



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
12.01.2022 Bulletin 2022/02

(51) Int Cl.:
F25B 1/00 (2006.01) **F25B 5/04** (2006.01)
F25B 6/04 (2006.01)

(21) Application number: **19917871.6**

(86) International application number:
PCT/JP2019/008866

(22) Date of filing: **06.03.2019**

(87) International publication number:
WO 2020/179015 (10.09.2020 Gazette 2020/37)

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

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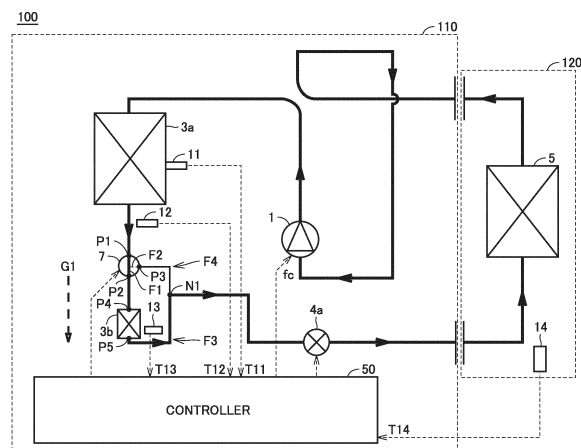
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(54) **REFRIGERATION CYCLE DEVICE**

(57) The refrigeration cycle apparatus (100) includes a compressor (1), a first heat exchanger (3a), a second heat exchanger (3b), a third heat exchanger (5), a first expansion valve (4a), and a first switch (7). The first switch (7) switches each of a first flow path (F1) and a second flow path (F2) between an open state and a closed state. When the first flow path (F1) is open, the refrigerant is circulated in the first circulation direction through the compressor (1), the first heat exchanger (3a), the first port (P1), the second port (P2), the second heat

exchanger (3b), the first expansion valve (4a), and the third heat exchanger (5). When the second flow passage (F2) is open, the refrigerant is circulated in the second circulation direction through the compressor (1), the first heat exchanger (3a), the first port (P1), the third port (P3), the first expansion valve (4a), and the third heat exchanger (5). When the circulation direction of the refrigerant is switched from the first circulation direction to the second circulation direction, a part of the refrigerant is stored in the second heat exchanger (3b).

FIG.1



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle apparatus that circulates refrigerant.

BACKGROUND ART

[0002] There is known a conventional refrigeration cycle apparatus that circulates refrigerant. For example, Japanese Patent Laying-Open No. 2015-87065 (PTL 1) discloses an air conditioner in which a part of refrigerant filled in a refrigerant circuit is stored in a plurality of receivers, and the remaining refrigerant is circulated in the refrigerant circuit. According to the air conditioner, by storing the refrigerant in a plurality of receivers, it is possible to adjust an amount of circulated refrigerant to an optimal amount in response to the operating condition, which makes it possible to efficiently perform the air conditioning operation.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2015-87065

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] According to the air conditioner disclosed in PTL 1, in order to adjust the amount of refrigerant that is circulated in the air conditioner (the amount of circulated refrigerant), it is necessary to dispose a plurality of receivers, which makes the air conditioner larger in size.

[0005] The present disclosure has been made in order to solve the above-described problems, and an object of the present disclosure is to improve the operation efficiency of a refrigeration cycle apparatus while preventing the refrigeration cycle apparatus from becoming larger in size.

SOLUTION TO PROBLEM

[0006] The refrigeration cycle apparatus according to the present disclosure circulates refrigerant. The refrigeration cycle apparatus includes a compressor, a first heat exchanger, a second heat exchanger, a third heat exchanger, a first expansion valve, and a first switch. The first switch includes a first port, a second port, and a third port. The first switch switches each of a first flow path and a second flow path between an open state and a closed state. The first flow path communicates the first port and the second port. The second flow path communicates the first port and the third port. When the first flow

path is open, the refrigerant is circulated in the first circulation direction through the compressor, the first heat exchanger, the first port, the second port, the second heat exchanger, the first expansion valve, and the third heat exchanger. When the second flow path is open, the refrigerant is circulated in the second circulation direction through the compressor, the first heat exchanger, the first port, the third port, the first expansion valve, and the third heat exchanger. When the circulation direction of the refrigerant is switched from the first circulation direction to the second circulation direction, a part of the refrigerant is stored in the second heat exchanger.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the refrigeration cycle apparatus according to the present disclosure, when the circulation direction of the refrigerant is switched from the first circulation direction to the second circulation direction, a part of the refrigerant is stored in the second heat exchanger, and thereby, it is possible to improve the operation efficiency of the refrigeration cycle apparatus while preventing the refrigeration cycle apparatus from becoming larger in size.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of a refrigeration cycle apparatus according to a first embodiment;

Fig. 2 is a functional block diagram illustrating a configuration of a controller of Fig. 1;

Fig. 3 is a diagram schematically illustrating a relationship between an amount of circulated refrigerant and a performance of the air conditioner of Fig. 1 during a high load operation and a low load operation;

Fig. 4 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of the refrigeration cycle apparatus according to the first embodiment and a flow of refrigerant during a low load operation;

Fig. 5 is a flowchart illustrating a process to be performed by the controller of Fig. 1 on a switch during a low load operation;

Fig. 6 is a diagram illustrating another flow of refrigerant from a heat exchanger;

Fig. 7 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of a refrigeration cycle apparatus according to a second embodiment and a flow of refrigerant during a high load cooling operation and a high load defrosting operation;

Fig. 8 is a functional block diagram illustrating a configuration of an air conditioner which serves as an

example of a refrigeration cycle apparatus according to the second embodiment and a flow of refrigerant during a low load cooling operation and a low load defrosting operation;

Fig. 9 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of a refrigeration cycle apparatus according to the second embodiment and a flow of refrigerant during a high load heating operation;

Fig. 10 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of a refrigeration cycle apparatus according to the second embodiment and a flow of refrigerant during a low load heating operation;

Fig. 11 is a flowchart illustrating a process to be performed by the controller of Fig. 9 on a switch during a low load operation;

Fig. 12 is a flowchart illustrating an exemplary defrosting determination process to be performed by the controller during the heating operation;

Fig. 13 is a flowchart illustrating a process to be performed by the controller of Fig. 7 during a reverse defrosting operation;

Fig. 14 is a diagram illustrating a flow of refrigerant when a condition for finishing a defrosting operation on one heat exchanger is satisfied but a condition for finishing a defrosting operation on the other heat exchanger is not satisfied;

Fig. 15 is a flowchart illustrating another exemplary defrosting determination process to be performed by the controller during the heating operation;

Fig. 16 is a functional block diagram illustrating a configuration of an air conditioner which serves as an example of a refrigeration cycle apparatus according to a third embodiment;

Fig. 17 is a flowchart illustrating a process to be performed by the controller of Fig. 16 on a three-way valve during a low load cooling operation;

Fig. 18 is a flowchart illustrating a process to be performed by the controller of Fig. 16 on a three-way valve during a low load heating operation;

Fig. 19 is a flowchart illustrating an exemplary defrosting determination process to be performed by the controller during the heating operation; and

Fig. 20 is a flowchart illustrating another exemplary defrosting determination process to be performed by the controller during the heating operation.

DESCRIPTION OF EMBODIMENTS

[0009] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the drawings. It should be noted that in the drawings, the same or corresponding portions are denoted by the same reference numerals, and the description thereof will not be repeated.

First Embodiment

[0010] Fig. 1 is a functional block diagram illustrating a configuration of an air conditioner 100 which serves as an example of a refrigeration cycle apparatus according to a first embodiment. In Fig. 1, the main flow of refrigerant is indicated by a thick line. The same applies to Figs. 4, 7 to 10 and 14 to be described later.

[0011] As illustrated in Fig. 1, the air conditioner 100 includes an outdoor unit 110 and an indoor unit 120. The air conditioner 100 performs a cooling operation on an indoor space where the indoor unit 120 is installed. The outdoor unit 110 includes a compressor 1, a heat exchanger 3a (a first heat exchanger), a heat exchanger 3b (a second heat exchanger), an expansion valve 4a (a first expansion valve), a switch 7 (a first switch), a controller 50, temperature sensors 11, 12, 13 and 14, and an outdoor fan (not shown). The indoor unit 120 includes a heat exchanger 5 (a third heat exchanger) and an indoor fan (not shown). The controller 50 may be included in the indoor unit 120, or may be provided separately from the outdoor unit 110 and the indoor unit 120. In Fig. 1, an arrow G1 indicates the direction of gravity around the heat exchanger 3b. The same applies to Figs. 6 to 10, 14 and 16 to be described later.

[0012] The switch 7 includes a port P1 (a first port), a port P2 (a second port), and a port P3 (a third port). The switch 7 selectively establishes a flow path F1 (a first flow path) and a flow path F2 (a second flow path). The flow path F1 communicates the ports P1 and P2. The flow path F2 communicates the ports P1 and P3.

[0013] When the flow path F1 is established, the refrigerant is circulated in a circulation direction (a first circulation direction) through the compressor 1, the heat exchanger 3a, the port P1, the port P2, the heat exchanger 3b, the expansion valve 4a, and the heat exchanger 5. When the flow path F1 is established, both the heat exchanger 3a and the heat exchanger 3b function as a condenser, and the heat exchanger 5 functions as an evaporator. The refrigerant flows into the heat exchanger 3b from a port P4 (a fourth port), and flows out of the heat exchanger 3b from a port P5 (a fifth port).

[0014] Each of the heat exchangers 3a, 3b and 5 is provided with a fan. The fan blows air to the corresponding heat exchanger so as to increase the heat exchanging efficiency between the refrigerant in the heat exchanger and the air. The fan may be, for example, a linear flow fan, a propeller fan, a turbo fan, or a multiblade fan. A plurality of fans may be provided for each heat exchanger, or a single fan may be provided for a plurality of heat exchangers.

[0015] The controller 50 obtains, from the temperature sensor 11 which is installed in a middle portion of the heat exchanger 3a, a temperature T11 of the refrigerant flowing in the heat exchanger 3a. The controller 50 obtains, from the temperature sensor 12, a temperature T12 of the refrigerant flowing between the heat exchanger 3a and the switch 7. The controller 50 obtains, from the tem-

perature sensor 13, a temperature T13 of the refrigerant flowing between the heat exchanger 3b and the expansion valve 4a. The controller 50 obtains, from the temperature sensor 14, a temperature T14 of the indoor space where the indoor unit 120 is installed.

[0016] The controller 50 controls the amount of refrigerant discharged from the compressor 1 per unit time by controlling the driving frequency of the compressor 1 according to a command value f_c so as to bring the temperature T14 of the indoor space to a target temperature (which may be set by a user, for example). The controller 50 uses the temperatures T 11 to T13 to calculate the degree of supercooling of the refrigerant flowing out of each heat exchanger which functions as a condenser.

[0017] The controller 50 controls the opening degree of the expansion valve 4a so as to maintain a pressure difference between a pressure of the refrigerant (high-pressure side refrigerant) which is discharged from the compressor 1 without being depressurized and a pressure of the refrigerant (low-pressure side refrigerant) which has been depressurized before it is sucked into the compressor 1 within a desired range.

[0018] Fig. 2 is a functional block diagram illustrating the configuration of the controller 50 of Fig. 1. As illustrated in Fig. 2, the controller 50 includes a circuitry 51, a memory 52, and an input/output unit 53. The circuitry 51 may be dedicated hardware, or may be a CPU (Central Processing Unit) that executes programs stored in the memory 52. When the circuitry 51 is dedicated hardware, the circuitry 51 may be, for example, a single circuit, a composite circuit, a programmable processor, a parallelly programmable processor, an ASIC (Application Specific Integrated Circuit), an FGA (Field Programmable Gate Array), or a combination thereof. When the circuitry 51 is a CPU, the function of the controller 50 may be realized by software, firmware, or a combination of software and firmware. Software or firmware may be described as a program and stored in the memory 52. The circuitry 51 reads a program stored in the memory and executes the program. The memory 52 includes a non-volatile or volatile semiconductor memory (for example, a RAM (Random Access Memory), a ROM (Read Only Memory), a flash memory, an EPROM (Erasable Programmable Read Only Memory), or an EEPROM (Electrically Erasable Programmable Read Only Memory)), a magnetic disk, a flexible disk, an optical disk, a compact disk, a mini disk, or a DVD (Digital Versatile Disc). Note that the CPU may be a central processing unit, a processing unit, an arithmetic unit, a microprocessor, a microcomputer, a processor, or a DSP (Digital Signal Processor).

[0019] The operating state of the air conditioner 100 is classified into a high load operation and a low load operation according to the load of the compressor 1. The driving frequency of the compressor 1 during the high load operation is higher than the driving frequency of the compressor 1 during the low load operation. The operating state of the air conditioner 100 is determined from

the command value f_c sent to the compressor 1. For example, if the driving frequency of the compressor 1 represented by the command value f_c is equal to or higher than a reference frequency, the operating state of the air conditioner 100 is determined as a high load operation; and if the driving frequency is lower than the reference frequency, the operating state of the air conditioner 100 is determined as a low load operation.

[0020] The command value f_c may be changed in response to the temperatures T11 to T14. For example, several stepwise temperature ranges (For example, 0°C or more and less than 1°C, 1°C or more and less than 2°C, and 2°C or more and less than 3°C) may be set in advance, and the driving frequency of the compressor 1 may be changed in response to any of the temperature ranges which includes therein the temperature difference between the temperature T14 and the target temperature of the indoor space.

[0021] Fig. 3 is a diagram schematically illustrating a relationship between an amount of circulated refrigerant and a performance of the air conditioner 100 of Fig. 1 during a high load operation and a low load operation. For example, COP (Coefficient of Performance) is used as an index to indicate the performance of the air conditioner 100. In Fig. 3, a curve C1 represents the relationship between an amount of circulated refrigerant and a performance of the air conditioner 100 during a high load operation. A curve C2 represents the relationship between an amount of circulated refrigerant and a performance of the air conditioner 100 during a low load operation. M10 represents the total amount of refrigerant sealed in the air conditioner 100. Since a part of the total amount of refrigerant M10 may dissolve in the refrigerator oil stored in the compressor 1, the amount of circulated refrigerant is smaller than the total amount of refrigerant M10.

