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(71) Applicant: **Yanmar Co., Ltd.**
Osaka-shi, Osaka 530-8311 (JP)

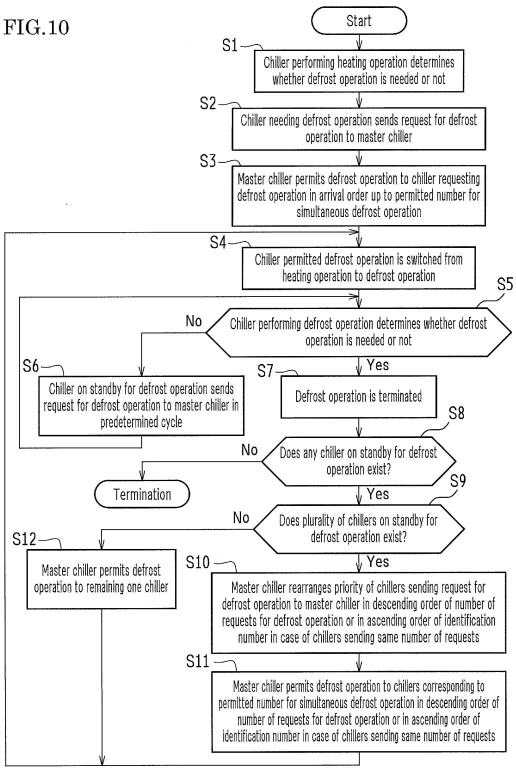
(72) Inventors:
- **MINAMIMOTO, Kotaro**
  Osaka-shi
  Osaka 530-0014 (JP)
- **TANAKA, Yuichiro**
  Osaka-shi
  Osaka 530-0014 (JP)
- **NISHI, Hiroyuki**
  Osaka-shi
  Osaka 530-0014 (JP)

(74) Representative: **Hinkelmann, Klaus**
Patentanwaltskanzlei Hinkelmann
Lyonel-Feininger-Strasse 28
80807 München (DE)

(54) **CHILLER SYSTEM**

(57) In a chiller system, any one of a plurality of chillers is designated as a master chiller. Out of the plurality of chillers, at least one chiller that needs a defrost operation sends a request for the defrost operation to the master chiller. The master chiller permits the defrost operation to the at least one chiller that has sent the request for the defrost operation in arrival order up to a predetermined number of chillers. At least one chiller on standby for the defrost operation sends the request for the defrost operation to the master chiller in a predetermined cycle. When there are multiple chillers that are on standby for the defrost operation, the master chiller permits a next defrost operation to one of the multiple chillers on standby in descending order of the number of the requests or a request time for the defrost operation.

FIG.10



EP 3 163 225 A1

Description

Technical Field

[0001] The present invention relates to a chiller system in which a plurality of heat pump chillers is connected to each other, the chillers regulating a temperature of a circulating liquid as a heat medium for temperature regulation by condensation heat or evaporation heat of a refrigerant.

Background Art

[0002] As a heat pump, a configuration is conventionally known, the configuration in which a defrost operation is performed, depending on conditions such as an outside air temperature, so as to remove frost that adheres to piping in a refrigerant-air heat exchanger that exchanges heat between a refrigerant and air when the refrigerant-air heat exchanger serves as an evaporator (see, for example, Patent Document 1). Specifically, Patent Document 1 discloses a configuration in which, when the defrost operation is performed, the refrigerant is evaporated by heat absorbed from an engine coolant in an exhaust heat recovery unit by completely closing an expansion valve for an indoor heat exchanger so that no refrigerant flows into the indoor heat exchanger.

[0003] Similarly, in a heat pump chiller for regulating a temperature of a circulating liquid as a heat medium for temperature regulation (for example, for air conditioning) by condensation heat or evaporation heat of a refrigerant, the defrost operation is performed so as to remove frost that adheres to piping in a refrigerant-air heat exchanger. However, when the defrost operation is performed in a chiller system in which a plurality of heat pump chillers is connected to each other, the temperature of the circulating liquid is not regulated during defrost operation. Therefore, if the chillers not less than a predetermined number (especially, all of the chillers) perform the defrost operation at the same time, the regulation of the temperature of the circulating liquid cannot be sufficiently (or cannot be at all) preformed.

[0004] In this regard, Patent Document 2 discloses a configuration in which: when the respective chilling units (chillers) send a request for the defrost operation, a defrost permission signal is output to the chilling units (chillers) on a predetermined number basis so that only the predetermined number of chilling units (chillers) simultaneously perform the defrost operation (see paragraph [0104] of Patent Document 2); and when the number of the chilling units (chillers) that can simultaneously perform the defrost operation is not less than two, the defrost permission signal is output in response to the defrost request signal until the number of the chilling units (chillers) reaches the number of the chilling units (chillers) that can perform the defrost operation (see paragraph [0111] of Patent Document 2). That is, Patent Document 2 discloses the configuration in which the defrost operation is permitted to the chillers in arrival order up to the number of the chillers that can simultaneously perform the defrost operation.

Prior Art Documents

Patent Documents

[0005]

[Patent Document 1] JP 4257351
[Patent Document 2] JP H10-122604 A

Summary of Invention

Problem to Be Solved by Invention

[0006] However, although Patent Document 2 discloses the configuration in which the defrost operation is permitted to the chillers in arrival order up to the number of the chillers that can simultaneously perform the defrost operation, it does not disclose the priority of the chillers on standby for the defrost operation.

[0007] In consideration of the above circumstances, an object of the present invention is to provide a chiller system in which a plurality of heat pump chillers is connected to each other, the chiller system capable of determining the priority of the chillers on standby for a defrost operation when the defrost operation is permitted to the chillers in arrival order up to a predetermined number of chillers.

Means for Solving Problem

[0008] In consideration of the above problems, the present invention provides a chiller system including a plurality of heat pump chillers being connected to each other, the plurality of heat pump chillers regulating a temperature of a circulating liquid as a heat medium for temperature regulation by condensation heat or evaporation heat of a refrigerant. Any one of the plurality of chillers is designated as a master chiller. Out of the plurality of chillers, at least one chiller that needs a defrost operation sends a request for the defrost operation to the master chiller. The master chiller permits the defrost operation to the at least one chiller that has sent the request for the defrost operation in arrival order up to a predetermined number of chillers. At least one chiller on standby for the defrost operation sends the request for the defrost operation to the master chiller in a predetermined cycle. When there are multiple chillers that are on standby for the defrost operation, the master chiller permits a next defrost operation to one of the multiple chillers on standby in descending order of the number of the requests or a request time for the defrost operation.

[0009] In an exemplary aspect of the present invention, when the chillers send the same number of the requests or have the same request time for the defrost operation, the master chiller permits the next defrost operation to one of the chillers in ascending order or in descending order of an identification number.

[0010] The present invention also provides a chiller system including a plurality of heat pump chillers being connected to each other, the plurality of heat pump chillers regulating a temperature of a circulating liquid as a heat medium for temperature regulation by condensation heat or evaporation heat of a refrigerant, in which the chiller system further includes a control mechanism configured to control operations of the plurality of chillers. Out of the plurality of chillers, at least one chiller that needs the defrost operation sends a request for the defrost operation to the control mechanism. The control mechanism permits the defrost operation to the at least one chiller that has sent the request for the defrost operation in arrival order up to the predetermined number of chillers. At least one chiller on standby for the defrost operation sends the request for the defrost operation to the control mechanism in a predetermined cycle. When there are multiple chillers that are on standby for the defrost operation, the control mechanism permits the next defrost operation to one of the multiple chillers on standby in descending order of the number of the requests or the request time for the defrost operation.

Effects of Invention

[0011] With the present invention providing a chiller system in which a plurality of heat pump chillers is connected to each other, it is possible to determine the priority of the chillers on standby for the defrost operation when the defrost operation is permitted to the chillers in arrival order up to a predetermined number of the chillers.

Brief Description of Drawings

[0012]

[FIG. 1]
FIG. 1 is a system diagram showing a schematic configuration of a chiller system according to an embodiment of the present invention.
[FIG. 2]
FIG. 2 is a schematic block diagram showing one chiller in the chiller system.
[FIG. 3]
FIG. 3 is a schematic block diagram showing a chiller that performs a cooling operation.
[FIG. 4]
FIG. 4 is a schematic block diagram showing a chiller that performs a heating operation.
[FIG. 5]
FIG. 5 is a schematic block diagram showing a chiller that performs a defrost operation.
[FIG. 6]
FIG. 6 is a conceptual diagram of one example of the chiller system in which the number of the chillers is set to eight, showing a state in which the chillers send a request for the defrost operation to a master chiller and the master chiller permits or inhibits the defrost operation to the chillers. The diagram shows that the master chiller permits the defrost operation in arrival order to two chillers that have sent the request for the defrost operation earlier than the others, and inhibits three chillers that have sent the request later than the two chillers from performing the defrost operation.
[FIG. 7]
FIG. 7 is a conceptual diagram of one example of the chiller system in which the number of the chillers is set to eight, showing a state in which the chillers send the request for the defrost operation to the master chiller and the master chiller permits or inhibits the defrost operation to the chillers. The diagram shows that, after termination of the defrost operation of the two chillers shown in FIG. 6, the master chiller permits the defrost operation, in descending order of the number of requests for the defrost operation, to two chillers on standby that have sent a greater number

of requests, and inhibits one chiller that have sent a smaller number of requests than the other two chillers from performing the defrost operation.

[FIG. 8]

FIG. 8 is a conceptual diagram of one example of the chiller system in which the number of the chillers is set to eight, showing a state in which the chillers send the request for the defrost operation to the master chiller and the master chiller permits or inhibits the defrost operation to the chillers. The diagram shows that, after termination of the defrost operation of the two chillers shown in FIG. 7, the master chiller permits the defrost operation to the remaining one chiller.

[FIG. 9]

FIG. 9 is a graph showing a temperature regulating capacity of the chiller system and a timing chart of respective operation states of the chillers in the example in FIGS. 6 to 8.

[FIG. 10]

FIG. 10 is a flowchart showing steps of one example of operations for the defrost control by the master chiller to the respective chillers.

Modes for Carrying out Invention

[0013] Hereinafter, an embodiment according to the present invention will be described with reference to the drawings.

[0014] FIG. 1 is a system diagram showing a schematic configuration of a chiller system 1 according to an embodiment of the present invention.

[0015] In the chiller system 1 shown in FIG. 1, a plurality of heat pump chillers 100 is connected in parallel. Hereinafter, a heat pump chiller is occasionally referred to, simply, as a chiller.

[0016] Specifically, the chiller system 1 includes: the plurality of chillers 100 (1) to 100 (n) (n is an integer of ≥ 2); and a circulating liquid circuit 200. Each of the chillers 100 (1) to 100 (n) has the same configuration. Accordingly, the rated output for each of the chillers 100 (1) to 100 (n) is set to the same value. Hereinafter, each of the chillers 100 (1) to 100 (n) is occasionally indicated simply with the reference numeral 100.

[0017] The chiller system 1 further includes: the circulating liquid circuit 200 that is installed in a temperature regulation target area (for example, an air conditioning target area, not shown) for circulating a circulating liquid as a heat medium for temperature regulation (for example, for air conditioning); and circulation pumps 300 (1) to 300 (n) respectively disposed corresponding to the chillers 100 (1) to 100 (n) in the circulating liquid circuit 200 so as to circulate the circulating liquid in the circulating liquid circuit 200. The circulation pumps 300 (1) to 300 (n) regulate the temperature of the circulating liquid that flows in the circulating liquid circuit 200. Here, any circulating liquid can be used provided that it serves as the heat medium, and representative examples thereof include water. However, the circulating liquid is not limited thereto. For example, water containing antifreeze liquid can be used.

[0018] The circulating liquid circuit 200 is constituted by: an inlet main pipe 210 to flow the circulating liquid toward the plurality of chillers100 (1) to 100 (n); inlet branch pipes 211 (1) to 211 (n) to divide and flow the circulating liquid from the inlet main pipe 210 into the respective chillers 100 (1) to 100 (n); an outlet main pipe 220 to flow the circulating liquid out of the plurality of chillers 100 (1) to 100 (n); and outlet branch pipes 221 (1) to 221 (n) to flow and join the circulating liquid from the plurality of chillers 100 (1) to 100 (n) to the outlet main pipe 220.

[0019] Specifically, the inlet branch pipes 211 (1) to 211 (n) each connect a branch portion of the inlet main pipe 210 that corresponds to each chiller 100 (1) to 100 (n) and a circulating liquid flowing-in side of each chiller 100 (1) to 100 (n). The outlet branch pipes 221 (1) to 221 (n) each connect a circulating liquid flowing-out side of each chiller 100 (1) to 100 (n) and a confluence portion of the outlet main pipe 220 that corresponds to each chiller 100 (1) to 100 (n). On one side of each pair of the inlet branch pipes 211 (1) to 211 (n) and the outlet branch pipe 221 (1) to 221 (n) (in this example, on the side of the outlet branch pipes 221 (1) to 221 (n)), each circulation pump 300 (1) to 300 (n) is disposed to circulate the circulating liquid in the circulating liquid circuit 200.

[0020] In the chiller system 1 having the above configuration, the circulating liquid that is circulated by the circulation pumps 300 (1) to 300 (n) is divided and flows, from the inlet main pipe 210, into each chiller 100 (1) to 100 (n) via each inlet branch pipe 211 (1) to 211 (n), and the temperature of the circulating liquid is regulated by each chiller 100 (1) to 100 (n). The circulating liquid whose temperature is regulated is joined, from each chiller 100 (1) to 100 (n), to the outlet main pipe 220 via each outlet branch pipe 221 (1) to 221 (n), and is circulated in the temperature regulation target area (for example, the air conditioning target area) of the circulating liquid circuit 200. The respective load sides of the inlet main pipe 210 and the outlet main pipe 220 are connected to each other, for example, via a heat exchanger not shown, and constitute a closed circuit.

[0021] FIG. 2 is a schematic block diagram showing one chiller 100 in the chiller system 1. Note that FIG. 2 shows one inlet branch pipe 211 out of the inlet branch pipes 211 (1) to 211 (n), one outlet branch pipe 221 out of the outlet branch pipes 221 (1) to 221 (n), and one circulation pump 300 out of the circulation pumps 300 (1) to 300 (n).

