG. 16 is a view corresponding to FIG. 12, illustrating a refrigeration apparatus according to another embodiment.

FIG. 17 is a view corresponding to FIG. 12, illustrating a refrigeration apparatus according to another embodiment.

FIG. 18 is a view corresponding to FIG. 12, illustrating a refrigeration apparatus according to another embodiment.

DESCRIPTION OF EMBODIMENTS

**[0026]** Embodiments of the present invention will be described below with reference to the drawings.

«Embodiment»

<General Configuration>

**[0027]** A refrigeration apparatus (1) according to an embodiment cools the air in a refrigeration warehouse. As illustrated in FIG. 1, the refrigeration apparatus (1) includes an outdoor unit (10) and an internal unit (50). The outdoor unit (10) is a heat source unit (10) and is placed outside. The internal unit (50) is a utilization unit (50).

**[0028]** The outdoor unit (10) includes a heat source circuit (11). The internal unit (50) includes a utilization circuit (51). The heat source circuit (11) and the utilization circuit (51) are connected to each other by connection pipes (3, 4) to form a refrigerant circuit (2) in the refrigeration apparatus (1). In the refrigerant circuit (2), a refrigerant circulates to perform a vapor compression refrigeration cycle.

**[0029]** The connection pipes connecting the heat source circuit (11) and the utilization circuit (51) to each other are a liquid connection pipe (3) and a gas connection pipe (4). One end of the liquid connection pipe (3) is connected to a liquid-side shutoff valve (17) connected to one end of the heat source circuit (11). One end of the gas connection pipe (4) is connected to a gas-side shutoff valve (18) connected to the other end of the heat source circuit (11).

<Outdoor Unit>

**[0030]** The outdoor unit (10) includes an outdoor fan (15), the heat source circuit (11), and a regulation mechanism (80). The heat source circuit (11) includes a compression element (20), a four-way switching valve (24), an outdoor heat exchanger (14), a receiver (39), and a subcooling heat exchanger (40).

<Compression Element and Peripheral Structure Thereof>

**[0031]** The compression element (20) compresses a refrigerant which is a heating medium. The compression element (20) constitutes a two-stage compression element that compresses the refrigerant in first compression sections (22, 23) at a lower pressure, and then compresses the refrigerant again in a second compression section (21) at a higher pressure. Specifically, the first compression sections (22, 23) include a first low-pressure compressor (22) and a second low-pressure compressor (23). The second compression section (21) is a high-pressure compressor (21). The first low-pressure compressor (22) and the second low-pressure compressor (23) are connected in parallel with each other. Each of the compressors (21 to 23) is a high pressure dome-shaped hermetic scroll compressor.

**[0032]** A compression mechanism (not shown) and an electric motor (not shown) that drives the compression mechanism are connected to each of the compressors (21 to 23). The electric motors of the high-pressure compressor (21) and the second low-pressure compressor (23) are connected to an inverter capable of freely changing the numbers of rotations of the electric motors within a predetermined range. The numbers of rotations of the electric motors can be adjusted by the inverter, thereby increasing or decreasing the operating capacities of the high-pressure compressor (21) and the second low-pressure compressor (23). The inverter is not connected to the electric motor of the first low-pressure compressor (22). Thus, the first low-pressure compressor (22) has a fixed operating capacity. The first low-pressure compressor (22) rotates at a constant rotational speed.

**[0033]** A first suction pipe (44) and a first discharge pipe (41) are connected to the high-pressure compressor (21). A first check valve (CV1) is connected to the first discharge pipe (41). The first check valve (CV1) allows the refrigerant to flow from a discharge end of the high-pressure compressor (21) to the four-way switching valve (24) which will be described later, and prohibits the refrigerant from flowing in the opposite direction. A second suction pipe (45) and a second discharge pipe (42) are connected to the first low-pressure compressor (22). A second check valve (CV2) is connected to the second discharge pipe (43). The second check valve (CV2) allows the refrigerant to flow from a discharge end of the first low-pressure compressor (22) to a second junction pipe (47) which will be described later, and prohibits the refrigerant from flowing in the opposite direction. A third suction pipe (46) and a third discharge pipe (43) are connected to the second low-pressure compressor (23). A third check valve (CV3) is connected to the third discharge pipe (43). The third check valve (CV3) allows the refrigerant to flow from a discharge end of the second low-pressure compressor (23) to the second junction pipe (47) which will be described later, and prohibits the refrigerant from flowing in the opposite direction.

**[0034]** The second suction pipe (45) and the third suction pipe (46) are connected to a first junction pipe (48). The second discharge pipe (42) and the third discharge pipe (43) are connected to the second junction pipe (47). The heat source circuit (11) has a connection pipe (49) having one end connected to the middle of the first junction pipe (48) and the other end connected to the middle of the second junction pipe (47). A sixth motor-operated valve (53) is connected to the connection pipe (49). The sixth motor-operated valve (53) is a flow rate regulating valve. The sixth motor-operated valve (53) regulates the flow rate of the refrigerant in the connection pipe (49).

<Four-Way Switching Valve>

**[0035]** The four-way switching valve (24) constitutes a switching mechanism that switches the channel of the refrigerant. The four-way switching valve (24) has first to fourth ports (P1 to P4). The first port (P1) is connected to the first discharge pipe (41) of the high-pressure compressor (21). The second port (P2) is connected to the first suction pipe (44). The third port (P3) communicates with a gas end of the outdoor heat exchanger (14). The fourth port (P4) is connected to the second junction pipe (47).

**[0036]** The four-way switching valve (24) is configured to be able to switch between a first state (the state indicated by solid curves in FIG. 1) and a second state (the state indicated by broken curves in FIG. 1). In the first state, the second port (P2) and the fourth port (P4) communicate with each other, and the first port (P1) and the third port (P3) communicate with each other. In the second state, the second port (P2) and the third port (P3) communicate with each other, and the first port (P1) and the fourth port (P4) communicate with each other.

<Outdoor Heat Exchanger>

**[0037]** The outdoor heat exchanger (14) is a heat source heat exchanger (14). The outdoor heat exchanger (14) is a fin-and-tube air heat exchanger. The outdoor fan (15) is arranged near the outdoor heat exchanger (14). The outdoor fan (15) transfers outdoor air. The outdoor heat exchanger (14) exchanges heat between the refrigerant flowing therethrough and the outdoor air transferred from the outdoor fan (15).

**[0038]** The gas end of the outdoor heat exchanger (14) communicates with the third port (P3) of the four-way switching valve (24). A liquid end of the outdoor heat exchanger (14) is connected to one end of a first pipe (3 1).

<Receiver, Subcooling Heat Exchanger, and Peripheral Structure Thereof>

**[0039]** The receiver (39) constitutes a container for storing the refrigerant. The receiver (39) separates the refrigerant into a gas refrigerant and a liquid refrigerant.

**[0040]** The subcooling heat exchanger (40) has a first channel (40a) and a second channel (40b). The first channel (40a) is connected to the middle of a liquid pipe (32, 33) through which the liquid refrigerant flows. The refrigerant which is a heating medium flows through the second channel (40b). The second channel cools the refrigerant flowing through the first channel (40a). In the subcooling heat exchanger (40), heat exchange occurs between the refrigerant flowing through the first channel (40a) and the refrigerant flowing through the second channel (40b).

**[0041]** The first pipe (31) connects the liquid end of the outdoor heat exchanger (14) and the top of the receiver (39). A fourth outdoor check valve (CV4) is connected to the first pipe (31). The fourth outdoor check valve (CV4) allows the refrigerant to flow from the outdoor heat exchanger (14) to the receiver (39), and prohibits the refrigerant from flowing in the opposite direction.

**[0042]** A second pipe (32) connects the bottom of the receiver (39) and one end of the first channel (40a) of the subcooling heat exchanger (40). The second pipe (32) constitutes part of the liquid pipe.

**[0043]** A third pipe (33) connects the other end of the first channel (40a) and the liquid-side shutoff valve (17). The third pipe (33) constitutes part of the liquid pipe. A fifth outdoor check valve (CV5) is connected to the third pipe (33). The fifth outdoor check valve (CV5) allows the refrigerant to flow from the first channel (40a) to an internal heat exchanger (54), and prohibits the refrigerant from flowing in the opposite direction.

**[0044]** A fourth pipe (34) is connected to the third pipe (33). One end of the fourth pipe (34) is connected to the third pipe (33) between the fifth outdoor check valve (CV5) and the liquid-side shutoff valve (17). The other end of the fourth pipe (34) is connected to the first pipe (31) between the fourth outdoor check valve (CV4) and the receiver (39). A sixth outdoor check valve (CV6) is connected to the fourth pipe (34). The sixth outdoor check valve (CV6) allows the refrigerant to flow from the internal heat exchanger (54) to the outdoor heat exchanger (14), and prohibits the refrigerant from flowing in the opposite direction.

**[0045]** A fifth pipe (35) is connected to the second pipe (32). One end of the fifth pipe (35) is connected to the middle of the second pipe (32). The other end of the fifth pipe (35) is connected to the first pipe (31) between the fourth outdoor check valve (CV4) and the outdoor heat exchanger (14). An outdoor expansion valve (25) is connected to the fifth pipe (35). The outdoor expansion valve

(25) is an electronic expansion valve having a variable opening degree. A seventh outdoor check valve (CV7) is connected to the fifth pipe (35). The seventh outdoor check valve (CV7) is provided between the junction of the first pipe (31) with the fifth pipe (35) and the outdoor expansion valve (25). The seventh outdoor check valve (CV7) allows the refrigerant to flow from the internal heat exchanger (54) to the outdoor heat exchanger (14), and prohibits the refrigerant from flowing in the opposite direction.

<Injection Circuit>

**[0046]** The heat source circuit (11) includes an injection circuit (60). The injection circuit (60) introduces an intermediate-pressure refrigerant in the liquid pipe (32, 33) into the compression element (20). The injection circuit (60) has one end branched from the liquid pipe (32, 33), and the other end communicating with an intermediate pressure portion of the compression element (20). The injection circuit (60) includes the second channel (40b), a first branch pipe (61), a relay pipe (62), and three injection pipes (63, 64, 65).

**[0047]** An inflow end of the first branch pipe (61) is connected to the third pipe (33) between the junction of the third pipe (33) with the fourth pipe (34) and the liquid-side shutoff valve (17). An outflow end of the first branch pipe (61) is connected to an inflow end of the second channel (40b) of the subcooling heat exchanger (40).

**[0048]** An injection valve (26) is connected to the first branch pipe (61). The injection valve (26) is an expansion valve (26) having a variable opening degree. The injection valve (26) is constituted of an electronic expansion valve.

**[0049]** An inflow end of the relay pipe (62) is connected to an outflow end of the second channel (40b). An outflow portion of the relay pipe (62) is connected to inflow ends of the first injection pipe (63), the second injection pipe (64), and the third injection pipe (65).

**[0050]** An outflow end of the first injection pipe (63) communicates with a compression chamber of the high-pressure compressor (21). An outflow end of the second injection pipe (64) communicates with a compression chamber of the first low-pressure compressor (22). An outflow end of the third injection pipe (65) communicates with a compression chamber of the second low-pressure compressor (23).

**[0051]** A first motor-operated valve (27) is connected to the first injection pipe (63). A second motor-operated valve (28) is connected to the second injection pipe (64). A third motor-operated valve (29) is connected to the third injection pipe (65). The first to third motor-operated valves (27 to 29) are flow rate regulating valves. Each of the first to third motor-operated valves (27 to 29) regulates the flow rate of the refrigerant in the corresponding injection pipes (63 to 65).

<Bypass Channel>

**[0052]** The fourth pipe (34) constitutes a bypass channel (70). The bypass channel (70) may include the first pipe (31), the second pipe (32), and the fifth pipe (35). The bypass channel (70) may further include the receiver (39). The bypass channel (70) is connected in parallel with the subcooling heat exchanger (40). The refrigerant in the bypass channel (70) bypasses the subcooling heat exchanger (40). Specifically, the refrigerant that has dissipated heat in the internal heat exchanger (54) in the second refrigeration cycle flows through the fourth pipe (34), the first pipe (31), the receiver (39), the second pipe (32), and the fifth pipe (35) in this order.

<Channel Switching Mechanism>

**[0053]** The sixth outdoor check valve (CV6) and the fifth outdoor check valve (CV5) constitute a channel switching mechanism (180). The channel switching mechanism (180) may include the fourth outdoor check valve (CV4) and the seventh outdoor check valve (CV7).

**[0054]** In the second refrigeration cycle, the channel switching mechanism (180) regulates the refrigerant flowing through the first channel (40a), and allows the refrigerant to flow through the bypass channel (70). Specifically, in the second refrigeration cycle, the channel switching mechanism (180) prohibits the refrigerant from flowing through the first channel (40a), and allows the refrigerant to flow through the bypass channel (70). In the first refrigeration cycle, the channel switching mechanism (180) allows the refrigerant to flow through the first channel (40a), and prohibits the refrigerant from flowing through the bypass channel (70).

**[0055]** Specifically, in the first refrigeration cycle, the seventh outdoor check valve (CV7) prohibits the refrigerant that has entered the first pipe (31) from the outdoor heat exchanger (14) from flowing through the fifth pipe (35). In the first refrigeration cycle, the sixth outdoor check valve (CV6) prohibits the refrigerant that has entered the first pipe (31) from the outdoor heat exchanger (14) from flowing through the fourth pipe (34). The outdoor expansion valve (25) is fully opened in the first refrigeration cycle. Thus, the outdoor expansion valve (25) allows the refrigerant to flow into the first channel (40a).

**[0056]** In the second refrigeration cycle, the fifth outdoor check valve (CV5) prohibits the refrigerant from flowing through the first channel (40a). In the second refrigeration cycle, the sixth outdoor check valve (CV6) allows the refrigerant to flow through the fourth pipe (34). In the second refrigeration cycle, the fourth outdoor check valve (CV4) prohibits the refrigerant that has entered the first pipe (31) from the fourth pipe (34) from flowing toward the outdoor heat exchanger (14). In the second refrigeration cycle, the outdoor expansion valve (25) decompresses the refrigerant. Thus, the outdoor expansion valve (25) allows the refrigerant to flow from the second pipe (32) into the fifth pipe (35). In the second refrigeration cycle, the seventh outdoor check valve (CV7) allows the refrigerant to flow through the fifth pipe (35).

**[0057]** The refrigerant downstream of the fifth outdoor check valve (CV5) has a higher pressure than the refrigerant upstream of the fifth outdoor check valve (CV5). This is because the pressure of the refrigerant in the first channel (40a) corresponds to the pressure of the refrigerant decompressed by the outdoor expansion valve (25). Thus, the refrigerant in the first channel (40a) does not pass through the fifth outdoor check valve (CV5).

<Sensor>

**[0058]** The outdoor unit (10) is provided with various sensors. For example, the first to third discharge pipes (41 to 43) are respectively provided with first to third discharge temperature sensors (71 to 73). The first discharge temperature sensor (71) detects a first discharge temperature (Td1) which is the temperature of the refrigerant discharged from the high-pressure compressor (21). The second discharge temperature sensor (72) detects a second discharge temperature (Td2) which is the temperature of the refrigerant discharged from the first low-pressure compressor (22). The third discharge temperature sensor (73) detects a third discharge temperature (Td3) which is the temperature of the refrigerant discharged from the second low-pressure compressor (23). The third pipe (33) is provided with a liquid temperature sensor (74). The liquid temperature sensor (74) detects the temperature (TL) of the refrigerant flowing through the third pipe (33).

**[0059]** The first branch pipe (61) is provided with a first temperature sensor (75). The first temperature sensor (75) is arranged between the injection valve (26) and the second channel (40b). The first temperature sensor (75) detects the temperature (Tg1) of the refrigerant flowing into the second channel (40b).

**[0060]** The relay pipe (62) is provided with a second temperature sensor (76). The second temperature sensor (76) is arranged close to the second channel (40b). The second temperature sensor (76) detects the temperature (Tg2) of the refrigerant that has just flowed into the relay pipe (62) from the second channel (40b). The relay pipe (62) is provided with a pressure sensor (77). The pressure sensor (77) detects the pressure (MP) of the refrigerant in the relay pipe (62).

<Internal Unit>

**[0061]** The internal unit (50) is a utilization unit. The internal unit (50) includes the utilization circuit (51) and an internal fan (52).

**[0062]** The utilization circuit (51) is connected to the liquid connection pipe (3) and the gas connection pipe (4). The utilization circuit (51) includes a heating pipe (55), an internal expansion valve (30), and the internal heat exchanger (54) arranged in this order from the liquid end to the gas end.

**[0063]** The heating pipe (55) is attached to a drain pan (59) connected to a lower portion of the internal heat exchanger (54). The drain pan (59) collects condensation water dripping from the internal heat exchanger (54). The heating pipe (55) heats the drain pan (59) to keep drain water from freezing.

**[0064]** The internal expansion valve (30) is a temperature-sensitive expansion valve having a feeler bulb. When the internal heat exchanger (54) functions as an evaporator, the opening degree of the internal expansion valve (30) is adjusted based on the temperature of the refrigerant at the outlet of the internal heat exchanger (54). When the internal heat exchanger (54) functions as a radiator, the internal expansion valve (30) is fully closed.

**[0065]** The internal heat exchanger (54) constitutes a utilization heat exchanger. The internal heat exchanger (54) is a fin-and-tube heat exchanger, and exchanges heat between the refrigerant and the air in the warehouse. The internal fan (52) is arranged near the internal heat exchanger (54). The internal fan (52) supplies the air in the warehouse to the internal heat exchanger (54).

**[0066]** The utilization circuit (51) includes an internal bypass channel (58) that bypasses the internal expansion valve (30). An internal check valve (CV8) is connected to the internal bypass channel (58). The internal check valve (CV8) allows the refrigerant to flow from the internal heat exchanger (54) to the heating pipe (55), and prohibits the refrigerant from flowing in the opposite direction.

<Controller>

**[0067]** A controller (100), which is a control unit, includes a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer. The controller (100) controls various components of the refrigeration apparatus (1) based on detection signals of various sensors.

**[0068]** As illustrated in FIG. 2, the controller (100) includes an outdoor controller (101) provided in the outdoor unit (10) and an internal controller (102) provided in the internal unit (50). The outdoor controller (101) is able to communicate with the internal controller (102).

**[0069]** The outdoor controller (101) serving as the control unit is connected to various sensors, such as the first to third discharge temperature sensors (71 to 73), the liquid temperature sensor (74), the first and second temperature sensors (75, 76), and the pressure sensor (77), via communication lines. The outdoor controller (101) is connected to the components of the refrigerant circuit (2), such as the injection valve (26), the first to third motor-operated valves (27 to 29), and the outdoor fan (15), via communication lines.