[0022] As illustrated in Fig. 3, during the high load operation, the performance of the air conditioner 100 is maximum when the amount of circulated refrigerant is equal to M1. Thus, the total amount of refrigerant M10 in the air conditioner 100 is determined in such a manner that the amount of circulated refrigerant obtained by subtracting the amount of refrigerant dissolved in the refrigerator oil or the like from the total amount of refrigerant M10 is equal to M1. On the other hand, during the low load operation, the performance of the air conditioner 100 is maximum when the amount of circulated refrigerant is equal to M2 ($M2 < M1$). Thus, if the low load operation is performed when the amount of circulated refrigerant is maintained at M1, the performance of the air conditioner 100 is not maximum.

[0023] Therefore, the air conditioner 100 is started to perform the low load operation from the state as illustrated by a thick line in Fig. 1, when it is determined that the amount of circulated refrigerant is excessive, the flow path F2 is established as illustrated by a thick line in Fig. 4 to separate the heat exchanger 3b from the circulation path of refrigerant. Since the degree of supercooling of

the refrigerant flowing out of a heat exchanger that functions as a condenser increases as the amount of circulated refrigerant increases, whether or not the amount of circulated refrigerant is excessive is determined by the degree of supercooling.

[0024] After the flow path F2 is established, the refrigerant is circulated in a circulation direction (a second circulation direction) through the compressor 1, the heat exchanger 3a, the port P1, the port P3, the expansion valve 4a, and the heat exchanger 5. When the circulation direction of the refrigerant is switched from the circulation direction of Fig. 1 to the circulation direction of Fig. 4, a part of the refrigerant is stored in the heat exchanger 3b.

[0025] When it is determined that the amount of circulated refrigerant is excessive during the low load operation, the amount of refrigerant stored in the heat exchanger 3b is excluded from the amount of circulated refrigerant M1, whereby the performance of the air conditioner 100 during the low load operation is improved. In the air conditioner 100, the heat exchanger 3b is designed in such a manner that the amount of refrigerant obtained by subtracting the amount of refrigerant stored in the heat exchanger 3b from the amount of circulated refrigerant M1 is equal to M2. Since the heat exchanger 3b in the air conditioner 100 may be used as a container for adjusting the amount of circulated refrigerant, there is no need to dispose another refrigerant container (such as a receiver) in addition to the heat exchanger 3b. According to the air conditioner 100, it is possible to improve the operation efficiency of the air conditioner 100 while preventing the air conditioner 100 from becoming larger in size.

[0026] With reference to Fig. 4, a flow path F3 extending from the heat exchanger 3b to the expansion valve 4a is connected to a flow path F4 (a fourth flow path) extending from the port P3 at a connection portion N1 (a specific portion). In order to prevent the refrigerant from flowing out of the heat exchanger 3b, the connection portion N1 is preferably located at a position higher than the port P5. The height of the connection portion N1 may be the same as the height of the port P5.

[0027] In Fig. 4, although the heat exchanger 3b is separated from the flow path of circulating refrigerant, since the port P5 is in communication with the flow path, the refrigerant is not sealed in the heat exchanger 3b. Even if the temperature of the heat exchanger 3b rises, the pressure of the refrigerant in the heat exchanger 3b hardly rises, which makes it possible to ensure the safety of the air conditioner 100.

[0028] Fig. 5 is a flowchart illustrating a process to be performed by the controller 50 of Fig. 1 on the switch 7 during a low load operation. The process illustrated in Fig. 5 is called at regular intervals by a main routine (not shown) for performing a comprehensive control on the air conditioner 100. Hereinafter, each step may be simply referred to as "S".

[0029] As illustrated in Fig. 5, the controller 50 determines whether or not the flow path F1 is established in S101. If it is determined that the flow path F1 is estab-

lished (YES in S101), the controller 50 sets the degree of supercooling of the refrigerant flowing out of the heat exchanger 3b to "SC" in S102, and proceeds the process to S104. If it is determined that the flow path F1 is not established (NO in S101), the controller 50 sets the degree of supercooling of the refrigerant flowing out of the heat exchanger 3a to "SC" in S103, and proceeds the process to S104.

[0030] In S104, the controller 50 determines whether or not the degree of supercooling SC is greater than a reference value SC1. If it is determined that the degree of supercooling SC is greater than the reference value SC1 (YES in S104), the controller 50 proceeds the process to S107. If it is determined that the degree of supercooling SC is equal to or smaller than the reference value SC1 (NO in S104), the controller 50 determines whether or not the degree of supercooling SC is smaller than a reference value SC2 ($SC2 < SC1$) in S105. If it is determined that the degree of supercooling SC is equal to or greater than the reference value SC2 (NO in S105), the controller 50 returns the process to the main routine. If it is determined that the degree of supercooling SC is smaller than the reference value SC2 (YES in S105), the controller 50 establishes the flow path F1 in S106, and proceeds the process to S107. The controller 50 establishes the flow path F2 in S107, and returns the process to the main routine.

[0031] The reference value SC1 and the reference value SC2 may be appropriately calculated by actual experiments or simulations. For example, the reference value SC1 and the reference value SC2 may be set as an upper limit (for example, 5°C) and a lower limit (for example, 3°C) of an allowable range (for example, 3°C or more and 5°C or less) of design values of the degree of supercooling SC, respectively.

[0032] As described above, in the air conditioner 100, it is described that the connection portion N1 between the flow paths F3 and F4 is established at a position higher than the port P5. However, as illustrated in Fig. 6, if the flow path F3 has a portion N2 (specific portion) located at a position higher than the port P5, a connection portion N1A between the flow paths F3 and F4 may be located at a position lower than the port P5. The height of the portion N2 may be the same as the height of the port P5.

[0033] The refrigerant sealed in the air conditioner 100 includes, for example, a HFC (Hydro Fluoro Carbon) refrigerant, a HFO (Hydro Fluoro Olefin) refrigerant, a HC (Hydro Carbon) refrigerant, or a non-azeotropic mixture refrigerant (such as R454A). In order to reduce GWP (Global Warming Point), a HC refrigerant (such as R290) or a non-azeotropic mixture refrigerant (such as R454A) may be used.

[0034] As described above, according to the refrigeration cycle apparatus according to the first embodiment, it is possible to improve the operation efficiency of the refrigeration cycle apparatus while preventing the refrigeration cycle apparatus from becoming larger in size.

Second Embodiment

[0035] In the first embodiment, the description has been carried out on a refrigeration cycle apparatus that performs a cooling operation on the indoor space where the indoor unit is disposed. In the second embodiment, a refrigeration cycle apparatus that performs a heating operation and a cooling operation on the indoor space and performs a defrosting operation during the heating operation will be described.

[0036] Figs. 7 and 8 are functional block diagrams illustrating the configuration of an air conditioner 200 which serves as an example of a refrigeration cycle apparatus according to the second embodiment and a flow of refrigerant during a cooling operation and a defrosting operation. The air conditioner 200 is different from the air conditioner 100 illustrated in Fig. 1 in that the air conditioner 200 further includes a four-way valve 2 (a second switch), an expansion valve 4b (a second expansion valve), temperature sensors 15 and 16, and a controller 50B instead of the controller 50. The other components are the same, and the description thereof will not be repeated. In Fig. 7, the expansion valve 4b that is fully opened is indicated by a dotted line. The same applies to Fig. 9 to be described later.

[0037] As illustrated in Fig. 7, the expansion valve 4b is connected between the heat exchanger 3a and the port P1. When the flow path F1 is established, the controller 50B fully opens the expansion valve 4b so that both the heat exchanger 3a and the heat exchanger 3b function as a condenser. As illustrated in Fig. 8, when the flow path F2 is established, the controller 50B controls the expansion valves 4a and 4b by adjusting the opening degrees of the expansion valves 4a and 4b so as to maintain the pressure difference between the high-pressure side refrigerant and the low-pressure side refrigerant within a desired range. When the flow path F2 is established, either the expansion valve 4a or the expansion valve 4b may be fully opened. The controller 50B controls the four-way valve 2 to switch the circulation direction of the refrigerant. During a low load cooling operation and a low load defrosting operation on the air conditioner 200, the process illustrated in Fig. 5 is performed.

[0038] Figs. 9 and 10 are functional block diagrams illustrating a configuration of an air conditioner 200 which serves as an example of a refrigeration cycle apparatus according to the second embodiment and a flow of refrigerant during a heating operation. As illustrated in Fig. 9, when the flow path F1 is established, the refrigerant is circulated in a circulation direction (a third circulation direction) opposite to the circulation direction illustrated in Fig. 7. When the flow path F1 is established, both the heat exchanger 3a and the heat exchanger 3b function as an evaporator. When the flow path F1 is established, the controller 50B fully opens the expansion valve 4b.

[0039] As illustrated in Fig. 10, when the flow path F2 is established, the refrigerant is circulated in a circulation direction (a fourth circulation direction) opposite to the

circulation direction as illustrated in Fig. 8. When the flow path F2 is established, the heat exchanger 3a functions as an evaporator. When the flow path F2 is established, the controller 50B controls the expansion valves 4a and 4b by controlling the opening degrees of the expansion valves 4a and 4b so as to maintain the pressure difference between the high-pressure side refrigerant and the low-pressure side refrigerant within a desired range. When the flow path F2 is established, either the expansion valve 4a or the expansion valve 4b may be fully opened. During the heating operation, the controller 50B uses temperatures T15 and T16 to calculate the degree of supercooling of the refrigerant flowing out of the heat exchanger 5.

[0040] Fig. 11 is a flowchart illustrating a process to be performed by the controller 50B of Fig. 9 on the switch 7 during a low load operation. The process illustrated in Fig. 11 is called at regular intervals by a main routine (not shown) for performing a comprehensive control on the air conditioner 200. The same applies to the processes illustrated in Figs. 12 and 13 to be described later.

[0041] As illustrated in Fig. 11, the controller 50B determines whether or not the degree of supercooling SC is greater than a reference value SC3 in S201. If it is determined that the degree of supercooling SC is greater than the reference value SC3 (YES in S201), the controller 50B proceeds the process to S204. If it is determined that the degree of supercooling SC is equal to or smaller than the reference value SC3 (NO in S201), the controller 50B determines whether or not the degree of supercooling SC is smaller than a reference value SC4 ($SC4 < SC3$) in S202. If it is determined that the degree of supercooling SC is equal to or greater than the reference value SC4 (NO in S202), the controller 50B returns the process to the main routine. If it is determined that the degree of supercooling SC is smaller than the reference value SC4 (YES in S202), the controller 50B establishes the flow path F1 in S203, and proceeds the process to S204. The controller 50B establishes the flow path F2 in S204, and returns the process to the main routine.

[0042] The reference value SC3 and the reference value SC4 are appropriately calculated by actual experiments or simulations. For example, the reference value SC3 and the reference value SC4 may be set as an upper limit (for example, 3°C) and a lower limit (for example, 1°C) of an allowable range (for example, 1°C or more and 3°C or less) of design values of the degree of supercooling SC, respectively.

[0043] Fig. 12 is a flowchart illustrating an exemplary defrosting determination process to be performed by the controller 50B during the heating operation. As illustrated in Fig. 12, the controller 50B determines whether or not a condition for starting a defrosting operation on the heat exchanger 3b is satisfied in S211. As an example of the condition for starting a defrosting operation on the heat exchanger 3b, a condition in which the temperature T13 is lower than a reference temperature Ds1 (for example, -3°C) may be given. If it is determined that the condition

for starting a defrosting operation on the heat exchanger 3b is not satisfied (NO in S211), the controller 50B returns the process to the main routine.

[0044] If it is determined that the condition for starting a defrosting operation on the heat exchanger 3b is satisfied (YES in S211), the controller 50B determines whether or not a condition for starting a defrosting operation on the heat exchanger 3a is satisfied in S212. As an example of the condition for starting a defrosting operation on the heat exchanger 3a, a condition in which the temperature T11 is lower than a reference temperature Ds2 (for example, -3°C) may be given. If it is determined that the condition for starting a defrosting operation on the heat exchanger 3a is not satisfied (NO in S212), the controller 50B returns the process to the main routine. If it is determined that the condition for starting a defrosting operation on the heat exchanger 3a is satisfied (YES in S212), the controller 50B proceeds the process to S213.

[0045] In S213, the controller 50B establishes the flow path F1, and proceeds the process to S214. The controller 50B fully opens the expansion valve 4b in S214, and proceeds the process to S215. In S215, the controller 50B switches the circulation direction of the refrigerant to the circulation direction as illustrated in Fig. 7, and returns the process to the main routine.

[0046] After S215, a reverse defrosting operation is started. In the reverse defrosting operation, both the heat exchanger 3a and the heat exchanger 3b function as a condenser. The heat exchangers 3a and 3b are defrosted by the condensation heat released from the refrigerant.

[0047] Fig. 13 is a flowchart illustrating a process to be performed by the controller 50B of Fig. 7 during the reverse defrosting operation. As illustrated in Fig. 13, the controller 50B determines whether or not a condition for finishing a defrosting operation on the heat exchanger 3a is satisfied in S221. As an example of the condition for finishing a defrosting operation on the heat exchanger 3a, a condition in which the temperature T11 is higher than a reference temperature Df1 (for example, 0°C) may be given. If it is determined that the condition for finishing a defrosting operation on the heat exchanger 3a is not satisfied (NO in S221), the controller 50B returns the process to the main routine. If it is determined that the condition for finishing a defrosting operation on the heat exchanger 3a is satisfied (YES in S221), the controller 50B switches the circulation direction of the refrigerant in S222, and proceeds the process to S223.