[0022] The chiller 100 drives a compressor 10 that compresses a refrigerant so as to regulate the temperature of the circulating liquid by the condensation heat or the evaporation heat of the refrigerant.

[0023] That is, the chiller 100 includes: the compressor 10 that sucks and discharges the refrigerant; a refrigerant-air heat exchanger 20 that exchanges heat between the refrigerant and air (specifically, outside air); a refrigerant-air heat exchanger fan 30 for the refrigerant-air heat exchanger 20; an expansion valve 40 that expands the refrigerant compressed by the compressor 10; a refrigerant-circulating liquid heat exchanger 50 that exchanges heat between the circulating liquid and the refrigerant; an engine 60 that drives the compressor 10; and an engine exhaust heat recovery unit 70 that recovers exhaust heat of the engine 60. The chiller 100 is capable of executing a heating operation, a cooling operation and a defrost operation as described later. In this example, the expansion valve 40 is constituted by a closable first expansion valve 41 and a closable second expansion valve 42.

[0024] The compressor 10 may be constituted by a plurality of compressors connected in parallel. Also, the refrigerant-air heat exchanger 20 may be constituted by a plurality of refrigerant-air heat exchangers connected in parallel.

[0025] Specifically, the chiller 100 further includes: a refrigerant circuit 110 to circulate the refrigerant; a coolant path 120 to circulate an engine coolant for cooling the engine 60; a circulation pump 130 for the coolant path 120; and a control device 140.

[0026] In the refrigerant circuit 110, the compressor 10, the refrigerant-air heat exchanger 20, the refrigerant-circulating liquid heat exchanger 50, the expansion valve 40 and the engine exhaust heat recovery unit 70 are disposed.

[0027] The refrigerant circuit 110 includes: a four-way valve 111; a bridge circuit 112; a high pressure gas refrigerant path 113a; a first low pressure gas refrigerant path 113b; a first gas refrigerant path 113c; a first refrigerant path 113d; a high pressure liquid refrigerant path 113e; a first low pressure gas-liquid two phase refrigerant path 113f; a second refrigerant path 113g; a second gas refrigerant path 113h; a second low pressure gas-liquid two phase refrigerant path 113i; and a second low pressure gas refrigerant path 113j.

[0028] The four-way valve 111 is switched, in response to an instruction signal from the control device 140, between a first connection state (state shown in FIG. 2) in which an inlet (lower side in FIG. 2) is connected to one connection port (left side in FIG. 2) and furthermore the other connection port (right side in FIG. 2) is connected to an outlet (upper side in FIG. 2), and a second connection state in which the inlet is connected to the other connection port and furthermore the one connection port is connected to the outlet. Thus, the four-way valve 111 can switch the flowing direction of the refrigerant.

[0029] The bridge circuit 112 includes four check valves (a first check valve 112a, a second check valve 112b, a third check valve 112c and a fourth check valve 112d), and is constituted by a first check valve line 1121 including two check valves (the first check valve 112a and the second check valve 112b) and a second check valve line 1122 including the remaining two check valves (the third check valve 112c and the fourth check valve 112d).

[0030] The first check valve line 1121 is constituted by the first check valve 112a and the second check valve 112b that are connected in series so that the refrigerant flows in the same direction. The second check valve line 1122 is constituted by the third check valve 112c and the fourth check valve 112d that are connected in series so that the refrigerant flows in the same direction. Furthermore, the first check valve line 1121 and the second check valve line 1122 are connected in parallel so that the refrigerant flows in the same direction.

[0031] In the bridge circuit 112, a connection point between the first check valve 112a and the second check valve 112b is referred to as a first intermediate connection point P1, a connection point between the first check valve 112a and the third check valve 112c is referred to as an outlet connection point P2, a connection point between the third check valve 112c and the fourth check valve 112d is referred to as a second intermediate connection point P3, and a connection point between the second check valve 112b and the fourth check valve 112d is referred to as an inlet connection point P4.

[0032] The high pressure gas refrigerant path 113a connects a discharge port of the compressor 10 and the inlet of the four-way valve 111. The first low pressure gas refrigerant path 113b connects the outlet of the four-way valve 111 and a suction port of the compressor 10. The first gas refrigerant path 113c connects the one connection port of the four-way valve 111 and one connection port of the refrigerant-air heat exchanger 20. The first refrigerant path 113d connects the other connection port of the refrigerant-air heat exchanger 20 and the first intermediate connection point P1 of the bridge circuit 112. The high pressure liquid refrigerant path 113e connects the outlet connection point P2 of the bridge circuit 112 and one side of the expansion valve 40 (specifically, the first expansion valve 41 and the second expansion valve 42). The first low pressure gas-liquid two phase refrigerant path 113f connects the other side of the first expansion valve 41 constituting the expansion valve 40 and the inlet connection point P4 of the bridge circuit 112. The second refrigerant path 113g connects the second intermediate connection point P3 of the bridge circuit 112 and one refrigerant connection port of the refrigerant-circulating liquid heat exchanger 50. The second gas refrigerant path 113h connects the other refrigerant connection port of the refrigerant-circulating liquid heat exchanger 50 and the other connection port of the four-way valve 111. The second low pressure gas-liquid two phase refrigerant path 113i connects the other side of the second expansion valve 42 constituting the expansion valve 40 and a refrigerant inlet of the engine exhaust heat recovery unit 70. The second low pressure gas refrigerant path 113j connects a refrigerant outlet of the engine exhaust heat recovery unit 70 and a confluence point P5 located in the middle of the first low pressure gas refrigerant path 113b. In the first low pressure gas refrigerant path 113b, the downstream side of the confluence point

P5 (the side of the compressor 10) is referred to as a confluence path 113b1.

[0033] The respective opening degrees of the first expansion valve 41 and the second expansion valve 42 can be adjusted in response to the instruction signal from the control device 140. Thus, the amount of the refrigerant circulating in the refrigerant circuit 110 can be adjusted by the first expansion valve 41 and the second expansion valve 42. Specifically, the first expansion valve 41 and the second expansion valve 42 are configured by connecting a plurality of closable expansion valves in parallel. In this way, the first expansion valve 41 and the second expansion valve 42 can adjust the amount of the refrigerant circulating in the refrigerant circuit 110 by being combined as the expansion valve(s) to be opened.

[0034] In this embodiment, the chiller 100 further includes an oil separator 81, an accumulator 82 and a receiver 83.

[0035] The oil separator 81 is disposed in the high pressure gas refrigerant path 113a, and separates a lubricant oil of the compressor 10 contained in the refrigerant so as to return the separated lubricant oil to the compressor 10 via a valve 81a (more specifically, a solenoid valve). The accumulator 82 is disposed in the confluence path 113b1 of the first low pressure gas refrigerant path 113b, and separates the liquid refrigerant that has not been completely evaporated by the refrigerant-circulating liquid heat exchanger 50 serving as an evaporator or by the refrigerant-air heat exchanger 20 serving as an evaporator. The receiver 83 is disposed in the high pressure liquid refrigerant path 113e, and temporarily stores the high pressure liquid refrigerant from the bridge circuit 112.

[0036] The coolant path 120 constitutes the path for the engine coolant that cools the engine 60, and includes a first thermostat type switching valve 121, a second thermostat type switching valve 122, a radiator 123, an outlet path 124a, an inlet path 124b, and a first path 124c to a fifth path 124g.

[0037] The outlet path 124a connects an outlet of the engine 60 and an inlet (lower side in FIG. 2) of the first thermostat type switching valve 121. The inlet path 124b connects an outlet of the radiator 123 and an inlet of the engine 60. The first path 124c connects one outlet (upper side in FIG. 2) of the first thermostat type switching valve 121 and an inlet (left side in FIG. 2) of the second thermostat type switching valve 122. The second path 124d connects the other outlet (right side in FIG. 2) of the first thermostat type switching valve 121 and an inlet of the radiator 123. The third path 124e connects one outlet (upper side in FIG. 2) of the second thermostat type switching valve 122 and a coolant inlet of the engine exhaust heat recovery unit 70. The fourth path 124f connects the other outlet (right side in FIG. 2) of the second thermostat type switching valve 122 and a confluence point P6 located in the middle of the inlet path 124b. The fifth path 124g connects a coolant outlet of the engine exhaust heat recovery unit 70 and a confluence point P7 located upstream of the confluence point P6 of the inlet path 124b. The circulation pump 130 is disposed in the inlet path 124b, between the inlet of the engine 60 and the confluence point P6. The circulation pump 130 circulates the engine coolant in the coolant path 120 in response to the instruction signal from the control device 140. The engine exhaust heat recovery unit 70 belongs to both of the refrigerant circuit 110 and the coolant path 120.

[0038] The first thermostat type switching valve 121 flows the engine coolant from the engine 60 toward the second thermostat type switching valve 122 when the temperature of the engine coolant is less than a predetermined first temperature (for example, 71°C). On the other hand, the first thermostat type switching valve 121 flows the engine coolant from the engine 60 toward the radiator 123 when the temperature of the engine coolant is not less than the first temperature. Thus, the coolant path 120 can circulate the engine coolant toward the second thermostat type switching valve 122 when the temperature of the engine coolant is less than the first temperature, while it can circulate the engine coolant toward the radiator 123 when the temperature of the engine coolant is not less than the first temperature.

[0039] The second thermostat type switching valve 122 flows the engine coolant from the first thermostat type switching valve 121 toward both of the engine exhaust heat recovery unit 70 and the confluence point P6 of the inlet path 124b when the temperature of the engine coolant is less than a predetermined second temperature (for example, 60°C) that is lower than the first temperature. On the other hand, the second thermostat type switching valve 122 flows the engine coolant from the first thermostat type switching valve 121 toward the engine exhaust heat recovery unit 70 when the temperature of the engine coolant is not less than the second temperature. Thus, the coolant path 120 can circulate the engine coolant toward both of the engine exhaust heat recovery unit 70 and the confluence point P6 of the inlet path 124b when the temperature of the engine coolant is less than the second temperature, while it can circulate the engine coolant toward the engine exhaust heat recovery unit 70 when the temperature of the engine coolant is not less than the second temperature but less than the first temperature.

[0040] The temperature of the engine coolant can be detected by a temperature sensor (not shown) disposed in the coolant path 120.

[0041] The inlet branch pipe 211, which is a part of the circulating liquid circuit 200, connects a circulating liquid inlet of the refrigerant-circulating liquid heat exchanger 50 and a branch portion of the inlet main pipe 210 (see FIG. 1) corresponding to the chiller 100. The outlet branch pipe 221, which is a part of the circulating liquid circuit 200, connects a circulating liquid outlet of the refrigerant-circulating liquid heat exchanger 50 and a confluence portion of the outlet main pipe 220 (see FIG. 1) corresponding to the chiller 100. The refrigerant-circulating liquid heat exchanger 50 belongs to both of the refrigerant circuit 110 and the circulating liquid circuit 200.

[0042] The compressor 10 is connected to the engine 60 via a clutch 11. The clutch 11 switches, in response to the instruction signal from the control device 140, between a connection state in which the drive force is transmitted from the engine 60 to the compressor 10 and a block state in which the transmission of the drive force from the engine 60 to the compressor 10 is blocked.

[0043] The chiller 100 further includes a first pressure sensor 151, a first temperature sensor 161, a second pressure sensor 152, a second temperature sensor 162 and a rotation speed sensor 170.

[0044] The first pressure sensor 151 and the first temperature sensor 161 are disposed in the confluence path 113b1, and detect respectively the pressure and the temperature of the refrigerant in the confluence path 113b1. The second pressure sensor 152 and the second temperature sensor 162 are disposed in the second low pressure gas refrigerant path 113j, and detect respectively the pressure and the temperature of the refrigerant in the second low pressure gas refrigerant path 113j. The rotation speed sensor 170 is disposed in the engine 60, and detects the rotational speed of the engine 60.

[0045] The circulating liquid circuit 200 includes an influent circulating liquid temperature sensor 231 and an effluent circulating liquid temperature sensor 232.

[0046] Specifically, the influent circulating liquid temperature sensor 231 is disposed in the inlet branch pipe 211, and detects the temperature of the circulating liquid that flows into the refrigerant-circulating liquid heat exchanger 50 (more specifically, the circulating liquid in the inlet branch pipe 211). The effluent circulating liquid temperature sensor 232 is disposed in the outlet branch pipe 221, and detects the temperature of the circulating liquid that flows out of the refrigerant-circulating liquid heat exchanger 50 (more specifically, the circulating liquid in the outlet branch pipe 221).

[0047] The control device 140 controls, according to detection signals from various sensors, driving of the refrigerant circuit 110, the coolant path 120 and the circulating liquid circuit 200. Thus, the chiller 100 can adjust the temperature of the circulating liquid that flows in the circulating liquid circuit 200.

[0048] Specifically, the control device 140 causes the compressor 10 to compress the refrigerant that is sucked from the first low pressure gas refrigerant path 113b and to discharge the compressed refrigerant to the high pressure gas refrigerant path 113a. When the cooling operation to cool the circulating liquid in the circulating liquid circuit 200 is performed, the control device 140 makes the four-way valve 111 a first connection state in which the high pressure gas refrigerant path 113a is communicated with the first gas refrigerant path 113c and furthermore the second gas refrigerant path 113h is communicated with the first low pressure gas refrigerant path 113b. Also, when the heating operation to heat the circulating liquid in the circulating liquid circuit 200 is performed, the control device 140 makes the four-way valve 111 a second connection state in which the high pressure gas refrigerant path 113a is communicated with the second gas refrigerant path 113h and furthermore the first gas refrigerant path 113c is communicated with the first low pressure gas refrigerant path 113b.

[0049] The refrigerant-air heat exchanger 20 serves as a condenser to cause the refrigerant to release heat and liquefy during cooling operation, and serves as an evaporator to cause the refrigerant to absorb heat and vaporize during heating operation. The refrigerant-circulating liquid heat exchanger 50 serves as a cooler to cause the refrigerant to absorb heat and cool the circulating liquid during cooling operation, and serves as a heater to cause the refrigerant to release heat and heat the circulating liquid during heating operation. The engine exhaust heat recovery unit 70 serves as an evaporator to cause the refrigerant to absorb heat and vaporize.

