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- **MATSUSHITA, Kaoru**
Fuji-shi
Shizuoka 416-8521 (JP)
- **MATSUMOTO, Yuuji**
Fuji-shi
Shizuoka 416-8521 (JP)
- **YAMAMOTO, Manabu**
Fuji-shi
Shizuoka 416-8521 (JP)

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(71) Applicant: **Toshiba Carrier Corporation**
Kawasaki-shi, Kanagawa 212-8585 (JP)

(74) Representative: **Lins, Martina**
Gramm, Lins & Partner
Patent- und Rechtsanwälte PartGmbB
Theodor-Heuss-Strasse 1
38122 Braunschweig (DE)

(72) Inventors:
• **TANNO, Hideki**
Fuji-shi
Shizuoka 416-8521 (JP)

(54) **HEAT SOURCE MACHINE AND HEAT SOURCE DEVICE**

(57) A heat source unit which comprises a plurality of compressors and a controller. When release control for reducing capacity of any one of the compressors is executed, the controller increases capacity of one or more of the compressors except the compressor subjected to the release control by an amount of the capacity reduced by the release control.

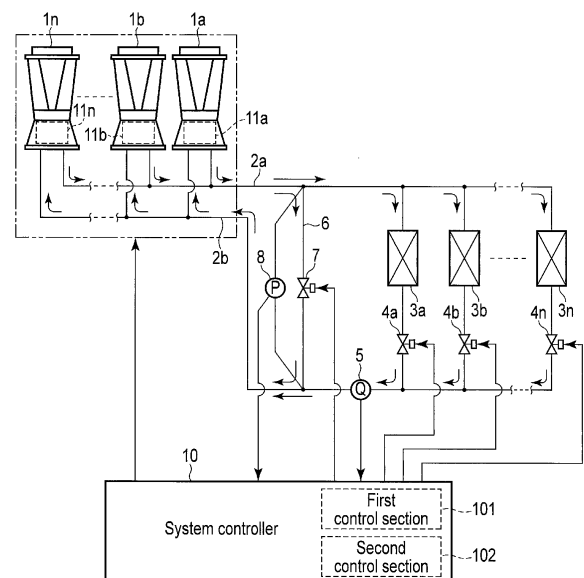


FIG. 1

Description

Brief Description of Drawings

Technical Field

[0008]

[0001] Embodiments described herein relate generally to a heat source unit comprising compressors and a heat source apparatus comprising heat source units.

5 FIG. 1 is a diagram showing a structure of a first embodiment.

Background Art

FIG. 2 is a diagram showing a structure of refrigeration cycles of each heat source unit according to each embodiment.

[0002] A heat source unit which comprises refrigeration cycles each including a compressor, and supplies heat or cold energy obtainable by operations of these refrigeration cycles to a load side (a use side) is known.

10 FIG. 3 is a diagram showing a structure of a module controller of each heat source unit according to the first embodiment.

FIG. 4 is a flowchart showing control executed by a system controller according to the first embodiment.

Citation List

15 FIG. 5 is a flowchart showing control executed by the module controller of each heat source unit according to the first embodiment.

Patent Literature

FIG. 6 is a diagram showing a structure of a module controller of each heat source unit according to a second embodiment.

[0003] Patent Literature 1
JP 2008-224182 A

20 FIG. 7 is a diagram showing a structure of a system controller according to the second embodiment.

Summary of Invention

FIG. 8 is a flowchart showing control executed by the module controller of each heat source unit according to the second embodiment.

Technical Problem

25 FIG. 9 is a flowchart showing control executed by

[0004] In a heat source unit comprising refrigeration cycles, there is a possibility that an operating status of any one of the refrigeration cycles is deteriorated and an operating current of a compressor in this refrigeration cycle is abnormally increased, for example, in the case of an imbalance in temperature and amount of air introduced to air heat exchangers of the respective refrigeration cycles. In this case, release control for stopping the abnormal increase of the operating current is executed, which causes a decrease in coefficient of performance (COP), i.e., energy efficiency of the heat source unit.

the system controller according to the second embodiment.

[0005] Embodiments described herein aim to provide a heat source unit and a heat source apparatus capable of preventing the decrease in the energy efficiency.

30 Mode for Carrying Out the Invention

[1] First Embodiment

Solution to Problem

35 **[0009]** The first embodiment will be described with reference to the accompanying drawings.

[0006] A heat source unit of Claim 1 comprises a plurality of compressors and a controller. When release control for reducing capacity of any one of the compressors is executed, the controller increases capacity of one or more of the compressors except the compressor subjected to the release control by an amount of the capacity reduced by the release control.

[0010] As shown in FIG. 1, heat source units 1a, 1b, . . . 1n are connected in parallel via a heat-transfer medium pipe 2a (hereinafter referred to as a water pipe 2a) and a heat-transfer medium pipe 2b (hereinafter referred to as a water pipe 2b). The parallel connection forms a heat source apparatus 1 equipped with the heat source units 1a, 1b, . . . 1n as modules.

[0007] A heat source apparatus of Claim 5 comprises a plurality of heat source units and a controller. When release control for reducing capacity of any one of the heat source units is executed, the controller increases capacity of one or more of the heat source units except the heat source unit subjected to the release control by an amount of the capacity reduced by the release control.

45 **[0011]** The heat source unit 1a comprises a heat-transfer medium heat exchanger, for example, an aquiferous heat exchanger, heat pump refrigeration cycles including a refrigerant channel of the aquiferous heat exchanger, and a pump. The heat source unit 1a introduces water (a heat-transfer medium) from the water pipe 2b into the water channel of the aquiferous heat exchanger by an inlet pressure of the pump, heats or cools the introduced water by refrigerant circulating by an operation of each heat pump refrigeration cycle, and supplies the heated or cooled water to the water pipe 2a by a discharge pressure of the pump. The heat source units 1b, . . . 1n have the same structure.