[0048] In S223, the controller 50B determines whether or not a condition for finishing a defrosting operation on the heat exchanger 3b is satisfied. As an example of the condition for finishing a defrosting operation on the heat exchanger 3b, a condition that the temperature T13 is higher than a reference temperature Df2 (for example, 0°C) may be given. If it is determined that the condition for finishing a defrosting operation on the heat exchanger 3b is satisfied (YES in S223), the controller 50B fully opens the expansion valve 4b in S224, and returns the

process to the main routine. The controller 50B controls the opening degree of the expansion valve 4a so as to maintain the pressure difference between the high-pressure side refrigerant and the low-pressure side refrigerant within a desired range. If it is determined that the condition for finishing a defrosting operation on the heat exchanger 3b is not satisfied (NO in S223), the controller 50B fully opens the expansion valve 4a in S225, and returns the process to the main routine.

[0049] Fig. 14 is a diagram illustrating a flow of refrigerant when the condition for finishing a defrosting operation on the heat exchanger 3a is satisfied but the condition for finishing a defrosting operation on the heat exchanger 3b is not satisfied (when S225 of Fig. 13 is performed). As illustrated in Fig. 14, since the expansion valve 4a is fully opened, the heat exchanger 3b functions as a condenser. The heat exchanger 3b is defrosted by the condensation heat released from the refrigerant. The heating of the heat exchanger 3b by the condensation heat released from the refrigerant is performed after the condition for finishing a defrosting operation on the heat exchanger 3b is satisfied. The controller 50B controls the opening degree of the expansion valve 4b so as to maintain the pressure difference between the high-pressure side refrigerant and the low-pressure side refrigerant within a desired range. After the defrosting operation on both the heat exchanger 3a and the heat exchanger 3b is finished, the heating operation is restarted. The restarted heating operation may be either a high load operation or a low load operation.

[0050] The heating of the heat exchanger 3b by the condensation heat released from the refrigerant may be performed to prevent frost from being formed on the heat exchanger 3b. Fig. 15 is a flowchart illustrating another exemplary defrosting determination process to be performed by the controller 50B during the heating operation. The flowchart illustrated in Fig. 15 is different from the flowchart illustrated in Fig. 12 with the addition of S216 and a reverse order of S212 and S213.

[0051] As illustrated in Fig. 15, if it is determined that the condition for starting a defrosting operation on the heat exchanger 3b is satisfied (YES in S211), the controller 50B establishes the flow path F1 in S213, and proceeds the process to S212. If it is determined that the condition for starting a defrosting operation on the heat exchanger 3a is not satisfied (NO in S212), the controller 50B fully opens the expansion valve 4a in S216, and returns the process to the main routine.

[0052] The flow of refrigerant in the air conditioner 200 after S216 is the same as the flow of refrigerant as illustrated in Fig. 14. In the air conditioner 200, since the expansion valve 4b is connected between the heat exchangers 3b and 3a, the expansion valve 4a may be fully opened so as to allow the liquid refrigerant to flow into the heat exchanger 3b. Since it is possible to store the liquid refrigerant in the heat exchanger 3b, as compared with the case where the expansion valve 4b is not provided and the refrigerant in the gas-liquid two-phase state

after depressurization by the expansion valve 4a is stored in the heat exchanger 3b, the heat exchanger 3b may be made smaller.

[0053] In the air conditioner 200, since the defrosting operation may be performed on the heat exchanger 3b without stopping the heating operation, it is possible to prevent the temperature of the indoor space from being decreased by the reverse defrosting operation. Further, when the non-azeotropic mixture refrigerant is sealed as the refrigerant, due to the temperature gradient, frost is likely to be formed around the port P5 of the heat exchanger 3b. In the air conditioner 200, since the refrigerant having a relatively high temperature flows into the heat exchanger 3b during the heating operation, it is possible to prevent frost from being formed around the port P5 of the heat exchanger 3b. Further, the prevention of frost on the heat exchanger 3b makes it possible to prevent frost from being spread to the heat exchanger 3a.

[0054] As described above, according to the refrigeration cycle apparatus of the second embodiment, it is possible to improve the operation efficiency of the refrigeration cycle apparatus during any of the cooling operation, the heating operation or the defrosting operation while preventing the refrigeration cycle apparatus from becoming larger in size.

Third Embodiment

[0055] In the first embodiment and the second embodiment, it is described that the first switch may selectively establish the first flow path and the second flow path. In the third embodiment, the description will be carried out on that the first switch may establish both the first flow path and the second flow path at an open state.

[0056] Fig. 16 is a functional block diagram illustrating the configuration of an air conditioner 300 which serves as an example of a refrigeration cycle apparatus according to the third embodiment. The air conditioner 300 is different from the air conditioner 200 illustrated in Fig. 7 in that the switch 7 and the controller 50B in Fig. 7 are replaced by a three-way valve 7C and a controller 50C, respectively. The other components are the same, and the description thereof will not be repeated.

[0057] As illustrated in Fig. 16, the three-way valve 7C includes a port P31 (a first port), a port P32 (a second port), a port P33 (a third port), a flow path F31 (a first flow path), and a flow path F32 (a second flow path). The flow path F31 communicates the ports P31 and P32. The flow path F32 communicates the ports P31 and P33. The three-way valve 7C may switch the flow paths F31 and F32 between an open state and a closed state.

[0058] Fig. 17 is a flowchart illustrating a process to be performed by the controller 50C of Fig. 16 on the three-way valve 7C during a low load cooling operation. The process illustrated in Fig. 17 is called at regular intervals by a main routine (not shown) for performing a comprehensive control on the air conditioner 300. The same applies to the process illustrated in Fig. 18.

[0059] As illustrated in Fig. 17, the controller 50C determines whether or not the flow path F31 is open in S301. If it is determined that the flow path F31 is open (YES in S301), the controller 50C sets the degree of supercooling of the refrigerant flowing out of the heat exchanger 3b to "SC" in S302, and proceeds the process to S304. If it is determined that the flow path F31 is closed (NO in S301), the controller 50C sets the degree of supercooling of the refrigerant flowing out of the heat exchanger 3a to "SC" in S303, and proceeds the process to S304.

[0060] In S304, the controller 50C determines whether or not the degree of supercooling SC is greater than a reference value SC1. If it is determined that the degree of supercooling SC is greater than the reference value SC1 (YES in S304), the controller 50C proceeds the process to S307.

[0061] If it is determined that the degree of supercooling SC is equal to or smaller than the reference value SC1 (NO in S304), the controller 50C determines whether or not the degree of supercooling SC is smaller than a reference value SC2 in S305. If it is determined that the degree of supercooling SC is equal to or greater than the reference value SC2 (NO in S305), the controller 50C returns the process to the main routine. If it is determined that the degree of supercooling SC is smaller than the reference value SC2 (YES in S305), the controller 50C opens the flow path F31 in S306, and proceeds the process to S307.

[0062] In step S307, the controller 50C opens the flow path F32, and proceeds the process to step S308. In S308, the controller 50C closes the flow path F31, and returns the process to the main routine.

[0063] When S306 and S307 are performed in this order, since both of the flow paths F31 and F32 are open, it is possible to prevent the amount of refrigerant stored in the heat exchanger 3b from changing rapidly. As a result, it is possible to easily maintain the degree of supercooling SC within the allowable range of design values, and it is possible to prevent the performance of the air conditioner 200 (such as the temperature of air blown from the indoor unit 120 to the indoor space) from varying.

[0064] Fig. 18 is a flowchart illustrating a process to be performed by the controller 50C of Fig. 16 on the three-way valve 7C during the low load heating operation. The process illustrated in Fig. 11 is called at regular intervals by a main routine (not shown) for performing a comprehensive control on the air conditioner 200. The same applies to the processes illustrated in Figs. 12 and 13 described later.

[0065] As illustrated in Fig. 18, the controller 50C determines whether or not the degree of supercooling SC is greater than a reference value SC3 in S311. If it is determined that the degree of supercooling SC is greater than the reference value SC3 (YES in S311), the controller 50C proceeds the process to S314. If it is determined that the degree of supercooling SC is equal to or smaller than the reference value SC3 (NO in S311), the controller 50C determines whether or not the degree of

supercooling SC is smaller than a reference value SC4 ($SC4 < SC3$) in S312. If it is determined that the degree of supercooling SC is equal to or greater than the reference value SC4 (NO in S312), the controller 50C returns the process to the main routine. If it is determined that the degree of supercooling SC is smaller than the reference value SC4 (YES in S312), the controller 50C opens the flow path F31 in S313, and proceeds the process to S314.

[0066] In step S314, the controller 50C opens the flow path F32, and proceeds the process to step S315. In S315, the controller 50C closes the flow path F31, and returns the process to the main routine.

[0067] Fig. 19 is a flowchart illustrating an exemplary defrosting determination process to be performed by the controller 50C during the heating operation. The flowchart illustrated in Fig. 19 is different from the flowchart illustrated in Fig. 12 in that S213 in Fig. 12 is replaced by S323, and S324 is performed between S323 and S214.

[0068] As illustrated in Fig. 19, if it is determined that the condition for starting a defrosting operation on the heat exchanger 3b is satisfied (YES in S211) and the condition for starting a defrosting operation on the heat exchanger 3a is satisfied (YES in S212), the controller 50C opens the flow path F31 in S323, closes the flow path F32 in S324, and proceeds the process to S214. The controller 50C performs S214 and S215 similar to the second embodiment, and returns the process to the main routine.

[0069] Fig. 20 is a flowchart illustrating another exemplary defrosting determination process to be performed by the controller 50C during the heating operation. The flowchart illustrated in Fig. 20 is obtained in such a manner that S213 of Fig. 15 is replaced by S323 of Fig. 19, and S324 of Fig. 19 is performed between S323 and S212 in Fig. 20. During the reverse defrosting operation, the controller 50C performs the process illustrated in Fig. 14.

[0070] As illustrated in Fig. 20, if it is determined that the condition for starting a defrosting operation on the heat exchanger 3b is satisfied (YES in S211), the controller 50C opens the flow path F31 in S323, closes the flow path F32 in S324, and proceeds the process to S212. The controller 50C performs S212 and S214 to S216 similar to the second embodiment, and returns the process to the main routine.

[0071] Instead of the three-way valve 7C, an electronic expansion valve may be connected to each of the flow paths F31 and F32. It is desirable that the amount of refrigerant flowing through each of the flow paths F31 and F32 per unit time be adjustable.

[0072] As described above, according to the refrigeration cycle apparatus of the third embodiment, it is possible to improve the operation efficiency of a refrigeration cycle apparatus while preventing the refrigeration cycle apparatus from becoming larger in size.

[0073] The embodiments disclosed herein are intended to be appropriately combined as long as they are not

technically inconsistent to each other. It should be understood that the embodiment disclosed herein is merely by way of illustration and example but not limited in all aspects. The scope of the present disclosure is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

10 REFERENCE SIGNS LIST

[0074] 1: compressor; 2: four-way valve; 3a, 3b, 5: heat exchanger; 4a, 4b: expansion valve; 7: switch; 7C: three-way valve; 11 to 16: temperature sensor; 50, 50B, 50C: controller; 51: processing circuit; 52: memory; 53: input/output unit; 100, 200, 300: air conditioner; 110: outdoor unit; 120: indoor unit; F1 to F4, F31, F32: flow path; P1 to P5, P31 to P33: port

20 Claims

1. A refrigeration cycle apparatus that circulates refrigerant, the refrigeration cycle apparatus comprising:

a compressor;
a first heat exchanger;
a second heat exchanger;
a third heat exchanger;
a first expansion valve; and
a first switch that includes a first port, a second port, and a third port,
the first switch switching each of a first flow path and a second flow path between an open state and a closed state, the first flow path communicating the first port and the second port, and the second flow path communicating the first port and the third port,
when the first flow path is open, the refrigerant being circulated in a first circulation direction through the compressor, the first heat exchanger, the first port, the second port, the second heat exchanger, the first expansion valve, and the third heat exchanger,
when the second flow path is open, the refrigerant being circulated in a second circulation direction through the compressor, the first heat exchanger, the first port, the third port, the first expansion valve, and the third heat exchanger, and
when the circulation direction of the refrigerant is switched from the first circulation direction to the second circulation direction, a part of the refrigerant being stored in the second heat exchanger.

2. The refrigeration cycle apparatus according to claim 1, wherein

the first switch selectively establishes the first flow path and the second flow path.

3. The refrigeration cycle apparatus according to claim 1 or 2, wherein

the second heat exchanger includes:

a fourth port through which the refrigerant flows into the second heat exchanger in the first circulation direction; and
a fifth port through which the refrigerant flows out of the second heat exchanger in the first circulation direction,

a third flow path extending from the second heat exchanger to the first expansion valve includes a specific portion located at a position higher than the fifth port.

4. The refrigeration cycle apparatus according to claim 3, wherein

a fourth flow path extending from the third port to the third flow path is connected to the third flow path at the specific portion.

5. The refrigeration cycle apparatus according to any one of claims 2 to 4, wherein

the refrigeration cycle apparatus further includes a controller that controls the first switch, the controller opens the first flow path when the degree of supercooling of the refrigerant flowing into the first expansion valve is smaller than a reference value.

6. The refrigeration cycle apparatus according to claim 5, wherein

the controller opens the second flow path when the degree of supercooling is greater than the reference value.

7. The refrigeration cycle apparatus according to claim 5 or 6, wherein

the refrigeration cycle apparatus further includes:

a second switch that switches the circulation direction of the refrigerant between the first circulation direction and a third circulation direction opposite to the first circulation direction, and switches the circulation direction of the refrigerant between the second circulation direction and a fourth circulation direction opposite to the second circulation direction; and
a second expansion valve which is connect-

ed between the first heat exchanger and the second heat exchanger,

when the circulation direction of the refrigerant is the first circulation direction or the second circulation direction, and when a condition for finishing a defrosting operation on the first heat exchanger is satisfied and a condition for finishing a defrosting operation on the second heat exchanger is not satisfied, the controller opens the first flow path so as to switch the circulation direction of the refrigerant to the third circulation direction, and fully opens the first expansion valve.