[0050] The first expansion valve 41 and the second expansion valve 42 are arranged, in parallel, downstream of the bridge circuit 112. In response to the instruction signal from the control device 140, the first expansion valve 41 adjusts the flow rate of the refrigerant that flows toward the refrigerant-circulating liquid heat exchanger 50 via the bridge circuit 112 during cooling operation, and adjusts the flow rate of the refrigerant that flows toward the refrigerant-air heat exchanger 20 via the bridge circuit 112 during heating operation. The second expansion valve 42 adjusts, in response to the instruction signal from the control device 140, the flow rate of the refrigerant that flows toward the engine exhaust heat recovery unit 70.

[0051] The control device 140 includes a processor 141 constituted of a microcomputer such as a CPU (central processing unit), and a memory 142 including a non-volatile memory such as a ROM (read only memory) and a volatile memory such as a RAM (random access memory).

[0052] In the control device 140, the processor 141 executes a control program previously stored in the ROM of the memory 142 by loading the control program on the RAM of the memory 142. Thus, operations of the respective component elements are controlled.

[0053] With the chiller 100 as described above, it is possible to adjust the temperature of the circulating liquid that flows in the circulating liquid circuit 200 by performing appropriately the cooling operation or the heating operation.

[0054] First, the cooling operation performed by the chiller 100 will be described with reference to FIG. 3. Next, the heating operation performed by the chiller 100 will be described with reference to FIG. 4.

[Cooling Operation]

[0055] FIG. 3 is a schematic block diagram showing the chiller 100 that performs the cooling operation.

[0056] When the chiller 100 performs the cooling operation, the control device 140 switches the four-way valve 111 to the first connection state in which the high pressure gas refrigerant path 113a is communicated with the first gas refrigerant path 113c and furthermore the second gas refrigerant path 113h is communicated with the first low pressure gas refrigerant path 113b. In this way, the refrigerant in a state of high pressure gas (hereinafter referred to as the "high pressure gas refrigerant") that is discharged from the compressor 10 flows into the refrigerant-air heat exchanger 20 via the oil separator 81.

[0057] The temperature of the high pressure gas refrigerant that flows into the refrigerant-air heat exchanger 20 is higher than the temperature of the air that passes through the refrigerant-air heat exchanger 20. For this reason, the heat is transferred from the high pressure gas refrigerant to the air. As a result, the high pressure gas refrigerant loses the condensation heat and liquefies, thus becomes the refrigerant in a state of a high pressure liquid (hereinafter referred to as the "high pressure liquid refrigerant"). That is, in the cooling operation, the refrigerant-air heat exchanger 20 serves as a condenser of the refrigerant, in which the high pressure gas refrigerant releases heat.

[0058] The high pressure liquid refrigerant flows from the refrigerant-air heat exchanger 20 to the first intermediate connection point P1 of the bridge circuit 112 via the first refrigerant path 113d. Since the first intermediate connection point P1 is located on the outlet side of the second check valve 112b and on the inlet side of the first check valve 112a, the high pressure liquid refrigerant does not flow to the second check valve 112b and the third check valve 112c, but flows to the high pressure liquid refrigerant path 113e from the first intermediate connection point P1, via the first check valve 112a and the outlet connection point P2.

[0059] When the control device 140 performs the cooling operation, it opens the first expansion valve 41 and closes the second expansion valve 42, so that the high pressure liquid refrigerant flows through the first expansion valve 41 but does not flow through the second expansion valve 42. Thus, the high pressure liquid refrigerant passes through the first expansion valve 41 via the receiver 83 disposed in the high pressure liquid refrigerant path 113e.

[0060] When passing through the first expansion valve 41, the high pressure liquid refrigerant expands and becomes a refrigerant in a state of a low pressure gas-liquid two phase (hereinafter referred to as the "low pressure gas-liquid two phase refrigerant"). The low pressure gas-liquid two phase refrigerant flows from the first low pressure gas-liquid two phase refrigerant path 113f to the inlet connection point P4 of the bridge circuit 112. The inlet connection point P4 is located on the inlet side of the second check valve 112b and the fourth check valve 112d. However, as described above, the high pressure liquid refrigerant flows through the first intermediate connection point P1 and the outlet connection point P2. For this reason, the low pressure gas-liquid two phase refrigerant does not flow to the second check valve 112b and the third check valve 112c because of the pressure difference from the high pressure liquid refrigerant that flows through the first intermediate connection point P1 and the outlet connection point P2. The low pressure gas-liquid two phase refrigerant flows from the inlet connection point P4 to the refrigerant-circulating liquid heat exchanger 50 via the fourth check valve 112d, the second intermediate connection point P3 and the second refrigerant path 113g.

[0061] The temperature of the low pressure gas-liquid two phase refrigerant that flows on the side of the refrigerant circuit 110 relative to the refrigerant-circulating liquid heat exchanger 50 is lower than the temperature of the circulating liquid that flows on the side of the circulating liquid circuit 200 relative to the refrigerant-circulating liquid heat exchanger 50. For this reason, the heat is transferred from the circulating liquid to the low pressure gas-liquid two phase refrigerant. As a result, the low pressure gas-liquid two phase refrigerant obtains the evaporation heat and vaporizes, thus becomes the refrigerant in a state of a low pressure gas (hereinafter referred to as the "low pressure gas refrigerant"). On the other hand, the circulating liquid is cooled by the heat absorbing action of the refrigerant. That is, in the cooling operation, the refrigerant-circulating liquid heat exchanger 50 serves as a cooler of the circulating liquid, in which the low pressure gas-liquid two phase refrigerant absorbs heat.

[0062] After that, the low pressure gas refrigerant flows from the refrigerant-circulating liquid heat exchanger 50 to the second gas refrigerant path 113h. At this time, the control device 140 communicates the second gas refrigerant path 113h with the first low pressure gas refrigerant path 113b by the four-way valve 111. Thus, the low pressure gas refrigerant is sucked into the compressor 10 via the accumulator 82 disposed in the first low pressure gas refrigerant path 113b.

[0063] In the chiller 100, the above-described series of operations as the cooling operation are repeatedly performed.

[Heating Operation]

[0064] FIG. 4 is a schematic block diagram showing the chiller 100 that performs the heating operation.

[0065] When the chiller 100 performs the heating operation, the control device 140 switches the four-way valve 111 to the second connection state in which the high pressure gas refrigerant path 113a is communicated with the second gas refrigerant path 113h and furthermore the first gas refrigerant path 113c is communicated with the first low pressure gas refrigerant path 113b. In this way, the high pressure gas refrigerant that is discharged from the compressor 10 flows into the refrigerant-circulating liquid heat exchanger 50 via the oil separator 81.

[0066] The temperature of the high pressure gas refrigerant that flows on the side of the refrigerant circuit 110 relative to the refrigerant-circulating liquid heat exchanger 50 is higher than the temperature of the circulating liquid that flows on the side of the circulating liquid circuit 200 relative to the refrigerant-circulating liquid heat exchanger 50. For this reason, the heat is transferred from the high pressure gas refrigerant to the circulating liquid. As a result, the high pressure gas refrigerant loses the condensation heat and liquefies, thus becomes the high pressure liquid refrigerant. On the other hand, the circulating liquid is heated by the heat releasing action of the refrigerant. That is, in the heating operation, the refrigerant-circulating liquid heat exchanger 50 serves as a heater of the circulating liquid, in which the high pressure gas refrigerant releases heat.

[0067] The high pressure liquid refrigerant flows from the refrigerant-circulating liquid heat exchanger 50 to the second intermediate connection point P3 of the bridge circuit 112 via the second refrigerant path 113g. Since the second intermediate connection point P3 is located on the inlet side of the third check valve 112c and on the outlet side of the fourth check valve 112d, the high pressure liquid refrigerant does not flow to the first check valve 112a and the fourth check valve 112d, but flows to the high pressure liquid refrigerant path 113e from the second intermediate connection point P3, via the third check valve 112c and the outlet connection point P2.

[0068] When the control device 140 performs the heating operation, it opens the first expansion valve 41 and closes the second expansion valve 42, so that the high pressure liquid refrigerant flows through the first expansion valve 41 but does not flow through the second expansion valve 42. Thus, the high pressure liquid refrigerant passes through the first expansion valve 41 via the receiver 83 disposed in the high pressure liquid refrigerant path 113e.

[0069] When passing through the first expansion valve 41, the high pressure liquid refrigerant expands and becomes the low pressure gas-liquid two phase refrigerant. The low pressure gas-liquid two phase refrigerant flows from the first low pressure gas-liquid two phase refrigerant path 113f to the inlet connection point P4 of the bridge circuit 112. The inlet connection point P4 is located on the inlet side of the second check valve 112b and the fourth check valve 112d. However, as described above, the high pressure liquid refrigerant flows through the second intermediate connection point P3 and the outlet connection point P2. For this reason, the low pressure gas-liquid two phase refrigerant does not flow to the fourth check valve 112d and the first check valve 112a because of the pressure difference from the high pressure liquid refrigerant that flows through the second intermediate connection point P3 and the outlet connection point P2. The low pressure gas-liquid two phase refrigerant flows from the inlet connection point P4 to the refrigerant-air heat exchanger 20 via the second check valve 112b and the first refrigerant path 113d.

[0070] The temperature of the low pressure gas-liquid two phase refrigerant that flows through the refrigerant-air heat exchanger 20 is lower than the temperature of the air that passes through the refrigerant-air heat exchanger 20. For this reason, the heat is transferred from the air to the low pressure gas-liquid two phase refrigerant. As a result, the low pressure gas-liquid two phase refrigerant obtains the evaporation heat and vaporizes, thus becomes the low pressure gas refrigerant. That is, in the heating operation, the refrigerant-air heat exchanger 20 serves as an evaporator of the refrigerant, in which the low pressure gas-liquid two phase refrigerant absorbs heat.

[0071] After that, the low pressure gas refrigerant flows from the refrigerant-air heat exchanger 20 to the first gas refrigerant path 113c. At this time, the control device 140 communicates the first gas refrigerant path 113c with the first low pressure gas refrigerant path 113b by the four-way valve 111. Thus, the low pressure gas refrigerant is sucked into the compressor 10 via the accumulator 82 disposed in the first low pressure gas refrigerant path 113b.

[0072] In the chiller 100, the above-described series of operations as the heating operation are repeatedly performed.

[Defrost Operation]

[0073] During heating operation, the low pressure gas-liquid two phase refrigerant is supplied to the refrigerant-air heat exchanger 20, thus piping in the refrigerant-air heat exchanger 20 is cooled. In this case, frost may adheres to the piping in the refrigerant-air heat exchanger 20 depending on conditions such as an outside air temperature. Then, the chiller 100 performs the defrost operation.

[0074] Next, the defrost operation performed by the chiller 100 will be described with reference to FIG. 5.

[0075] FIG. 5 is a schematic block diagram showing the chiller 100 that performs the defrost operation.

[0076] When the chiller 100 performs the defrost operation, the control device 140 switches, as in the cooling operation, the four-way valve 111 to the first connection state in which the high pressure gas refrigerant path 113a is communicated with the first gas refrigerant path 113c and furthermore the second gas refrigerant path 113h is communicated with the first low pressure gas refrigerant path 113b. In this way, the high pressure gas refrigerant that is discharged from the compressor 10 flows into the refrigerant-air heat exchanger 20 via the oil separator 81.

[0077] The high pressure gas refrigerant that flows through the refrigerant-air heat exchanger 20 loses, as in the cooling operation, the condensation heat and liquefies, thus becomes the high pressure liquid refrigerant. That is, in the defrost operation, the refrigerant-air heat exchanger 20 serves as a condenser of the refrigerant, in which the high pressure gas refrigerant releases heat.

[0078] Similarly to the cooling operation, the high pressure liquid refrigerant flows from the refrigerant-air heat exchanger 20 to the high pressure liquid refrigerant path 113e via the first refrigerant path 113d, and the first intermediate connection point P1, the first check valve 112a and the outlet connection point P2 of the bridge circuit 112.

[0079] When the control device 140 performs the defrost operation, it opens the second expansion valve 42 and closes the first expansion valve 41, so that the high pressure liquid refrigerant flows through the second expansion valve 42 but does not flow through the first expansion valve 41. Thus, the high pressure liquid refrigerant passes through the second expansion valve 42 via the receiver 83 disposed in the high pressure liquid refrigerant path 113e.

[0080] When passing through the second expansion valve 42, the high pressure liquid refrigerant expands and becomes the low pressure gas-liquid two phase refrigerant. The low pressure gas-liquid two phase refrigerant flows from the second low pressure gas-liquid two phase refrigerant path 113i to the engine exhaust heat recovery unit 70.

[0081] The temperature of the low pressure gas-liquid two phase refrigerant that flows on the side of the refrigerant circuit 110 relative to the engine exhaust heat recovery unit 70 is lower than the temperature of the engine coolant that flows on the side of the coolant path 120 relative to the engine exhaust heat recovery unit 70. For this reason, the heat is transferred from the engine coolant to the low pressure gas-liquid two phase refrigerant. As a result, the low pressure gas-liquid two phase refrigerant obtains the evaporation heat and vaporizes, thus becomes the low pressure gas refrigerant. That is, in the defrost operation, the engine exhaust heat recovery unit 70 serves as an evaporator of the refrigerant, in which the low pressure gas-liquid two phase refrigerant absorbs heat.

[0082] After that, the low pressure gas refrigerant flows from the engine exhaust heat recovery unit 70, and is sucked into the compressor 10 via the second low pressure gas refrigerant path 113j, the confluence point P5 of the first low pressure gas refrigerant path 113b, the confluence path 113b1, and the accumulator 82.

[0083] In the chiller 100, the above-described series of operations as the defrost operation are repeatedly performed.

[0084] In the defrost operation, the high pressure gas refrigerant is supplied to the refrigerant-air heat exchanger 20, thus, the piping in the refrigerant-air heat exchanger 20 is heated. As a result, frost that adheres to the refrigerant-air heat exchanger 20 is removed by the heating operation. Furthermore, in the defrost operation, since the low pressure gas-liquid two phase refrigerant does not flow to the refrigerant-circulating liquid heat exchanger 50, the decrease in the temperature of the circulating liquid according to evaporation of the refrigerant does not occur.