**[0070]** The internal controller (102) is connected to the components of the refrigerant circuit (2), such as the internal expansion valve (30) and the internal fan (52), via communication lines.

**[0071]** The outdoor controller (101) receives a signal from the internal controller (102) and controls the four-way switching valve (24) for switching between the first refrigeration cycle and the second refrigeration cycle. When the four-way switching valve (24) is switched to the first state, the first refrigeration cycle is performed. In the first refrigeration cycle, the outdoor heat exchanger (14) serves as a radiator, and the internal heat exchanger (54) serves as an evaporator. In the first refrigeration cycle, a refrigeration operation for cooling the air in the warehouse is performed. When the four-way switching valve (24) is switched to the second state, the second refrigeration cycle is performed. In the second refrigeration cycle, the internal heat exchanger (54) serves as a radiator, and the outdoor heat exchanger (14) serves as an evaporator. In the second refrigeration cycle, a defrosting operation for removing frost adhering to the internal heat exchanger (54) is performed.

<Regulation Mechanism>

**[0072]** The regulation mechanism (80) includes the injection valve (26) and the controller (100). Before the first refrigeration cycle is switched to the second refrigeration cycle, the regulation mechanism (80) performs a first operation of reducing the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0073]** In the first operation, the controller (100) controls the opening degree of the injection valve (26) to reduce the cooling capability.

**[0074]** In the first operation, the reduction of the cooling capability raises the temperature of the refrigerant flowing through the first channel (40a). The cooling capability is represented by, for example, a value obtained by multiplying a difference between specific enthalpies of the refrigerant at the outlet and inlet of the second channel (40b) by the flow rate of the refrigerant flowing through the second channel (40b).

**[0075]** When the temperature of the refrigerant flowing through the first channel (40a) exceeds a predetermined value, the four-way switching valve (24) switches from the first state to the second state. In other words, the switching mechanism (24) switches from the first refrigeration cycle to the second refrigeration cycle. The predetermined value is a target temperature (target TL) of the refrigerant that comes from the first channel (40a) and flows through the third pipe (33) in the first state. Details of the target temperature (target TL) will be described later.

-Operation-

<Cooling Operation>

**[0076]** In the cooling operation, the compressors (21 to 23), the outdoor fan (15), and the internal fan (52) operate. The four-way switching valve (24) is set to the first state, and the outdoor expansion valve (25) is fully closed. The opening degrees of the internal expansion valve (30), the injection valve (26), and the first to third motor-operated valves (27 to 29) are suitably adjusted. The sixth motor-operated valve (53) is fully closed, and no refrigerant flows through the connection pipe (49).

**[0077]** In the cooling operation, the four-way switching valve (24) is in the first state. In the first state, the first refrigeration cycle is performed in which the outdoor heat exchanger (14) serves as a condenser (radiator), and the internal heat exchanger (54) serves as an evaporator.

**[0078]** As illustrated in FIG. 3, the refrigerant compressed by the first low-pressure compressor (22) and the second low-pressure compressor (23) flows through the second junction pipe (47) in the cooling operation. This refrigerant passes through the four-way switching valve (24) and the first suction pipe (44), and is introduced into the compression chamber of the high-pressure compressor (21). The high-pressure refrigerant compressed by the high-pressure compressor (21) passes through the first discharge pipe (41) and the four-way switching valve (24), and flows into the outdoor heat exchanger (14). The refrigerant dissipates heat to the outdoor air in the outdoor heat exchanger (14). The refrigerant that has dissipated heat in the outdoor heat exchanger (14) flows through the first pipe (31). The seventh outdoor check valve (CV7) and the sixth outdoor check valve (CV6) regulate the refrigerant flowing through the fifth pipe (35) and the fourth pipe (34) which are part of the bypass channel (70). Thus, the refrigerant flows into the receiver (39), and passes through the second pipe (32) and the first channel (40a) of the subcooling heat exchanger (40).

**[0079]** When the injection valve (26) is opened, part of the refrigerant in the third pipe (33) flows through the first branch pipe (61). The refrigerant in the first branch pipe (61) is decompressed by the injection valve (26), and then flows through the second channel (40b) of the subcooling heat exchanger (40). In the subcooling heat exchanger (40), heat exchange occurs between the refrigerant in the second channel (40b) and the refrigerant in the first channel (40a). The refrigerant in the second channel (40b) absorbs heat from the refrigerant in the first channel (40a) and evaporates. This cools the refrigerant in the first channel (40a), increasing the degree of subcooling of the refrigerant.

**[0080]** The refrigerant that has flowed through the second channel is introduced into the compression chambers of the compressors (21 to 23) from the injection pipes (63 to 65) via the relay pipe (62).

**[0081]** The refrigerant cooled in the first channel (40a) flows through the third pipe (33) and the liquid connection pipe (3), and is sent to the internal unit (50).

**[0082]** In the internal unit (50), the refrigerant passes through the heating pipe (55), and is decompressed by the internal expansion valve (30). The refrigerant flows into the internal heat exchanger (54), and absorbs heat from the air in the warehouse to evaporate. Thus, the air in the warehouse is cooled.

**[0083]** The refrigerant evaporated in the internal heat exchanger (54) is sent to the outdoor unit (10) through the gas connection pipe (4). This refrigerant flows through the first junction pipe (48), and is sucked into the first low-pressure compressor (22) and the second low-pressure compressor (23). This circulation of the refrigerant achieves the cooling operation of maintaining the temperature in the refrigeration warehouse at a set temperature.

<Defrosting Operation>

**[0084]** In the defrosting operation, the high-pressure compressor (21) and the outdoor fan (15) operate, and the internal fan (52) stops. The four-way switching valve (24) is set to the second state, and the internal expansion valve (30) is fully closed. The sixth motor-operated valve (53) is fully opened. In the defrosting operation, the refrigerant may flow through the injection circuit (60) as in the cooling operation. The injection valve (26) may be fully closed so that no refrigerant flows through the injection circuit (60).

**[0085]** In the defrosting operation, the four-way switching valve (24) is in the second state. In the second state, the second refrigeration cycle is performed in which the outdoor heat exchanger (14) serves as an evaporator, and the internal heat exchanger (54) serves as a condenser (radiator).

**[0086]** As illustrated in FIG. 4, the refrigerant compressed in the high-pressure compressor (21) flows through the first discharge pipe (41), the four-way switching valve (24), the second junction pipe (47), the connection pipe (49), and the first junction pipe (48) in this order in the defrosting operation. This refrigerant is sent to the internal unit (50) through the gas connection pipe (4). The refrigerant flows through the internal heat exchanger (54) in the internal unit (50). The refrigerant melts the frost on the surface of the internal heat exchanger (54). The refrigerant that has dissipated heat in the internal heat exchanger (54) flows through the internal bypass channel (58) and the heating pipe (55). This refrigerant flows through the liquid connection pipe (3), and is sent to the outdoor unit (10).

**[0087]** The refrigerant in the outdoor unit (10) enters the fourth pipe (34) from the third pipe (33). The refrigerant then flows through the first pipe (31), the receiver (39), and the second pipe (32) in this order. This refrigerant enters the fifth pipe (35), and is then decompressed by the outdoor expansion valve (25). A flow of this refrigerant into the first channel (40a) is regulated. This is because, as described above, the differential pressure across the fifth outdoor check valve (CV5) prohibits the refrigerant from flowing through the fifth outdoor check valve (CV5). The refrigerant flowing through the fifth pipe (35) passes through the first pipe (31), and then flows into the outdoor heat exchanger (14).

**[0088]** In the outdoor heat exchanger (14), the low-pressure refrigerant exchanges heat with the outdoor air to evaporate. The refrigerant evaporated in the outdoor heat exchanger (14) passes through the four-way switching valve (24) and the first suction pipe (44), and is introduced into the compression chamber of the high-pressure compressor (21). This circulation of the refrigerant achieves the defrosting operation of removing the frost adhering to the internal heat exchanger (54).

-Problem at the time of Switching from Second Refrigeration Cycle to First Refrigeration Cycle-

**[0089]** The direction of the refrigerant flowing in the first refrigeration cycle and the direction of the refrigerant flowing in the second refrigeration cycle are opposite to each other. Thus, when the refrigeration apparatus (1) including the subcooling heat exchanger (40) connected between the channel of the outdoor heat exchanger (14) and the channel of the internal heat exchanger (54) is switched from the first refrigeration cycle to the second refrigeration cycle, a relatively high-temperature refrigerant flows from the internal heat exchanger (54) into the channel (first channel (40a)) of the subcooling heat exchanger (40). If the high-temperature refrigerant suddenly flows into the first channel (40a) that has been cooled in the first refrigeration cycle, thermal stress on the subcooling heat exchanger (40) increases due to the temperature difference. This may damage the subcooling heat exchanger (40).

**[0090]** Strictly speaking, the refrigerant does not continuously flow through the first channel (40a) in the defrosting operation (second refrigeration cycle). Since the refrigerant has a higher pressure at the outlet of the fifth outdoor check valve (CV5) than at the inlet of the fifth outdoor check valve (CV5), the refrigerant is prohibited from continuously flowing from the first channel (40a) to the third pipe (33). This is because the pressure of the refrigerant in the first channel (40a) corresponds to the pressure of the refrigerant decompressed by the outdoor expansion valve (25).

**[0091]** However, as illustrated in FIG. 4, part of the refrigerant flowing from the receiver (39) into the second pipe (32) goes into the first channel (40a) at the start of the defrosting operation. If the high-temperature refrigerant suddenly flows into the first channel (40a) that has been cooled in the first refrigeration cycle, thermal stress on the subcooling heat exchanger (40) increases, and the subcooling heat exchanger (40) may be damaged.

**[0092]** In consideration of such a problem, the refrigeration apparatus (1) of the present embodiment performs the following operation before switching from the first refrigeration cycle to the second refrigeration cycle in order to keep the thermal stress in the first channel (40a) from increasing.

<First Operation>

**[0093]** A first operation will be described in detail below. When a condition for starting the defrosting operation is met in the cooling operation, the internal controller (102) transmits a defrost request signal. The outdoor controller (101) receives the request for the defrosting operation. The outdoor controller (101) serving as the regulation mechanism (80) performs the first operation. Specifically, in the first operation, the outdoor controller (101) controls the injection valve (26) and the second and third motor-operated valves (28, 29).

**[0094]** As illustrated in FIG. 5, receiving a command to execute the first operation, the outdoor controller (101) stores the current opening degree (Pls1) of the injection valve (26) in Step ST1.

**[0095]** In Step ST2, the outdoor controller (101) determines whether a condition indicating that the discharge temperature of the compression element (20) is high is met. Specifically, the outdoor controller (101) determines whether a condition indicating that the second discharge temperature (Td2) of the first low-pressure compressor (22) and the third discharge temperature (Td3) of the second low-pressure compressor (23) are both high is met. More specifically, the outdoor controller (101) determines whether the following conditions a) and b) are met in Step ST2.

a) The second discharge temperature (Td2) of the first low-pressure compressor (22) is lower than a predetermined value. The predetermined value is, for example, 95°C.

b) The third discharge temperature (Td3) of the second low-pressure compressor (23) is lower than a predetermined value. The predetermined value is, for example, 95°C.

**[0096]** If both of the conditions a) and b) are met in Step ST2, the process proceeds to Step ST3. If at least one of the conditions a) or b) is not met in Step ST2, the process proceeds to Steps ST4 to ST6.

**[0097]** In Step ST3, the outdoor controller (101) performs first control to reduce the opening degree of the injection valve (26) so that the flow rate of the refrigerant in the second channel (40b) decreases. The first control lowers the flow rate of the refrigerant flowing through the second channel (40b). Thus, the amount of heat exchanged between the refrigerant in the second channel (40b) and the refrigerant in the first channel (40a) decreases. This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). As a result, the temperature of the refrigerant flowing through the first channel (40a) rises, and the temperature (TL) of the refrigerant in the third pipe (33) rises.

**[0098]** The outdoor controller (101) performs the first control until the refrigerant temperature (TL) of the third pipe (33) detected by the liquid temperature sensor (74) reaches the target temperature (target TL). A thermal stress is applied to the subcooling heat exchanger (40) due to the difference in temperature of the refrigerant before and after switching from the cooling operation (first refrigeration cycle) to the defrosting operation (second refrigeration cycle). The outdoor controller (101) sets the target temperature (target TL) to a temperature at which the subcooling heat exchanger (40) can withstand the thermal stress. Specifically, the outdoor controller (101) sets the target temperature (target TL) to the lower one of temperature A or temperature B. The temperature A is calculated based on a target temperature of the refrigerant discharged from the compression element (20) during the defrosting operation. The temperature A is calculated also in consideration of the number of times of the defrosting operation and the temperature of the liquid refrigerant during the cooling operation. The temperature B is a saturation temperature corresponding to the high pressure during the cooling operation.

**[0099]** In the first control, the outdoor controller (101) sets an upper limit value of a control range of the opening degree of the injection valve (26). This upper limit value is the opening degree (Pls1) stored in Step ST1. Thus, in the first control, the outdoor controller (101) adjusts the opening degree of the injection valve (26) within a range not exceeding the upper limit opening degree (Pls1).

**[0100]** In Step ST4, the outdoor controller (101) performs second control to increase the opening degree of the injection valve (26) so that the pressure of the refrigerant in the second channel (40b) rises. The second control raises the evaporation temperature of the refrigerant in the second channel (40b). This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). As a result, the temperature of the refrigerant flowing through the first channel (40a) rises, and the temperature (TL) of the refrigerant in the third pipe (33) rises.

**[0101]** The outdoor controller (101) performs the second control until the pressure (MP) detected by the pressure sensor (77) reaches a target intermediate pressure (target MP). The target intermediate pressure (target MP) is calculated based on the saturation pressure corresponding to the target temperature (target TL) of the refrigerant in the third pipe (33).

**[0102]** In Step ST5, the outdoor controller (101) adjusts the opening degree of the second motor-operated valve (28) so that the second discharge temperature (Td2) approaches a predetermined value. Specifically, the outdoor controller (101) adjusts the amount of the refrigerant introduced into an intermediate pressure portion of the first low-pressure compressor (22). The predetermined value is, for example, 95°C.

**[0103]** In Step ST6, the outdoor controller (101) adjusts the opening degree of the third motor-operated valve (29) so that the third discharge temperature (Td3) approaches a predetermined value. Specifically, the outdoor controller (101) adjusts the amount of the refrigerant introduced into an intermediate pressure portion of the second low-pressure compressor (23). The predetermined value is, for example, 95°C.

**[0104]** In Step ST7, the outdoor controller (101) determines whether the temperature (TL) of the refrigerant in the third pipe (33) is higher than the target temperature (target TL). If the temperature (TL) of the refrigerant in the third pipe (33) is higher than the target temperature (target TL), the outdoor controller (101) finishes the first operation, and the process proceeds to Step ST8. If the temperature (TL) of the refrigerant in the third pipe (33) is equal to or lower than the target temperature (target TL), the process proceeds to Step ST2.

**[0105]** In Step ST8, the outdoor controller (101) switches the four-way switching valve (24) from the first state to the second state to switch the first refrigeration cycle to the second refrigeration cycle (start the defrosting operation).

-Advantages of Embodiment-

**[0106]** The heat source unit of the embodiment includes: a heat source circuit (11) including a compression element (20), a heat source heat exchanger (14), a subcooling heat exchanger (40), and a switching mechanism (24), the heat source unit being connected to a utilization unit (50) having a utilization heat exchanger (54) to constitute a refrigerant circuit (2) that performs a refrigeration cycle. The switching mechanism (24) is configured to switch the refrigeration cycle between a first refrigeration cycle in which the heat source heat exchanger (14) serves as a radiator and the utilization heat exchanger (54) serves as an evaporator and a second refrigeration cycle in which the utilization heat exchanger (54) serves as a radiator and the heat source heat exchanger (14) serves as an evaporator. The subcooling heat exchanger (40) has a first channel (40a) connected to a middle portion of a liquid pipe (32, 33) through which a liquid refrigerant in the heat source circuit (11) flows, and a second channel (40b) through which a heating medium for cooling the refrigerant in the first channel (40a) flows. The heat source unit further comprises a regulation mechanism configured to perform a first operation of reducing a capability of the second channel (40b) of cooling the refrigerant in the first channel (40a) before switching from the first refrigeration cycle to the second refrigeration cycle.

**[0107]** In this configuration, the first operation is performed before the first refrigeration cycle is switched to the second refrigeration cycle, thereby reducing the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). As a result, the temperature of the refrigerant in the first channel (40a) rises. This can reduce the increase in thermal stress on the subcooling heat exchanger (40) caused by the high-temperature refrigerant flowing into the first channel (40a). This can protect the subcooling heat exchanger (40) from damage.

**[0108]** According to the embodiment, the switching mechanism (24) switches to the second refrigeration cycle when the temperature of the refrigerant in the first channel (40a) exceeds a predetermined value in the first operation.

**[0109]** In this configuration, the second refrigeration cycle starts when the temperature of the refrigerant in the first channel (40a) is higher than the predetermined value. The predetermined value is the target temperature (target TL) of the refrigerant that flows from the first channel (40a) to the third pipe (33). The target temperature (TL) is a temperature at which the subcooling heat exchanger (40) can withstand the thermal stress caused by the high-temperature refrigerant flowing from the internal heat exchanger (54) into the first channel (40a) in the defrosting operation (second refrigeration cycle). This can reliably protect the subcooling heat exchanger (40) from damage even if the high-temperature refrigerant flows into the first channel (40a) just after the start of the defrosting operation (second refrigeration cycle).

**[0110]** According to the embodiment, the heat source circuit (11) includes: an injection circuit (60) having one end branched from the liquid pipe (32, 33) and the other end communicating with an intermediate pressure portion of the compression element (20), and including the second channel (40b) through which a refrigerant as the heating medium flows; and an expansion valve (26) connected to an upstream side of the second channel (40b) in the injection circuit (60). The regulation mechanism (80) includes the expansion valve (26) and a control unit (101) configured to control an opening degree of the expansion valve (26) so that the cooling capability is reduced in the first operation.

**[0111]** In this configuration, the outdoor controller (101) controls the opening degree of the expansion valve (26). The expansion valve (26) regulates the pressure and flow rate of the refrigerant flowing into the second channel (40b). This can reliably reduce the refrigerating capacity of the second channel (40b).

**[0112]** In addition, the injection circuit (60) communicates with the intermediate pressure portion of each of the compressors (21 to 23). Thus, the refrigerant flowing through the injection circuit (60) can be injected into each of the compressors (21 to 23).