[0012] For example, use side devices 3a, 3b, . . . 3n, which are loads, are connected to the water pipes 2a and

2b extending from the heat source apparatus 1. The use side devices 3a, 3b, . . . 3n are connected in parallel via the water pipes 2a and 2b, comprise a use side heat exchanger which executes heat exchange between water from the water pipe 2a and indoor air from an indoor fan, and lets the water flow into the water pipe 2b after the heat exchange.

[0013] Flow regulating valves 4a, 4b, . . . 4n are provided in branch pipes of the water pipe 2b connected to water outlets of the use side devices 3a, 3b, . . . 3n. The amounts of water flowing into the use side devices 3a, 3b, . . . , 3n are regulated by changing the degrees of opening of the flow regulating valves 4a, 4b, . . . 4n regulate.

[0014] In the water pipe 2b, a flow sensor 5 is provided at a point downstream from the branch pipes connected to the water outlets of the use side devices 3a, 3b, . . . 3n. The flow sensor 5 detects an amount of water Q flowing through the use side devices 3a, 3b, . . . 3n.

[0015] One end of a bypass pipe 6 is connected to a point between where the heat source units 1a, 1b, . . . 1n are connected in the water pipe 2a and where the use side devices 3a, 3b, . . . 3n are connected in the water pipe 2a. The other end of the bypass pipe 6 is connected to a point downstream from the flow sensor 5 in the water pipe 2b. The bypass pipe 6 causes the water flowing from the heat source units 1a, 1b, . . . 1n toward the use side devices 3a, 3b, . . . 3n to bypass the use side devices 3a, 3b, . . . 3n and be returned to the heat source units 1a, 1b, . . . 1n. A flow regulating valve 7 is provided at a midstream portion of the bypass pipe 6. The flow regulating valve 7 is also called a bypass valve. The amount of water flowing into the bypass pipe 6 is regulated by changing the degree of opening of the flow regulating valve 7.

[0016] At a point between both ends of the bypass pipe 6, a differential pressure sensor 8 is provided as a pressure difference detecting means. The differential pressure sensor 8 detects a difference P between the water pressure on one end of the bypass pipe 6 and the water pressure on the other end of the same (i.e., a difference between water pressures at both ends of the bypass pipe 6).

[0017] FIG. 2 shows heat pump refrigeration cycles provided in the heat source unit 1a.

[0018] A refrigerant discharged from a compressor 21 flows into air heat exchangers 23a and 23b via a four-way valve 22. The refrigerant which has passed through the air heat exchangers 23a and 23b flows into a first refrigerant channel of the aquiferous heat exchanger (heat-transfer medium heat exchanger) 30 via electronic expansion valves 24a and 24b. The refrigerant which has passed through the first refrigerant channel of the aquiferous heat exchanger 30 is drawn into the compressor 21 via the four-way valve 22 and an accumulator 25. The above flowing direction of the refrigerant corresponds to one at the time of a cooling operation (a cold-water generation operation), in which the air heat exchangers 23a

and 23b serve as condensers and the first refrigerant channel of the aquiferous heat exchanger 30 serves as an evaporator. At the time of a heating operation (a hot-water generation operation), the channel of the four-way valve 22 is switched and the flowing direction of the refrigerant is reversed. Accordingly, the first refrigerant channel of the aquiferous heat exchanger 30 serves as a condenser and the air heat exchangers 23a and 23b serve as evaporators.

[0019] A first heat pump refrigeration cycle is constituted by the compressor 21, the four-way valve 22, the air heat exchangers 23a and 23b, the electronic expansion valves 24a and 24b, the first refrigerant channel of the aquiferous heat exchanger 30, and the accumulator 25. An outdoor fan 26 for introduction of external air is provided near the air heat exchangers 23a and 23b. Temperature sensors 27a and 27b which detect a condensation temperature Tc of the refrigerant are attached to refrigerant pipes between the air heat exchangers 23a and 23b and the electronic expansion valves 24a and 24b.

[0020] In the same manner as the first heat pump refrigeration cycle, a second heat pump refrigeration cycle is constituted by a compressor 41, a four-way valve 42, air heat exchangers 43a and 43b, electronic expansion valves 44a and 44b, a second refrigerant channel of the aquiferous heat exchanger 30, and an accumulator 45, a third heat pump refrigeration cycle is constituted by a compressor 51, a four-way valve 52, air heat exchangers 53a and 53b, electronic expansion valves 54a and 54b, a first refrigerant channel of an aquiferous heat exchanger 60, and an accumulator 55, and a fourth heat pump refrigeration cycle is constituted by a compressor 71, a four-way valve 72, air heat exchangers 73a and 73b, electronic expansion valves 74a and 74b, a second refrigerant channel of the aquiferous heat exchanger 60, and an accumulator 75.

[0021] An outdoor fan 46 for introduction of external air is provided near the air heat exchangers 43a and 43b, an outdoor fan 56 for introduction of external air is provided near the air heat exchangers 53a and 53b, and an outdoor fan 76 for introduction of external air is provided near the air heat exchangers 73a and 73b.

[0022] Temperature sensors 47a and 47b which detect a condensation temperature Tc of the refrigerant are attached to refrigerant pipes between the air heat exchangers 43a and 43b and the electronic expansion valves 44a and 44b, temperature sensors 57a and 57b which detect a condensation temperature Tc of the refrigerant are attached to refrigerant pipes between the air heat exchangers 53a and 53b and the electronic expansion valves 54a and 54b, and temperature sensors 77a and 77b which detect a condensation temperature Tc of the refrigerant are attached to refrigerant pipes between the air heat exchangers 73a and 73b and the electronic expansion valves 74a and 74b.

[0023] Each of the compressors 21, 41, 51 and 71 in the heat pump refrigeration cycles has a motor which operates by an alternating voltage supplied from corre-

sponding one of inverters 91, 92, 93 and 94. The capacity of each compressor is changed in accordance with a speed of rotation of the motor. Each of the inverters 91, 92, 93 and 94 rectifies a voltage of a commercial alternating-current power supply 90, converts a direct-current voltage after the rectification into an alternating voltage of a predetermined frequency by switching in accordance with an instruction from a system controller 10 to be described later, and supplies the converted alternating voltage as power to drive the motor of corresponding one of the compressors 21, 41, 51 and 71.