[Control on Each Chiller in Chiller System]

[0085] In the chiller system 1 in which the plurality of chillers 100 (1) to 100 (n) is connected to each other, when performing the defrost operation so as to remove frost that adheres to the piping in the refrigerant-air heat exchanger 20, the temperature of the circulating liquid is not regulated (i.e., the heating operation is not performed) during defrost operation. Therefore, if the chillers 100 not less than a predetermined number (especially, all of the chillers 100 (1) to 100 (n)) perform the defrost operation at the same time, the regulation of the temperature of the circulating liquid cannot be sufficiently (or cannot be at all) preformed.

[0086] In this regard, in the conventional chiller system as described above, when the respective chillers send the request for the defrost operation, only the predetermined number of chillers are permitted to simultaneously perform the defrost operation, and when the number of chillers that can simultaneously perform the defrost operation is not less than two, the defrost operation is permitted to the chillers in arrival order up to the number of the chillers that can simultaneously perform the defrost operation (see Patent Document 2). However, the conventional system does not have a configuration to determine the priority of the chillers on standby for the defrost operation.

[0087] In consideration of the above circumstances, the chiller system 1 according to this embodiment includes a control mechanism to control the operation of each chiller 100 (1) to 100 (n) as described below.

[0088] That is, in this embodiment, the control mechanism is an aggregate of the respective control devices 140 of the chillers 100 (1) to 100 (n). The control devices 140 (1) to 140 (n) are connected to each other in order to communicate with each other. In the chiller system 1, one chiller is designated as a master chiller (i) (i is an integer of from 1 to n) out of the plurality of chillers 100 (1) to 100 (n). Note that the control mechanism may be a control device that integrally controls the chillers 100 (1) to 100 (n) and that is provided separated from the chillers 100 (1) to 100 (n).

[0089] The chillers 100 (1) to 100 (n) perform the defrost operation for defrost control to remove frost that adheres to the refrigerant-air heat exchanger 20. The chiller 100 performing the heating operation determines, for example, that the defrost operation is required when the continuous execution time of the heating operation exceeds a predetermined time. The defrost control is prepared to address a case in which it is determined that the defrost operation is required. The defrost control is to cause the chillers 100, which determine that the defrost operation is needed while performing the heating operation, to perform the defrost operation until the number of the chillers to perform reaches a permitted number to perform simultaneously the defrost operation, without causing the chillers 100 that are beyond the predetermined number of the chillers (i.e., permitted number of the chillers to perform simultaneously the defrost operation) to perform the defrost operation.

[0090] In this embodiment, the permitted number of the chillers to perform simultaneously the defrost operation can be set to the number adding one chiller to the value that is obtained by: dividing the number, which is obtained by subtracting one chiller from the number of the connected chillers 100, by a permission reference number (in this example, four chillers) that serves as the reference for permitting the defrost operation; and rounding the above-obtained value down to the nearest whole number .

[0091] That is, when the connected number is represented as n (n ≥ 2) and the permission reference number is represented as c, the permitted number m for simultaneous defrost operation can be calculated by the following expression (1):

$$m = \mathrm{INT}\ [(n-1) / c] + 1 \qquad \text{(Expression (1))}$$

where "INT" in the above expression (1) is a function for rounding down the value obtained by the expression in the square brackets [(n-1) / c] to the nearest whole number.

[0092] For example, in the case where the permission reference number c is set to 4, when the connected number n is in the range of not less than 2 to not more than 4, the permitted number m for simultaneous defrost operation is 1. When the connected number n is in the range of not less than 5 to not more than 8, the permitted number m for simultaneous defrost operation is 2.

[0093] When the plurality of chillers 100 (1) to 100 (n) (servant chillers and the master chiller 100 (i)) determines that the defrost operation is required, the chillers 100 that need the defrost operation send the request for the defrost operation (specifically, transmit a signal to request the defrost operation) to the master chiller 100 (i) (specifically, the control device 140(i)). If the chiller 100 that sends the request for the defrost operation is the master chiller 100 (i) itself, the master chiller 100 (i) sends the request for the defrost operation to itself.

[0094] Also, the master chiller 100 (i) permits the defrost operation (specifically, transmits a signal to permit the defrost operation) to the chillers, out of the chillers 100 that have sent the request for the defrost operation to the master chiller 100 (i), in arrival order of the requests up to the permitted number m for simultaneous defrost operation. If the chiller 100 that receives the permission of the defrost operation is the master chiller 100 (i) itself, the master chiller 100 (i) receives the permission of the defrost operation.

[0095] For example, when the connected number n of the chillers 100 is set to eight, and when the arrival of the request for the defrost operation from each chiller 100 (1), 100 (4) and 100 (6) to 100 (8) to the master chiller 100 (i) is in the order of: the chiller 100 (1); the chiller 100 (4); the chiller 100 (6); the chiller 100 (7); and the chiller 100 (8), the master chiller 100 (i) permits the defrost operation to the chiller 100 (1) and the chiller 100 (4) in arrival order of the requests up to the permitted number m for simultaneous defrost operation (in this example, two chillers).

[0096] Also, in the chillers 100 (1) to 100 (n), the chiller 100 on standby for the defrost operation sends the request for the defrost operation (specifically, transmit the signal to request the defrost operation) to the master chiller 100 (i) in a predetermined cycle (specifically, at each processing time).

[0097] Here, the chiller 100 on standby means the chiller that sends the request for the defrost operation to the master chiller 100 (i) while the master chiller 100 (i) does not permit the defrost operation (i.e., inhibits the defrost operation).

[0098] When a plurality of chillers 100 on standby for the defrost operation exists, the master chiller 100 (i) permits a next defrost operation in descending order of the number of the requests or the request time for the defrost operation (the number of the requests in the example shown in FIGS. 6 to 10 described later). Here, the number of the requests for the defrost operation means the total number of the requests for the defrost operation by the chiller 100 that needs the defrost operation from the first request for the defrost operation to the latest permission determination of the defrost operation by the master chiller 100 (i). Also, the request time for the defrost operation means the total request time from the first request for the defrost operation by the chiller 100 that needs the defrost operation to the latest permission determination of the defrost operation by the master chiller 100 (i).

[0099] Identification numbers that differ from one another (in this example, 1 to n) are respectively given to the chillers 100 (1) to 100 (n). When the chillers 100 send the same number of the requests or have the same request time for the defrost operation, the master chiller 100 (i) permits the next defrost operation in ascending order or in descending order of the identification number (in ascending order in the example shown in FIGS. 6 to 10).

[0100] FIGS. 6 to 8 are conceptual diagrams of one example of the chiller system 1 in which the connected number n of the chillers 100 is set to eight, showing a state in which the chillers 100 (1) to 100 (8) send the request for the defrost operation to the master chiller 100 (i) and the master chiller 100 (i) permits or inhibits the defrost operation to the chillers100 (1) to 100 (8).

[0101] In the example shown in FIGS. 6 to 8, the total operation capacity of six chillers 100 out of the chillers 100 (1) to 100 (8) is sufficient with respect to the load capacity, accordingly, two chillers 100 (3) and 100 (5) are stopped while six chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8) perform the heating operation. Specifically, out of the chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8) that perform the heating operation, the chillers 100 (1), 100 (4) and 100 (6) to 100 (8) determine that the defrost operation is needed and send the request for the defrost operation to the master chiller 100 (i). Among such chillers that have sent the request for the defrost operation, the top two chillers 100 in request arrival order are the chiller 100 (1) and the chiller 100 (4), in this order. The priority of the remaining chillers 100 (6) to

100 (8) is in the order of the chiller 100 (6), the chiller 100 (8) and the chiller 100 (7), in descending order of the number of the requests for the defrost operation.

[0102] That is, in FIG. 6, the master chiller 100 (i) permits the defrost operation in arrival order to the two chillers 100 (1) and 100 (4) that have sent the request for the defrost operation earlier, and inhibits the three chillers 100 (6) to 100 (8) that have sent the request later than the two chillers 100 (1) and 100 (4) from performing the defrost operation.

[0103] In FIG. 7, after termination of the defrost operation of the two chillers 100 (1) and 100 (4) shown in FIG. 6, the master chiller 100 (i) permits the defrost operation, in descending order of the number of the requests for the defrost operation, to the two chillers 100 (6) and 100 (8) on standby that have sent a greater number of requests, and inhibits the chiller 100 (7) that has sent a smaller number of requests than the two chillers 100 (6) and 100 (8) from performing the defrost operation (i.e., the chiller 100 (7) is continuously in the standby state).

[0104] Also, in FIG. 8, after termination of the defrost operation of the two chillers 100 (6) and 100 (8) shown in FIG. 7, the master chiller 100 (i) permits the defrost operation to the remaining one chiller 100 (7).

[0105] FIG. 9 is a graph showing a temperature regulating capacity of the chiller system 1 and a timing chart of respective operation states of the chillers 100 (1) to 100 (8) in the example in FIGS. 6 to 8.

[0106] In FIG. 9, the term "Thermo-ON" means that the compressor 10 is being operated, and the "Thermo-OFF" means that the compressor 10 is being stopped. Also, the "Defrost operation ON" means that the defrost operation is being operated, and the "Defrost operation OFF" means that the defrost operation is not being operated. In the example shown in FIGS. 6 to 9, the chillers 100 (1), 100 (2), 100 (4), and 100 (6) to 100 (8) in the thermo-ON state perform the heating operation when they are in the defrost operation OFF state. They perform the defrost operation when they are in the defrost operation ON state. Furthermore, the originally stopped chillers 100 (3) and 100 (5) are being stopped when they are in the thermo-OFF state, and perform the heating operation in the thermo-ON state.

(Operation of Master Chiller to Control Each Chiller)

[0107] Hereinafter, the operation of the master chiller 100 (i) to control each chillers 100 (1) to 100 (n) will be described with reference to the example shown in FIGS. 6 to 9.

[0108] FIG. 10 is a flowchart showing steps of one example of operations for the defrost control by the master chiller (i) to the respective chillers 100 (1) to 100 (n).

[0109] In the chiller system 1, when two chillers 100 (3) and 100 (5) are stopped and six chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8) perform the heating operation out of the eight chillers 100 (1) to 100 (8) (see α1 in FIG. 9), the chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8) performing the heating operation determine whether the defrost operation is needed or not (step S1). According to determination results, when five chillers 100 (1), 100 (4) and 100 (6) to 100 (8) need the defrost operation out of the six chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8) performing the heating operation, the chillers 100 (1), 100 (4) and 100 (6) to 100 (8) that need the defrost operation set respective defrost request flags FLa (1), FLa (4) and FLa (6) to FLa (8) to ON (see FIG. 6) so as to send the request for the defrost operation to the master chiller 100 (i) (step S2). Here, the defrost request flags FLa (1) to FLa (8) and defrost permission flags FLb (1) to FLb (8) (described later) are in the OFF state in the initial state.

[0110] Next, the master chiller 100 (i) sets, among the defrost permission flags FLb (1) to FLb (8) respectively corresponding to the chillers 100 (1) to 100 (8), the defrost permission flags FLb (1) and FLb (4) to ON (see FIG. 6) to the chillers 100 (chillers 100 (1) and 100 (4) in this example) in the arrival order of the requests for the defrost operation up to the permitted number m for simultaneous defrost operation (two chillers in this example), out of the chillers 100 (chillers 100 (1), 100 (4) and 100 (6) to 100 (8) in this example) that send the request for the defrost operation to the master chiller 100 (i). Thus, the master chiller 100 (i) permits the defrost operation to the chillers 100 (1) and 100 (4) corresponding to the permitted number (two chillers in this example) for simultaneous defrost operation in arrival order of the requests for the defrost operation (step S3).

[0111] Then, the two chillers 100 (1) and 100 (4) permitted to perform the defrost operation are switched from the heating operation to the defrost operation (step S4). Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is reduced by two, thus becomes four (i.e., chillers 100 (2) and 100 (6) to 100 (8)), which results in reduction in the air conditioning capacity (see α2 in FIG. 9). For this reason, the master chiller 100 (i) switches the two stopped chillers 100 (3) and 100 (5) in the thermo-OFF state to the thermo-ON state so that they perform the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (four chillers) is increased by two, thus becomes six (i.e., chillers 100 (2), 100 (3), 100 (5) and 100 (6) to 100 (8)) (see α3 in FIG. 9).

[0112] Next, while the chillers 100 (1) and 100 (4) are continuously performing the defrost operation (step S5: No), the chillers 100 (6) to 100 (8) on standby for the defrost operation send the request for the defrost operation to the master chiller 100 (i) in the predetermined cycle (step S6). On the other hand, when the frost is removed from the chillers 100 (1) and 100 (4) performing the defrost operation and the defrost operation is not necessary any more (step S5: Yes), the defrost operation is terminated (step S7) and the defrost request flags FLa (1) and FLa (4) are set to OFF. Thus, the master chiller 100 (i) sets the defrost permission flags FLb (1) and FLb (4) to OFF (see FIG. 7).

[0113] Then, the two chillers 100 (1) and 100 (4) that have set the defrost request flags FLa (1) and FLa (4) to OFF are returned from the defrost operation to the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is increased by two, thus becomes eight (i.e., chillers 100 (1) to 100 (8)), which results in increase in the air conditioning capacity (see α4 in FIG. 9). For this reason, the master chiller 100 (i) switches the two chillers 100 (3) and 100 (5), which are performing the heating operation in the thermo-ON state despite the originally stopped state, to the thermo-OFF state so that they are stopped. Thus, the number of the chillers 100 performing the heating operation (eight chillers) is reduced by two, thus becomes six (i.e., chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8)) (see α5 in FIG. 9).

[0114] Next, the procedure advances to step S10 via step S8 (step S8: Yes) and step S9 (step S9: Yes), where the master chiller 100 (i) rearranges the priority of the chillers 100 (chillers 100 (6) to 100 (8) in this example) that send the request for the defrost operation to the master chiller 100 (i) in descending order of the number of the requests for the defrost operation. If the chillers 100 send the same number of the requests, the master chiller 100 (i) rearranges their priority in ascending order of the identification number (step S10). Thus, the priority of the chillers 100 (6) to 100 (8) is in the order of: the chiller (6); the chiller (8); and the chiller (7). In this example, since the number of the requests from the chiller 100 (8) is greater than that from the chiller 100 (7), the priority of the chillers 100 (6) to 100 (8) is in the order of the chiller 100 (6), the chiller 100 (8) and the chiller 100 (7). However, if the chiller 100 (8) and the chiller 100 (7) send the same number of the requests, the priority of the chillers 100 (6) to 100 (8) is in the order of the chiller (6), the chiller (7) and the chiller (8), because the chiller 100 (8) has the identification number of "8" while the chiller 100 (7) has the identification number of "7".