**[0113]** The injected refrigerant can lower the temperatures (Td2, Td3) of the refrigerant discharged from the first and second low-pressure compressors (21, 22).

**[0114]** According to the embodiment, the control unit (101) performs the first control in the first operation to reduce the opening degree of the expansion valve (26) so that the flow rate of the refrigerant in the second channel (40b) decreases.

**[0115]** In this configuration, the first control lowers the flow rate of the refrigerant flowing into the second channel (40b).

Thus, the amount of heat exchanged between the refrigerant in the second channel (40b) and the refrigerant in the first channel (40a) can be reduced. This can reliably reduce the cooling capability of the second channel (40b).

**[0116]** According to the embodiment, the control unit (101) performs the second control in the first operation to increase the opening degree of the expansion valve

(26) so that the pressure of the refrigerant in the second channel (40b) rises.

**[0117]** In this configuration, the second control raises the evaporation temperature of the refrigerant in the second channel (40b). This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0118]** The increased opening degree of the injection valve (26) (expansion valve) can introduce the refrigerant from the injection circuit (60) to the first low-pressure compressor (22) and the second low-pressure compressor (23). This can control the second discharge temperature (Td2) of the first low-pressure compressor (22) and the third discharge temperature (Td3) of the second low-pressure compressor (23).

**[0119]** According to the embodiment, the control unit (101) performs, in the first operation, first control to reduce the opening degree of the expansion valve (26) so that a flow rate of the refrigerant in the second channel (40b) decreases when a condition indicating that a discharge temperature, which is a temperature of the refrigerant discharged from the compression element (20), is low is met, and second control to increase the opening degree of the expansion valve (26) so that a pressure of the refrigerant in the second channel (40b) rises when a condition indicating that the discharge temperature of the compression element (20) is high is met.

**[0120]** In this configuration, the first control reduces the opening degree of the injection valve (26), thereby quickly reducing the cooling capability of the second channel (40b). The temperature of the refrigerant in the first channel (40a) can be easily raised without regulating the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23). The second control increases the opening degree of the injection valve (26), thereby reducing the cooling capability of the second channel (40b). The refrigerant is introduced into the first and second low-pressure compressors (22, 23), and thus, the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23) can be reliably reduced.

**[0121]** According to the embodiment, the heat source circuit (11) includes a flow rate regulating valve (28, 29) connected to a downstream side of the second channel (40b) in the injection circuit (60), and the second control performed in the first operation regulates an opening degree of the flow rate regulating valve (28, 29) so that a discharge temperature of the refrigerant discharged from the compression element (20) approaches a predetermined value.

**[0122]** In this configuration, adjustment of the opening degrees of the second motor-operated valve (28) and the third motor-operated valve (29), which are the flow rate regulating valves, can regulate the amount of refrigerant introduced into the first and second low-pressure compressors (22, 23). This can control the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23). As a result, an increase in temperature of the refrigerant flowing into the high-pressure compressor (21) is reduced, keeping the degree of superheat of the refrigerant discharged from the high-pressure compressor (21) from excessively increasing.

**[0123]** The heat exchange unit of the embodiment includes: a subcooling heat exchanger (40) having the first channel (40a) and the second channel (40b); a bypass channel (70) configured to allow at least part of the refrigerant that has dissipated heat in the utilization heat exchanger (54) to bypass the first channel (40a) in the second refrigeration cycle; and a channel switching mechanism (180) configured to regulate the refrigerant flowing through the first channel (40a) and allow the refrigerant to flow through the bypass channel (70) in the second refrigeration cycle.

**[0124]** In this configuration, all or part of the refrigerant flows through the bypass channel (70) when the second refrigeration cycle starts. Thus, the refrigerant flowing through the first channel (40a) can be regulated in the second refrigeration cycle. Thus, the thermal stress on the subcooling heat exchanger (40) can be kept from increasing even if a relatively high-temperature refrigerant flows into the outdoor unit (10) immediately after switching from the first refrigeration cycle to the second refrigeration cycle. This can avoid damage to the subcooling heat exchanger (40).

**[0125]** In addition, the refrigerant flowing through the bypass channel (70) is regulated in the first refrigeration cycle. Thus, a sufficient amount of refrigerant can flow through the first channel (40a) of the subcooling heat exchanger (40) during the first refrigeration cycle. This can improve the cooling capability of the internal unit (50).

**[0126]** According to the embodiment, the compression element (20) is a two-stage compression element having a first compression section (22, 23) and a second compression section (21), and is configured to compress the refrigerant in the first compression section (22, 23) and then compress the refrigerant again in the second compression section (21) in the first refrigeration cycle.

**[0127]** In this configuration, the evaporation pressure in the first refrigeration cycle is lower than that of a single-stage compressor. Thus, the refrigerant is cooled in the first channel (40a) to a relatively low temperature (e.g., -35°C) in the first refrigeration cycle. When the first refrigeration cycle is switched to the second refrigeration cycle, the relatively high-temperature refrigerant that has received heat in the internal heat exchanger (54) flows into the heat source circuit (11). Thus, the two-stage compression element has a significant problem of high thermal stress on the subcooling heat exchanger (40) due to the temperature difference. However, the heat source circuit (11) of the present embodiment having the regulation mechanism (80) can reduce the refrigerating capacity of the second channel (40b) in the first operation. Thus, the outdoor unit (10) including the compression element configured as the two-stage compression element can reduce an increase in thermal stress in the first channel (40a) due to the switching from the first refrigeration cycle to the second refrigeration cycle.

«First Variation»

**[0128]** A first variation has been made by partially modifying the configuration of the heat source unit (10) of the embodiment. Thus, the following description will be focused on the differences with the embodiment.

<Injection Circuit>

**[0129]** As illustrated in FIG. 6, one end of the relay pipe (62) in the injection circuit (60) is connected to an outflow end of the second channel (40b). The other end of the relay pipe (62) communicates with the suction portion of the first low-pressure compressor (22) and the suction portion of the second low-pressure compressor. Specifically, the relay pipe (62) has one end connected to one end of the second channel (40b), and the other end connected to the middle of the first junction pipe (48).

**[0130]** The relay pipe (62) is provided with a fourth motor-operated valve (68). The fourth motor-operated valve (68) is a flow rate regulating valve that regulates the flow rate of the refrigerant introduced into the first low-pressure compressor (22) and the second low-pressure compressor (23).

**[0131]** One end of the first injection pipe (63) is connected to an intermediate pressure portion of the high-pressure compressor (21). The other end of the first injection pipe (63) is connected to one end of the second injection pipe (64) and one end of the third injection pipe (65). The other end of the second injection pipe (64) is connected to an intermediate pressure portion of the first low-pressure compressor (22), and the other end of the third injection pipe (65) is connected to an intermediate pressure portion of the second low-pressure compressor (23).

**[0132]** The injection circuit includes a second branch pipe (66). One end of the second branch pipe (66) is connected to the first branch pipe (61) between the junction of the first branch pipe (61) with the third pipe (33) and the injection valve (26). The other end of the second branch pipe (66) is connected to the first injection pipe (63) between the junction of the second injection pipe (64) and the third injection pipe (65) and the first motor-operated valve (27).

-Operation-

**[0133]** According to the first variation, as in the above embodiment, the refrigerant from the outdoor heat exchanger (14) passes through the first channel (40a) and flows into the third pipe (33) in the cooling operation. Part of the refrigerant in the third pipe (33) flows into the first branch pipe (61). The rest of the refrigerant in the third pipe (33) flows toward the internal heat exchanger (54).

**[0134]** Part of the refrigerant in the first branch pipe (61) flows into the second branch pipe (66). The refrigerant in the second branch pipe (66) diverges into the first to third injection pipes (63 to 65). The refrigerant in each of the first to third injection pipes (63 to 65) has its flow rate suitably regulated by the corresponding one of the first to third motor-operated valves (27 to 29), and is introduced into the intermediate pressure portion of the corresponding one of the compressors (21 to 23).

**[0135]** The rest of the refrigerant in the first branch pipe (61) is decompressed by the injection valve (26), and flows into the second channel (40b). Heat exchange between the refrigerant in the second channel (40b) and the refrigerant in the first channel (40a) cools the refrigerant in the first channel (40a).

**[0136]** The refrigerant that has passed through the second channel (40b) flows through the relay pipe (62) and the first junction pipe (48) in this order. This refrigerant is diverged into the second suction pipe (45) and the third suction pipe (46). The diverged flows of the refrigerant are introduced into the suction portion of the first low-pressure compressor (22) and the suction portion of the second low-pressure compressor (23).

**[0137]** Specifically, according to the first variation, the outdoor controller (101) controls the injection valve (26) and the fourth motor-operated valve (68) in the first operation.

**[0138]** As illustrated in FIG. 7, when the outdoor controller (101) receives a command to execute the first operation, the second discharge temperature sensor (72) and the third discharge temperature sensor (73) detect the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23) in Step ST11.

**[0139]** Specifically, the outdoor controller (101) determines whether a condition indicating that the second discharge temperature (Td2) of the first low-pressure compressor (22) and the third discharge temperature (Td3) of the second low-pressure compressor (23) are both high is met. More specifically, the outdoor controller (101) determines whether the following conditions a) and b) are met.

a) The second discharge temperature (Td2) of the first low-pressure compressor (22) is lower than a predetermined value. The predetermined value is, for example, 95°C.
b) The third discharge temperature (Td3) of the second low-pressure compressor (23) is lower than a predetermined value. The predetermined value is, for example, 95°C.

**[0140]** If both of the conditions a) and b) are met in Step ST 11, the process proceeds to Step ST12. If at least one of the conditions a) or b) is not met in Step ST11, the process proceeds to Step ST13.

**[0141]** In Step ST12, the outdoor controller (101) performs the first control to fully close the injection valve (26). In the first control, no refrigerant flows into the second channel (40b). This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). As a result, the temperature of the refrigerant in the first channel (40a) rises.

**[0142]** In Step ST13, the outdoor controller (101) performs the second control to fully open the injection valve (26). In the second control, the refrigerant that has entered the first branch pipe (61) flows into the second channel (40b) without being decompressed by the injection valve (26). This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). As a result, the temperature of the refrigerant in the first channel (40a) rises.

**[0143]** In Step ST14, the outdoor controller (101) adjusts the opening degree of the fourth motor-operated valve (68) so that each of the second discharge temperature (Td2) and the third discharge temperature (Td3) reaches the target discharge temperature. The refrigerant that has passed through the second channel (40b) passes through the relay pipe (62), and is diverged into the second suction pipe (45) and the third suction pipe (46). The divided flows of the refrigerant are respectively introduced into the suction portions of the first low-pressure compressor (22) and the second low-pressure compressor (23). The outdoor controller (101) controls the fourth motor-operated valve (68) of the relay pipe (62) to regulate the flow rate of the refrigerant introduced into the first low-pressure compressor (22) and the second low-pressure compressor (23). Thus, the second discharge temperature (Td2) and the third discharge temperature (Td3) are controlled to the target discharge temperature. The target discharge temperature is, for example, 95°C.

**[0144]** In Step ST15, the outdoor controller (101) determines whether the temperature (TL) of the refrigerant in the third pipe (33) is higher than a target temperature (target TL). If the temperature (TL) of the refrigerant in the third pipe (33) is higher than the target temperature (target TL), the outdoor controller (101) finishes the first operation, and the process proceeds to Step ST16. If the temperature (TL) of the refrigerant in the third pipe (33) is equal to or lower than the target temperature (target TL), the process proceeds to Step ST11.

**[0145]** In Step ST16, the outdoor controller (101) switches the four-way switching valve (24) from the first state to the second state to switch the first refrigeration cycle to the second refrigeration cycle (start the defrosting operation).

**[0146]** In the first variation, the injection valve (26) is fully opened in the first control, and is fully closed in the second control. This can reliably reduce the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0147]** In the first control, it is only necessary to fully close the injection valve (26). In the second control, it is only necessary to fully open the injection valve (26). This can make the control of the first operation easy.

**[0148]** In the second control, the refrigerant flowing through the injection circuit (60) is introduced into the suction portions of the first low-pressure compressor (22) and the second low-pressure compressor (23). Also in the first variation, the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23) can be lowered.

«Second Variation»

**[0149]** A second variation has been made by partially modifying the configuration of the heat source unit (10) of the embodiment. Thus, the following description will be focused on the differences with the embodiment.

<Injection Circuit>

**[0150]** As illustrated in FIG. 8, the injection circuit (60) includes a third branch pipe (67). One end of the third branch pipe (67) is connected to the first branch pipe (61) between the junction of the first branch pipe (61) with the third pipe (33) and the injection valve (26). An outflow portion of the third branch pipe (67) is connected to inflow ends of the first to third injection pipes (63 to 65).

**[0151]** The third branch pipe (67) is provided with a fifth motor-operated valve (69). The fifth motor-operated valve (69) is a flow rate regulating valve that regulates the flow rate of the refrigerant in the third branch pipe (67).

-Operation-

**[0152]** According to the second variation, as in the above embodiment, the refrigerant from the outdoor heat exchanger (14) passes through the first channel (40a) and flows into the third pipe (33) in the cooling operation. Part of the refrigerant in the third pipe (33) flows into the first branch pipe (61). The rest of the refrigerant in the third pipe (33) flows toward the internal heat exchanger (54).

**[0153]** Part of the refrigerant in the first branch pipe (61) flows into the third branch pipe (67). The refrigerant in the third branch pipe (67) is diverged into the first to third injection pipes (63 to 65). The refrigerant in each of the first to third injection pipes (63 to 65) has its flow rate suitably regulated by the corresponding one of the first to third motor-operated valves (27 to 29), and is introduced into the intermediate pressure portion of the corresponding one of the compressors (21 to 23).

**[0154]** The rest of the refrigerant in the first branch pipe (61) is decompressed by the injection valve (26), and flows into the second channel (40b). Heat exchange between the refrigerant in the second channel (40b) and the refrigerant in the first channel (40a) cools the refrigerant in the first channel (40a).

**[0155]** The refrigerant that has passed through the second channel (40b) flows through the relay pipe (62) and the first junction pipe (48) in this order. This refrigerant is diverged into the second suction pipe (45) and the third suction pipe (46). The diverged flows of the refrigerant are introduced into the suction portion of the first low-pressure compressor (22) and the suction portion of the second low-pressure compressor (23).

**[0156]** According to the second variation, the controller (100) controls the injection valve (26) and the fifth motor-operated valve (69) in the first operation.

**[0157]** Specifically, the controller (100) fully closes the injection valve (26) in the first operation. Thus, no refrigerant flows into the second channel (40b). This reduces the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0158]** The reduction of the cooling capability of the second channel (40b) raises the temperature of the refrigerant in the first channel (40a). When the temperature detected by the liquid temperature sensor (74) reaches the target temperature, the first operation ends and the defrosting operation starts. The target temperature referred herein is the same as the target temperature described in the above embodiment.

**[0159]** In the first operation, the amounts of refrigerant introduced into the first and second low-pressure compressors (21, 22) are adjusted so that each of the second and third discharge temperatures reaches the target discharge temperature. Specifically, the fifth motor-operated valve (69) regulates the flow rate of the refrigerant flowing through the third branch pipe (67). This refrigerant is diverged into the second injection pipe (64) and the third injection pipe (65). Thereafter, the second motor-operated valve (28) and the third motor-operated valve (29) regulate the flow rates of the diverged flows of the refrigerant. The flows of the refrigerant are introduced into the intermediate pressure portions of the first and second low-pressure compressors (21, 22).

**[0160]** Also in the second variation, the first operation can reduce the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a). This can keep the thermal stress on the subcooling heat exchanger (40) from increasing.

**[0161]** According to the second variation, the injection valve (26) is fully closed and the flow rate of the refrigerant introduced into each of the first and second low-pressure compressors (21, 22) is regulated by the fifth motor-operated valve (69) in the first operation, regardless of the discharge temperatures (Td2, Td3) of the first and second low-pressure compressors (22, 23). This can make the control of the first operation easy.

«Third Variation»

**[0162]** As illustrated in FIG. 9, a third variation has been made by partially modifying the configuration of the outdoor unit (10) of the embodiment. Thus, the following description will be focused on the differences with the embodiment.

<Bypass Channel>

**[0163]** The heat source circuit (11) according to the third variation includes a sixth pipe (36). The sixth pipe (36) is a bypass channel (70) that bypasses the first channel (40a). The sixth pipe (36) is connected to the liquid pipes (32, 33) in parallel with the subcooling heat exchanger (40). Specifically, one end of the sixth pipe (36) is connected to the second pipe (32). The other end of the sixth pipe (36) is connected to the third pipe (33) downstream of the fifth outdoor check valve (CV5). An eighth outdoor check valve (CV9) is connected to the sixth pipe (36). The eighth outdoor check valve (CV9) allows the refrigerant to flow from the internal heat exchanger (54) to the outdoor heat exchanger (14) and prohibits the refrigerant from flowing in the opposite direction in the second refrigeration cycle.

<Channel Switching Mechanism>

**[0164]** The channel switching mechanism (180) includes the eighth outdoor check valve (CV9) and the fifth outdoor check valve (CV5). The fifth outdoor check valve (CV5) is connected to the third pipe (33) between the junction of the third pipe (33) with the sixth pipe (36) and an end of the first channel (40a) toward the internal heat exchanger (54). The fifth outdoor check valve (CV5) allows the refrigerant to flow from the outdoor heat exchanger (14) to the internal heat exchanger (54), and prohibits the refrigerant from flowing in the opposite direction.

<Injection Circuit, Other Pipes>

**[0165]** An inflow end of the first branch pipe (61) of the injection circuit (60) is connected to the third pipe (33) between the junction of the third pipe (33) with the sixth pipe (36) and the liquid-side shutoff valve (17). An outflow portion of the first branch pipe (61) is connected to the first to third injection pipes (63 to 65).

**[0166]** One end of the fourth pipe (34) is connected to the second pipe (32) between the junction with the sixth pipe (36) and the junction with the fifth pipe (35). The other end of the fourth pipe (34) is connected to the first pipe (31) downstream of the fourth outdoor check valve (CV4).

-Operation-

<Cooling Operation>

**[0167]** As illustrated in FIG. 10, the refrigerant compressed in the low-pressure compressors (22, 23) and compressed again in the high-pressure compressor (21) dissipates heat to the outdoor air in the outdoor heat exchanger (14). The refrigerant that has dissipated heat in the outdoor heat exchanger (14) flows through the first pipe (31). The refrigerant flows into the receiver (39), and then flows through the second pipe (32) toward the subcooling heat exchanger (40). The refrigerant in the second pipe (32) flows through the first channel (40a) of the subcooling heat exchanger (40). The eighth outdoor check valve (CV9) prohibits the refrigerant from flowing into the sixth pipe (36) serving as the bypass channel (70).