[0024] The speed of rotation of the motor of each of the compressors 21, 41, 51 and 71 is changed by changing a frequency (output frequency) F of the output voltage of corresponding one of the inverters 91, 92, 93 and 94. As a result, the capacity of each of the compressors 21, 41, 51 and 71 is also changed.

[0025] Current sensors 96, 97, 98 and 99 are provided in the power distribution lines between the output terminals of the inverters 91, 92, 93 and 94 and the motors of the compressors 21, 41, 51 and 71. Each of the current sensors 96, 97, 98 and 99 detects a current I_m flowing through the motor of corresponding one of the compressors 21, 41, 51 and 71 as an operating current.

[0026] Water flows from the water pipe 2b to the water pipe 2a via the water channels of the aquiferous heat exchangers 60 and 30. An inlet water temperature sensor 9b is provided in the water pipe 2b and an outlet water temperature sensor 9a is provided in the water pipe 2a. The inlet water temperature sensor 9b detects a temperature T_{wi} of water flowing into the heat source unit and the outlet water temperature sensor 9a detects a temperature T_{wo} of water flowing from the heat source unit.

[0027] A pump 80 is provided in a water pipe between the water pipe 2b and the water channel of the aquiferous heat exchanger 60. The pump 80 has a motor which operates by an alternating voltage supplied from an inverter 95. The capacity (lifting height) of the pump 80 is changed in accordance with a speed of rotation of the motor. The inverter 95 rectifies the voltage of the commercial alternating-current power supply 90, converts a direct-current voltage after the rectification into an alternating voltage of a predetermined frequency by switching in accordance with an instruction from a module controller 11a to be described later, and supplies the converted alternating voltage as capacity to drive the motor of the pump 80. The speed of rotation of the motor of the pump 80 is changed by changing a frequency (output frequency) F of the output voltage of the inverter 95. As a result, the capacity of the pump 80 is also changed.

[0028] The first to fourth heat pump refrigeration cycles are also provided in each of the heat source units 1b, . . . 1n.

[0029] The heat source unit 1a comprises a module controller 11a which controls operations of the first to fourth heat pump refrigeration cycles provided in the heat source unit 1a. The other heat source units 1b, . . . 1n also comprise module controllers 11b, . . . 11n which

control operations of the first to fourth heat pump refrigeration cycles.

[0030] The module controllers 11a, 11b, . . . 11n are connected to the system controller 10 via communication lines. The flow regulating valves 4a, 4b, . . . 4n, the flow sensor 5, the flow regulating valve 7 and the differential pressure sensor 8 are also connected to the system controller 10.

[0031] The system controller 10 executes overall control of the heat source units 1a, 1b, . . . 1n, the flow regulating valves 4a, 4b, . . . 4n and the flow regulating valve 7. As the main function, the system controller 10 includes a first control section 101 and a second control section 102.

[0032] The first control section 101 controls the number of heat source units 1a, 1b, . . . 1n to be operated, and the regulation (the degree of opening) of each of the flow regulating valves 4a, 4b, . . . 4n, in accordance with the required capacity of the use side devices 3a, 3b, . . . 3n which are the loads (i.e., a difference between an indoor air temperature T_a and a preset temperature T_s).

[0033] The second control section 102 controls the regulation (the degree of opening) of the flow regulating valve 7, in accordance with a flow rate Q_t detected by the flow sensor 5.

[0034] As shown in FIG. 3, the module controller 11a includes a capacity control section 111, a release control section 112 and a capacity compensation control section 113 as the main function.

[0035] The capacity control section 111 controls the capacity (operating frequency F) of each of the compressors 21, 41, 51 and 71 such that the water temperature T_{wo} detected by the outlet water temperature sensor 9b is equal to a preset target outlet water temperature T_{wt} .

[0036] When the operating current I_m of any one of the compressors 21, 41, 51 and 71 (i.e., a current detected by any one of the current sensors 96, 97, 98 and 99) is abnormally increased and reaches a defined value I_{ms} close to the allowable upper limit, the release control section 112 executes release control for reducing the capacity (operating frequency F) of the compressor in which the current is abnormally increased.

[0037] When the release control is executed, the capacity compensation control section 113 increases the capacity of one or more compressors (in operation) except the compressor in which the release control is executed, by the amount of capacity reduced by the release control.

[0038] More specifically, when the release control is executed, the capacity compensation control section 113 distributes the amount of capacity of one of the compressors 21, 41, 51 and 71 subjected to the release control reduced by the release control, proportionally among one or more compressors (in operation) except the compressor subjected to the release control. Then, the capacity compensation control section 113 increases the capacity of one or more compressors (in operation) except the compressor subjected to the release control by the dis-

tributed amounts of the reduced capacity.

[0039] Each of the module controllers 11b, ... 11n also includes the capacity control section 111, the release control section 112 and the capacity compensation control section 113.

[0040] Next, the control executed by the system controller 10 will be described with reference to a flowchart of FIG. 4.

[0041] The system controller 10 controls the number of heat source units 1a, 1b, ... 1n to be operated, and the regulation (the degree of opening) of each of the flow regulating valves 4a, 4b, ... 4n, in accordance with the required capacity of the use side devices 3a, 3b, ... 3n which are the loads (i.e., the difference between the indoor air temperature Ta and the preset temperature Ts) (step S1). The system controller 10 controls the regulation (the degree of opening) of the flow regulating valve 7 in accordance with the flow rate Qt detected by the flow sensor 5 (step S2). Then, the system controller 10 returns to step S1.

[0042] Next, the control executed by the module controller 11a will be described with reference to a flowchart of FIG. 5. The control executed by the module controllers 11b, ... 11n is the same as the control executed by the module controller 11a and thus description is omitted.

[0043] The module controller 11a controls the capacity (operating frequency F) of the compressors 21, 41, 51 and 71 such that the water temperature Two detected by the outlet water temperature sensor 9a is equal to a preset target outlet water temperature Twt (step S11).