[0115] After that, the master chiller 100 (i) sets, among the defrost permission flags FLb (1) to FLb (8) respectively corresponding to the chillers 100 (1) to 100 (8), the defrost permission flags FLb (6) and FLb (8) to ON (see FIG. 7) to the chillers 100 (chillers 100 (6) and 100 (8) in this example), in descending order of the number of the requests for the defrost operation or in ascending order of the identification number in case of the chillers sending the same number of the requests, up to the permitted number m for simultaneous defrost operation (two chillers in this example), out of the chillers 100 (chillers 100 (6) to 100 (8) in this example) that send the request for the defrost operation to the master chiller 100 (i). Thus, the master chiller 100 (i) permits the defrost operation to the chillers 100 (6) and 100 (8) corresponding to the permitted number (here, two chillers) for simultaneous defrost operation in descending order of the number of the requests for the defrost operation or in ascending order of the identification number in case of the chillers sending the same number of the requests (step S11).

[0116] Then, the two chillers 100 (6) and 100 (8) permitted to perform the defrost operation are switched from the heating operation to the defrost operation (step S4). Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is reduced by two, thus becomes four (i.e., chillers 100 (1), 100 (2), 100 (4) and 100 (7)), which results in reduction in the air conditioning capacity (see α6 in FIG. 9). For this reason, the master chiller 100 (i) switches the two stopped chillers 100 (3) and 100 (5) in the thermo-OFF state to the thermo-ON state so that they perform the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (four chillers) is increased by two, thus becomes six (i.e., chillers 100 (1) to 100 (5) and 100 (7)) (see α7 in FIG. 9).

[0117] Next, while the chillers 100 (6) and 100 (8) are continuously performing the defrost operation (step S5: No), the chiller 100 (7) on standby for the defrost operation sends the request for the defrost operation to the master chiller 100 (i) in the predetermined cycle (step S6). On the other hand, when the frost is removed from the chillers 100 (6) and 100 (8) performing the defrost operation and the defrost operation is not necessary any more (step S5: Yes), the defrost operation is terminated (step S7) and the defrost request flags FLa (6) and FLa (8) are set to OFF. Thus, the master chiller 100 (i) sets the defrost permission flags FLb (6) and FLb (8) to OFF (see FIG. 8).

[0118] Then, the two chillers 100 (6) and 100 (8) that have set the defrost request flags FLa (6) and FLa (8) to OFF are returned from the defrost operation to the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is increased by two, thus becomes eight (i.e., chillers 100 (1) to 100 (8)), which results in increase in the air conditioning capacity (see α8 in FIG. 9). For this reason, the master chiller 100 (i) switches the two chillers 100 (3) and 100 (5), which are performing the heating operation in the thermo-ON state despite the originally stopped state, to the thermo-OFF state so that they are stopped. Accordingly, the number of the chillers 100 performing the heating operation (eight chillers) is reduced by two, thus becomes six (i.e., chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8)) (see α9 in FIG. 9).

[0119] Next, the procedure advances to step S12 via step S8 (step S8: Yes) and step S9 (step S9: No), where the master chiller 100 (i) sets, among the defrost permission flags FLb (1) to FLb (8) respectively corresponding to the chillers 100 (1) to 100 (8), the defrost permission flag FLb (7) to ON (see FIG. 8) to the remaining one chiller 100 (chiller 100 (7) in this example) that sends the request for the defrost operation to the master chiller 100 (i). Thus, the master chiller 100 (i) permits the defrost operation to the remaining one chiller 100 (7) (step S12).

[0120] Then, the one chiller 100 (7) permitted to perform the defrost operation is switched from the heating operation to the defrost operation (step S4). Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is reduced by one, thus becomes five (i.e., chillers 100 (1), 100 (2), 100 (4), 100 (6) and 100 (8)), which results in reduction in the air conditioning capacity (see α10 in FIG. 9). For this reason, the master chiller 100 (i) switches the one stopped chillers 100 (chiller 100 (3) in this example) in the thermo-OFF state to the thermo-ON state so that it performs the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (five chillers) is increased by one, thus becomes six (i.e., chillers 100 (1) to 100 (4), 100 (6) and 100 (8)) (see α11 in FIG. 9).

[0121] Next, when the frost is removed from the chiller 100 (7) performing the defrost operation and the defrost operation is not necessary any more (step S5: Yes), the defrost operation is terminated (step S7) and the defrost request flag FLa (7) is set to OFF. Thus, the master chiller 100 (i) sets the defrost permission flag FLb (7) to OFF.

[0122] Then, the one chiller 100 (7) that has set the defrost request flag FLa (7) to OFF is returned from the defrost operation to the heating operation. Accordingly, the number of the chillers 100 performing the heating operation (six chillers) is increased by one, thus becomes seven (i.e., chillers 100 (1) to 100 (4) and 100 (6) to 100 (8)), which results in increase in the air conditioning capacity (see α12 in FIG. 9). For this reason, the master chiller 100 (i) switches the one chiller 100 (3), which is performing the heating operation in the thermo-ON state despite the originally stopped state, to the thermo-OFF state so that it is stopped. Accordingly, the number of the chillers 100 performing the heating operation (seven chillers) is reduced by one, thus becomes six (i.e., chillers 100 (1), 100 (2), 100 (4) and 100 (6) to 100 (8)) (see α13 in FIG. 9).

[0123] When there remains no chiller 100 on standby for the defrost operation (step S8: No), the defrost control is terminated.

[0124] In the example shown in FIGS. 6 to 10, the number of the chillers 100 is set to eight. However, the number of the chillers 100 is not limited thereto. The number of the chillers 100 may be in the range of two to seven or may be nine or more.

[0125] Also, in the example shown in FIGS. 6 to 10, when a plurality of chillers on standby for the defrost operation exists, the next defrost operation is permitted to the chiller in descending order of the number of the requests. However, the priority is not limited thereto. The next defrost operation may be permitted to the chiller in descending order of the request time.

[0126] In the example shown in FIGS. 6 to 10, when the chillers 100 send the same number of the requests for the defrost operation, the master chiller 100 (i) permits the next defrost operation to the chiller in ascending order of the identification number. However, the next defrost operation may be permitted to the chiller in descending order of the identification number.

(Embodiment of Present Invention)

[0127] As described above, with the chiller system 1 according to this embodiment, the control mechanism (master chiller 100 (i) in this example) permits the defrost operation to the chillers, out of the chillers 100 that have sent the request for the defrost operation, in arrival order of the requests for the defrost operation up to the predetermined number (permitted number m for simultaneous defrost operation). The chiller 100 on standby for the defrost operation sends the request for the defrost operation to the control mechanism (master chiller 100 (i) in this example) in the predetermined cycle. When a plurality of chillers 100 on standby for the defrost operation exists, the master chiller 100 (i) permits the next defrost operation to the chiller in descending order of the number of the requests or the request time for the defrost operation. Thus, it is possible to permit the next defrost operation to the chiller among the chillers 100 on standby for the defrost operation in descending order of necessity. Therefore, it is possible to determine the priority of the chillers 100 on standby for the defrost operation when permitting the defrost operation in arrival order up to the predetermined number of chillers.

[0128] Also, in this embodiment, when the chillers 100 send the same number of the requests or have the same request time for the defrost operation, the control mechanism (master chiller 100 (i) in this example) permits the next defrost operation in ascending order or in descending order of the identification number. Thus, it is possible to reliably determine the priority of the chillers 100 even when the chillers 100 on standby for the defrost operation send the same number of the requests or have the same request time for the defrost operation.

[0129] The present invention is not limited to the above-described embodiment, and may be embodied in other forms without departing from the gist or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects as illustrative and not limiting. The scope of the invention is indicated by the appended claims rather than by the foregoing description, and all modifications and changes that come within the meaning and range of equivalency of the claims are intended to be embraced therein.

[0130] This application claims priority based on Patent Application No. 2014-129487 filed in Japan on June 24, 2014. The entire contents thereof are hereby incorporated in this application by reference.

Industrial Applicability

[0131] The present invention relates to a chiller system in which a plurality of heat pump chillers is connected to each other. The present invention is particularly suitable for determining the priority of the chillers on standby for the defrost operation when permitting the defrost operation to the chillers in arrival order up to the predetermined number of chillers.

Description of Reference Numerals

[0132]

1	Chiller system
10	Compressor
11	Clutch
20	Refrigerant-air heat exchanger
30	Refrigerant-air heat exchanger fan
40	Expansion valve
41	First expansion valve
42	Second expansion valve
50	Refrigerant-circulating liquid heat exchanger
60	Engine
70	Engine exhaust heat recovery unit
81	Oil separator
81a	Valve
82	Accumulator
83	Receiver
100	Chiller
110	Refrigerant circuit
111	Four-way valve
112	Bridge circuit
1121	First check valve line
1122	Second check valve line
112a	First check valve
112b	Second check valve
112c	Third check valve
112d	Fourth check valve
113a	High pressure gas refrigerant path
113b	First low pressure gas refrigerant path
113b1	Confluence path
113c	First gas refrigerant path
113d	First refrigerant path
113e	High pressure liquid refrigerant path
113f	First low pressure gas-liquid two phase refrigerant path
113g	Second refrigerant path
113h	Second gas refrigerant path
113i	Second low pressure gas-liquid two phase refrigerant path
113j	Second low pressure gas refrigerant path
120	Coolant path
121	First thermostat type switching valve
122	Second thermostat type switching valve
123	Radiator
124a	Outlet path
124b	Inlet path
124c	First path
124d	Second path
124e	Third path
124f	Fourth path
124g	Fifth path
130	Circulation pump
140	Control device
141	Processor
142	Memory

151	First pressure sensor
152	Second pressure sensor
161	First temperature sensor
162	Second temperature sensor
170	Rotation speed sensor
200	Circulating liquid circuit
210	Inlet main pipe
211	Inlet branch pipe
220	Outlet main pipe
221	Outlet branch pipe
231	Influent circulating liquid temperature sensor
232	Effluent circulating liquid temperature sensor
300	Circulation pump
FLa	Defrost request flag
FLb	Defrost permission flag
P1	First intermediate connection point
P2	Outlet connection point
P3	Second intermediate connection point
P4	Inlet connection point
P5	Confluence point
P6	Confluence point
P7	Confluence point
c	Permission reference number
m	Permitted number for simultaneous defrost operation
n	Connected number

Claims

1. A chiller system comprising a plurality of heat pump chillers being connected to each other, the plurality of heat pump chillers regulating a temperature of a circulating liquid as a heat medium for temperature regulation by condensation heat or evaporation heat of a refrigerant,
wherein any one of the plurality of chillers is designated as a master chiller,
wherein, out of the plurality of chillers, at least one chiller that needs a defrost operation sends a request for the defrost operation to the master chiller,
wherein the master chiller permits the defrost operation to the at least one chiller that has sent the request for the defrost operation in arrival order up to a predetermined number of chillers,
wherein, at least one chiller on standby for the defrost operation sends the request for the defrost operation to the master chiller in a predetermined cycle, and
wherein, when there are multiple chillers that are on standby for the defrost operation, the master chiller permits a next defrost operation to one of the multiple chillers on standby in descending order of a number of the requests or a request time for the defrost operation.

2. The chiller system according to claim 1,
wherein, when the chillers on standby send a same number of the requests or have a same request time for the defrost operation, the master chiller permits the next defrost operation to one of the chillers on standby in ascending order or in descending order of an identification number.

3. A chiller system comprising a plurality of heat pump chillers being connected to each other, the plurality of heat pump chillers regulating a temperature of a circulating liquid as a heat medium for temperature regulation by condensation heat or evaporation heat of a refrigerant,
wherein the chiller system includes a control mechanism configured to control operations of the plurality of chillers,
wherein, out of the plurality of chillers, at least one chiller that needs a defrost operation sends a request for the defrost operation to the control mechanism,
wherein the control mechanism permits the defrost operation to the at least one chiller that has sent the request for the defrost operation in arrival order up to a predetermined number of chillers,
wherein, at least one chiller on standby for the defrost operation sends the request for the defrost operation to the control mechanism in a predetermined cycle, and

wherein, when there are multiple chillers that are on standby for the defrost operation, the control mechanism permits a next defrost operation to one of the multiple chillers on standby in descending order of a number of the requests or a request time for the defrost operation.