**[0168]** The refrigerant flowing through the first channel (40a) exchanges heat with the refrigerant flowing through the second channel (40b), and is cooled. Part of the refrigerant that has entered the third pipe (33) flows into the first branch pipe (61), and the rest of the refrigerant flows toward the internal heat exchanger (54).

**[0169]** The refrigerant that has entered the first branch pipe (61) is introduced from the injection pipes (63 to 65) into the compression chambers of the compressors (21 to 23).

**[0170]** The refrigerant flowing toward the internal unit (50) is sent to the internal unit (50) through the liquid connection pipe (3).

<Defrosting Operation>

**[0171]** As illustrated in FIG. 11, the injection valve (26) is fully closed in the defrosting operation. Thus, no refrigerant flows into the second channel (40b).

**[0172]** In the second refrigeration cycle, the refrigerant from the internal unit (50) passes through the liquid connection pipe (3) and flows into the third pipe (33). The refrigerant in the third pipe (33) is blocked from flowing into the first channel (40a) by the fifth outdoor check valve (CV5) and passes through the sixth pipe (36) serving as the bypass channel (70). The refrigerant that has passed through the sixth pipe (36) flows through the second pipe (32), the fourth pipe (34), the first pipe (31), the receiver (39), and the second pipe (32) in this order. The refrigerant is decompressed by the outdoor expansion valve (25), and then passes through the fifth pipe (35) and the first pipe (31) to flow into the outdoor heat exchanger (14). The refrigerant flowing into the second pipe (32) from the sixth pipe (36) does not pass through the first channel (40a). This is because the differential pressure across the fifth outdoor check valve (CV5) does not allow the refrigerant to flow through the fifth outdoor check valve (CV5). Likewise, the pressure difference across the fourth outdoor check valve (CV4) does not allow the refrigerant that has entered the first pipe (31) to flow toward the receiver (39).

**[0173]** In the third variation, the fifth outdoor check valve (CV5) and the eighth outdoor check valve (CV9) prohibit the refrigerant from flowing through the first channel (40a) and allow the refrigerant to flow through the bypass channel (70) in the second refrigeration cycle. Thus, in the second refrigeration cycle, the refrigerant coming from the internal unit (50) passes through the sixth pipe (36) serving as the bypass channel (70), and a flow of the refrigerant through the first channel (40a) is regulated. Thus, also in the first variation, a flow of a relatively high-temperature refrigerant into the first channel (40a) immediately after switching from the first refrigeration cycle to the second refrigeration cycle can be regulated. This can keep the thermal stress on the subcooling heat exchanger (40) from increasing.

**[0174]** In addition, the channel that the refrigerant flows can be automatically switched at the switching between the first refrigeration cycle and the second refrigeration cycle. Thus, also in the first variation, the thermal stress on the subcooling heat exchanger (40) can be reliably kept from increasing immediately after switching from the first refrigeration cycle to the second refrigeration cycle.

**[0175]** In the first refrigeration cycle, the entire amount of the refrigerant flows through the first channel (40a), and no refrigerant is allowed to pass through the bypass channel. Thus, the subcooling heat exchanger (40) can cool the entire amount of refrigerant in the first refrigeration cycle.

«Fourth Variations

**[0176]** A fourth variation has been made by partially modifying the configuration of the channel switching mechanism (180) of the third variation. Thus, the following description will be focused on the differences with the third variation.

<Channel Switching Mechanism>

**[0177]** As illustrated in FIG. 12, a channel switching mechanism (180) according to the second variation includes a first three-way switching valve (81) and a second three-way switching valve (82).

**[0178]** The first three-way switching valve (81) is connected to the junction of the second pipe (32) with the sixth pipe (36). Specifically, the third port (P3) of the first three-way switching valve (81) is connected to the second pipe (32) extending from the outdoor heat exchanger (14). The second port (P2) is connected to one end of the sixth pipe (36). The first port (P1) is connected to the second pipe (32) extending from the first channel (40a).

**[0179]** The second three-way switching valve (82) is connected to the junction of the third pipe (33) with the sixth pipe (36). Specifically, the first port (P1) of the second three-way switching valve (82) is connected to the third pipe (33) extending from the internal heat exchanger (54). The second port (P2) is connected to the other end of the sixth pipe (36). The third port (P3) is connected to the third pipe (33) extending from the first channel (40a).

**[0180]** The controller (100) controls the channel switching mechanism (180). In the first state (the state indicated by the solid curves in FIG. 12), the first port (P1) and the third port (P3) are connected to each other in each of the first three-way switching valve (81) and the second three-way switching valve (82). In the second state (the state indicated by the broken curves in FIG. 12), the first port (P1) and the second port (P2) are connected to each other in each of the first three-way switching valve (P1) and the second three-way switching valve (P2).

**[0181]** As illustrated in FIG. 13, the channel switching mechanism (180) is in the first state in the first refrigeration cycle. In the first state, the refrigerant does not flow into the sixth pipe (36) serving as the bypass channel (70), but flows through the first channel (40a). Thus, in the first refrigeration cycle, no refrigerant is allowed to enter the bypass channel (70), and the entire amount of the refrigerant can flow through the first channel (40a).

**[0182]** As illustrated in FIG. 14, the channel switching mechanism (180) is in the second state in the second refrigeration cycle. In the second state, the refrigerant does not flow into the first channel (40a), but flows through the sixth pipe (36) serving as the bypass channel (70). Thus, in the second refrigeration cycle, no refrigerant is allowed to enter the first channel (40a), and the entire amount of the refrigerant can flow through the bypass channel (70).

**[0183]** Also in the fourth variation, the refrigerant flowing from the internal heat exchanger (54) bypasses the first channel (40a) in the second refrigeration cycle. Thus, the thermal stress on the subcooling heat exchanger (40) can be kept from increasing immediately after switching from the first refrigeration cycle to the second refrigeration cycle.

«Fifth Variation»

**[0184]** A fifth variation has been made by partially modifying the configuration of the subcooling heat exchanger (40) of the third and fourth variations. Thus, the following description will be focused on the differences with the third and fourth variations.

<Subcooling Circuit>

**[0185]** As illustrated in FIG. 15, an outdoor unit (10) of the fifth variation includes a subcooling unit (90). The subcooling unit (90) includes a subcooling circuit (91) and a subcooling fan (94).

**[0186]** The subcooling circuit (91) includes a subcooling compressor (92), a subcooling heat exchanger (93), a subcooling expansion valve (26), and a second channel (40b). The subcooling circuit (91) is a refrigerant circuit independent of the heat source circuit (11). The subcooling circuit (91) is configured to allow the refrigerant as the heating medium to flow through the subcooling compressor (92), the subcooling heat exchanger (93), the subcooling expansion valve (26), and the second channel (40b) in this order.

**[0187]** The subcooling compressor (92) is a high-pressure dome-shaped hermetic scroll compressor. A compressor section (not shown) and an electric motor (not shown) that drives the compressor section are connected to the subcooling compressor (92). The electric motor of the subcooling compressor (92) is connected to an inverter capable of freely changing the number of rotations of the electric motor within a predetermined range. The number of rotations of the electric motor can be adjusted by the inverter, thereby increasing or decreasing the operating capacity of the subcooling compressor (92).

**[0188]** The subcooling heat exchanger (93) is a fin-and-tube air heat exchanger. The subcooling fan (94) is arranged near the subcooling heat exchanger (93). The subcooling fan (94) transfers outdoor air. The subcooling heat exchanger (93) exchanges heat between the high-pressure refrigerant flowing therethrough and the outdoor air transferred from the subcooling fan (94).

**[0189]** The subcooling expansion valve (26) is an electronic expansion valve having a variable opening degree. Adjusting the opening degree of the subcooling expansion valve (26) controls the temperature of the refrigerant flowing through the second channel (40b).

**[0190]** The refrigerant that has its pressure reduced by the subcooling expansion valve (26) flows through the second channel (40b). The refrigerant flowing through the second channel (40b) absorbs heat from the refrigerant flowing through the first channel (40a) and evaporates.

-Operation-

<Cooling Operation>

**[0191]** The subcooling compressor (92) and the subcooling fan (94) of the subcooling unit (90) operate in the cooling operation. The opening degree of the subcooling expansion valve (26) is suitably adjusted.

**[0192]** In the subcooling circuit (91), the refrigerant compressed by the subcooling compressor (92) dissipates heat to the outdoor air in the subcooling heat exchanger (93). The refrigerant that has dissipated heat is decompressed by the subcooling expansion valve (26), and flows into the second channel (40b). The refrigerant in the second channel (40b) exchanges heat with the refrigerant flowing through the first channel (40a), and is then sucked into the subcooling compressor (92) again.

**[0193]** In the heat source circuit, as in the third and fourth variations, the refrigerant compressed in the low-pressure compressors (22, 23) and the high-pressure compressor (21) dissipates heat to the outdoor air in the outdoor heat exchanger (14). The refrigerant that has dissipated heat flows through the first pipe (31). The refrigerant flows into the receiver (39), passes through the second pipe (32), and flows through the first channel (40a) of the subcooling heat exchanger (40).

**[0194]** The refrigerant flowing through the first channel (40a) exchanges heat with the refrigerant flowing through the second channel (40b), and is cooled. Part of the refrigerant that has entered the third pipe (33) flows into the first branch pipe (61), and the rest of the refrigerant flows toward the internal heat exchanger (54).

<Defrosting Operation>

**[0195]** The subcooling compressor (92) stops operating in the defrosting operation. Thus, no refrigerant flows into the second channel (40b).

**[0196]** As in the third and fourth variations, the refrigerant from the internal unit (50) passes through the liquid connection pipe (3) and flows into the third pipe (33). The refrigerant in the third pipe (33) is blocked from flowing into the first channel (40a) by the fifth outdoor check valve (CV5) and passes through the sixth pipe (36) serving as the bypass channel (70). The refrigerant that has passed through the sixth pipe (36) flows through the second pipe (32), the fourth pipe (34), the first pipe (31), the receiver (39), and the second pipe (32) in this order. The refrigerant is decompressed by the outdoor expansion valve (25), and then passes through the fifth pipe (35) and the first pipe (31) to flow into the outdoor heat exchanger (14). Note that the pressure difference across the fifth outdoor check valve (CV5) does not allow the refrigerant that has entered the second pipe (32) from the sixth pipe (36) to flow through the first channel (40a). Likewise, the pressure difference across the fourth outdoor check valve (CV4) does not allow the refrigerant that has entered the first pipe (31) from the fifth pipe (35) to flow into the receiver (39).

**[0197]** Also in the fifth variation, the refrigerant flowing from the internal heat exchanger (54) bypasses the first channel (40a) in the second refrigeration cycle. Thus, the thermal stress on the subcooling heat exchanger (40) can be kept from increasing immediately after the switching from the first refrigeration cycle to the second refrigeration cycle.

**[0198]** In addition, the subcooling unit (90) includes the subcooling circuit (91) that is a refrigerant circuit independent of the heat source circuit (11). Thus, the temperature of the refrigerant flowing through the second channel (40b) can be independently controlled.

«Other Embodiments»

**[0199]** The above-described embodiment may be modified as follows.

**[0200]** The second refrigeration cycle may be a heating operation in which the internal heat exchanger (54) serves as a radiator and the outdoor heat exchanger (14) serves as an evaporator. When the controller (100) receives an instruction to perform the heating operation during the cooling operation, the refrigeration apparatus (1) performs the first operation. When the temperature of the refrigerant in the first channel (40a) reaches the target temperature (target TL), the heating operation starts. After the switching to the heating operation, the refrigerant flowing from the internal heat exchanger (54) to the outdoor heat exchanger (14) bypasses the first channel (40a). Also in this case, the thermal stress on the subcooling heat exchanger (40) can be kept from increasing.

**[0201]** The compression element (20) may be a single-stage compression element. In this case, the high-pressure compressor (21) operates, and the first low-pressure compressor (22) and the second low-pressure compressor (23) stop operating in the first refrigeration cycle (cooling operation) of the above embodiment. The sixth motor-operated valve (53) is fully opened. The refrigerant that has entered the first junction pipe (48) from the internal heat exchanger (54) flows through the connection pipe (49), and is sucked into the high-pressure compressor (21). The refrigerant compressed by the high-pressure compressor (21) flows through the outdoor heat exchanger (14), the receiver (39), and the subcooling heat exchanger (40), as in the above embodiment. In this way, the refrigerant flows through the refrigerant circuit (2).

**[0202]** The compression element (20) may be a single-stage compression element having a plurality of compressors connected in parallel.

**[0203]** In the above embodiment, the first control in the first operation (Step ST3 in FIG. 5) may fully close the injection valve (26). In this case, no refrigerant flows into the second channel (40b), reducing the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0204]** In the above embodiment, the second control in the second operation (Step ST4 in FIG. 5) may fully open the injection valve (26). In this case, the refrigerant is not decompressed by the injection valve (26), reducing the capability of the second channel (40b) of cooling the refrigerant in the first channel (40a).

**[0205]** In the above embodiment, the value of the temperature (Tg1) of the refrigerant flowing into the second channel (40b) detected by the first temperature sensor (75) may be replaced with a value of the pressure sensor (77) converted to a saturated liquid temperature. The value of the pressure (MP) of the refrigerant in the relay pipe (62) detected by the pressure sensor (77) may be replaced with a value of the first temperature sensor (75) converted to a saturated liquid pressure.

**[0206]** In the above embodiment and variations, the heat source unit (10) may have no bypass channel (70). Likewise, the heat source unit (10) may have no channel switching mechanism (180).

**[0207]** In the above embodiment, the utilization circuit (51) may have no internal bypass channel (58). In this case, the internal expansion valve (30) is an electronic expansion valve having a variable opening degree. When the internal heat exchanger (54) functions as a radiator, the internal expansion valve (30) is fully opened.

**[0208]** The channel switching mechanism (180) may be a motor-operated valve having a variable opening degree. Specifically, the fifth outdoor check valve (CV5) and sixth outdoor check valve (CV6) of the above embodiment and the fifth outdoor check valve (CV5) and eighth outdoor check valve (CV9) of the third variation may be motor-operated valves. In the first and second refrigeration cycles, adjusting the opening degrees of the motor-operated valves can regulate the flow rate of the refrigerant in the first channel (40a) and the flow rate of the refrigerant in the bypass channel (70). This allows at least part of the refrigerant to flow through the bypass channel (70) in the second refrigeration cycle. Thus, the regulation of the flow rate of the refrigerant in the bypass channel (70) can keep the thermal stress on the subcooling heat exchanger (40) from increasing in the second refrigeration cycle. Also in the first refrigeration cycle, the regulation allows at least part of the refrigerant to flow through the bypass channel (70). This can control the amount of refrigerant that exchanges heat in the first channel (40a) in the first refrigeration cycle.

**[0209]** The channel switching mechanism (180) may be an on-off valve that simply opens and closes. Specifically, the fifth outdoor check valve (CV5) and sixth outdoor check valve (CV6) of the above embodiment and the fifth outdoor check valve (CV5) and eighth outdoor check valve (CV9) of the third variation may be on-off valves that simply open and close. In the first refrigeration cycle, one of the valves is opened to allow the refrigerant to flow through the first channel (40a), and the other is closed to block the refrigerant from flowing through the bypass channel (70). Thus, the entire amount of the refrigerant can flow through the first channel (40a). In the second refrigeration cycle, one of the valves is closed to block the refrigerant from flowing through the first channel (40a), and the other is opened to allow the refrigerant to flow through the bypass channel (70). This allows the entire amount of refrigerant to flow through the bypass channel (70).

**[0210]** As illustrated in FIG. 16, the channel switching mechanism (180) of the third and fourth variations may include the first three-way switching valve (81) and the fifth outdoor check valve (CV5). In the first refrigeration cycle, the first port (P1) and third port (P3) of the first three-way switching valve (81) are connected to each other. Thus, the refrigerant is prohibited from flowing into the sixth pipe (36) in the first refrigeration cycle. This allows the entire amount of refrigerant to flow through the first channel (40a) in the first refrigeration cycle.

**[0211]** In the second refrigeration cycle, the first port (P1) and second port (P2) of the first three-way switching valve (81) are connected to each other. Thus, the refrigerant is prohibited from flowing into the first channel (40a) in the second refrigeration cycle. This allows the entire amount of refrigerant to flow through the sixth pipe (36) in the second refrigeration cycle.

**[0212]** As illustrated in FIG. 17, the channel switching mechanism (180) of the third and fourth variations may include the second three-way switching valve (82) and the eighth outdoor check valve (CV9). In the first refrigeration cycle, the first port (P1) and third port (P3) of the second three-way switching valve (82) are connected to each other. Thus, the refrigerant is prohibited from flowing into the sixth pipe (36) in the first refrigeration cycle. This allows the entire amount of refrigerant to flow through the first channel (40a) in the first refrigeration cycle.

**[0213]** In the second refrigeration cycle, the first port (P1) and second port (P2) of the second three-way switching valve (82) are connected to each other. Thus, the refrigerant is prohibited from flowing into the first channel (40a) in the second refrigeration cycle. This allows the entire amount of refrigerant to flow through the sixth pipe (36) in the second refrigeration cycle.

**[0214]** As illustrated in FIG. 18, the channel switching mechanism (180) of the third and fourth variations may include the second three-way switching valve (82) only. In the first refrigeration cycle, the first port (P1) and third port (P3) of the second three-way switching valve (82) are connected to each other. In the second refrigeration cycle, the first port (P1) and second port (P2) of the second three-way switching valve (82) are connected to each other.

**[0215]** The injection circuit (60) is not limited to the one described in the above embodiment. The injection circuit (60) may be modified as appropriate without deteriorating intended functions disclosed in the above embodiment.

**[0216]** In the above embodiment, the utilization circuit (51) may have no internal bypass channel (58). In this case, the internal expansion valve (30) is an electronic expansion valve having a variable opening degree. When the internal heat exchanger (54) functions as a radiator, the internal expansion valve (30) is fully opened.

**[0217]** The outdoor expansion valve (25) of the above embodiment may be connected to the second pipe (32) between the receiver (39) and the end of the fifth pipe (35) connected to the second pipe (32).