8. The refrigeration cycle apparatus according to claim 7, wherein

when the circulation direction of the refrigerant is the third circulation direction or the fourth circulation direction, and when a condition for starting a defrosting operation on the second heat exchanger is satisfied and a condition for starting a defrosting operation on the first heat exchanger is not satisfied, the controller opens the first flow path, and fully opens the first expansion valve.

9. The refrigeration cycle apparatus according to any one of claims 1 to 8, wherein

the refrigerant includes a HC (Hydro Carbon) refrigerant.

10. The refrigeration cycle apparatus according to any one of claims 1 to 8, wherein

the refrigerant includes a non-azeotropic mixture refrigerant.

FIG. 1

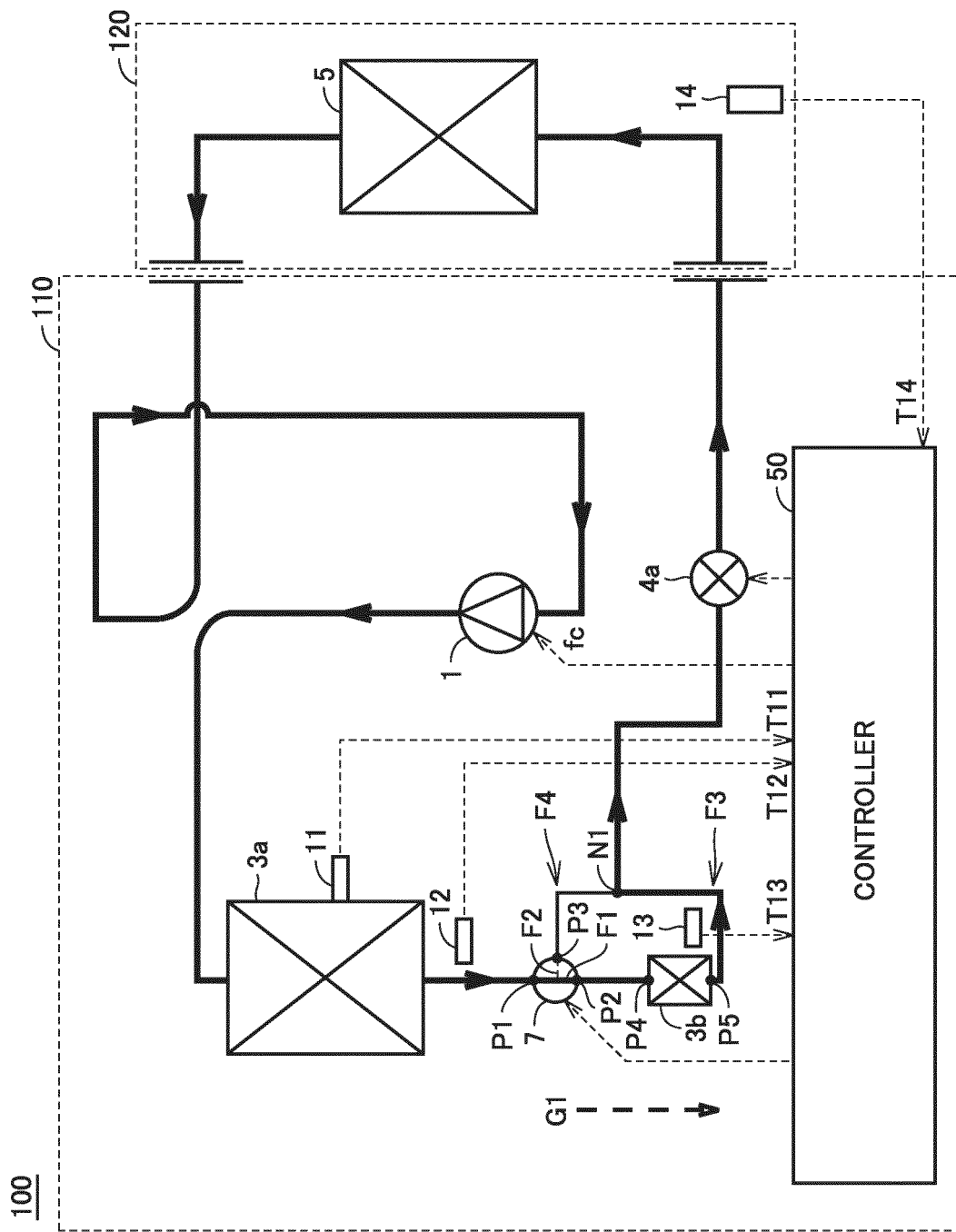


FIG.2

50

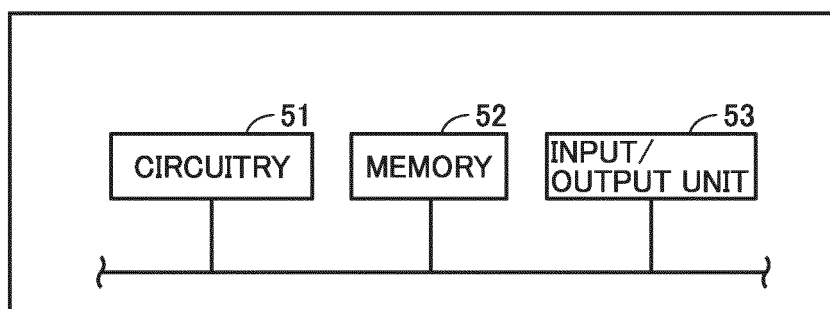


FIG.3

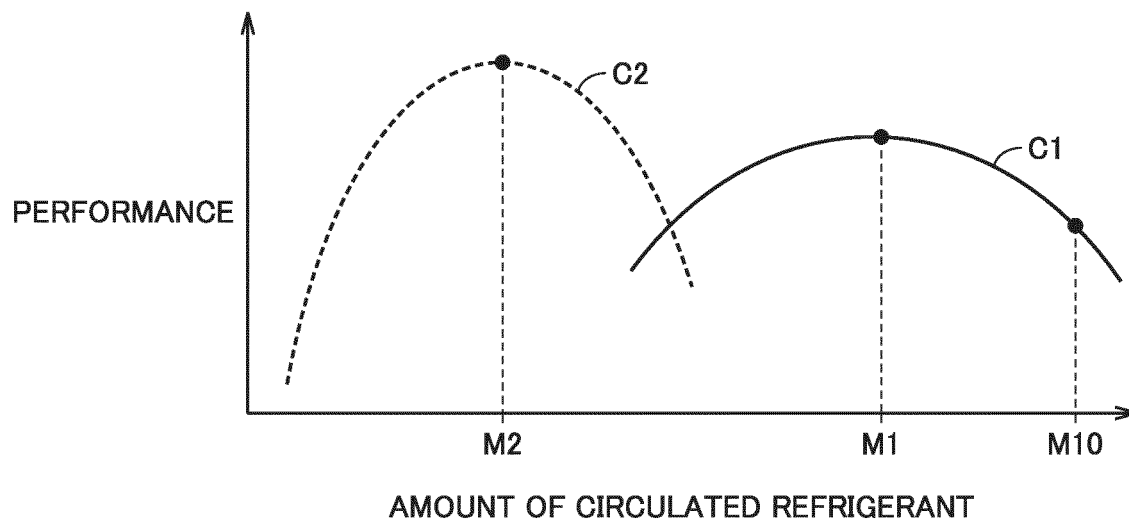


FIG. 4

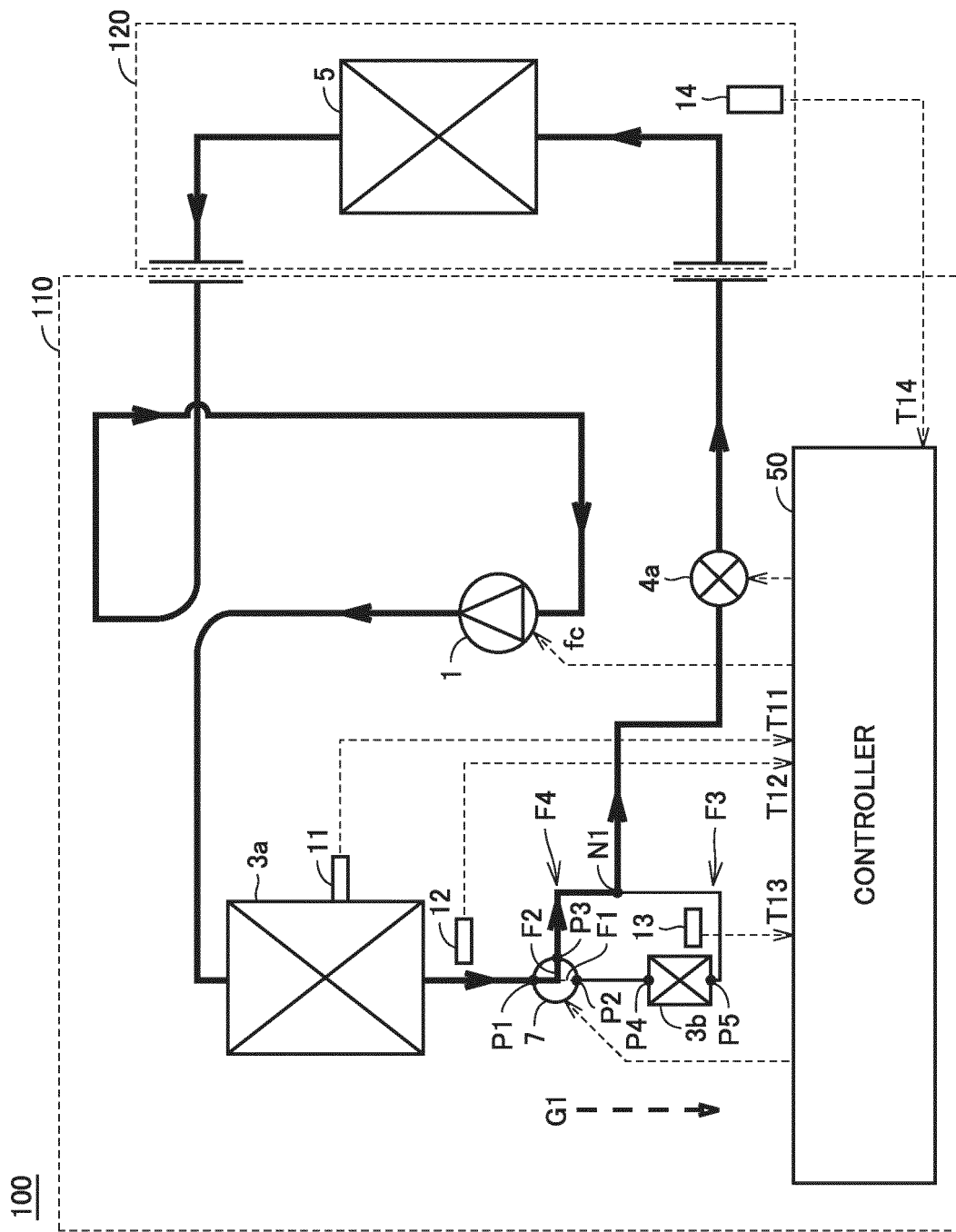


FIG.5

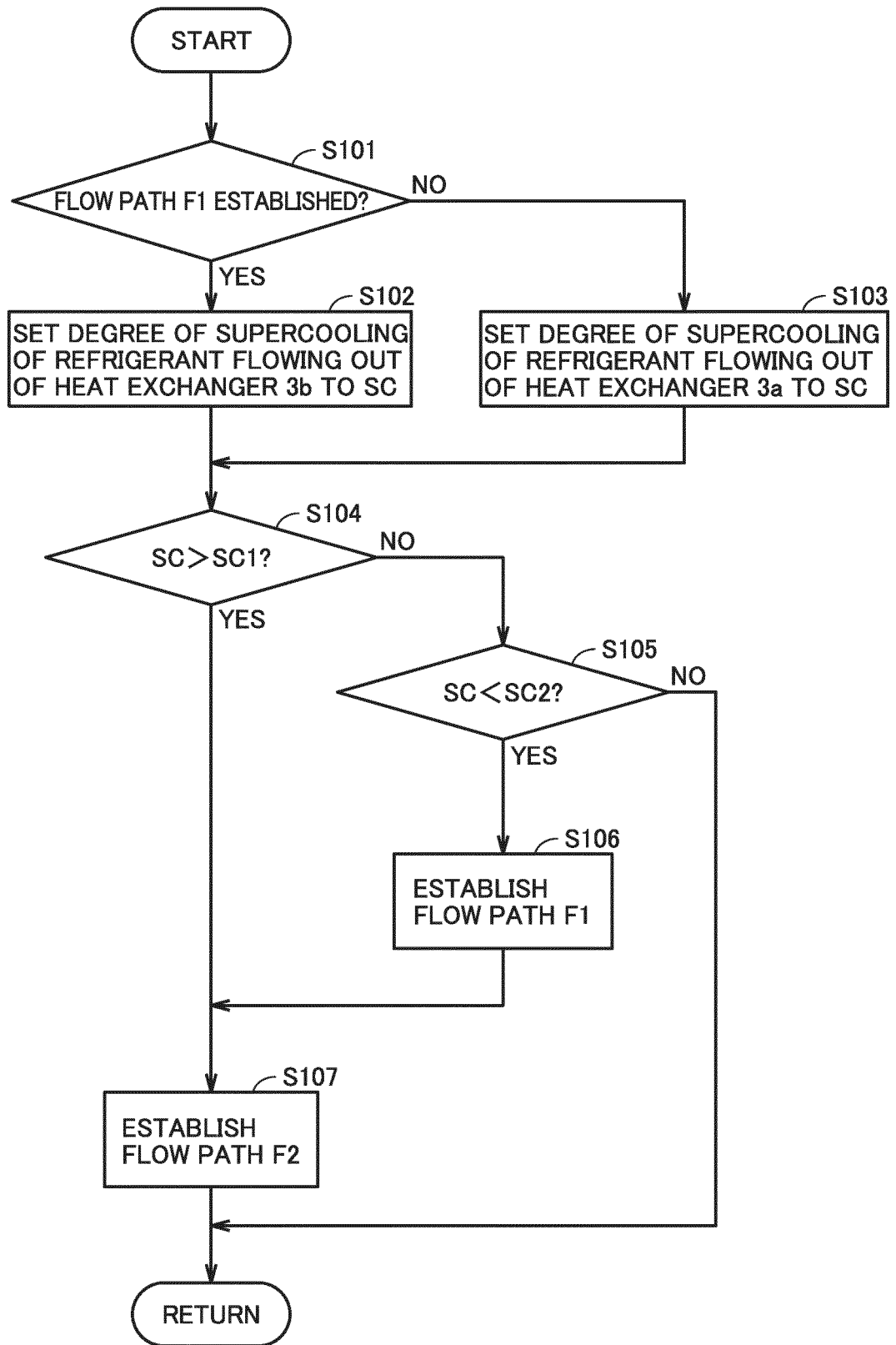


FIG.6

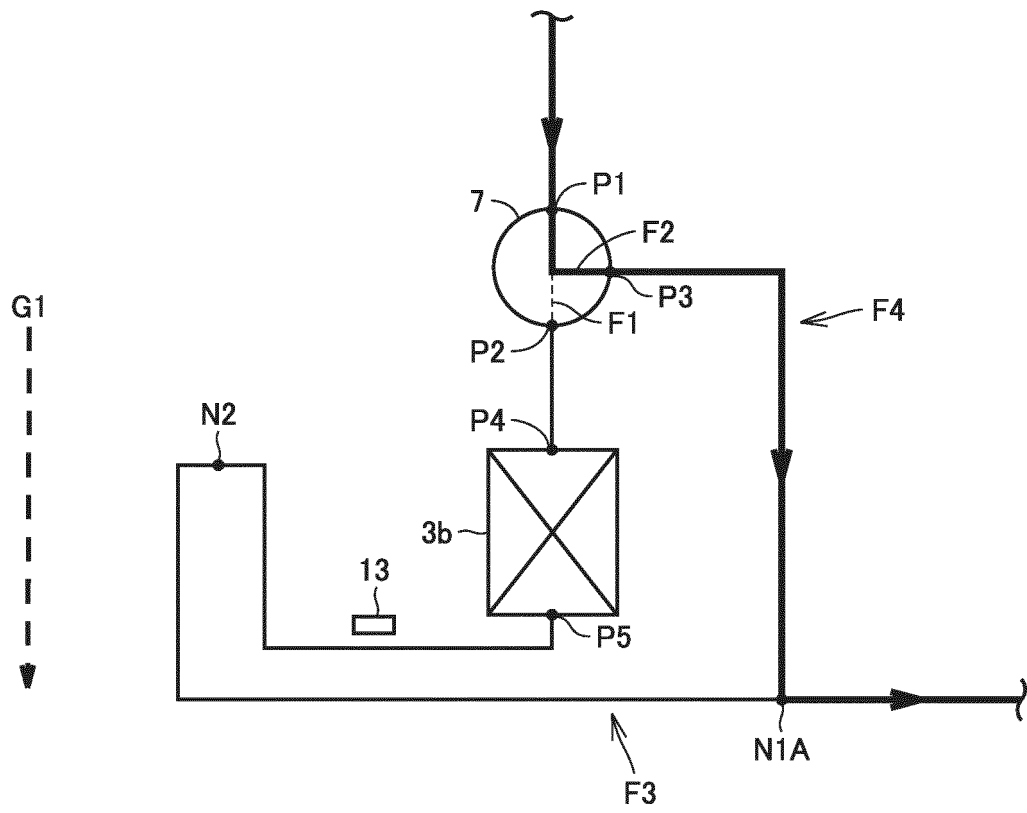


FIG.7

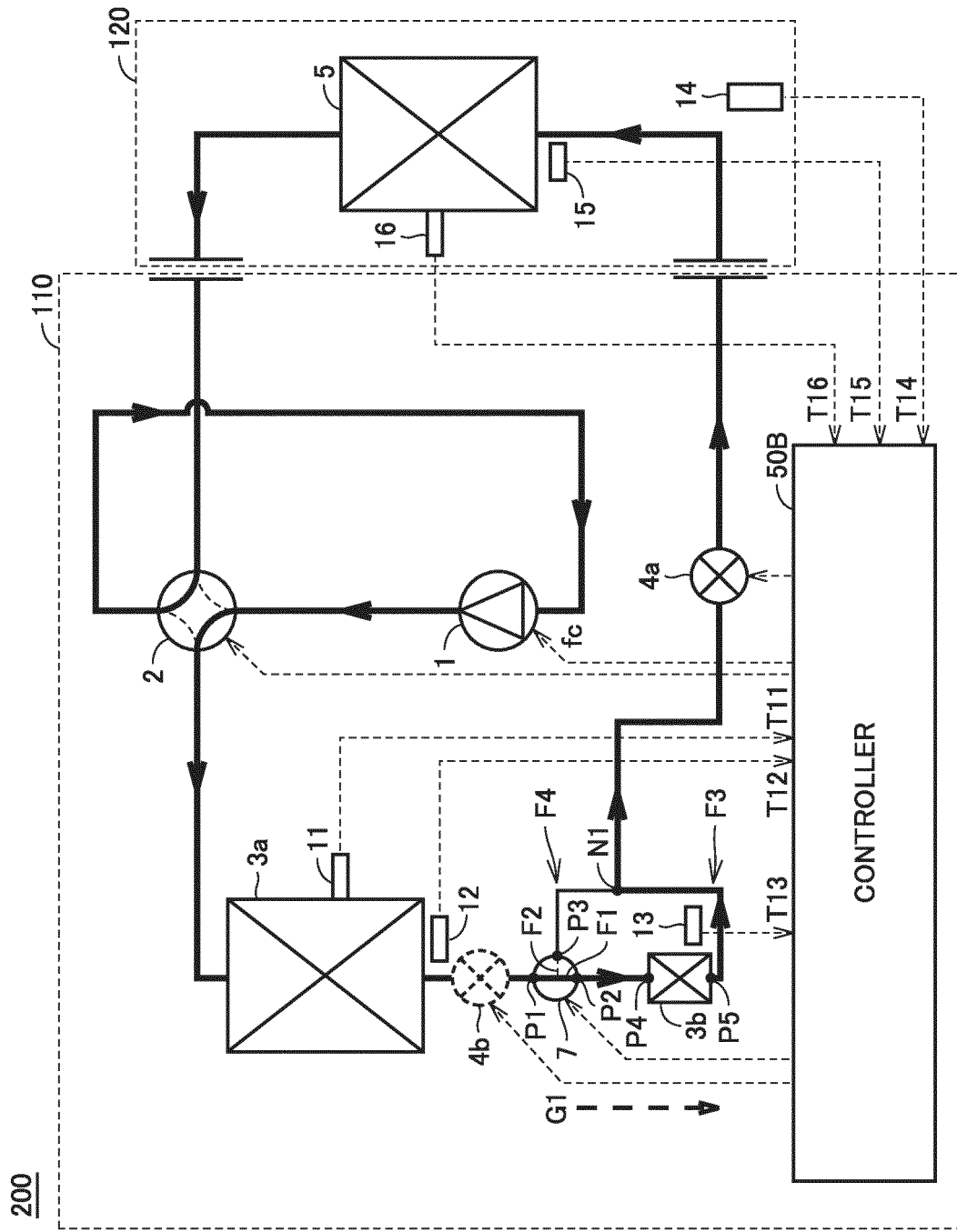


FIG. 8

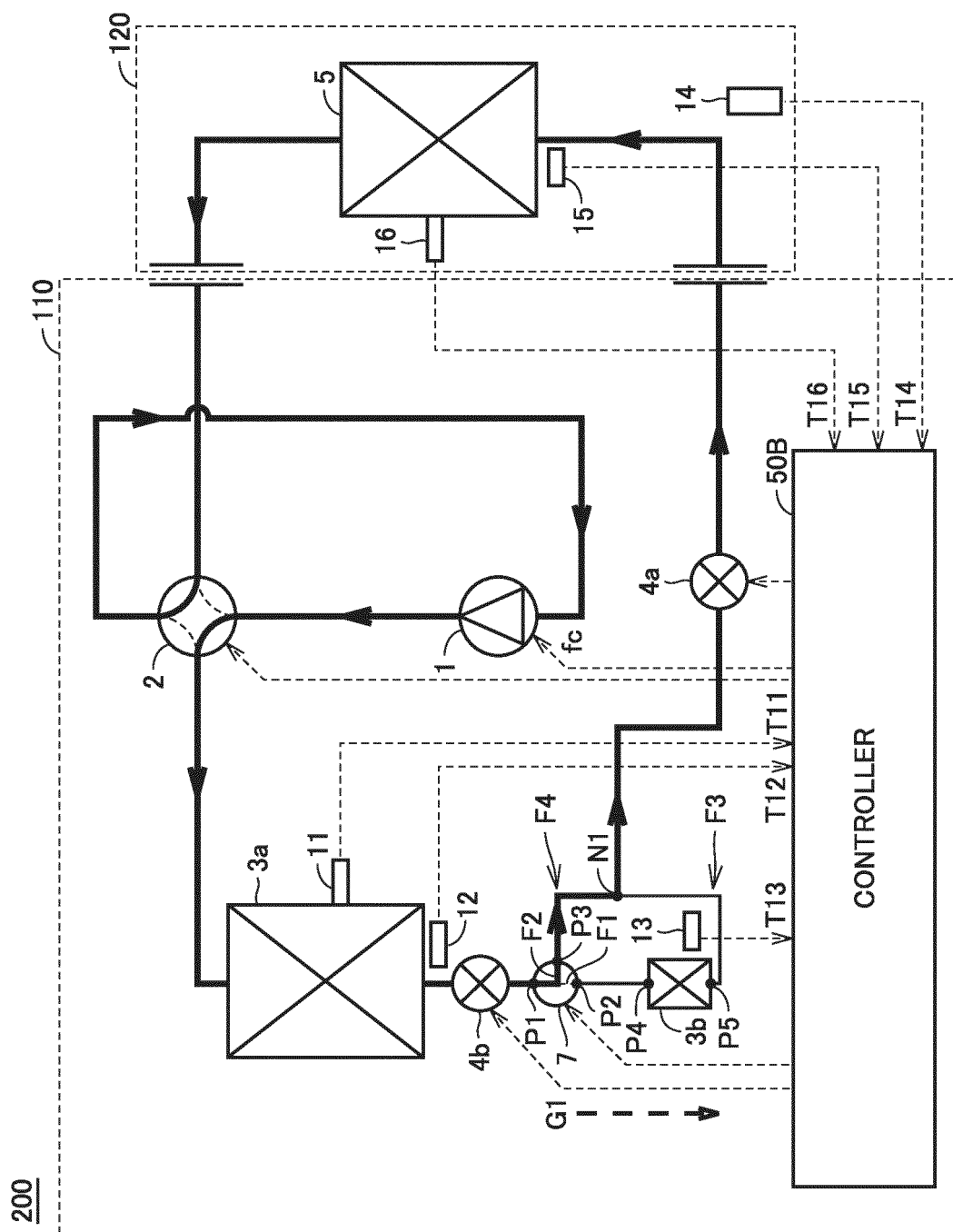


FIG. 9

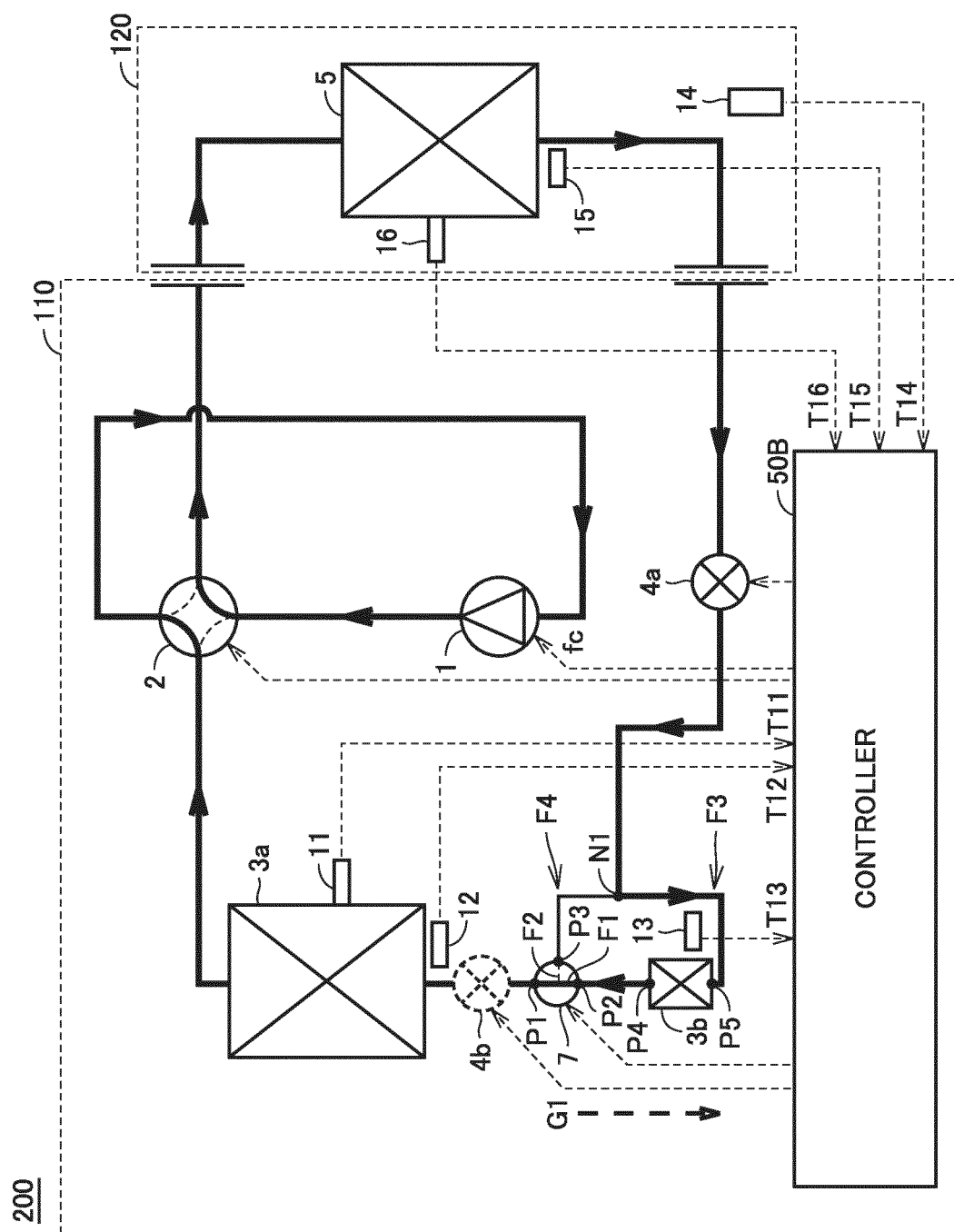


FIG.10

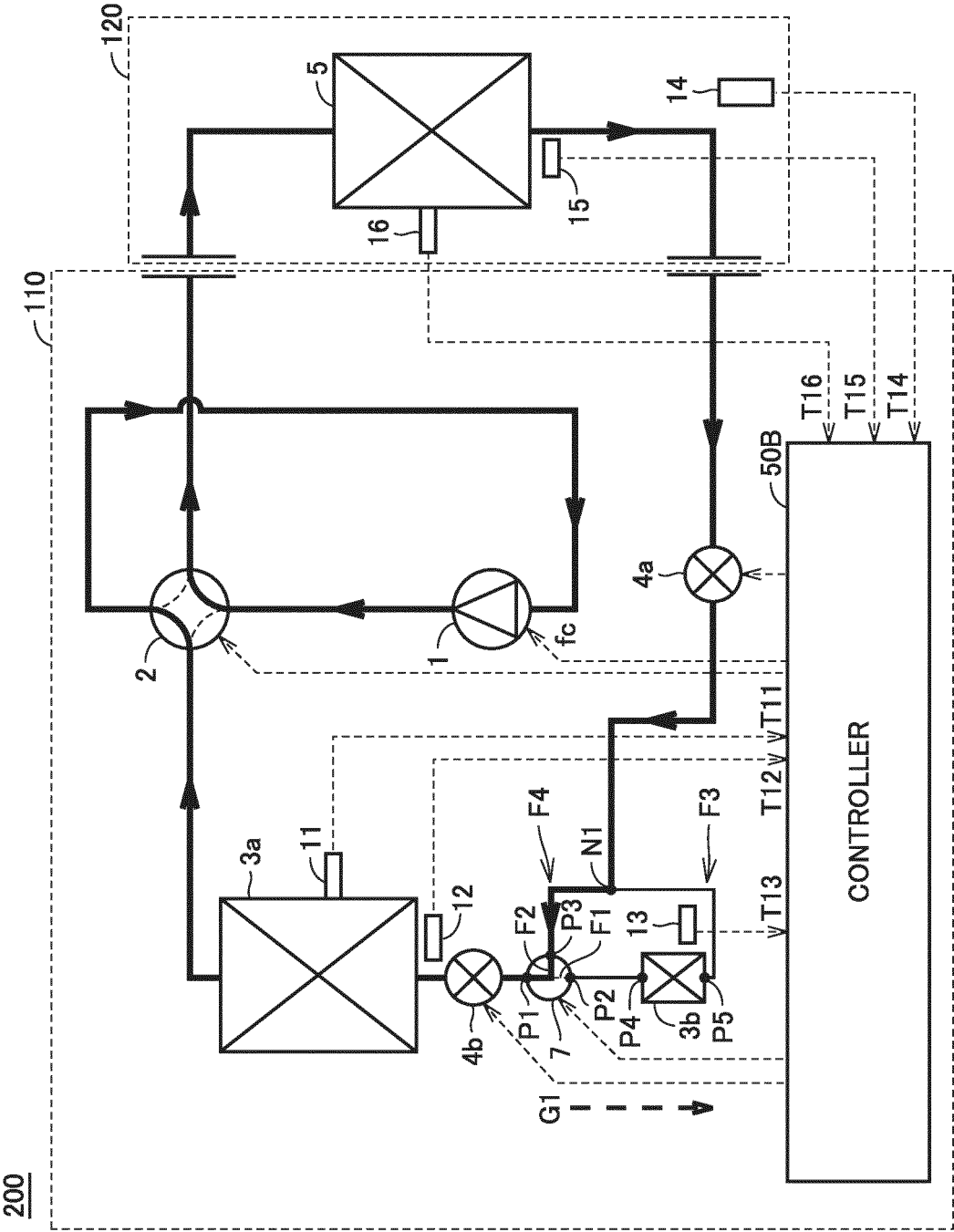


FIG.11