[0044] Then, the module controller 11a compares the operating current Im of the compressor 21 with the defined value Ims (step S12). If the operating current Im of the compressor 21 is less than the defined value Ims (NO in step S12), the module controller 11a returns to step S11.

[0045] For example, the following description is based on the assumption that the operating status of the first heat pump refrigeration cycle is deteriorated and the operating current Im of the compressor 21 in the heat source unit 1a is abnormally increased due to an imbalance in the temperature and amount of air introduced to the air heat exchangers of the first to fourth heat pump refrigeration cycles in the heat source unit 1a caused by changes in the installation and ambient conditions.

[0046] If the operating current Im of the compressor 21 is abnormally increased and reaches the defined value Ims (YES in step S12), the module controller 11a executes release control for reducing the output frequency F of the inverter 91 by a predetermined value Fa (step S13). By the release control, the capacity of the compressor 21 is reduced and the operating current Im of the compressor 21 is decreased below the defined value Ims, which can avoid an unnecessary increase in the temperature of electronic devices in the heat source unit 1a.

[0047] Along with the release control, the module controller 11a increases the capacity of one or more operating compressors (compressor 41, 51 or 71) other than

the compressor 21 subjected to the release control by the amount of capacity reduced by the release control (step S14).

[0048] More specifically, the module controller 11a distributes the amount of capacity of the compressor 21 reduced by the release control proportionally among one or more operating compressors (compressor 41, 51 or 71), and increases the output frequency F of each of one or more inverters (inverter 92, 93 or 94) by a frequency ΔF corresponding to the distributed amount of capacity. That is, the capacity of each of the one or more operating compressors (compressor 41, 51 or 71) is increased by the distributed amount of capacity. When distributing the amount of capacity proportionally, the module controller 11a determines the distribution ratio based on the rating capacity and the current capacity of each of the operating compressors 41, 51 and 71.

[0049] The reduction of the capacity of the compressor 21 by the release control can be compensated for by distributing the amount of capacity of the compressor 21 reduced by the release control proportionally among one or more other operating compressors (compressor 41, 51 or 71) and increasing the capacity of each of the one or more operating compressors (compressor 41, 51 or 71) by the distributed amount of capacity.

[0050] If the capacity of the compressor 21 is reduced by the release control, the coefficient of performance (COP), i.e., energy efficiency of the heat source unit 1a is decreased. However, such a decrease in COP of the heat source unit 1a can be avoided by increasing the capacity of one or more other operating compressors (compressor 41, 51 or 71) and thereby compensating for the reduction of the capacity of the compressor 21 by the release control.

[0051] After step S14, the system controller 10 returns to step S11.

[2] Second Embodiment

[0052] The second embodiment will be described with reference to the accompanying drawings.

[0053] As shown in FIG. 6, the module controller 11a includes a capacity control section 211 and a release control section 212.

[0054] The capacity control section 211 controls the capacity (operating frequency F) of the compressors 21, 41, 51 and 71 such that the water temperature Two detected by the outlet water temperature sensor 9a is equal to the preset target outlet water temperature Twt. The capacity control section 211 executes control for increasing the capacity (operating frequency F) of the compressors 21, 41, 51 and 71 as appropriate when receiving an instruction to increase the capacity from a capacity compensation control section 203 to be described later.

[0055] When the operating current Im of any one of the compressors 21, 41, 51 and 71 (i.e., a current detected by any one of the current sensors 96, 97, 98 and 99) is abnormally increased and reaches the defined value Ims

close to the allowable upper limit, the release control section 212 executes release control for reducing the capacity (operating frequency F) of the compressor in which the current is abnormally increased.

[0056] Each of the module controllers 11b, . . . 11n also includes the capacity control section 211 and the release control section 212.

[0057] As shown in FIG. 7, the system controller 10 includes a first control section 201, a second control section 202 and a capacity compensation control section 203.

[0058] The first control section 201 controls the number of heat source units 1a, 1b, . . . 1n to be operated, and the regulation (the degree of opening) of each of the flow regulating valves 4a, 4b, . . . 4n, in accordance with the required capacity of the use side devices 3a, 3b, . . . 3n which are the loads (i.e., the difference between the indoor air temperature Ta and the preset temperature Ts).

[0059] The second control section 202 controls the regulation (the degree of opening) of the flow regulating valve 7, in accordance with the flow rate Qt detected by the flow sensor 5.

[0060] When release control is executed in any one of the heat source units 1a, 1b, . . . 1n, the capacity compensation control section 203 instructs the module controllers 11a, 11b, . . . 11n of the heat source units 1a, 1b, . . . 1n to increase the capacity of one or more operating heat source units except one of the heat source units 1a, 1b, . . . 1n in which the release control is executed by the amount of capacity reduced by the release control.

[0061] More specifically, when the release control is executed in any one of the heat source units 1a, 1b, . . . 1n, the capacity compensation control section 203 distributes the amount of capacity of the heat source unit in which the release control is executed reduced by the release control proportionally among one or more operating heat source units except the heat source unit in which the release control is executed. Then, the capacity compensation control section 203 increases the capacity of each of one or more operating heat source units except the heat source unit in which the release control is executed by the distributed amount of capacity.

[0062] The other structures are the same as those of the first embodiment and thus description is omitted.

[0063] Next, the control executed by the module controller 11a will be described with reference to a flowchart of FIG. 8. The control executed by the module controllers 11b, . . . 11n is the same as the control executed by the module controller 11a and thus description is omitted.

[0064] The module controller 11a controls the capacity (operating frequency F) of the compressors 21, 41, 51 and 71 such that the water temperature Two detected by the outlet water temperature sensor 9a is equal to the preset target outlet water temperature Twt (step S21).

[0065] Then, the module controller 11a compares the operating current Im of the compressor 21 with the defined value Ims (step S22). If the operating current Im of the compressor 21 is less than the defined value Ims (NO

in step S22), the module controller 11a returns to step S21.