## INDUSTRIAL APPLICABILITY

**[0218]** As can be seen in the foregoing, the present invention is useful for a refrigeration apparatus.

## DESCRIPTION OF REFERENCE CHARACTERS

**[0219]**

| | |
|---|---|
| 1 | Refrigeration Apparatus |
| 2 | Refrigerant Circuit |
| 10 | Outdoor Unit (Heat Source Unit) |
| 11 | Heat Source Circuit |
| 14 | Outdoor Heat Exchanger (Heat Source Heat Exchanger) |
| 20 | Compression Element |
| 21 | High-Pressure Compressor (Second Compression Section) |
| 22 | First Low-Pressure Compressor (First Compression Section) |
| 23 | Second Low-Pressure Compressor (First Compression Section) |
| 24 | Four-Way Switching Valve (Switching Mechanism) |
| 26 | Injection Valve (Expansion Valve) |
| 28 | Second Motor-Operated Valve (Flow Rate Regulating Valve) |
| 29 | Third Motor-Operated Valve (Flow Rate Regulating Valve) |
| 32 | Second Pipe (Liquid Pipe) |
| 33 | Third Pipe (Liquid Pipe) |
| 40 | Subcooling Heat Exchanger |
| 40a | First Channel |
| 40b | Second Channel |

50 Internal Unit (Utilization Unit)
54 Internal Heat Exchanger (Utilization Heat Exchanger)
60 Injection Circuit
70 Bypass Channel
80 Regulation Mechanism
101 Outdoor Controller (Control Unit)
180 Channel Switching Mechanism

## Claims

**1.** A refrigeration apparatus, comprising:

a utilization unit (50) having a utilization heat exchanger (54), and a heat source unit (10), wherein the heat source unit (10) comprises:

a heat source circuit (11) including a compression element (20), a heat source heat exchanger (14), a subcooling heat exchanger (40), and a switching mechanism (24), the heat source unit being connected to the utilization unit (50) having the utilization heat exchanger (54) to constitute a refrigerant circuit (2) that performs a refrigeration cycle, wherein
the switching mechanism (24) is configured to switch the refrigeration cycle between

a first refrigeration cycle in which the heat source heat exchanger (14) serves as a radiator and the utilization heat exchanger (54) serves as an evaporator, and
a second refrigeration cycle in which the utilization heat exchanger (54) serves as a radiator and the heat source heat exchanger (14) serves as an evaporator,

the subcooling heat exchanger (40) has a first channel (40a) connected to a middle portion of a liquid pipe (32, 33) through which a liquid refrigerant in the heat source circuit (11) flows, and a second channel (40b) through which a heating medium for cooling the refrigerant in the first channel (40a) flows,
the heat source unit (10) further comprises a regulation mechanism including an expansion valve (26) connected to an upstream side of the second channel (40b) and a control unit (101),

**characterized in that**
the control unit (101) is
configured to control an opening degree of the expansion valve (26) so that the cooling capability is reduced in a first operation of reducing a capability of the second channel (40b) of cooling the refrigerant in the first channel (40a) before switching from the first refrigeration cycle to the second refrigeration cycle.

**2.** The refrigeration apparatus of claim 1, wherein
the switching mechanism (24) is configured to switch the refrigeration cycle to the second refrigeration cycle when a temperature of the refrigerant flowing through the first channel (40a) exceeds a predetermined value in the first operation.

**3.** The refrigeration apparatus of claim 1 or 2, wherein the heat source circuit (11) includes:

an injection circuit (60) having one end branched from the liquid pipe (32, 33) and the other end communicating with an intermediate pressure portion or a suction portion of the compression element (20), and including the second channel (40b) through which a refrigerant as the heating medium flows; and
the expansion valve (26) is connected to the upstream side of the second channel (40b) in the injection circuit (60).

**4.** The refrigeration apparatus of any one of claims 1 to 3, wherein
the control unit (101) performs first control in the first operation to reduce the opening degree of the expansion valve (26) so that a flow rate of the refrigerant in the second channel (40b) decreases.

**5.** The refrigeration apparatus of any one of claim 1 to 4, wherein
the control unit (101) performs second control in the first operation to increase the opening degree of the expansion valve (26) so that a pressure of the refrigerant in the second channel (40b) rises.

**6.** The refrigeration apparatus of any of the preceding claims, wherein
the control unit (101) performs, in the first operation,

first control to reduce the opening degree of the expansion valve (26) so that a flow rate of the refrigerant in the second channel (40b) decreases when a condition indicating that a discharge temperature, which is a temperature of the refrigerant discharged from the compression element (20), is low is met, and
second control to increase the opening degree of the expansion valve (26) so that a pressure of the refrigerant in the second channel (40b) rises when a condition indicating that the discharge temperature of the compression element

(20) is high is met.

**7.** The refrigeration apparatus of claim 5 or 6, wherein

the heat source circuit (11) includes a flow rate regulating valve (28, 29) connected to a downstream side of the second channel (40b) in the injection circuit (60), and
the second control performed in the first operation regulates an opening degree of the flow rate regulating valve (28, 29) so that a discharge temperature, which is a temperature of the refrigerant discharged from the compression element (20), approaches a predetermined value.

**8.** The refrigeration apparatus of any one of claims 1 to 7, further comprising:

a subcooling heat exchanger (40) having the first channel (40a) and the second channel (40b);
a bypass channel (70) configured to allow at least part of the refrigerant that has dissipated heat in the utilization heat exchanger (54) to bypass the first channel (40a) in the second refrigeration cycle; and
a channel switching mechanism (180) configured to regulate the refrigerant flowing through the first channel (40a) and allow the refrigerant to flow through the bypass channel (70) in the second refrigeration cycle.

**9.** The refrigeration apparatus of any one of claims 1 to 8, wherein
the compression element (20) is a two-stage compression element having a first compression section (22, 23) and a second compression section (21), and is configured to compress the refrigerant in the first compression section (22, 23) and then compress the refrigerant again in the second compression section (21) in the first refrigeration cycle.

## Patentansprüche

**1.** Kühlvorrichtung, umfassend:
eine Nutzungseinheit (50), die einen Nutzungswärmetauscher (54) aufweist, und eine Wärmequelleneinheit (10), wobei die Wärmequelleneinheit (10) Folgendes umfasst:

einen Wärmequellenkreislauf (11), einschließend ein Verdichtungselement (20), einen Wärmequellenwärmetauscher (14), einen Unterkühlungswärmetauscher (40) und einen Schaltmechanismus (24), wobei die Wärmequelleneinheit mit der Nutzungseinheit (50), die den Nutzungswärmetauscher (54) aufweist, verbunden ist, um einen Kältemittelkreislauf (2) zu bilden, der einen Kühlzyklus durchführt, wobei der Schaltmechanismus (24) so ausgebildet ist, dass er den Kühlzyklus umschaltet zwischen

einem ersten Kühlzyklus, in dem der Wärmequellenwärmetauscher (14) als Kühler und der Nutzungswärmetauscher (54) als Verdampfer dient, und
einem zweiten Kühlzyklus, in dem der Nutzungswärmetauscher (54) als Kühler und der Wärmequellenwärmetauscher (14) als Verdampfer dient,

der Unterkühlungswärmetauscher (40) einen ersten Kanal (40a), der mit einem mittleren Abschnitt einer Flüssigkeitsleitung (32, 33) verbunden ist, durch die ein flüssiges Kältemittel im Wärmequellenkreislauf (11) strömt, und einen zweiten Kanal (40b) aufweist, durch den ein Heizmedium zum Kühlen des Kältemittels im ersten Kanal (40a) strömt,
die Wärmequelleneinheit (10) weiter einen Regelungsmechanismus umfasst, einschließend ein Expansionsventil (26), das mit einer stromaufwärtigen Seite des zweiten Kanals (40b) verbunden ist, und eine Steuereinheit (101),
**dadurch gekennzeichnet, dass**
die Steuereinheit (101) so ausgebildet ist, dass sie einen Öffnungsgrad des Expansionsventils (26) steuert, sodass die Kühlleistung in einem ersten Betrieb der Verringerung einer Leistung des zweiten Kanals (40b) zur Kühlung des Kältemittels im ersten Kanal (40a) vor dem Umschalten von dem ersten Kühlzyklus zu dem zweiten Kühlzyklus verringert wird.

**2.** Kühlvorrichtung nach Anspruch 1, wobei
der Schaltmechanismus (24) so ausgebildet ist, dass er den Kühlzyklus auf den zweiten Kühlzyklus umschaltet, wenn eine Temperatur des durch den ersten Kanal (40a) strömenden Kühlmittels einen vorbestimmten Wert im ersten Betrieb überschreitet.

**3.** Kühlvorrichtung nach Anspruch 1 oder 2, wobei der Wärmequellenkreislauf (11) Folgendes einschließt:

einen Einspritzkreislauf (60), der ein Ende aufweist, das von der Flüssigkeitsleitung (32, 33) abzweigt, und dessen anderes Ende mit einem Zwischendruckabschnitt oder einem Ansaugabschnitt des Verdichtungselements (20) in Verbindung steht, und einschließend den zweiten Kanal (40b), durch den ein Kältemittel als Heizmedium strömt; und
das Expansionsventil (26) mit der stromaufwärtigen Seite des zweiten Kanals (40b) im Einspritzkreislauf (60) verbunden ist.

4. Kühlvorrichtung nach einem der Ansprüche 1 bis 3, wobei
die Steuereinheit (101) eine erste Steuerung im ersten Betrieb durchführt, um den Öffnungsgrad des Expansionsventils (26) zu verringern, sodass eine Durchflussrate des Kältemittels im zweiten Kanal (40b) abnimmt.

5. Kühlvorrichtung nach einem der Ansprüche 1 bis 4, wobei
die Steuereinheit (101) im ersten Betrieb eine zweite Steuerung durchführt, um den Öffnungsgrad des Expansionsventils (26) zu vergrößern, sodass ein Druck des Kältemittels im zweiten Kanal (40b) ansteigt.

6. Kühlvorrichtung nach einem der vorstehenden Ansprüche, wobei die Steuereinheit (101) im ersten Betrieb die Folgendes durchführt,

erste Steuerung zur Verringerung des Öffnungsgrades des Expansionsventils (26), sodass eine Durchflussrate des Kältemittels im zweiten Kanal (40b) abnimmt, wenn eine Bedingung erfüllt ist, die angibt, dass eine Ausstoßtemperatur, die eine Temperatur des von dem Verdichtungselement (20) ausgestoßenen Kältemittels ist, niedrig ist, und
zweite Steuerung zur Vergrößerung des Öffnungsgrades des Expansionsventils (26), sodass ein Druck des Kältemittels im zweiten Kanal (40b) ansteigt, wenn eine Bedingung erfüllt ist, die angibt, dass die Ausstoßtemperatur des Verdichtungselements (20) hoch ist.

7. Kühlvorrichtung nach Anspruch 5 oder 6, wobei

der Wärmequellenkreislauf (11) ein Durchflussratenregulierungsventil (28, 29) einschließt, das mit einer stromabwärtigen Seite des zweiten Kanals (40b) im Einspritzkreislauf (60) verbunden ist, und
die zweite Steuerung, die im ersten Betrieb durchgeführt wird, einen Öffnungsgrad des Durchflussratenregulierungsventils (28, 29) reguliert, sodass eine Ausstoßtemperatur, die eine Temperatur des von dem Verdichtungselement (20) ausgestoßenen Kältemittels ist, sich einem vorbestimmten Wert nähert.

8. Kühlvorrichtung nach einem der Ansprüche 1 bis 7, weiter umfassend:

einen Unterkühlungswärmetauscher (40), der den ersten Kanal (40a) und den zweiten Kanal (40b) aufweist;
einen Bypass-Kanal (70), der so ausgebildet ist, dass er es ermöglicht, dass zumindest ein Teil des Kältemittels, das im Nutzungswärmetauscher (54) Wärme abgeführt hat, den ersten Kanal (40a) im zweiten Kühlzyklus umgeht; und
einen Kanalumschaltmechanismus (180), der so ausgebildet ist, dass er das durch den ersten Kanal (40a) strömende Kältemittel reguliert und dem Kältemittel erlaubt, im zweiten Kühlzyklus durch den Bypass-Kanal (70) zu strömen.

9. Kühlvorrichtung nach einem der Ansprüche 1 bis 8, wobei
das Verdichtungselement (20) ein zweistufiges Verdichtungselement ist, das einen ersten Verdichtungsteilabschnitt (22, 23) und einen zweiten Verdichtungsteilabschnitt (21) aufweist, und so ausgebildet ist, dass es das Kältemittel im ersten Verdichtungsteilabschnitt (22, 23) verdichtet und dann das Kältemittel im zweiten Verdichtungsteilabschnitt (21) im ersten Kühlzyklus erneut verdichtet.

**Revendications**

1. Appareil de réfrigération, comprenant :
une unité d'utilisation (50) ayant un échangeur de chaleur d'utilisation (54) et une unité de source de chaleur (10), dans lequel l'unité de source de chaleur (10) comprend :

un circuit de source de chaleur (11) incluant un élément de compression (20), un échangeur de chaleur à source de chaleur (14), un échangeur de chaleur de sous-refroidissement (40), et un mécanisme de commutation (24), l'unité de source de chaleur étant reliée à l'unité d'utilisation (50) ayant l'échangeur de chaleur d'utilisation (54) pour constituer un circuit de réfrigération (2) qui met en oeuvre un cycle de réfrigération, dans lequel
le mécanisme de commutation (24) est configuré pour commuter le cycle de réfrigération entre

un premier cycle de réfrigération dans lequel l'échangeur thermique à source de chaleur (14) sert de radiateur et l'échangeur thermique d'utilisation (54) sert d'évaporateur, et
un second cycle de réfrigération dans lequel l'échangeur thermique d'utilisation (54) sert de radiateur et l'échangeur thermique à source de chaleur (14) sert d'évaporateur,

l'échangeur de chaleur de sous-refroidissement (40) a un premier canal (40a) relié à une partie médiane d'un tuyau de liquide (32, 33) à travers lequel s'écoule un réfrigérant liquide dans le circuit de source de chaleur (11) , et un second canal (40b) à travers lequel s'écoule un fluide

chauffant pour refroidir le réfrigérant dans le premier canal (40a),
l'unité de source de chaleur (10) comprend en outre un mécanisme de régulation incluant un détendeur (26) relié à un côté amont du second canal (40b) et une unité de commande (101),
**caractérisé en ce que**
l'unité de commande (101) est configurée pour commander un degré d'ouverture du détendeur (26) de sorte que la capacité de refroidissement est réduite dans une première opération de réduction d'une capacité du second canal (40b) de refroidissement du réfrigérant dans le premier canal (40a) avant de commuter du premier cycle de réfrigération au second cycle de réfrigération.

**2.** Appareil de réfrigération selon la revendication 1, dans lequel
le mécanisme de commutation (24) est configuré pour commuter le cycle de réfrigération sur le second cycle de réfrigération lorsqu'une température du réfrigérant circulant à travers le premier canal (40a) dépasse une valeur prédéterminée dans la première opération.

**3.** Appareil de réfrigération selon la revendication 1 ou la revendication 2, dans lequel le circuit de source de chaleur (11) inclut :

un circuit d'injection (60) ayant une extrémité dérivée du tuyau de liquide (32, 33) et l'autre extrémité communiquant avec une partie de pression intermédiaire ou une partie d'aspiration de l'élément de compression (20), et incluant le second canal (40b) à travers lequel circule un réfrigérant en tant que fluide chauffant ; et
le détendeur (26) est relié au côté amont du second canal (40b) dans le circuit d'injection (60).

**4.** Appareil de réfrigération selon l'une quelconque des revendications 1 à 3, dans lequel
l'unité de commande (101) met en oeuvre une première commande dans la première opération pour réduire le degré d'ouverture du détendeur (26) de sorte qu'un débit du réfrigérant dans le second canal (40b) diminue.

**5.** Appareil de réfrigération selon l'une quelconque des revendications 1 à 4, dans lequel
l'unité de commande (101) met en oeuvre une seconde commande dans la première opération pour augmenter le degré d'ouverture du détendeur (26) de sorte qu'une pression du réfrigérant dans le second canal (40b) augmente.

**6.** Appareil de réfrigération selon l'une quelconque des revendications précédentes, dans lequel l'unité de commande (101) met en oeuvre, dans la première opération,

une première commande pour réduire le degré d'ouverture du détendeur (26) de sorte qu'un débit du réfrigérant dans le second canal (40b) diminue lorsqu'une condition indiquant qu'une température d'évacuation, qui est une température du réfrigérant évacué de l'élément de compression (20), est basse est remplie, et
une seconde commande pour augmenter le degré d'ouverture du détendeur (26) de sorte qu'une pression du réfrigérant dans le second canal (40b) augmente lorsqu'est remplie une condition indiquant que la température d'évacuation de l'élément de compression (20) est élevée.

**7.** Appareil de réfrigération selon la revendication 5 ou la revendication 6, dans lequel

le circuit de source de chaleur (11) inclut une vanne de régulation de débit (28, 29) reliée à un côté aval du second canal (40b) dans le circuit d'injection (60), et
la seconde commande mise en oeuvre dans la première opération régule un degré d'ouverture de la vanne de régulation de débit (28, 29) de sorte qu'une température d'évacuation, qui est une température du réfrigérant évacué de l'élément de compression (20), s'approche d'une valeur prédéterminée.

**8.** Appareil de réfrigération selon l'une quelconque des revendications 1 à 7, comprenant en outre :

un échangeur de chaleur de sous-refroidissement (40) ayant le premier canal (40a) et le second canal (40b) ;
un canal de dérivation (70) configuré pour permettre à au moins une partie du réfrigérant qui a dissipé la chaleur dans l'échangeur de chaleur d'utilisation (54) de contourner le premier canal (40a) dans le second cycle de réfrigération ; et
un mécanisme de commutation de canal (180) configuré pour réguler le réfrigérant circulant à travers le premier canal (40a) et permettre au réfrigérant de circuler à travers le canal de dérivation (70) dans le second cycle de réfrigération.

**9.** Appareil de réfrigération selon l'une quelconque des revendications 1 à 8, dans lequel
l'élément de compression (20) est un élément de compression à deux étages ayant une première section de compression (22, 23) et une seconde section de compression (21), et est configuré pour comprimer le réfrigérant dans la première section de com-

pression (22, 23), et ensuite comprimer à nouveau le réfrigérant dans la seconde section de compression (21) dans le premier cycle de réfrigération.