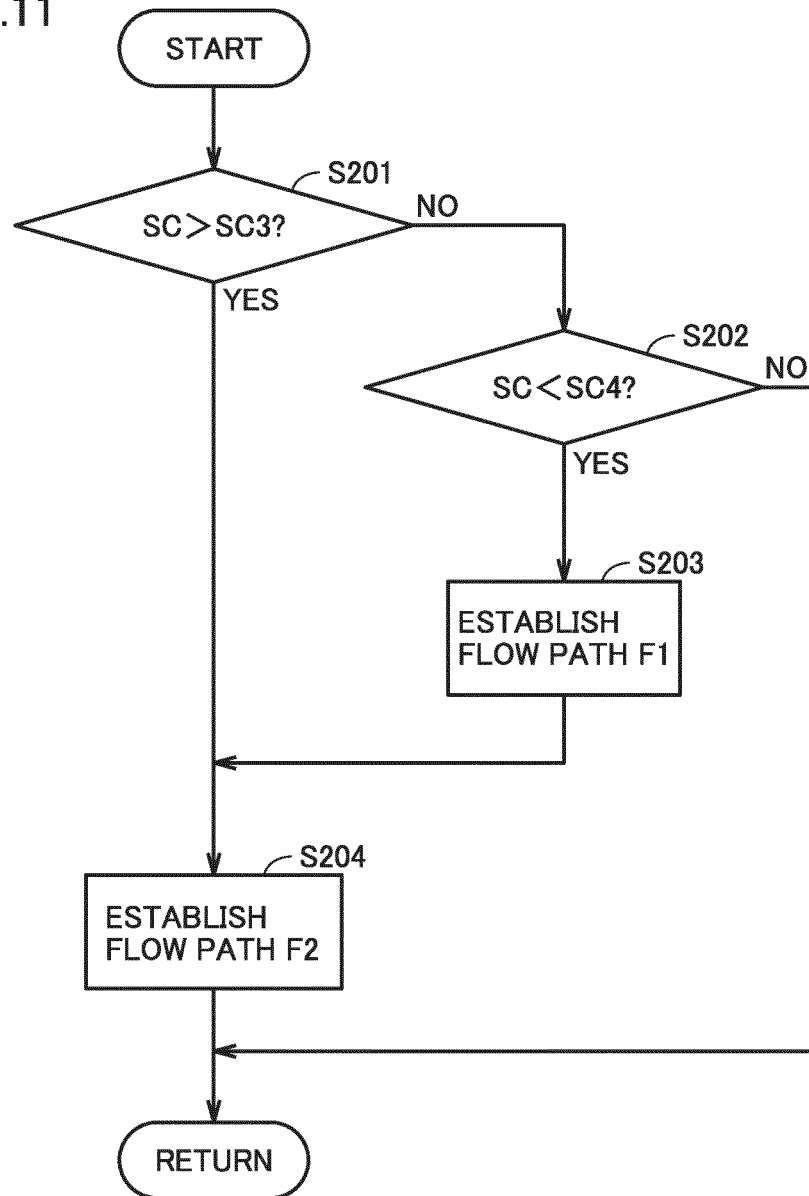


FIG.12

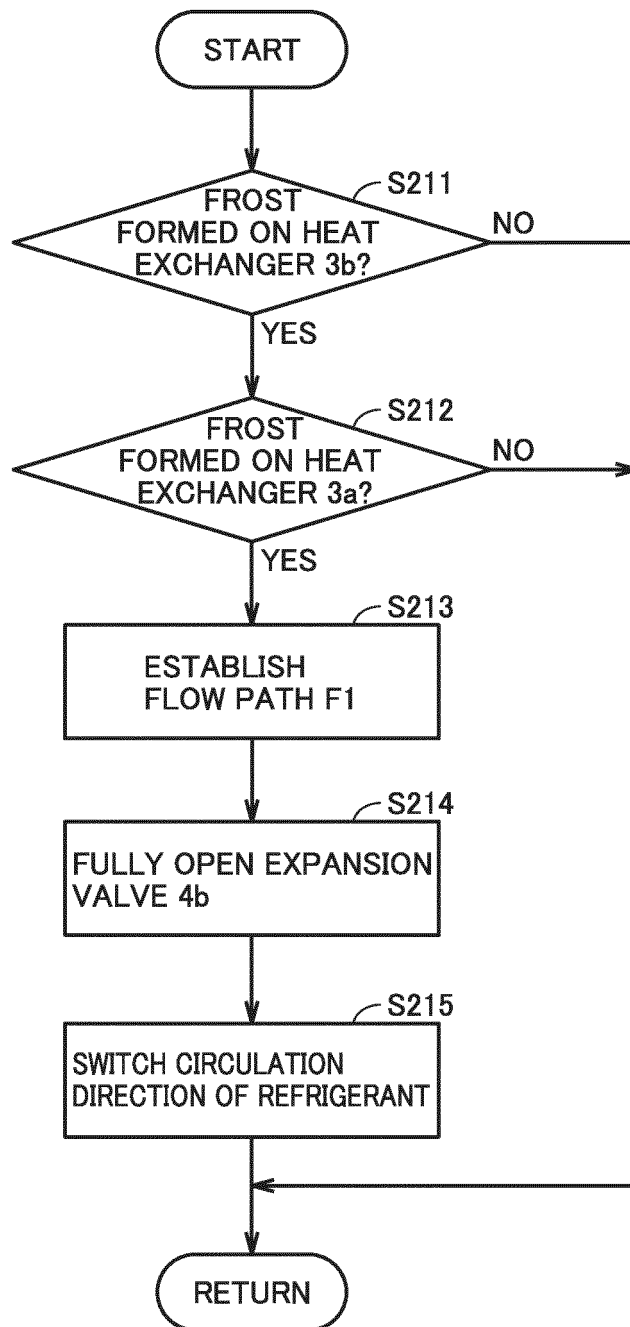


FIG.13

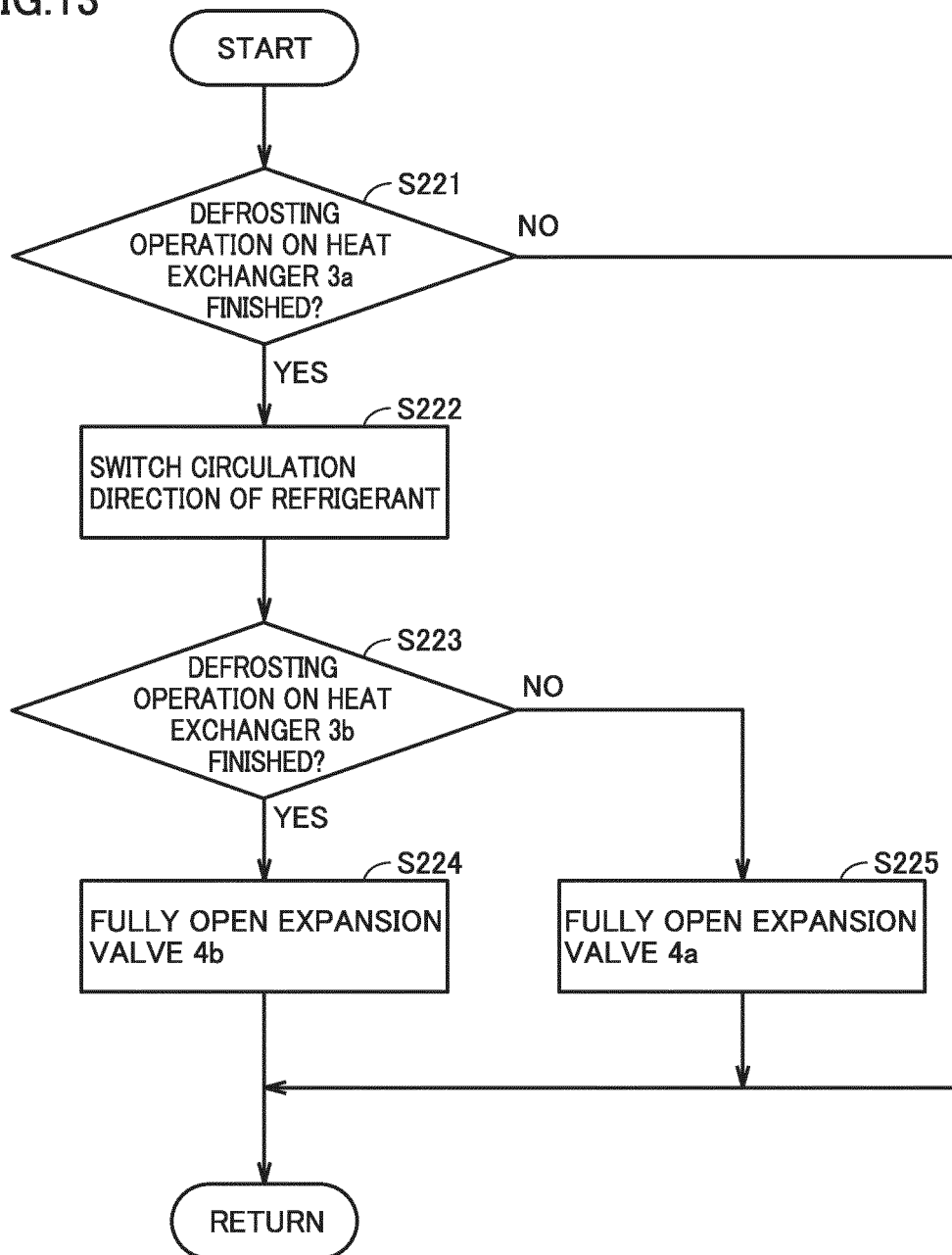


FIG.14

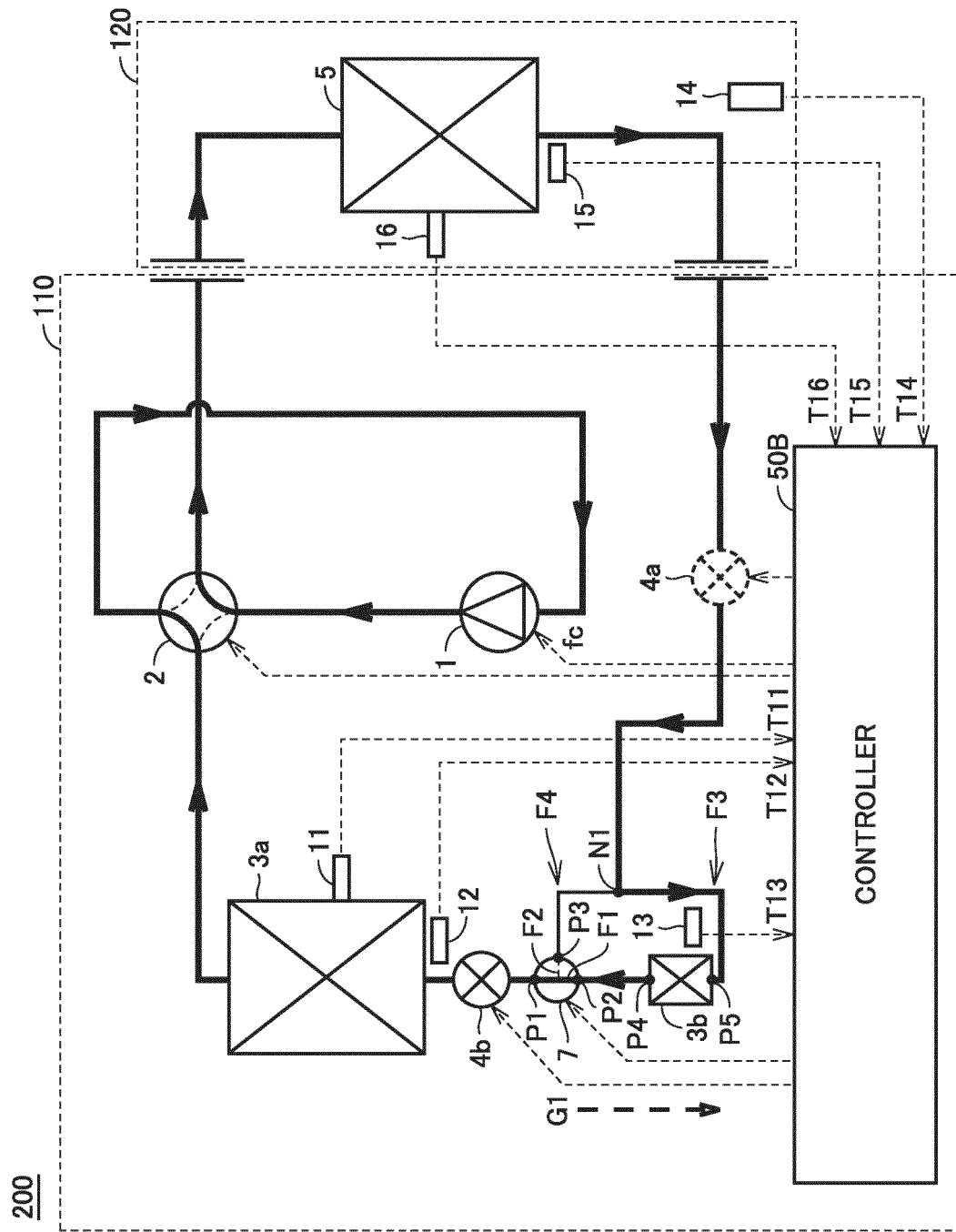


FIG.15

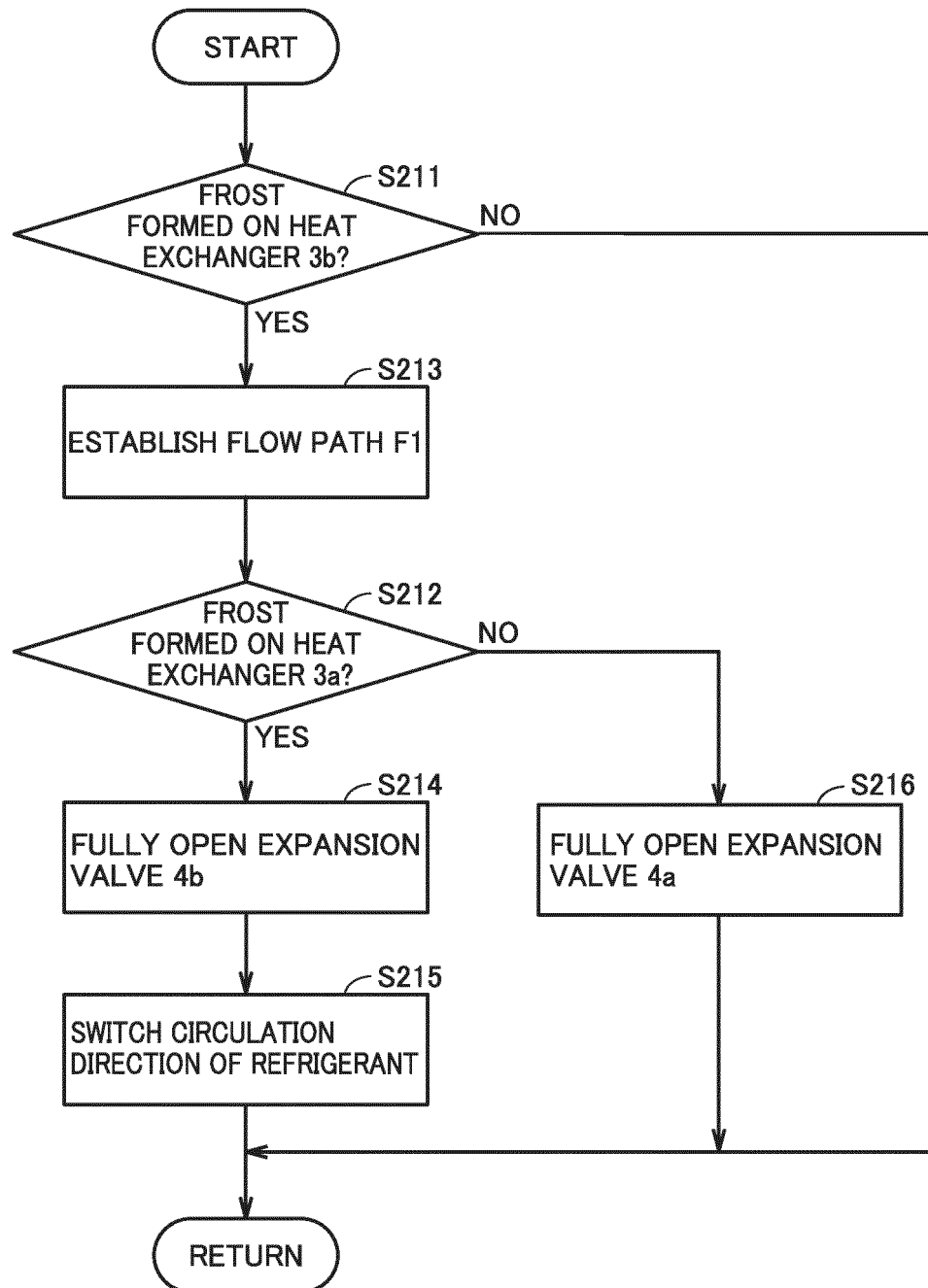


FIG. 16

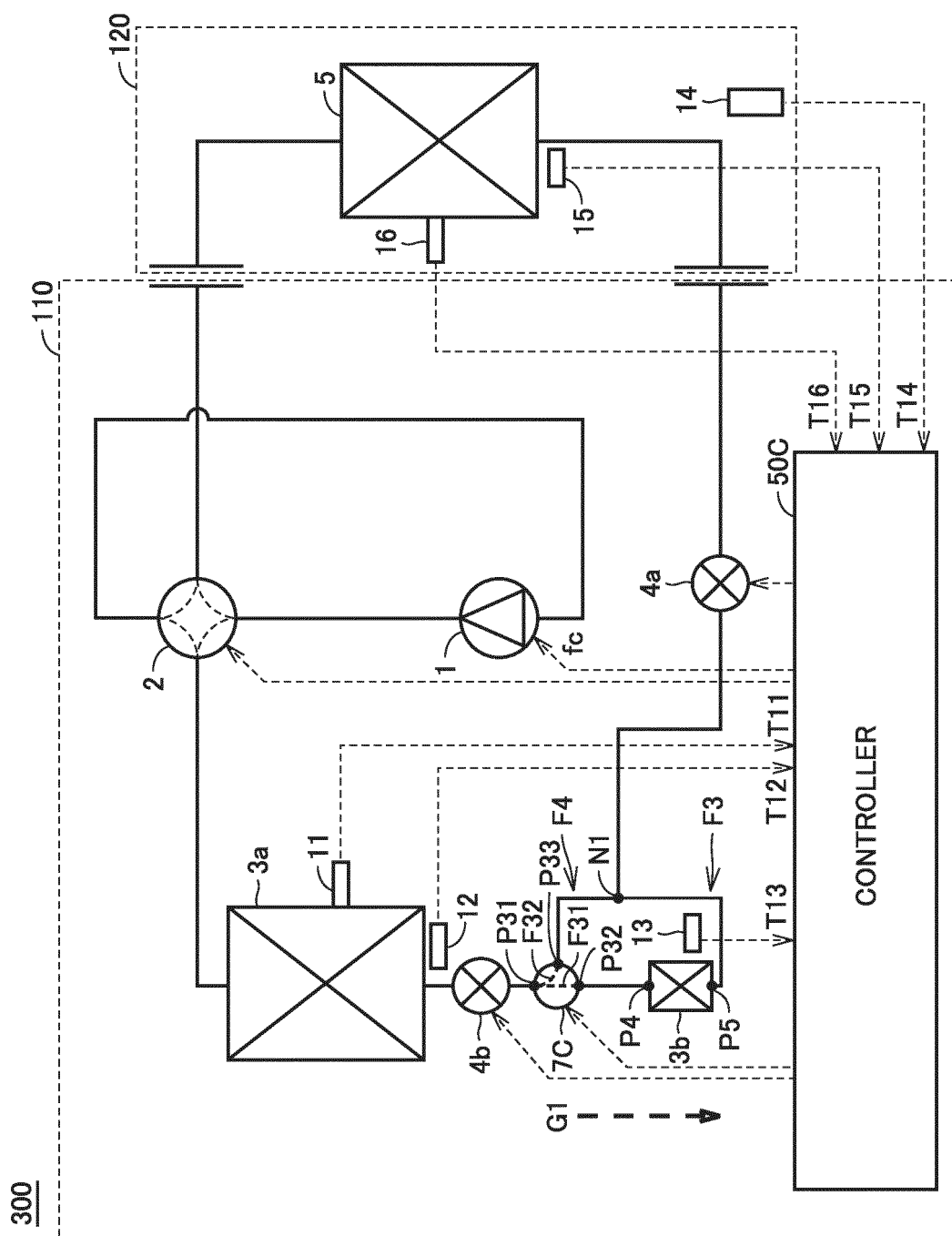


FIG.17

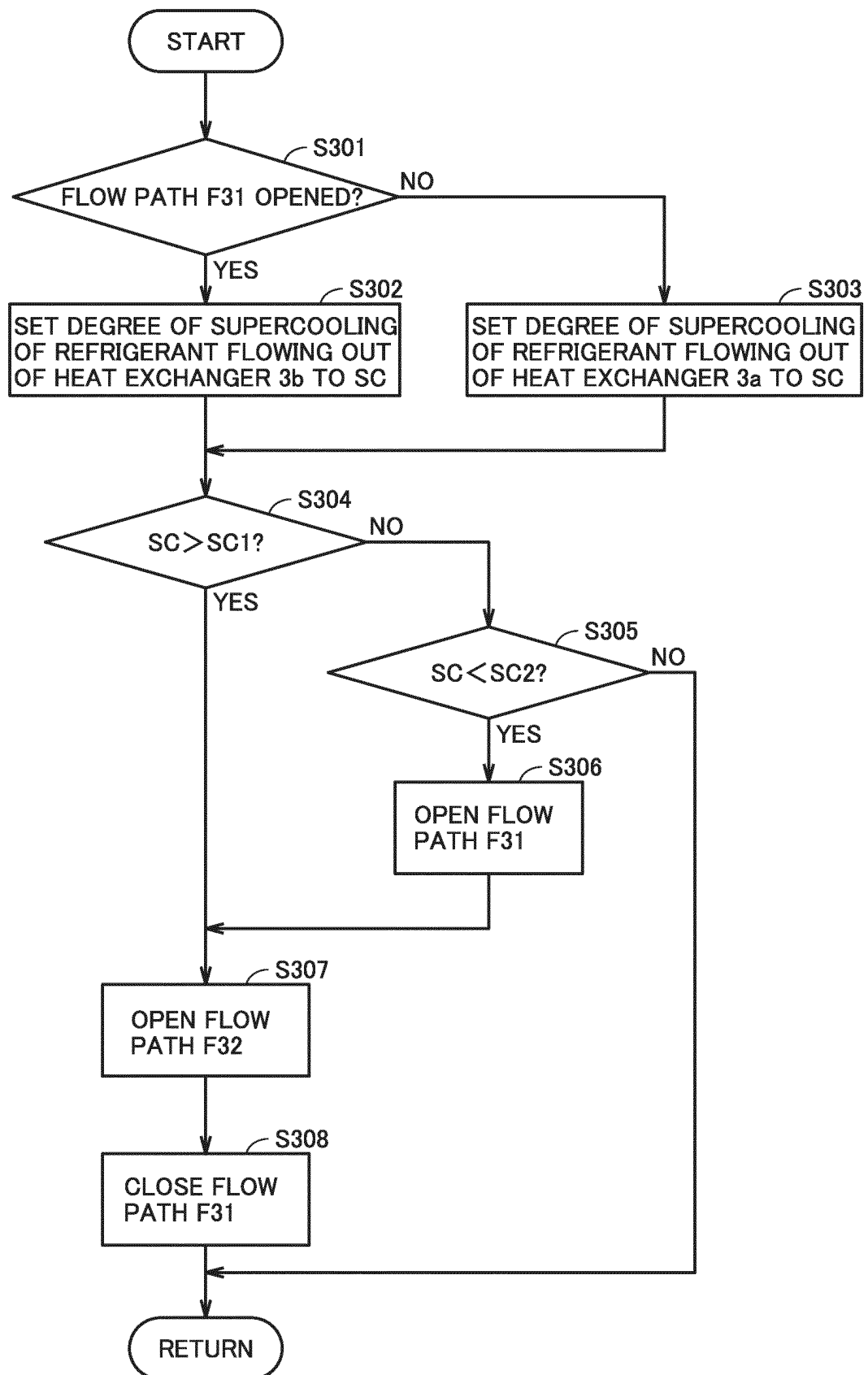


FIG.18

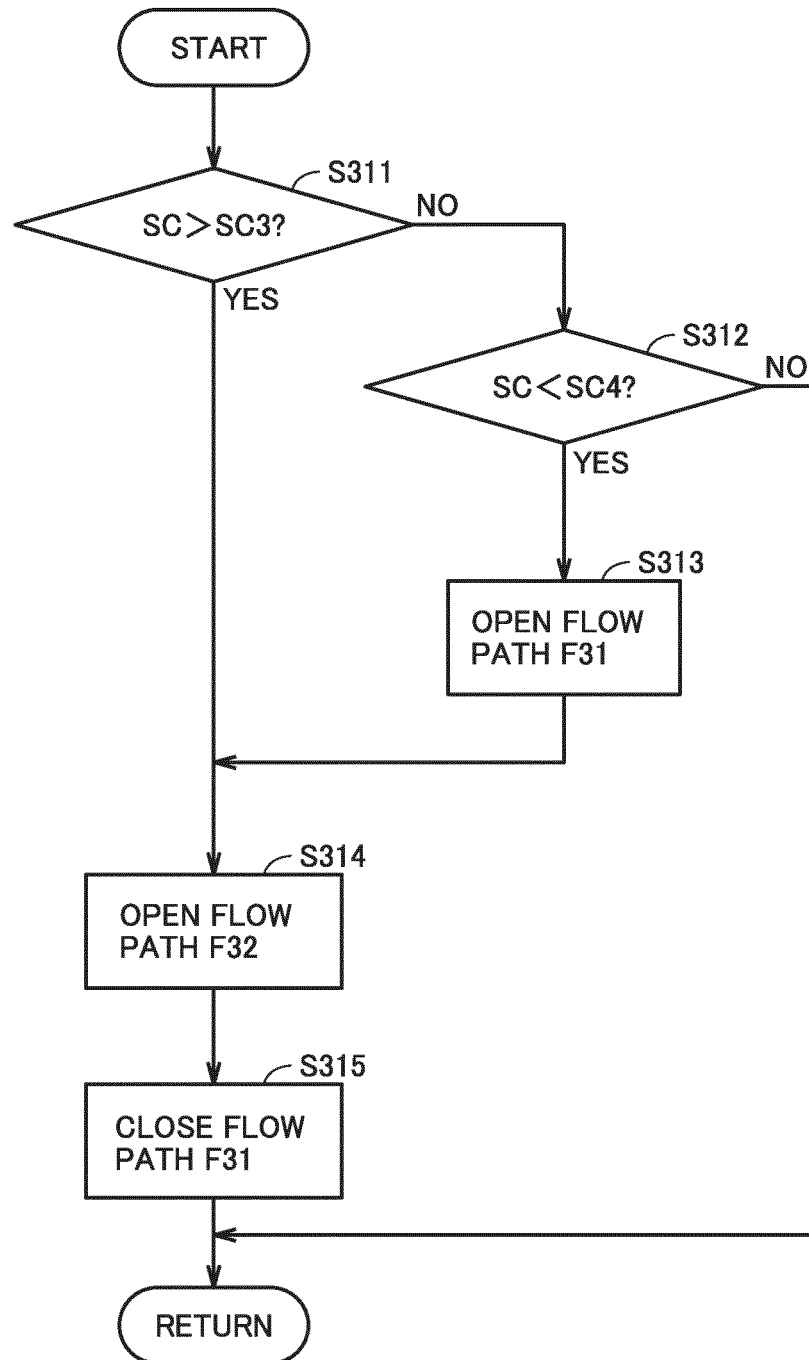


FIG.19

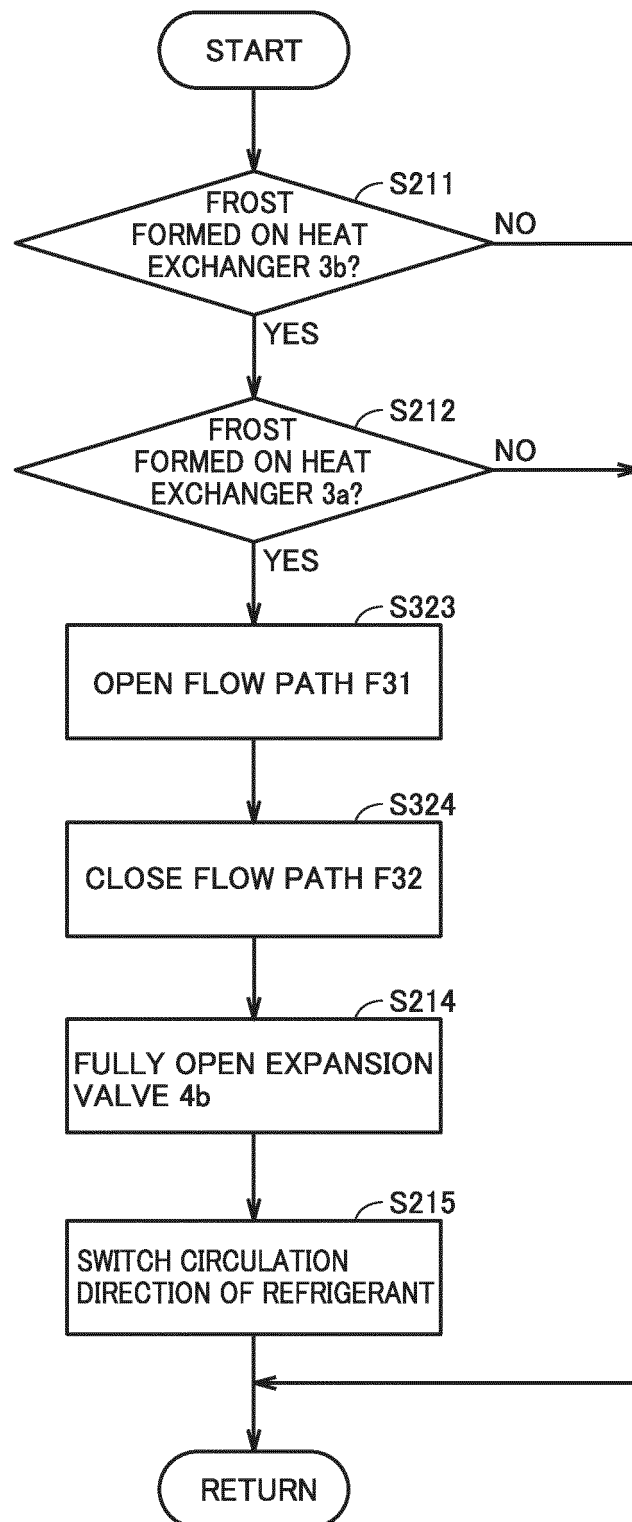
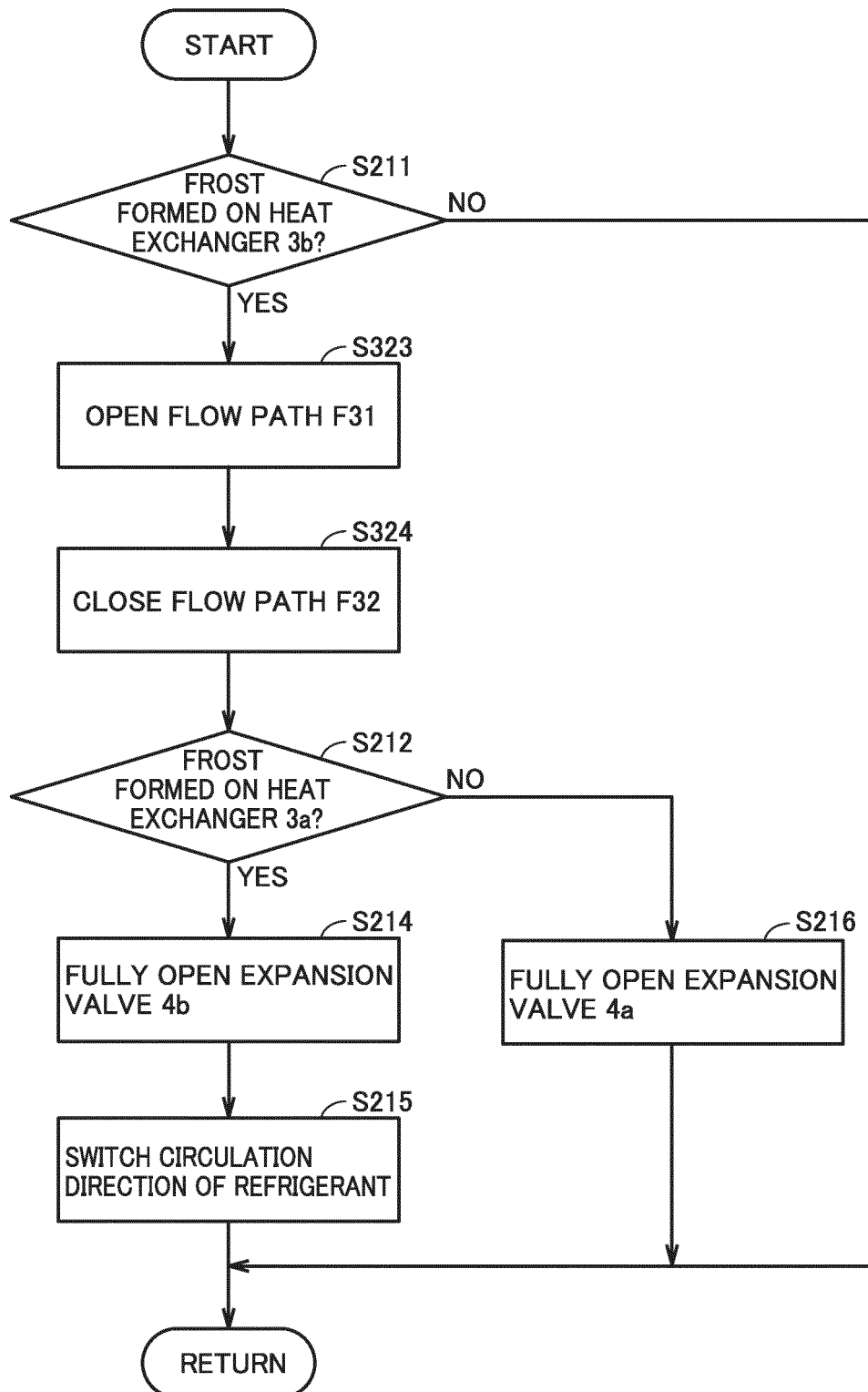


FIG.20



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/008866

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B1/00 (2006.01) i, F25B5/04 (2006.01) i, F25B6/04 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F25B1/00, F25B5/04, F25B6/04

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 10815/1988 (Laid-open No. 116366/1989) (FUJITSU GENERAL LIMITED) 04 August 1989, specification, page 1, line 11 to page 4, line 14, drawings (Family: none)	1-6, 9-10 7-8
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 154667/1981 (Laid-open No. 60168/1983) (SANYO ELECTRIC CO., LTD.) 22 April 1983, specification, page 3, line 5 to page 6, line 11, drawings (Family: none)	1-6, 9-10 7-8

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"&" document member of the same patent family

Date of the actual completion of the international search
15.05.2019Date of mailing of the international search report
28.05.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/008866

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2009-41829 A (PANASONIC CORPORATION) 26 February 2009, paragraphs [0008]-[0014], fig. 1, 2 (Family: none)	5-6, 9-10
A	JP 2006-317063 A (SHARP CORPORATION) 24 November 2006, entire text, all drawings (Family: none)	1-10
A	JP 2018-87675 A (DAIKIN INDUSTRIES, LTD.) 07 June 2018, entire text, all drawings (Family: none)	1-10

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2015087065 A [0002] [0003]