FIG.1

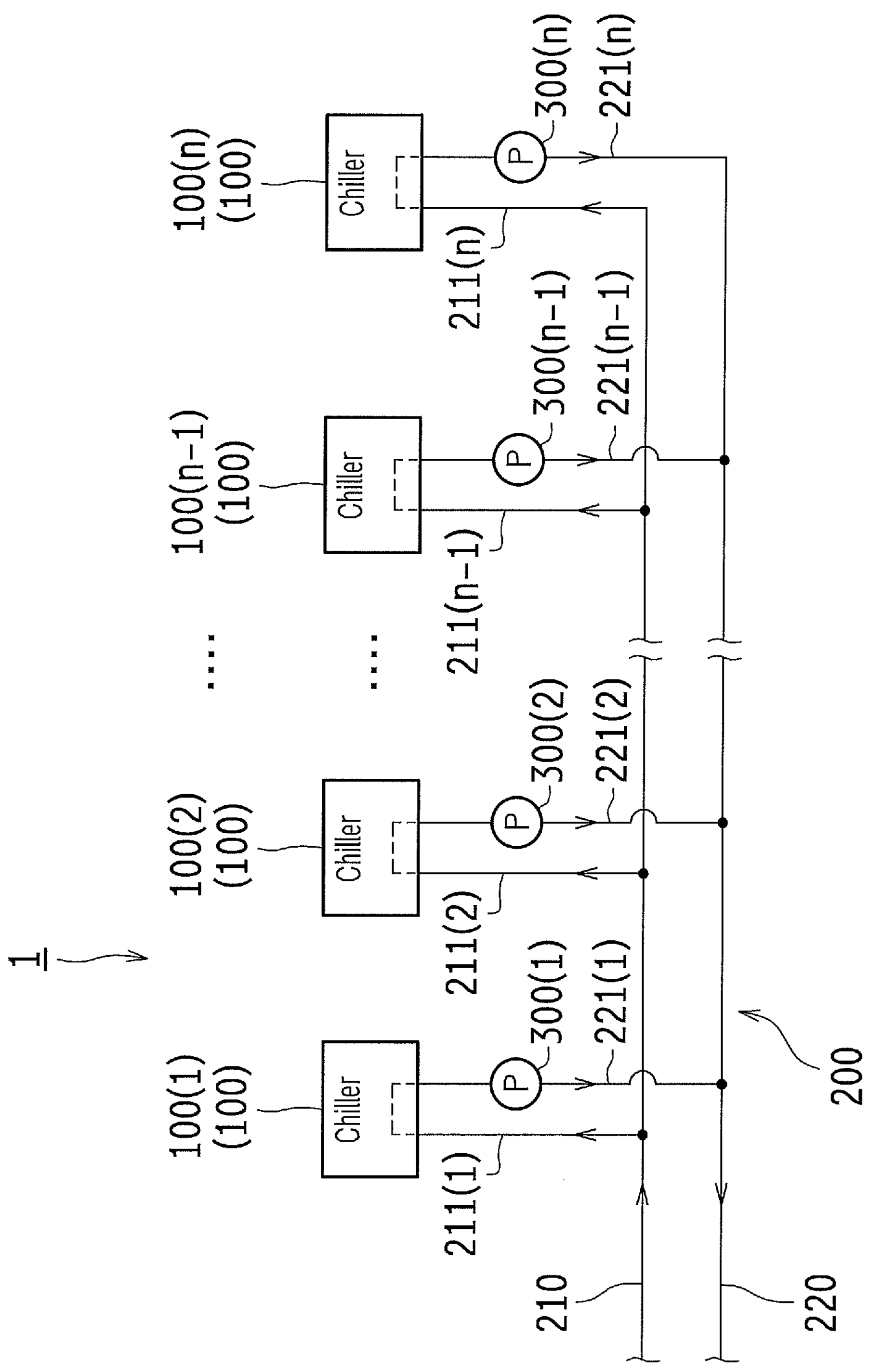

1
Chiller
100(1)
(100)
100(2)
(100)
100(n-1)
(100)
100(n)
(100)
300(1)
300(2)
300(n-1)
300(n)
211(1)
211(2)
211(n-1)
211(n)
221(1)
221(2)
221(n-1)
221(n)
200
210
220

FIG.2

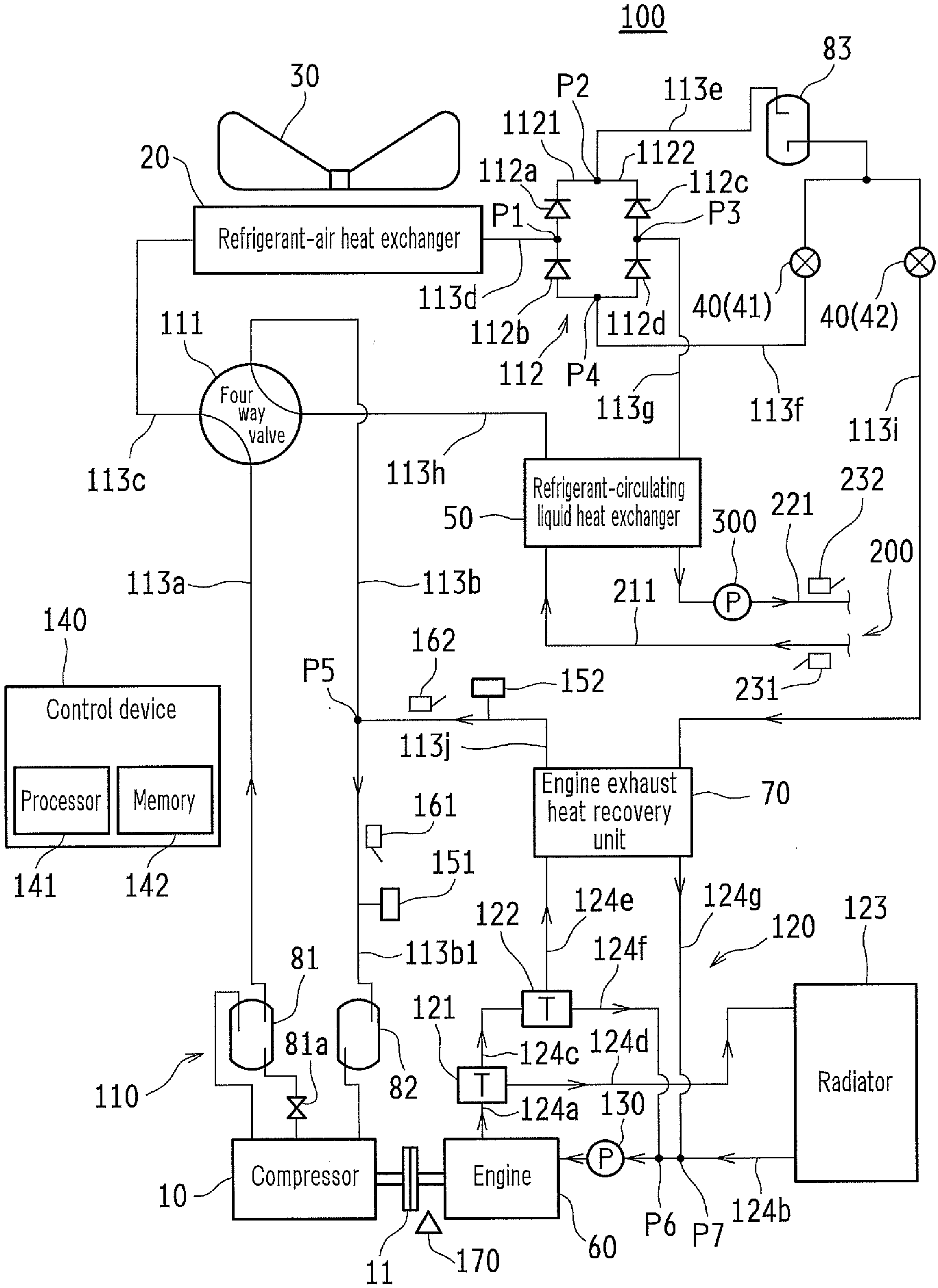

100
30
20
Refrigerant-air heat exchanger
P2
113e
83
1121
1122
112a
112c
P1
P3
113d
112b
112d
40(41)
40(42)
111
112
P4
Four way valve
113g
113f
113i
113c
113h
Refrigerant-circulating liquid heat exchanger
50
300
221
232
200
113a
113b
211
140
162
Control device
P5
152
231
113j
Processor
Memory
Engine exhaust heat recovery unit
70
141
142
161
151
122
124e
124g
120
123
81
113b1
124f
121
81a
124c
124d
110
82
T
T
Radiator
124a
130
P
Compressor
Engine
10
P6
P7
124b
60
11
170
P
P

FIG.3

(Cooling operation)

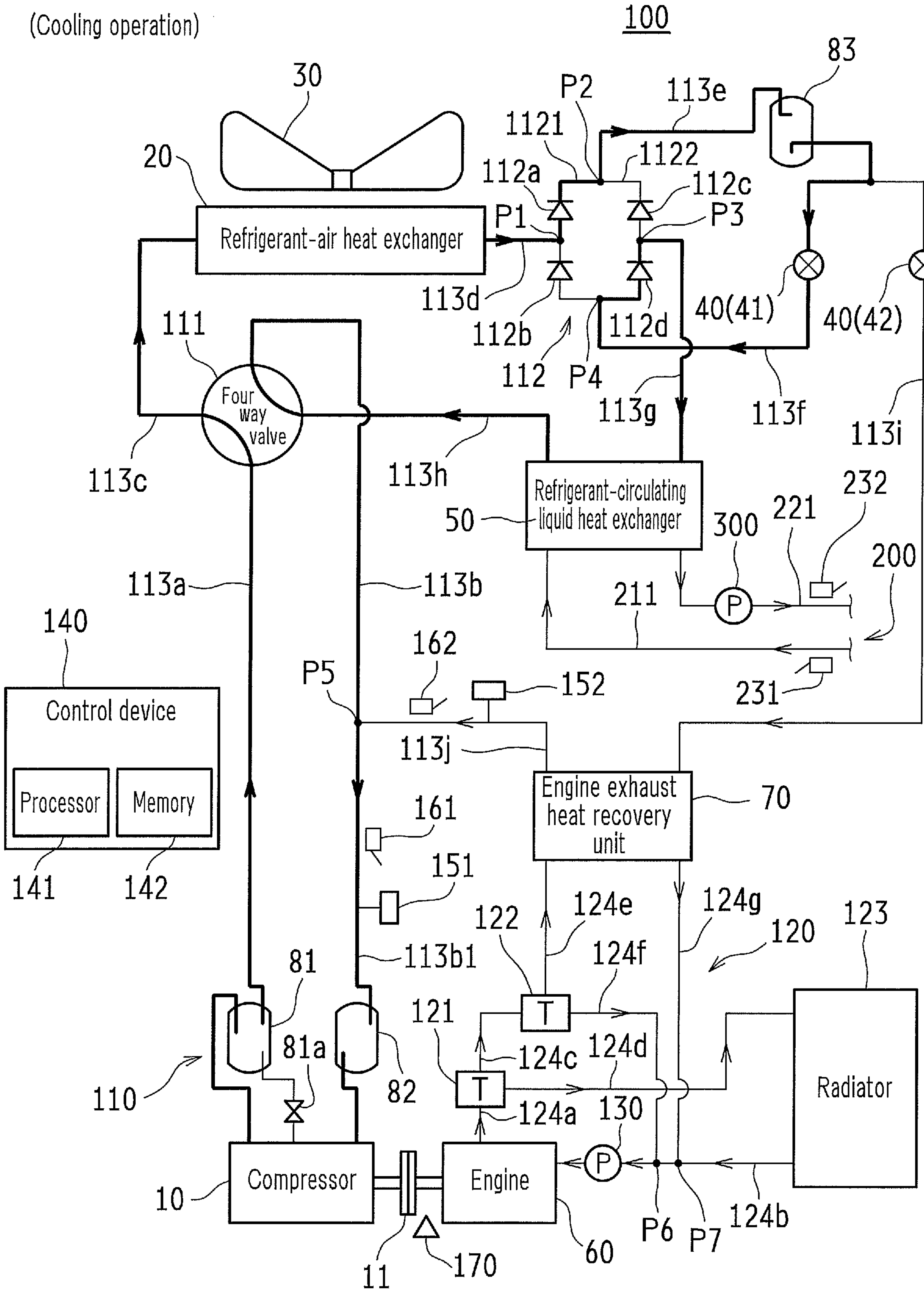


FIG.4

(Heating operation)

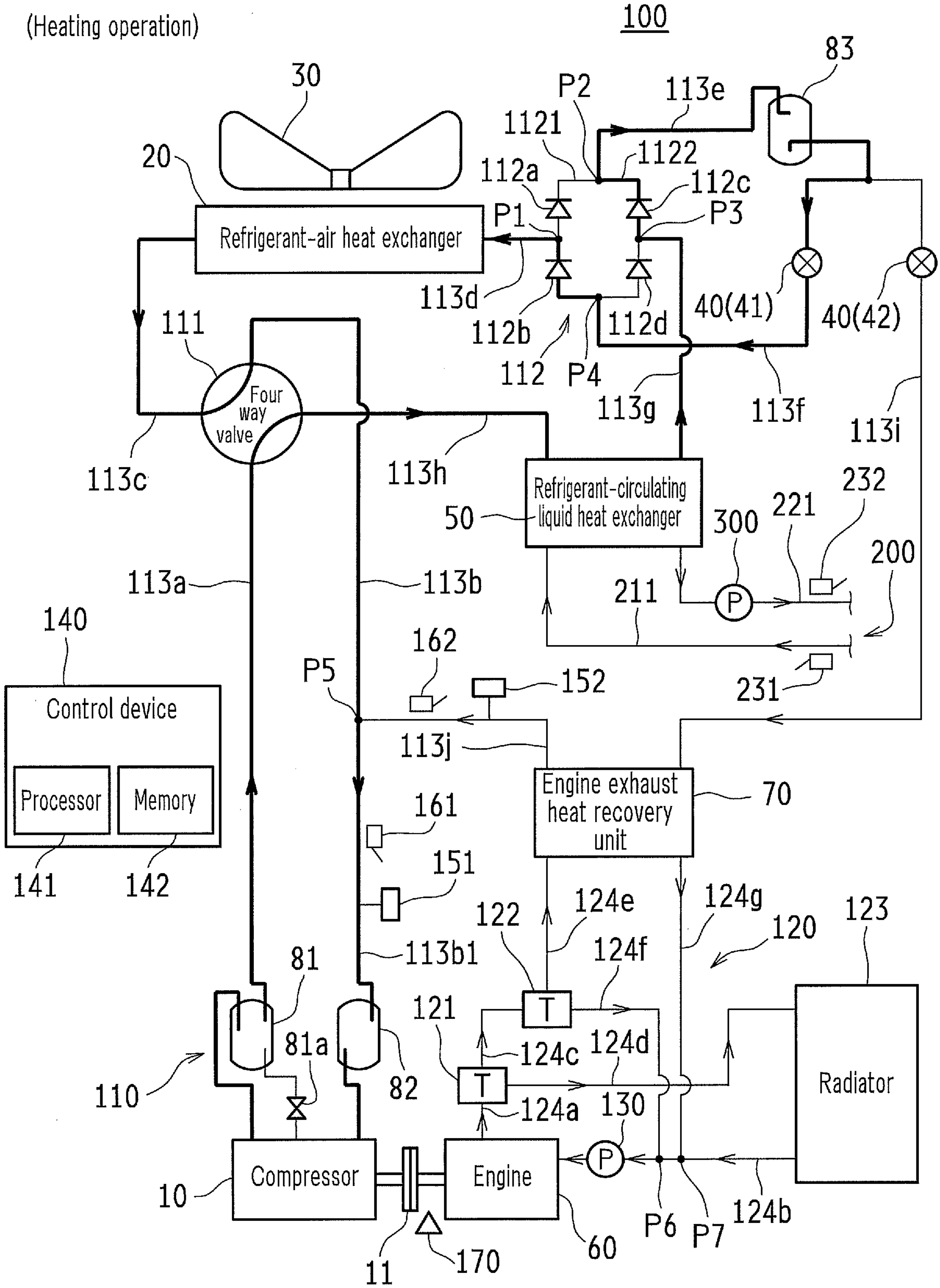


FIG.5

(Defrost operation)