# FIG.1

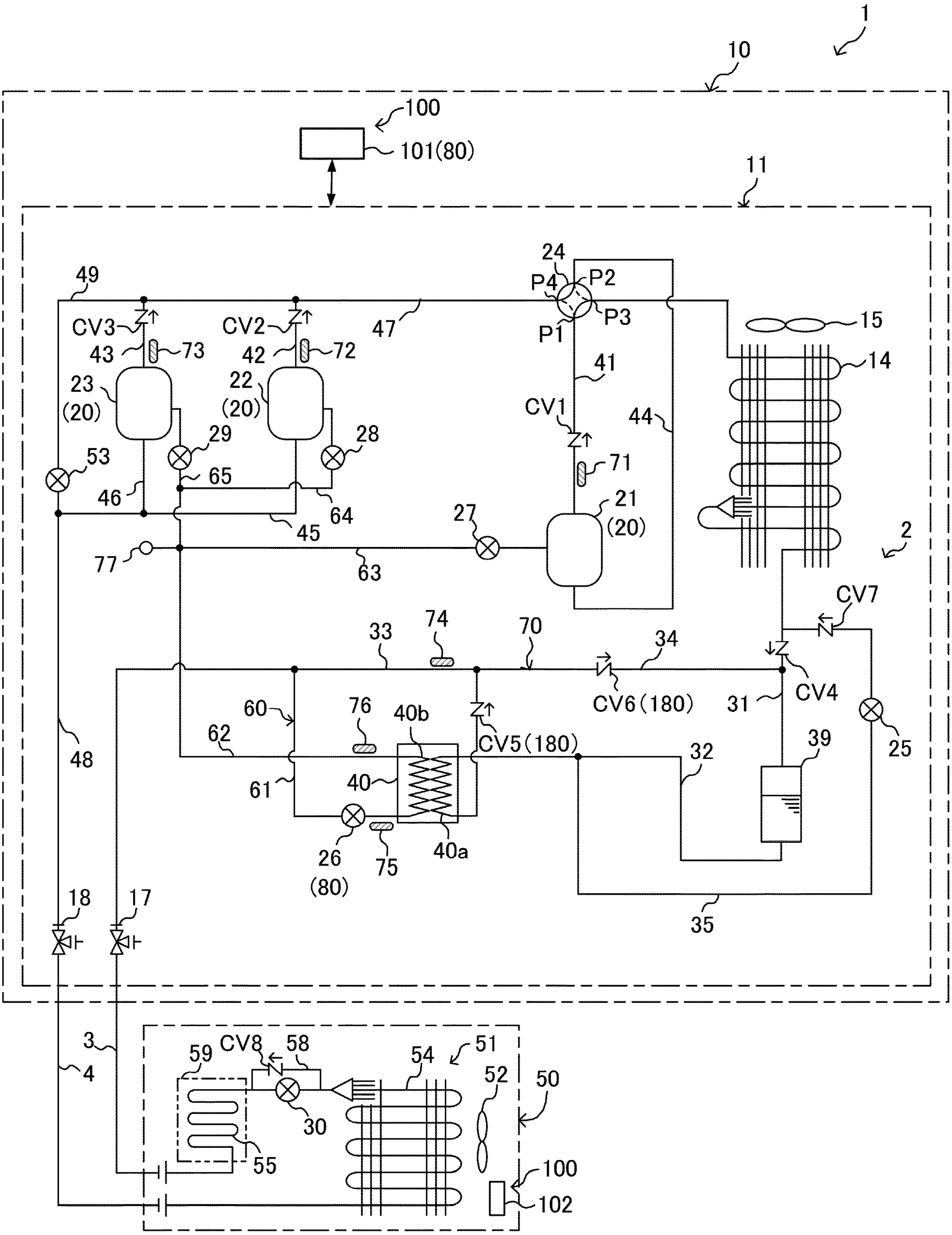

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
43
73
CV2
42
72
47
15
14
41
23
(20)
22
(20)
CV1
44
29
28
71
53
65
21
(20)
46
64
45
27
2
77
63
CV7
33
74
70
34
CV4
CV6(180)
31
60
76
40b
62
CV5(180)
32
39
25
48
40
61
26
(80)
75
40a
35
18
17
3
4
59
CV8
58
51
54
52
50
30
55
100
102

FIG.2

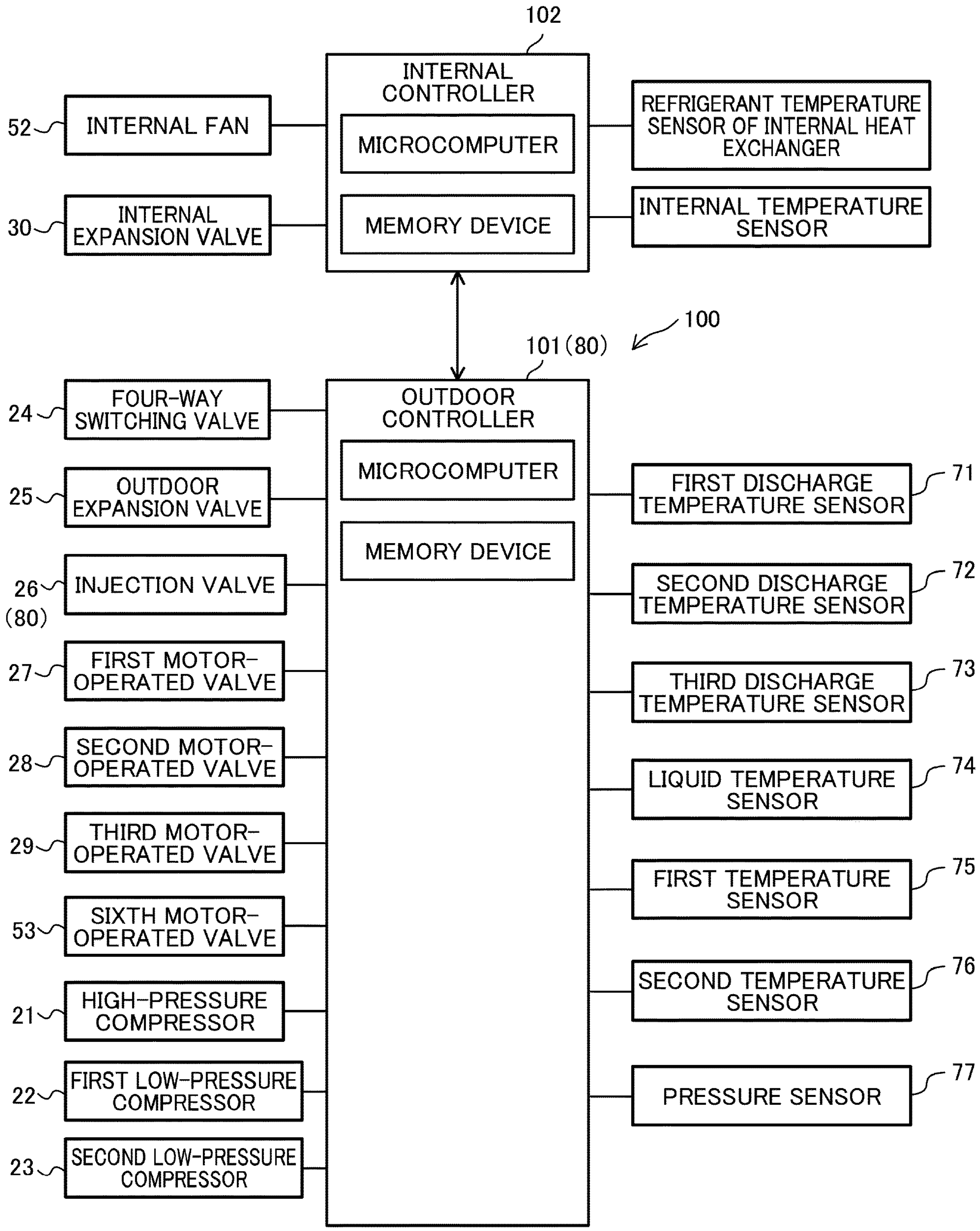

102
INTERNAL CONTROLLER
MICROCOMPUTER
MEMORY DEVICE
52
INTERNAL FAN
30
INTERNAL EXPANSION VALVE
REFRIGERANT TEMPERATURE SENSOR OF INTERNAL HEAT EXCHANGER
INTERNAL TEMPERATURE SENSOR
100
101(80)
OUTDOOR CONTROLLER
MICROCOMPUTER
MEMORY DEVICE
24
FOUR-WAY SWITCHING VALVE
25
OUTDOOR EXPANSION VALVE
26
(80)
INJECTION VALVE
27
FIRST MOTOR-OPERATED VALVE
28
SECOND MOTOR-OPERATED VALVE
29
THIRD MOTOR-OPERATED VALVE
53
SIXTH MOTOR-OPERATED VALVE
21
HIGH-PRESSURE COMPRESSOR
22
FIRST LOW-PRESSURE COMPRESSOR
23
SECOND LOW-PRESSURE COMPRESSOR
FIRST DISCHARGE TEMPERATURE SENSOR
71
SECOND DISCHARGE TEMPERATURE SENSOR
72
THIRD DISCHARGE TEMPERATURE SENSOR
73
LIQUID TEMPERATURE SENSOR
74
FIRST TEMPERATURE SENSOR
75
SECOND TEMPERATURE SENSOR
76
PRESSURE SENSOR
77

FIG.3

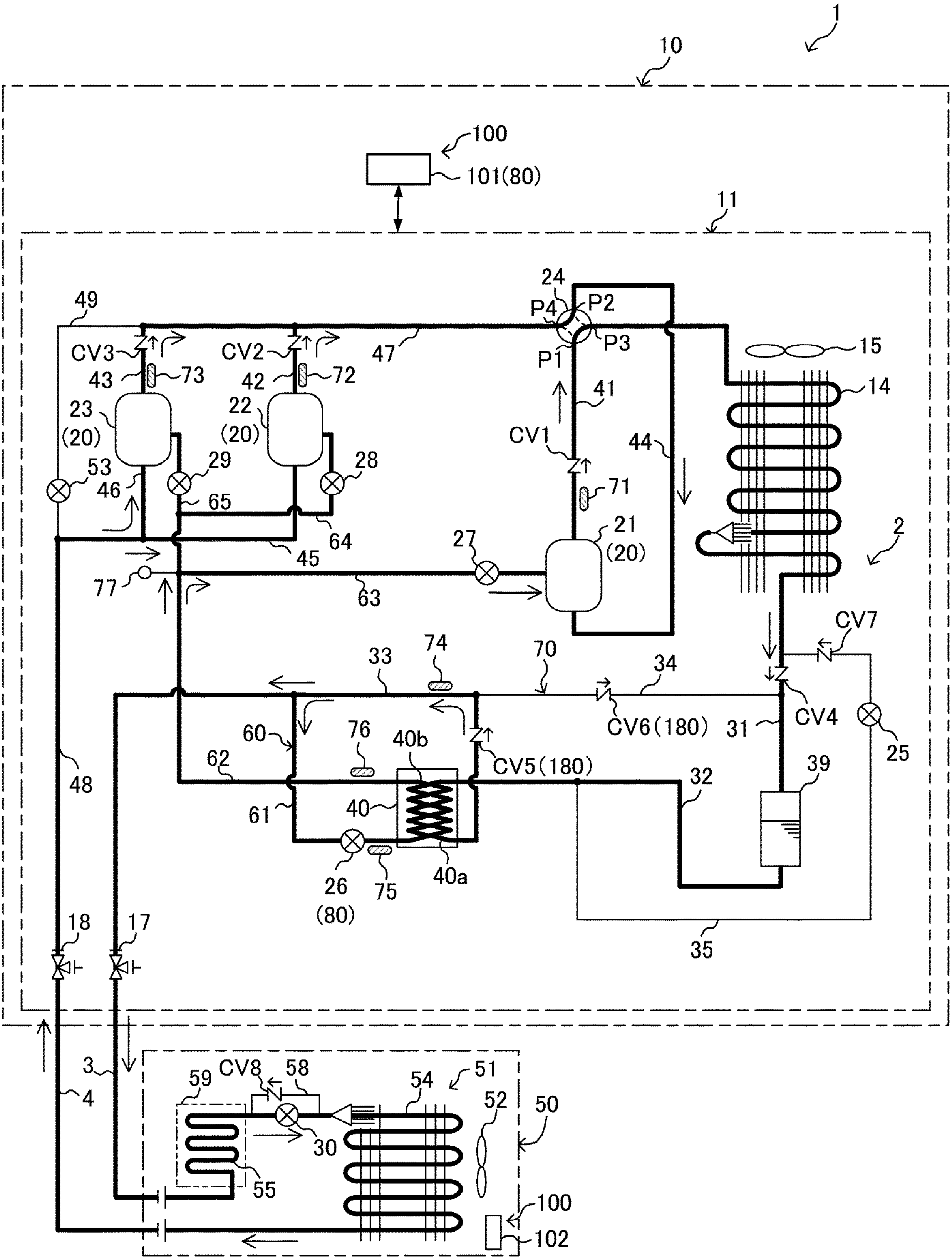

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
43
73
CV2
42
72
47
41
15
14
23
(20)
22
(20)
CV1
44
53
46
29
28
71
65
64
45
27
21
(20)
2
77
63
74
70
34
CV7
33
CV4
60
76
40b
CV5(180)
CV6(180)
31
25
62
39
48
40
32
61
26
(80)
75
40a
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

FIG.4

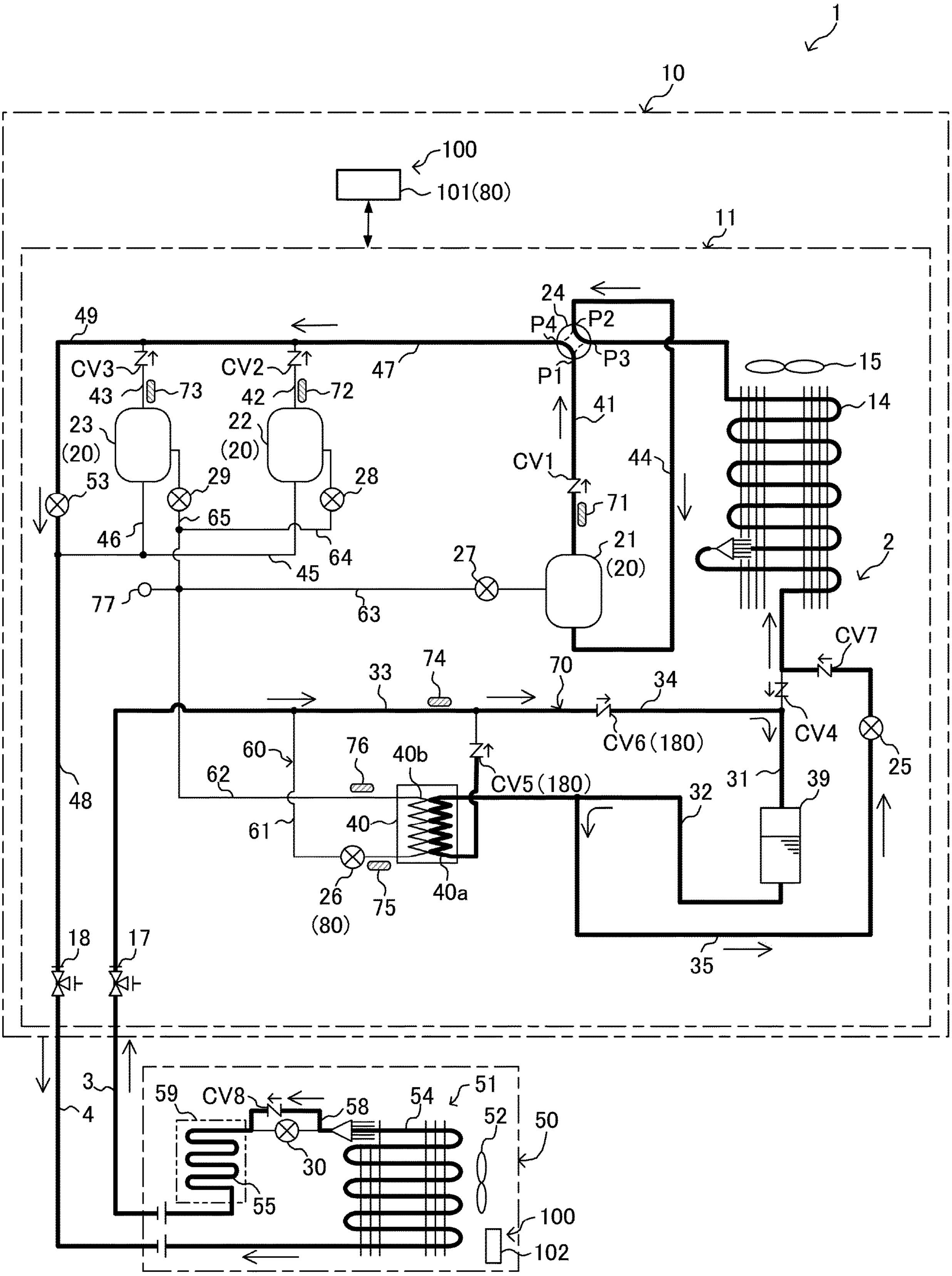
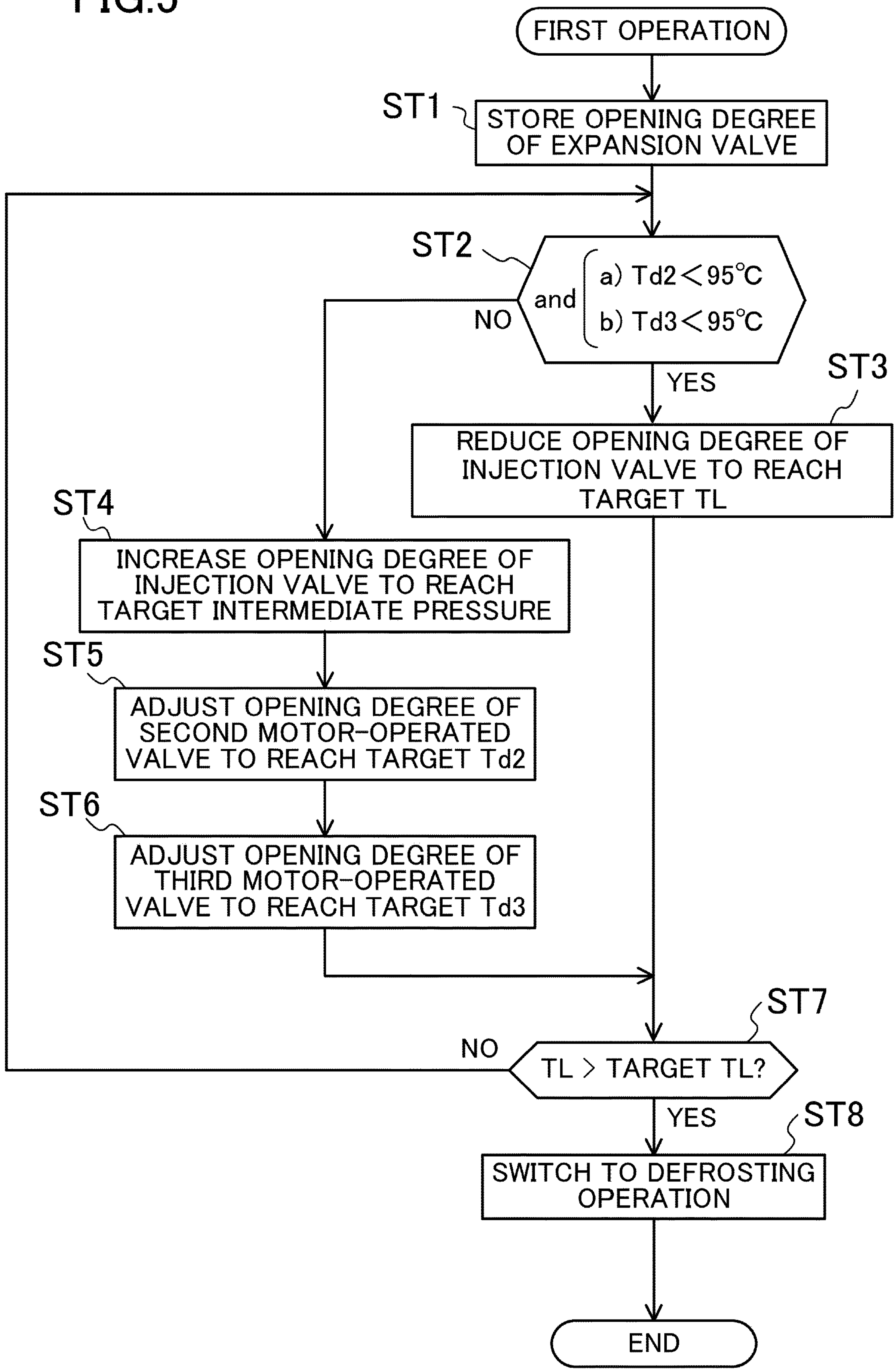