[0066] For example, the following description is based on the assumption that the operating status of the first heat pump refrigeration cycle is deteriorated and the operating current Im of the compressor 21 in the heat source unit 1a is abnormally increased due to an imbalance in the temperature and amount of air introduced to the air heat exchangers of the first to fourth heat pump refrigeration cycles in the heat source unit 1a caused by changes in the installation and ambient conditions.

[0067] If the operating current Im of the compressor 21 in the heat source unit 1a is abnormally increased and reaches the defined value Ims (YES in step S22), the module controller 11a executes release control for reducing the output frequency F of the inverter 91 by the predetermined value Fa (step S23). By the release control, the capacity of the compressor 21 is reduced and the operating current Im of the compressor 21 is decreased below the defined value Ims, which can avoid an unnecessary increase in the temperature of electronic devices in the heat source unit 1a.

[0068] Next, the control executed by the system controller 10 will be described with reference to a flowchart of FIG. 9.

[0069] The system controller 10 controls the number of heat source units 1a, 1b, . . . 1n to be operated, and the regulation (the degree of opening) of each of the flow regulating valves 4a, 4b, . . . 4n, in accordance with the required capacity of the use side devices 3a, 3b, . . . 3n which are the loads (i.e., the difference between the indoor air temperature Ta and the preset temperature Ts) (step S31). The system controller 10 also controls the regulation (the degree of opening) of the flow regulating valve 7 in accordance with the flow rate Qt detected by the flow sensor 5 (step S32).

[0070] The system controller 10 monitors the execution of release control in the heat source units 1a, 1b, . . . 1n (step S33). If no release control is executed in the heat source units 1a, 1b, . . . 1n (NO in step S33), the system controller 10 returns to step S31.

[0071] For example, if the release control is executed in the heat source unit 1a (YES in step S33), the system controller 10 increases the capacity of one or more operating heat source units (one of heat source units 1b, . . . 1n) other than the heat source unit 1a in which the release control is executed, by the amount of capacity reduced by the release control (step S34).

[0072] More specifically, the system controller 10 distributes the amount of capacity of the heat source unit 1a reduced by the release control proportionally among one or more other operating heat source units (one of heat source units 1b, . . . 1n) and notifies the result of distribution to the module controllers (one of module controllers 11b to 11n) of the one or more operating heat source units (one of heat source units 1b, . . . 1n). When distributing the amount of capacity proportionally, the system controller 10 determines the distribution ratio

based on the rating capacity and the current capacity of each of the heat source units 1b to 1n.

[0073] For example, when notified of the distribution, the module controller 11b of the heat source unit 1b increases the capacity of one or more operating compressors in the heat source unit 1b by the amount of capacity distributed to the heat source unit 1b in the capacity control of step S21. In this case, the module controller 11b distributes the amount of capacity distributed to the heat source unit 1b proportionally among one or more operating compressors in the heat source unit 1b and increases the operating frequency F of each of the one or more operating compressors by a frequency ΔF corresponding to the distributed amount of capacity. That is, the total capacity of one or more operating compressors in the heat source unit 1b is increased by the capacity distributed to the heat source unit 1b.

[0074] The module controllers 11c to 11n of the other operating heat source units 1c to 1n also execute the same control as the module controller 11b of the heat source unit 1b when notified of the distribution.

[0075] As described above, the reduction of the capacity of the heat source unit 1a by the release control can be compensated for by distributing the amount of capacity of the heat source unit 1a reduced by the release control proportionally among one or more other operating heat source units 1b to 1n and increasing the capacity of each of the one or more heat source units 1b to 1n by the distributed amount of capacity.

[0076] If the capacity of the heat source unit 1a is reduced by the release control, the coefficient of performance (COP), i.e., energy efficiency of the heat source apparatus 1 is decreased. However, such a decrease in COP of the heat source apparatus 1 can be avoided by increasing the capacity of one or more other operating heat source units 1b to 1n and thereby compensating for the reduction of the capacity of the heat source unit 1a by the release control.

[0077] After step S34, the system controller 10 returns to step S31.

[Modified Examples]

[0078] In the first embodiment, the reduction of the capacity by the release control is compensated for by increasing the capacity of the other operating compressors, but may be compensated for by changing a speed of rotation of each of the outdoor fans 26, 46, 56 and 76. Otherwise, the reduction may be compensated for by both the increase in the capacity of the compressors and the change in the speed of rotation of each of the outdoor fans 26, 46, 56 and 76.

[0079] At the time of a cooling operation, the module controller 11a obtains a pinch point which is a difference between an outdoor air temperature T_o and a condensation temperature T_c of refrigerant in each of the air heat exchangers 23a to 73b (i.e., a temperature detected by each of the temperature sensors 27a to 77b), and

controls the speed of rotation of each of the outdoor fans 26 to 76 such that the pinch points are uniform. This control of the speed of rotation can also be used for increasing the capacity. The same control of the speed of rotation is executed by the other module controllers 11b to 11n.

[0080] Each of the above embodiments was described by referring to the heat source units 1a, 1b, ... 1n each comprising four heat pump refrigeration cycles and two aquiferous heat exchangers as an example. However, the numbers of heat pump refrigeration cycles and aquiferous heat exchangers of each heat source unit can be selected as required.

[0081] Each of the above embodiments was described by referring to a case where the load is an air heat exchanger. However, the embodiments can similarly be put into practice in a case where the load is, for example, water in a hot-water storage tank.

[0082] Each of the above embodiments was described by referring to the system controller 10 which controls the number of heat source units 1a, 1b, ... 1n to be operated in accordance with the required capacity of the use side devices 3a, 3b, ... 3n which are the loads (i.e., the difference between the indoor air temperature T_a and the preset temperature T_s). However, the system controller 10 can control the number of heat source units 1a, 1b, ... 1n to be operated in accordance with the required capacity of the heat source apparatus 1 calculated from water temperatures detected by the inlet water temperature sensors 9b and the outlet water temperature sensors 9a of the heat source units 1a, 1b, ... 1n and the target outlet water temperature T_{wt} .