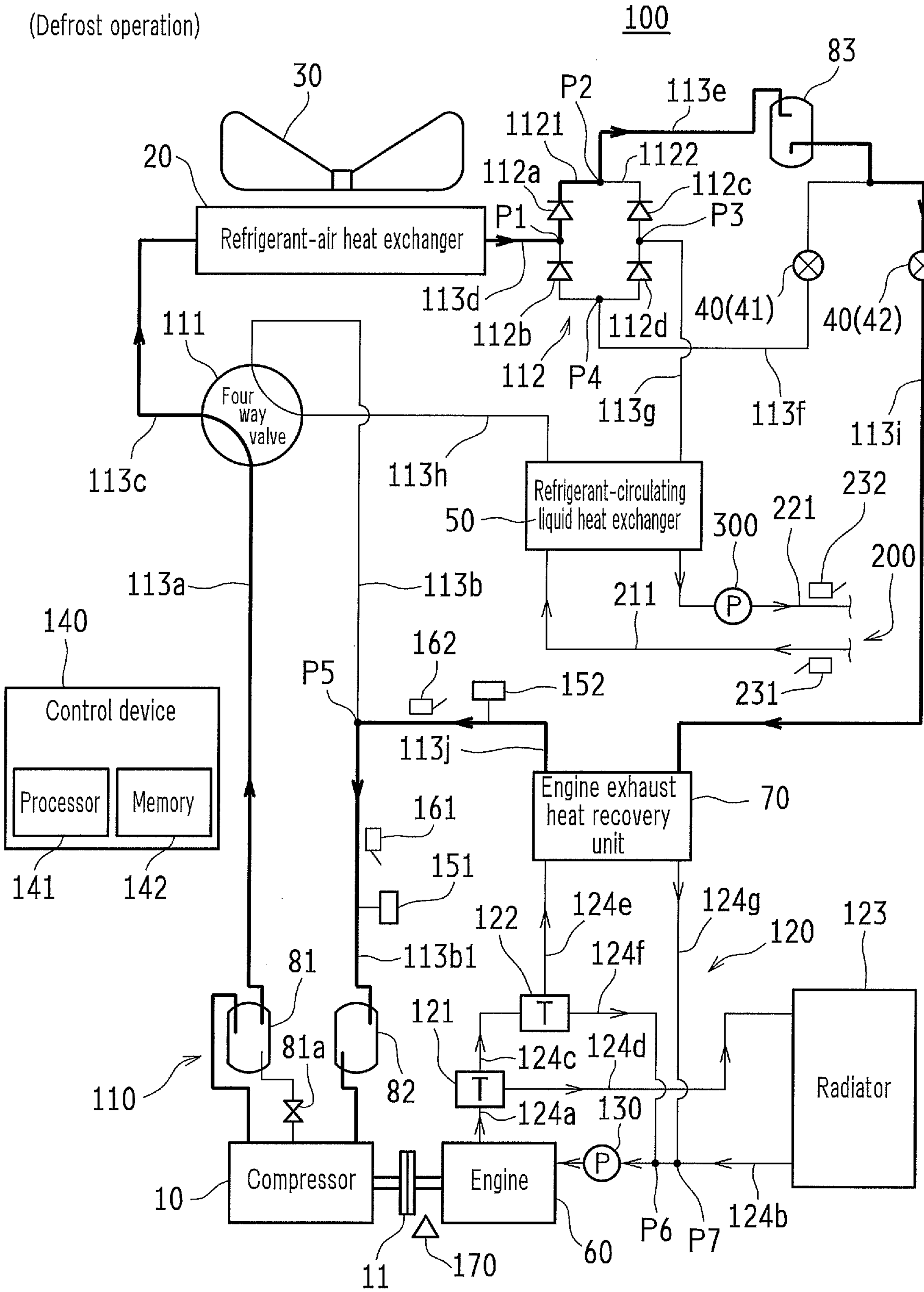


FIG.6

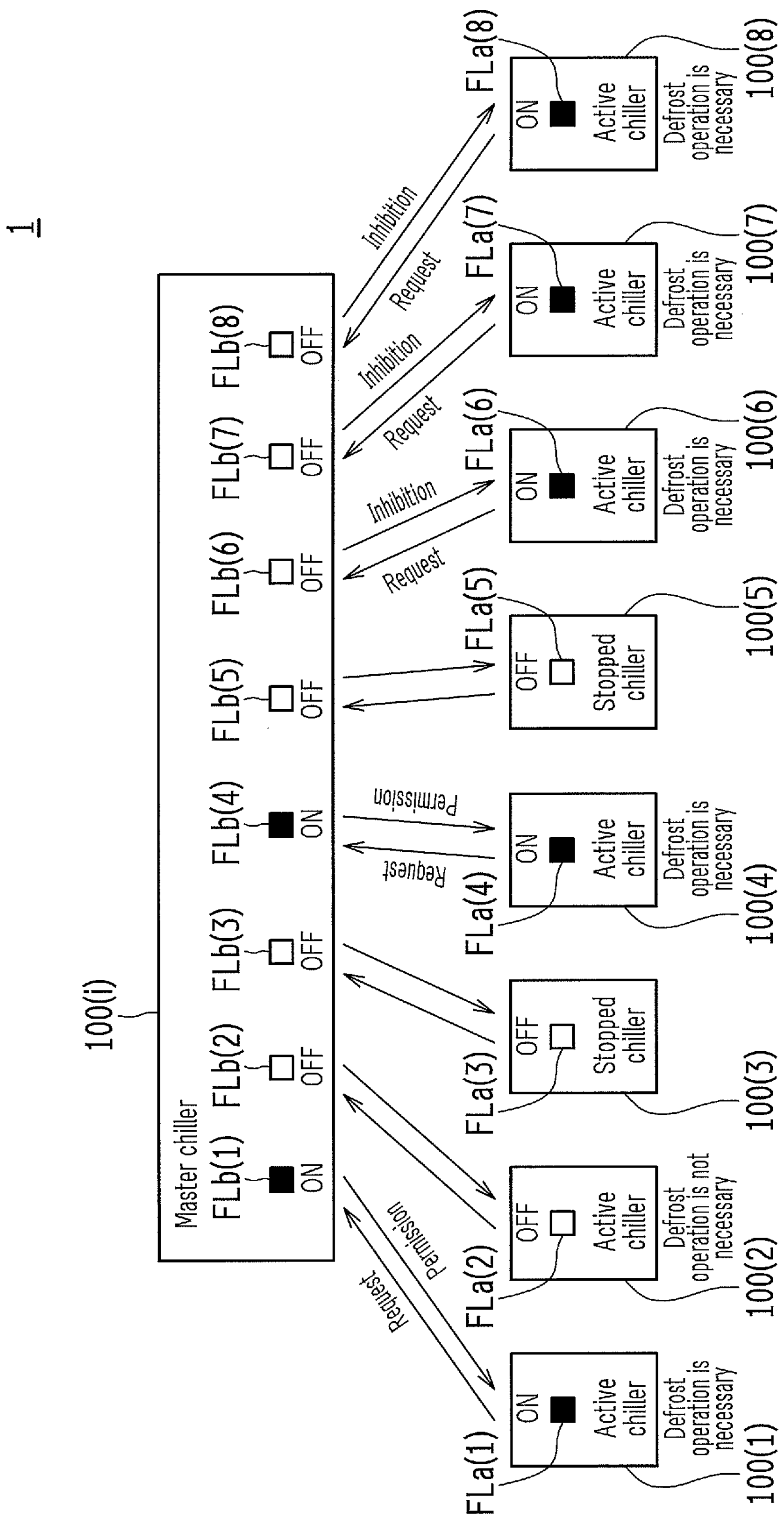

1
100(i)
Master chiller
FLb(1)
ON
FLb(2)
OFF
FLb(3)
OFF
FLb(4)
ON
FLb(5)
OFF
FLb(6)
OFF
FLb(7)
OFF
FLb(8)
OFF
Request
Permission
Request
Permission
Request
Inhibition
Request
Inhibition
Request
Inhibition
FLa(1)
ON
Active chiller
Defrost operation is necessary
100(1)
FLa(2)
OFF
Active chiller
Defrost operation is not necessary
100(2)
FLa(3)
OFF
Stopped chiller
100(3)
FLa(4)
ON
Active chiller
Defrost operation is necessary
100(4)
FLa(5)
OFF
Stopped chiller
100(5)
FLa(6)
ON
Active chiller
Defrost operation is necessary
100(6)
FLa(7)
ON
Active chiller
Defrost operation is necessary
100(7)
FLa(8)
ON
Active chiller
Defrost operation is necessary
100(8)

FIG.7

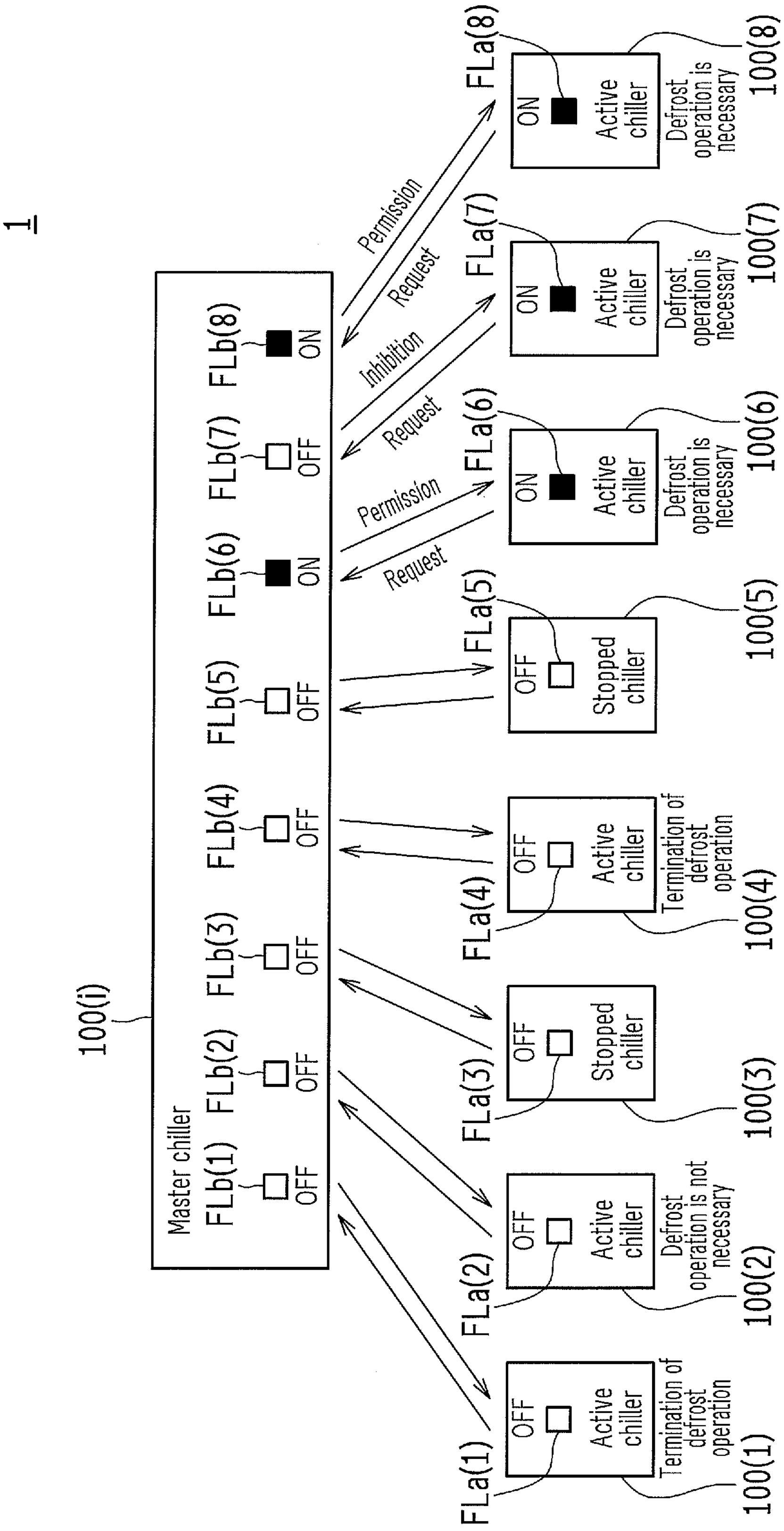

1
100(i)
Master chiller
FLb(1)
OFF
FLb(2)
OFF
FLb(3)
OFF
FLb(4)
OFF
FLb(5)
OFF
FLb(6)
ON
FLb(7)
OFF
FLb(8)
ON
Permission
Request
Inhibition
Request
Permission
Request
FLa(1)
OFF
Active chiller
Termination of defrost operation
100(1)
FLa(2)
OFF
Active chiller
Defrost operation is not necessary
100(2)
FLa(3)
OFF
Stopped chiller
100(3)
FLa(4)
OFF
Active chiller
Termination of defrost operation
100(4)
FLa(5)
OFF
Stopped chiller
100(5)
FLa(6)
ON
Active chiller
Defrost operation is necessary
100(6)
FLa(7)
ON
Active chiller
Defrost operation is necessary
100(7)
FLa(8)
ON
Active chiller
Defrost operation is necessary
100(8)