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
43
73
CV2
42
72
47
15
14
23
(20)
22
(20)
41
CV1
44
53
29
28
71
46
65
64
45
21
(20)
27
2
77
63
33
74
70
34
CV7
CV4
CV6(180)
60
76
40b
25
62
CV5(180)
32
31
39
48
61
40
26
(80)
75
40a
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

FIG.5


FIRST OPERATION
ST1
STORE OPENING DEGREE OF EXPANSION VALVE
ST2
and
a) Td2＜95℃
b) Td3＜95℃
NO
YES
ST3
REDUCE OPENING DEGREE OF INJECTION VALVE TO REACH TARGET TL
ST4
INCREASE OPENING DEGREE OF INJECTION VALVE TO REACH TARGET INTERMEDIATE PRESSURE
ST5
ADJUST OPENING DEGREE OF SECOND MOTOR-OPERATED VALVE TO REACH TARGET Td2
ST6
ADJUST OPENING DEGREE OF THIRD MOTOR-OPERATED VALVE TO REACH TARGET Td3
ST7
TL ＞ TARGET TL?
NO
YES
ST8
SWITCH TO DEFROSTING OPERATION
END

# FIG.6

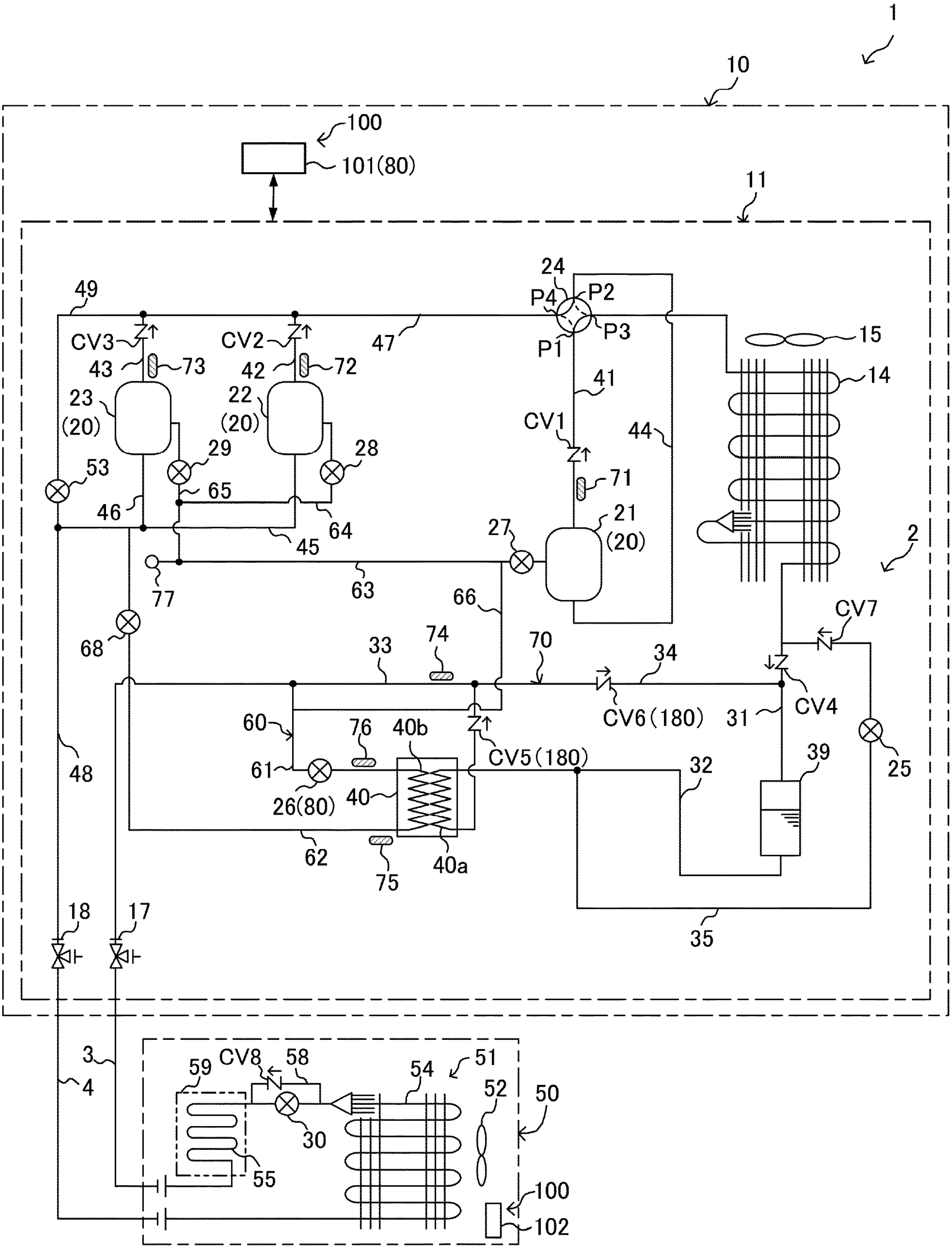
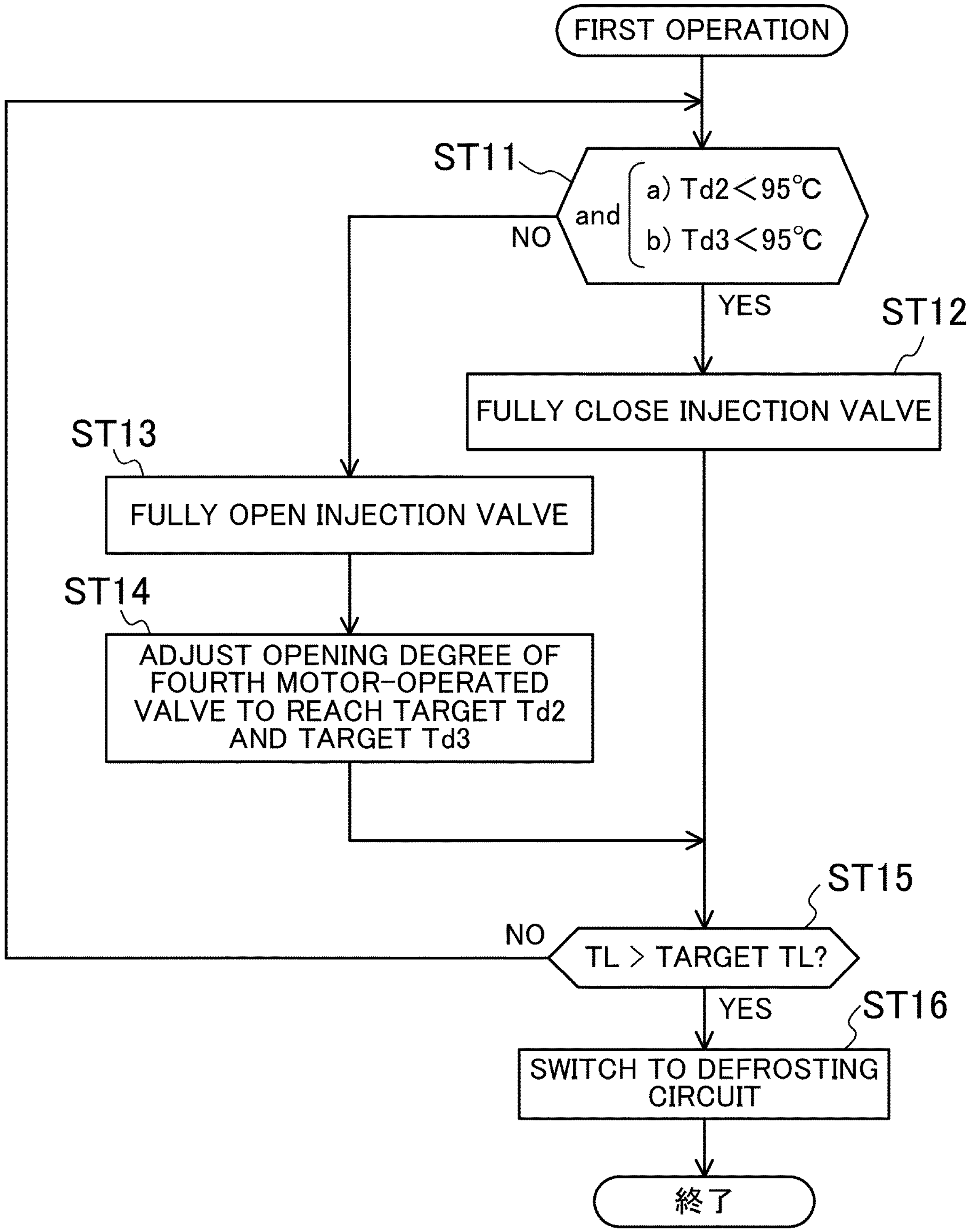
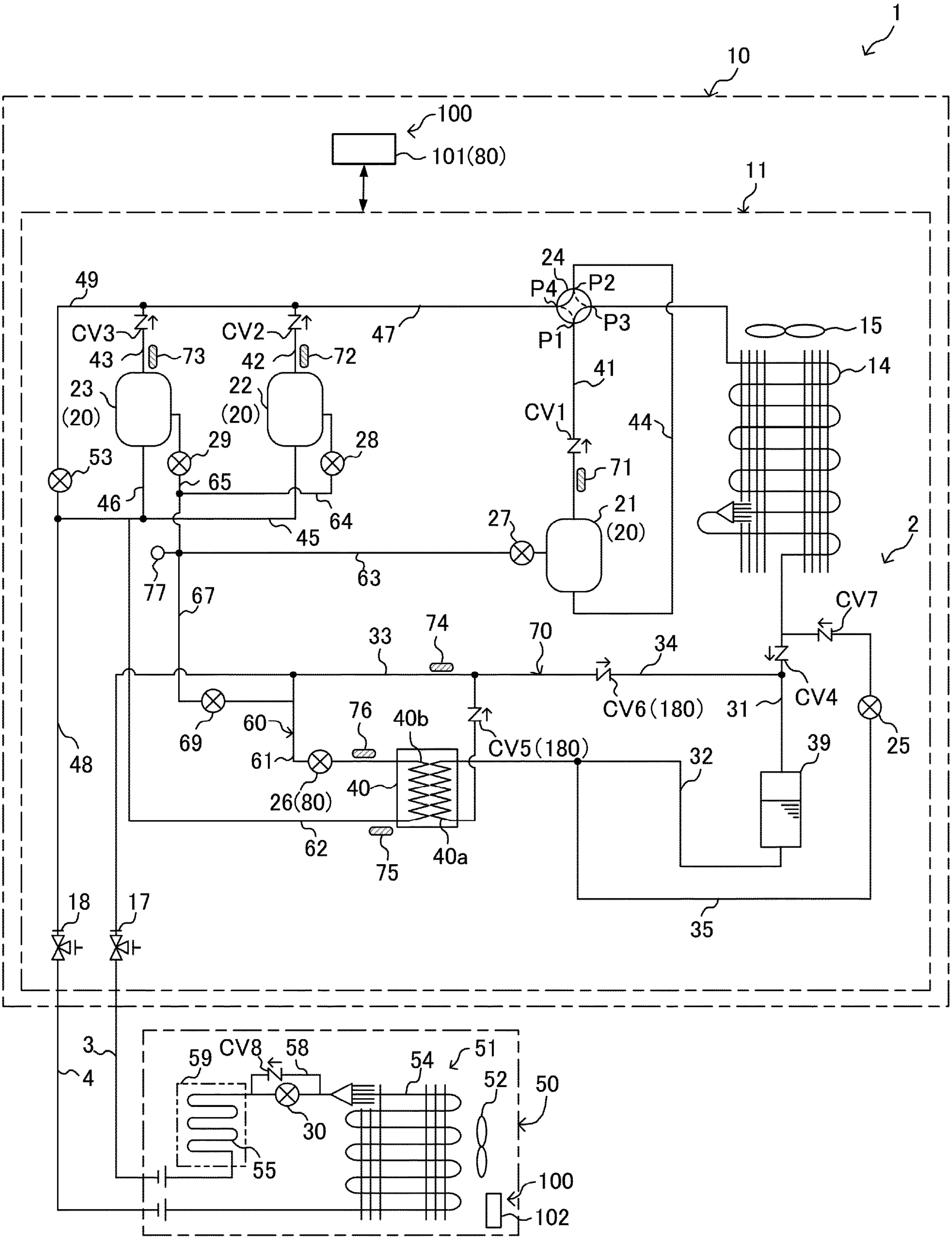

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
43
73
CV2
42
72
47
15
14
41
23
(20)
22
(20)
CV1
44
53
29
28
65
71
46
64
45
27
21
(20)
2
77
63
66
CV7
68
33
74
70
34
CV6(180)
31
CV4
60
76
40b
CV5(180)
61
26(80)
40
32
39
25
48
62
75
40a
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

FIG.7


FIRST OPERATION
ST11
and
a) Td2<95°C
b) Td3<95°C
NO
YES
ST12
FULLY CLOSE INJECTION VALVE
ST13
FULLY OPEN INJECTION VALVE
ST14
ADJUST OPENING DEGREE OF FOURTH MOTOR-OPERATED VALVE TO REACH TARGET Td2 AND TARGET Td3
ST15
NO
TL > TARGET TL?
YES
ST16
SWITCH TO DEFROSTING CIRCUIT
終了

# FIG.8


1
10
100
101(80)
11
24
P4
P2
P1
P3
49
CV3
43
73
CV2
42
72
47
15
14
23
(20)
22
(20)
41
CV1
44
29
28
53
65
71
46
64
27
21
(20)
2
45
77
63
67
CV7
33
74
70
34
CV4
69
60
CV6(180)
31
25
76
40b
39
61
CV5(180)
32
48
40
26(80)
62
75
40a
35
18
17
3
4
59
CV8
58
51
54
52
50
30
55
100
102