[0083] While certain embodiments and modification examples have been described, they have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions. Reference Signs List

- 1: heat source apparatus
- 1a to 1n: heat source unit
- 2a, 2b: water pipe (heat-transfer medium pipe)
- 3: use side device (load)
- 4a to 4n: flow regulating valve
- 5: flow sensor
- 6: bypass pipe
- 7: flow regulating valve
- 8: differential pressure sensor
- 10: system controller
- 11a to 11n: module controller
- 21, 41, 51, 71: compressor
- 23a to 73b: air heat exchanger
- 30, 60: aquiferous heat exchanger (heat-transfer

medium heat exchanger)
 80: pump
 90: commercial alternating-current power supply
 91 to 95: inverter
 96 to 99: current sensor

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executed, the controller configured to increase capacity of one or more of the heat source units except the heat source unit subjected to the release control by an amount of the capacity reduced by the release control.

Claims

1. A heat source unit **characterized by** comprising:
 - a plurality of compressors; and
 - a controller, when release control for reducing capacity of any one of the compressors is executed, the controller configured to increase capacity of one or more of the compressors except the compressor subjected to the release control by an amount of the capacity reduced by the release control.
2. The heat source unit of Claim 1, **characterized in that**
 When an operating current of any one of the compressors is abnormally increased, the controller is configured to execute release control for reducing capacity of the compressor in which the operating current is abnormally increased, and increase capacity of one or more of the compressors except the compressor subjected to the release control by an amount of the capacity reduced by the release control.
3. The heat source unit of Claim 1, **characterized in that**
 When an operating current of any one of the compressors is abnormally increased, the controller is configured to execute release control for reducing capacity of the compressor in which the operating current is abnormally increased, distribute an amount of the capacity of the compressor subjected to the release control reduced by the release control proportionally among one or more of the compressors except the compressor subjected to the release control, and increase capacity of one or more of the compressors except the compressor subjected to the release control by the distributed amounts of the capacity.
4. The heat source unit of Claim 1, **characterized by** further comprising a plurality of refrigeration cycles including the compressors, respectively.
5. A heat source apparatus **characterized by** comprising:
 - a plurality of heat source units; and
 - a controller, when release control for reducing capacity of any one of the heat source units is

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6. The heat source apparatus of Claim 5, **characterized in that**
 each of the heat source units includes at least one compressor, and when an operating current of the compressor is abnormally increased, executes release control for reducing capacity of the compressor.
7. The heat source apparatus of Claim 6, **characterized in that**
 the controller is configured to distribute the amount of the capacity of the heat source unit subjected to the release control reduced by the release control proportionally among one or more of the heat source units except the heat source unit subjected to the release control, and
 the controller is configured to increase the capacity of one or more of the heat source units except the heat source unit subjected to the release control by the distributed amounts of the capacity.