FIG.8

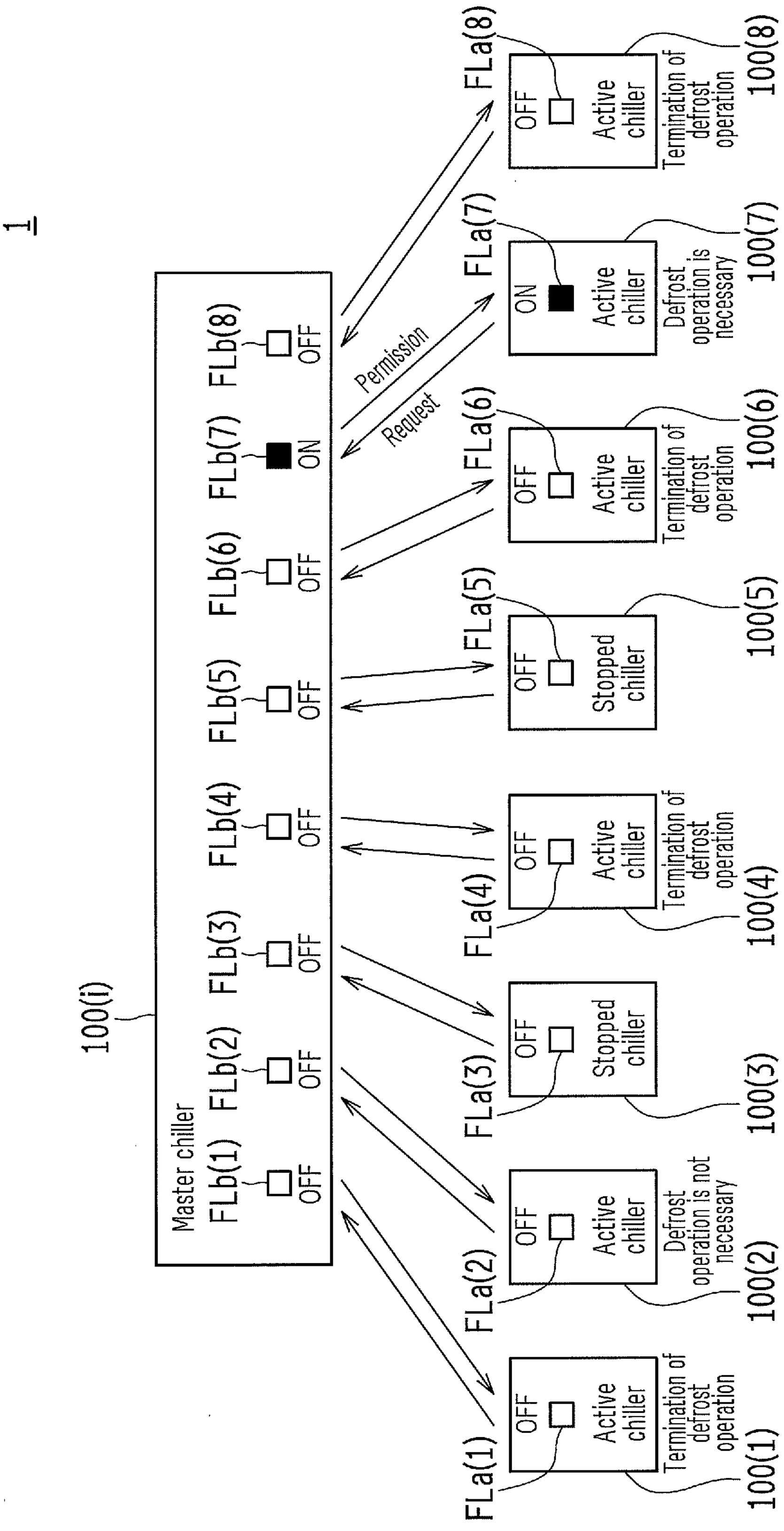

1
100(i)
Master chiller
FLb(1) OFF
FLb(2) OFF
FLb(3) OFF
FLb(4) OFF
FLb(5) OFF
FLb(6) OFF
FLb(7) ON
FLb(8) OFF
Permission
Request
FLa(1) OFF Active chiller
Termination of defrost operation
100(1)
FLa(2) OFF Active chiller
Defrost operation is not necessary
100(2)
FLa(3) OFF Stopped chiller
100(3)
FLa(4) OFF Active chiller
Termination of defrost operation
100(4)
FLa(5) OFF Stopped chiller
100(5)
FLa(6) OFF Active chiller
Termination of defrost operation
100(6)
FLa(7) ON Active chiller
Defrost operation is necessary
100(7)
FLa(8) OFF Active chiller
Termination of defrost operation
100(8)

FIG.9

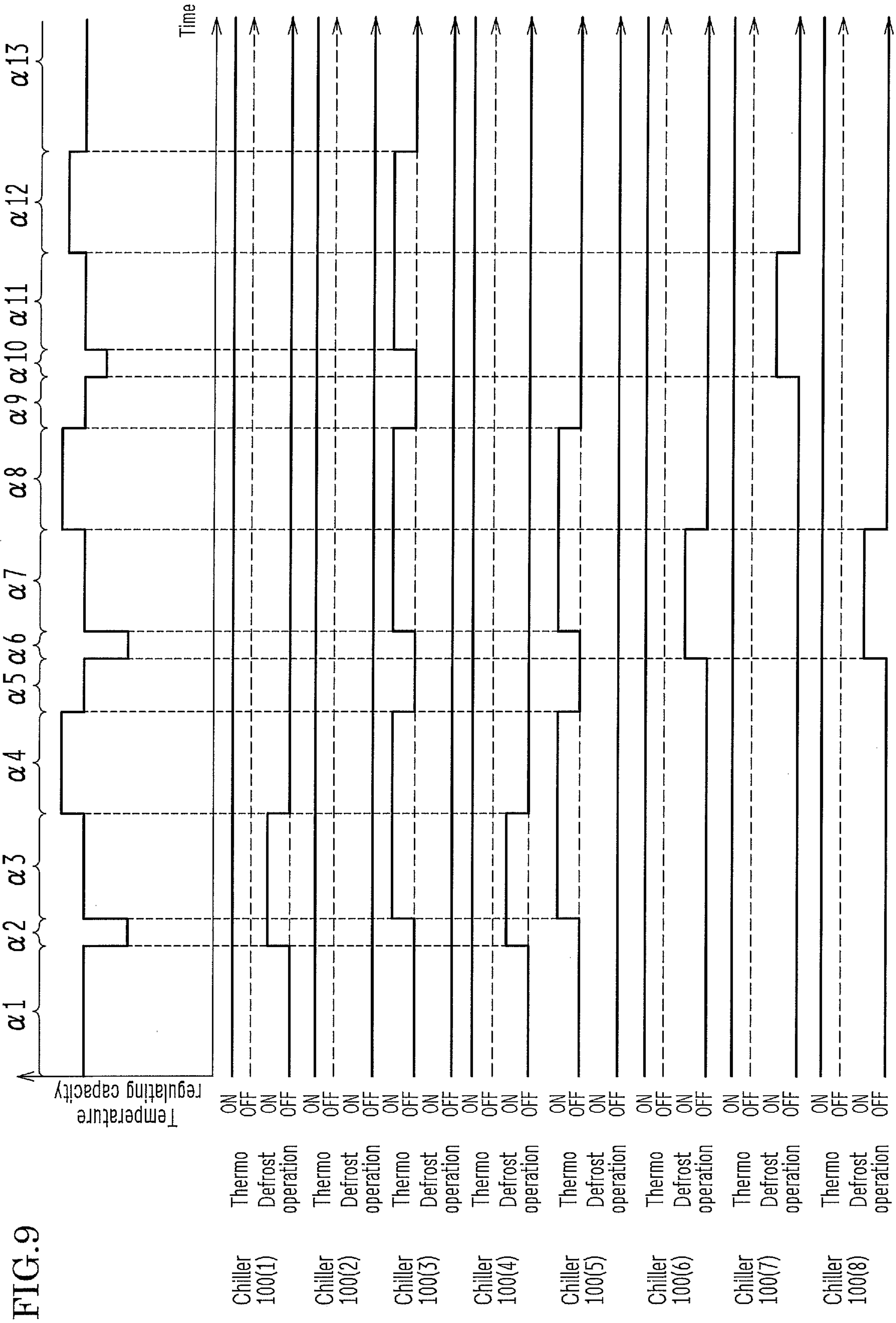
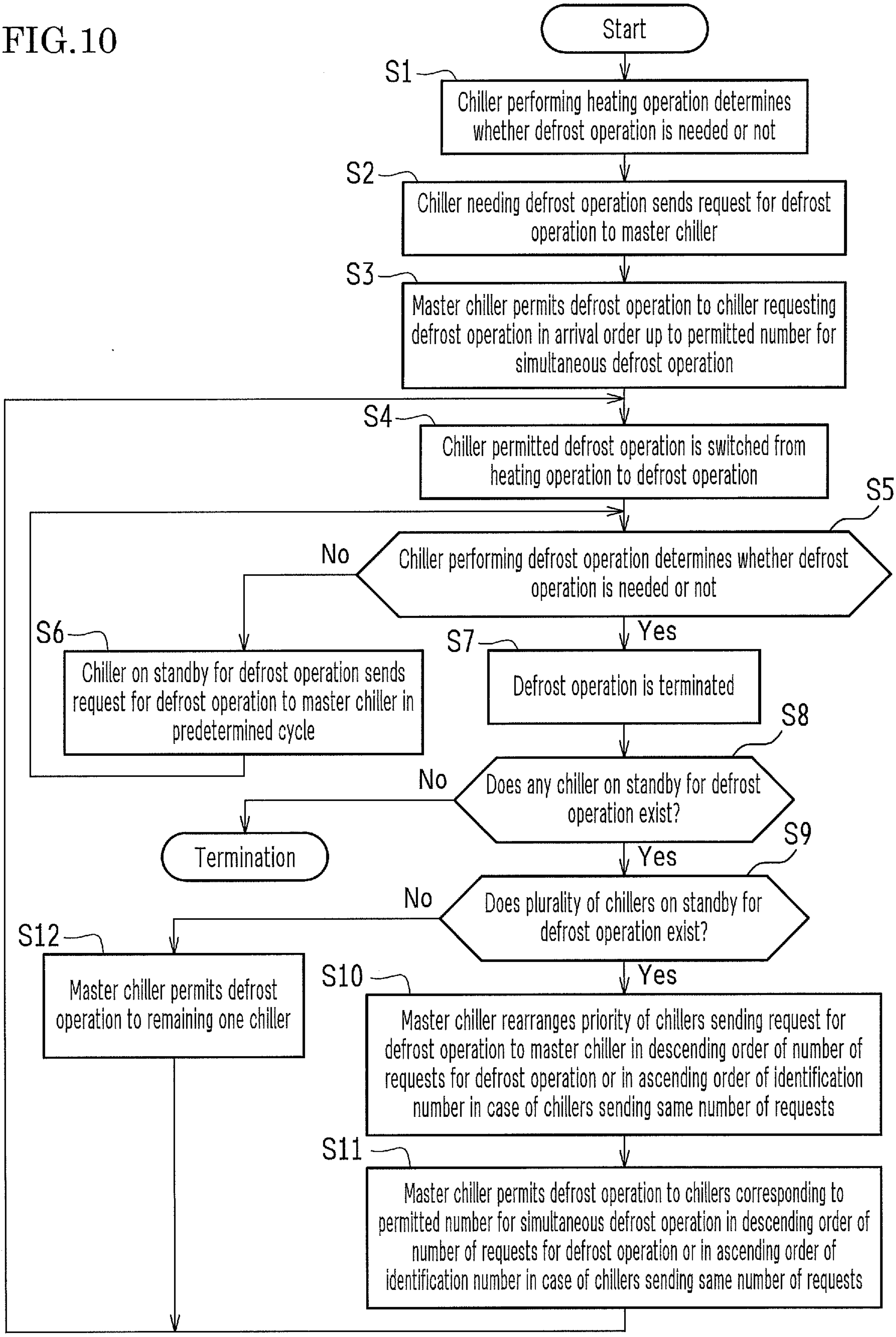

α1
α2
α3
α4
α5
α6
α7
α8
α9
α10
α11
α12
α13
Temperature regulating capacity
Time
Chiller 100(1)
Chiller 100(2)
Chiller 100(3)
Chiller 100(4)
Chiller 100(5)
Chiller 100(6)
Chiller 100(7)
Chiller 100(8)
Thermo
Defrost operation
ON
OFF

FIG.10


Start
S1
Chiller performing heating operation determines whether defrost operation is needed or not
S2
Chiller needing defrost operation sends request for defrost operation to master chiller
S3
Master chiller permits defrost operation to chiller requesting defrost operation in arrival order up to permitted number for simultaneous defrost operation
S4
Chiller permitted defrost operation is switched from heating operation to defrost operation
S5
Chiller performing defrost operation determines whether defrost operation is needed or not
No
Yes
S6
Chiller on standby for defrost operation sends request for defrost operation to master chiller in predetermined cycle
S7
Defrost operation is terminated
S8
Does any chiller on standby for defrost operation exist?
No
Yes
Termination
S9
Does plurality of chillers on standby for defrost operation exist?
No
Yes
S12
Master chiller permits defrost operation to remaining one chiller
S10
Master chiller rearranges priority of chillers sending request for defrost operation to master chiller in descending order of number of requests for defrost operation or in ascending order of identification number in case of chillers sending same number of requests
S11
Master chiller permits defrost operation to chillers corresponding to permitted number for simultaneous defrost operation in descending order of number of requests for defrost operation or in ascending order of identification number in case of chillers sending same number of requests

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/064033

A. CLASSIFICATION OF SUBJECT MATTER
F25B47/02(2006.01)i, *F24F11/02*(2006.01)i, *F25B1/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B47/02, F24F11/02, F25B1/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 56-025631 A (Daikin Industries, Ltd.), 12 March 1981 (12.03.1981), page 1, lower left column, line 4 to lower right column, line 3; page 2, upper left column, line 20 to lower left column, line 9; page 3, lower left column, line 13 to lower right column, line 7 (Family: none)	1-3
A	JP 2009-186123 A (Mitsubishi Electric Corp.), 20 August 2009 (20.08.2009), abstract; paragraphs [0041] to [0044]; fig. 5 (Family: none)	1-3

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
22 July 2015 (22.07.15)	04 August 2015 (04.08.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/064033

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 07-332817 A (Daikin Industries, Ltd.), 22 December 1995 (22.12.1995), paragraphs [0019], [0034] (Family: none)	1-3

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4257351 B **[0005]**
- JP H10122604 A **[0005]**
- JP 2014129487 A **[0130]**