# FIG.9

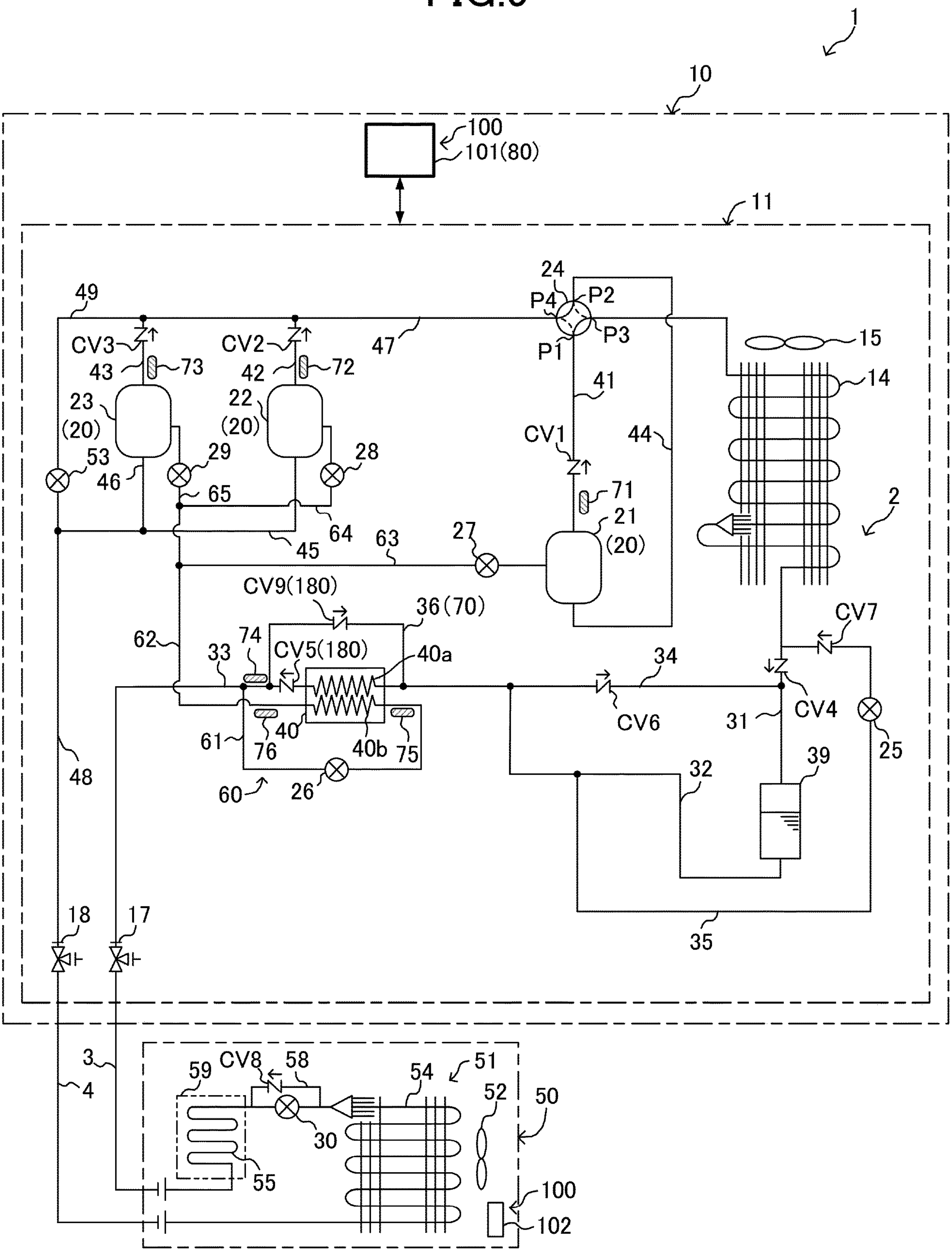
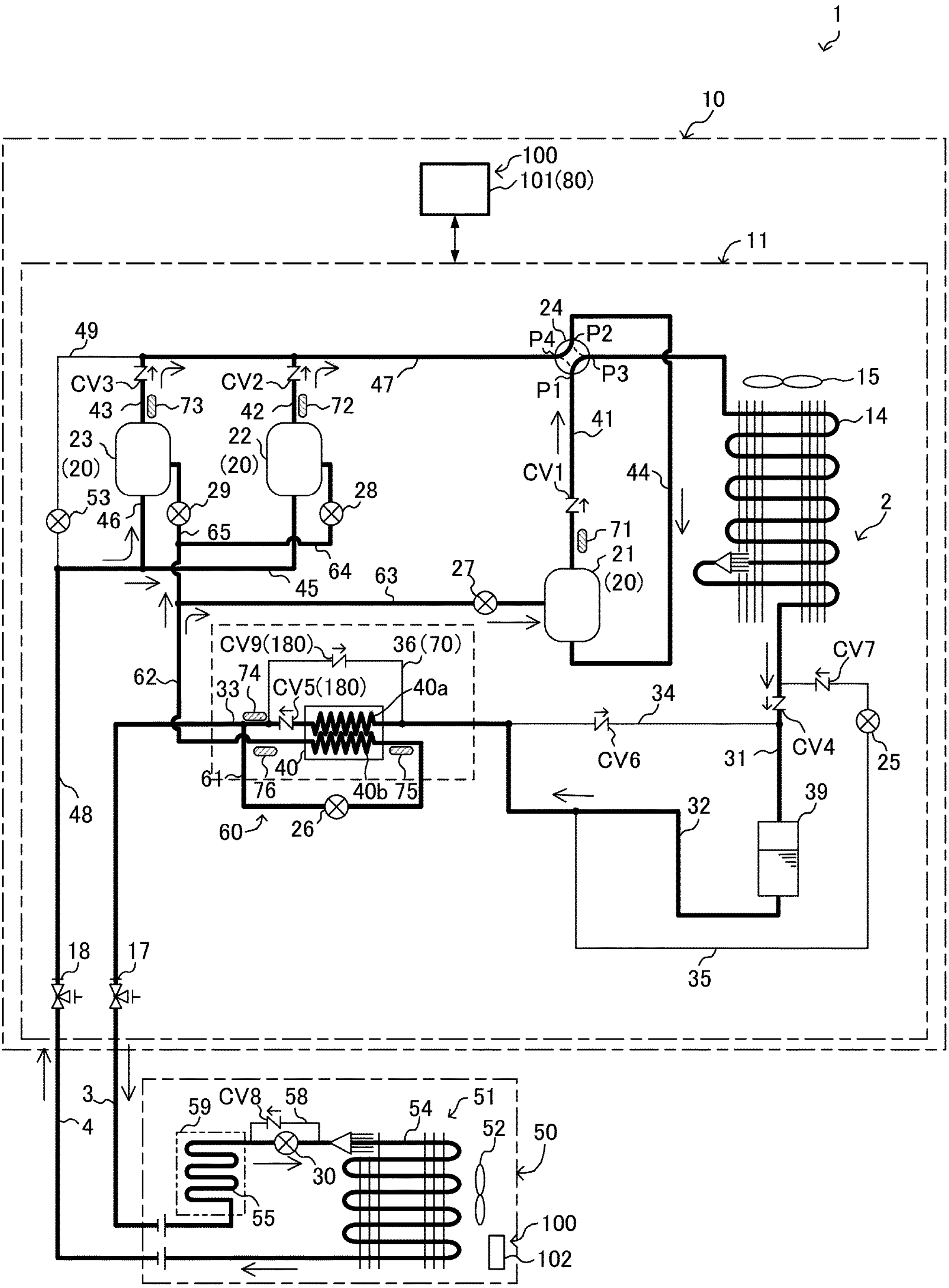

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
CV2
47
15
43
73
42
72
14
23
(20)
22
(20)
41
CV1
44
53
29
28
46
65
71
21
(20)
2
64
27
45
63
CV9(180)
36(70)
62
74
CV5(180)
40a
CV7
33
34
CV4
CV6
31
61
76
40
40b
75
25
48
60
26
32
39
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

FIG.10


1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
CV2
47
15
43
73
42
72
41
14
23
(20)
22
(20)
CV1
44
2
53
46
29
28
65
71
21
(20)
64
45
63
27
CV9(180)
36(70)
CV7
62
74
33
CV5(180)
40a
34
40
CV6
31
CV4
25
61
76
40b
75
32
39
48
60
26
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

# FIG.11

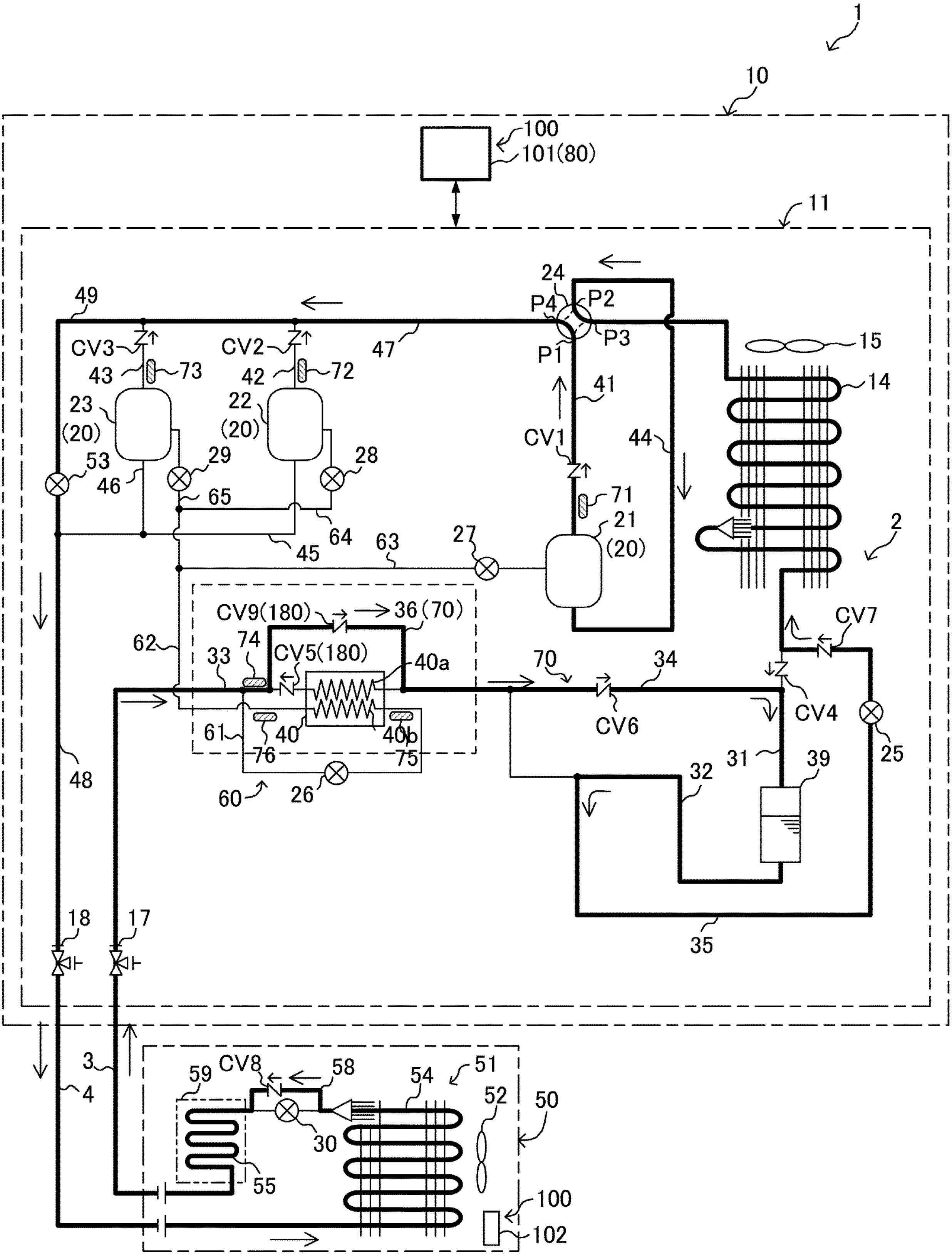

1
10
100
101(80)
11
24
P4
P2
P3
P1
49
47
15
14
CV3
43
73
CV2
42
72
41
23
(20)
22
(20)
CV1
44
53
46
29
28
71
65
21
(20)
64
45
63
27
2
CV9(180)
36(70)
CV7
62
74
33
CV5(180)
40a
70
34
61
40
40b
76
75
CV6
CV4
31
39
25
48
32
60
26
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

FIG.12

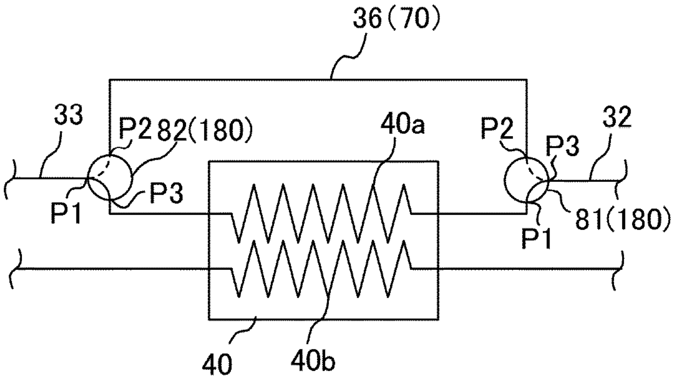



FIG.13

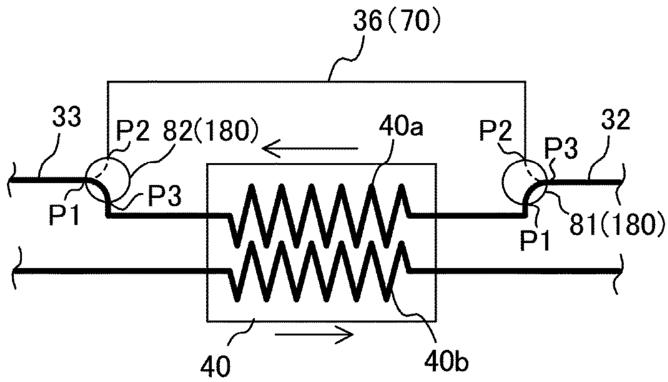
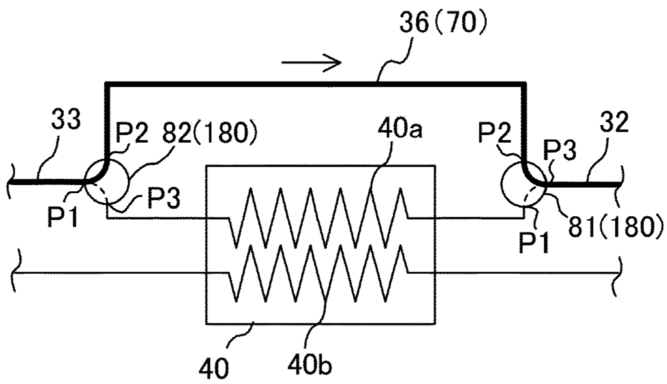
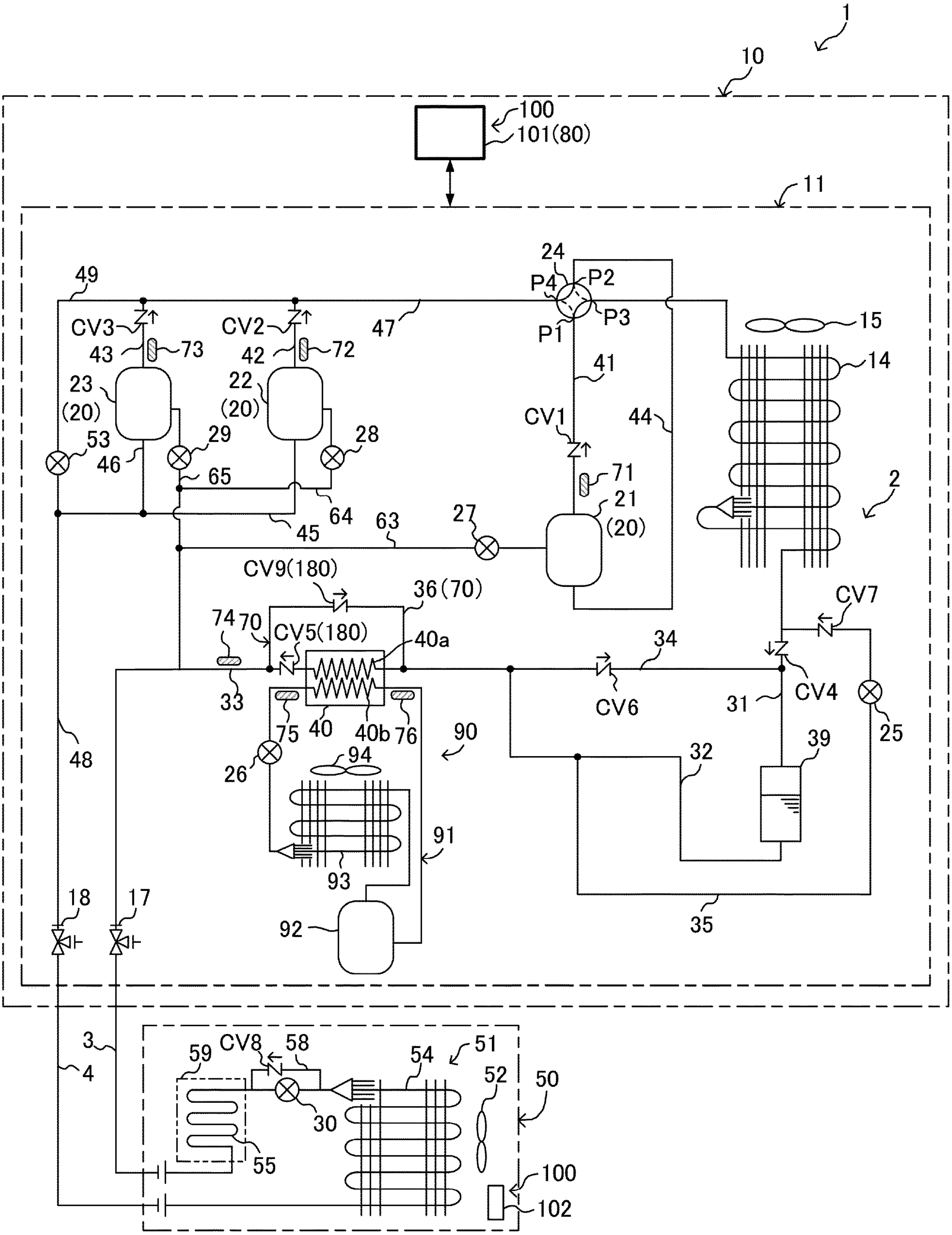


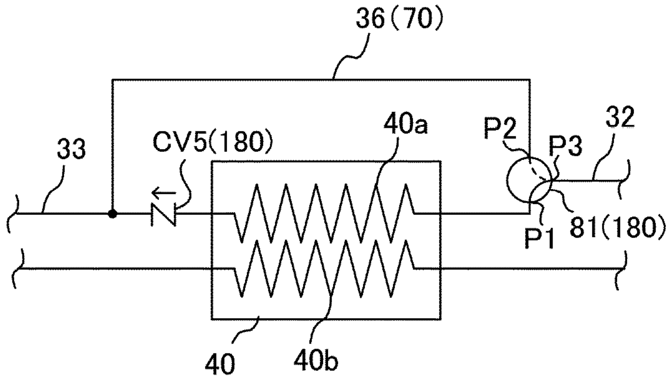

FIG.14



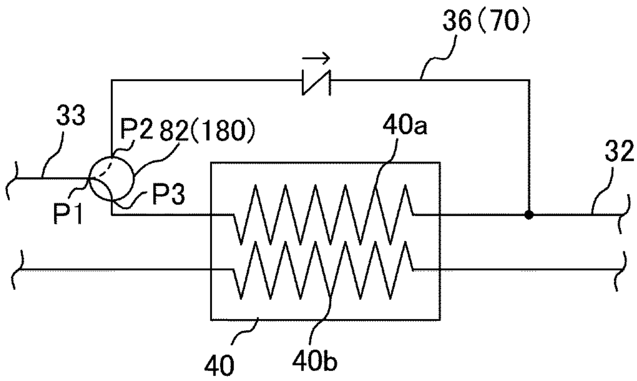
# FIG.15


1
10
100
101(80)
11
24
P4
P2
P3
P1
49
CV3
CV2
47
15
43
73
42
72
14
23
(20)
22
(20)
41
CV1
44
53
46
29
28
65
71
21
(20)
2
64
45
63
27
CV9(180)
36(70)
74
70
CV5(180)
40a
34
CV7
CV4
33
75
40
40b
76
CV6
31
90
25
48
26
94
32
39
91
93
92
35
18
17
3
4
59
CV8
58
54
51
52
50
30
55
100
102

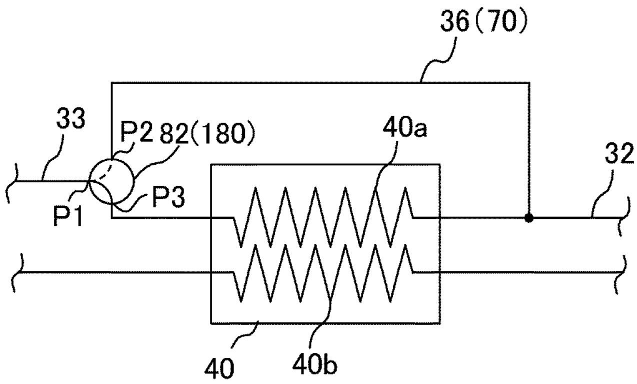
# FIG.16




# FIG.17




# FIG.18



## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2015048983 A **[0002]**
- JP 2015068571 A **[0004]**
- JP 2010236712 A **[0004]**