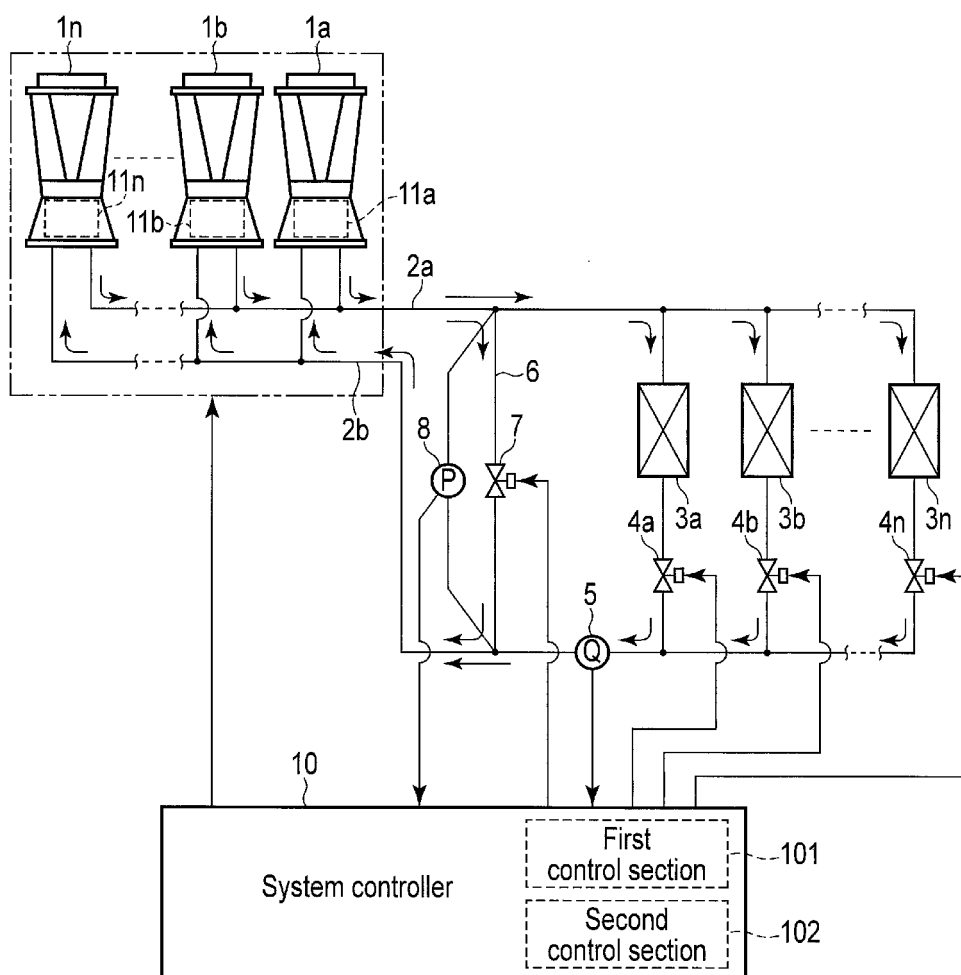


FIG. 1

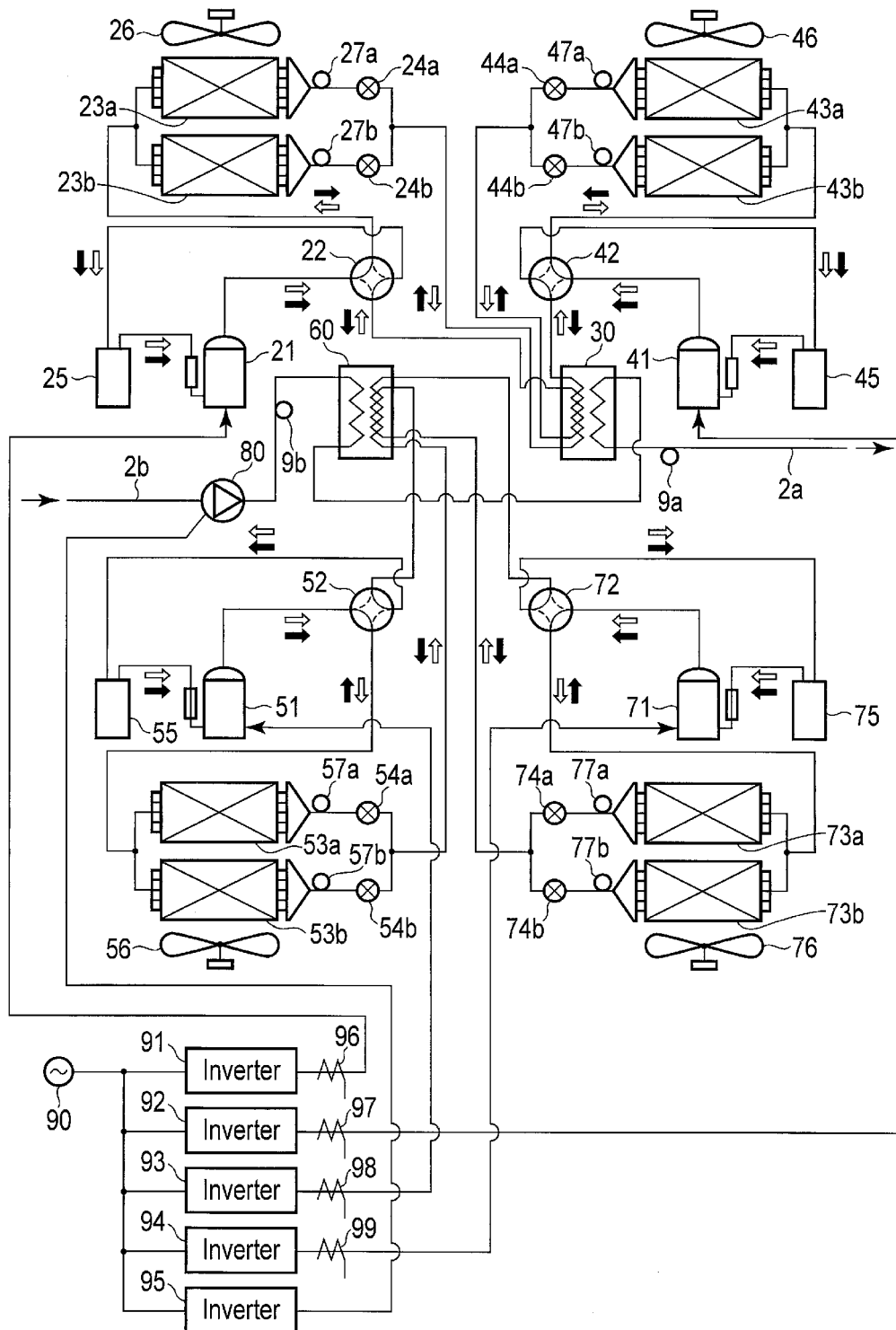


FIG. 2

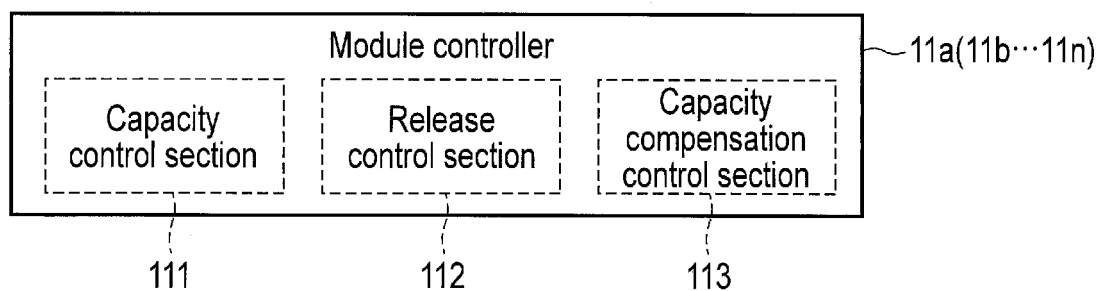


FIG. 3

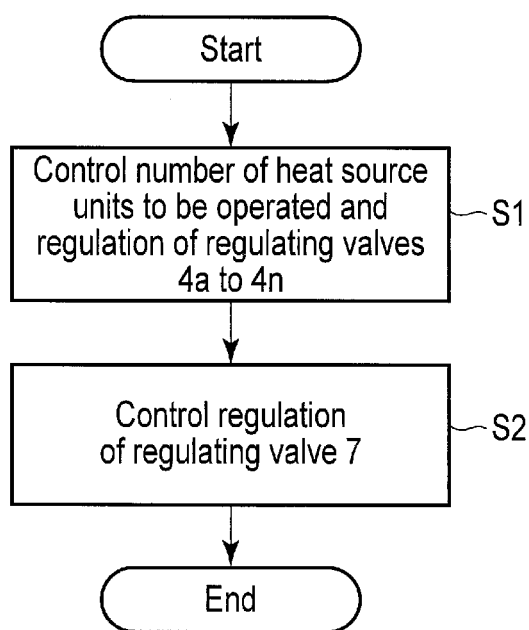


FIG. 4

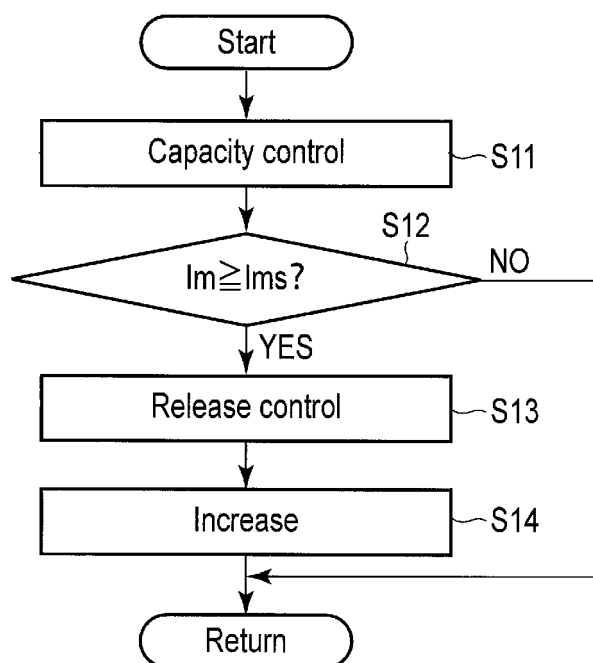


FIG. 5

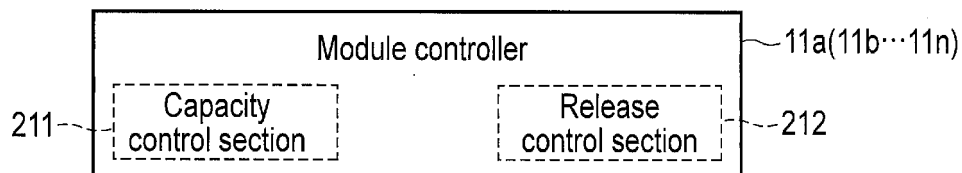


FIG. 6

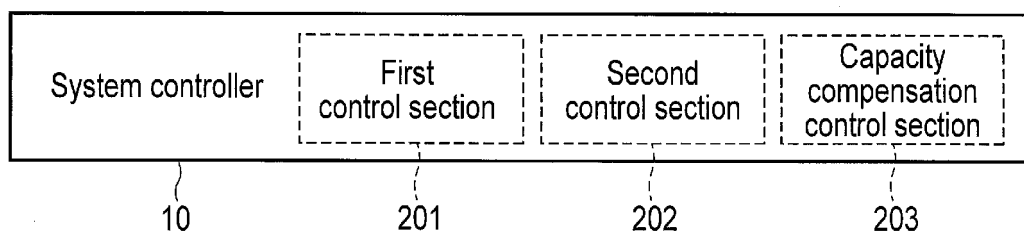


FIG. 7

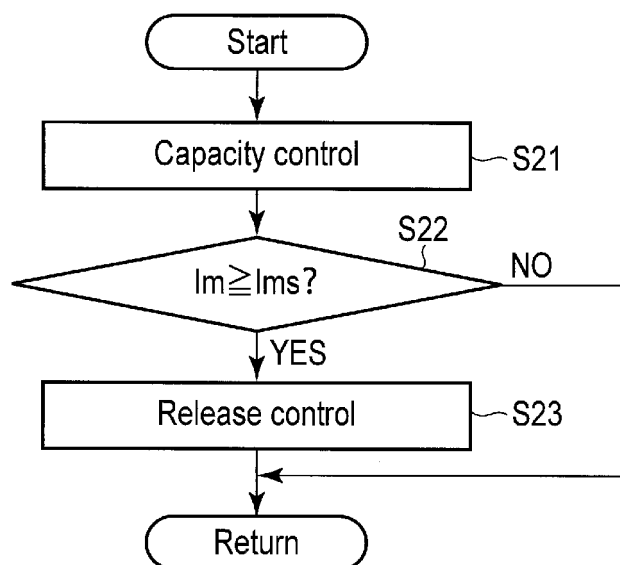


FIG. 8

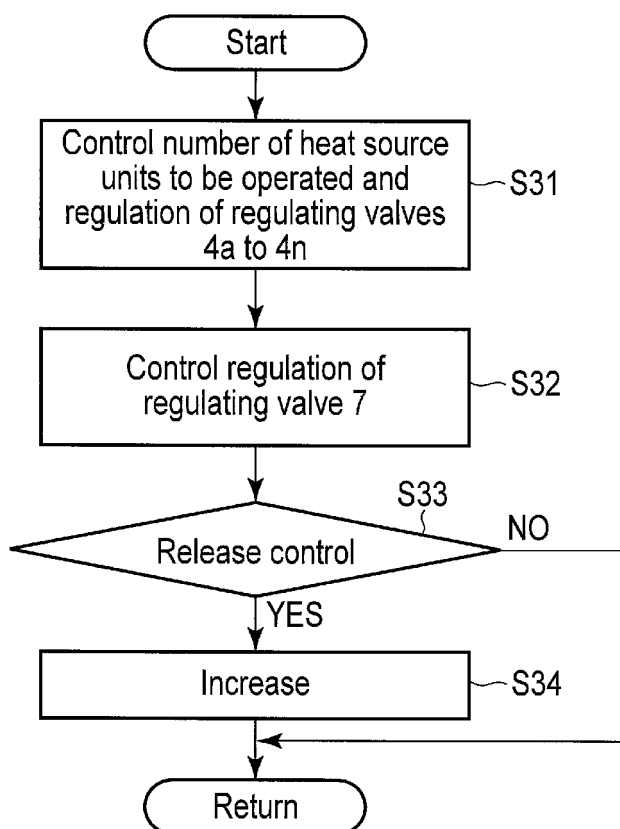


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/066750

A. CLASSIFICATION OF SUBJECT MATTER

F25B49/02(2006.01)i, F24F11/02(2006.01)i, F25B1/00(2006.01)i, F25B13/00(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)

F25B49/02, F24F11/02, F25B1/00, F25B13/00

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.
Y	JP 2013-231590 A (Toshiba Carrier Corp.), 14 November 2013 (14.11.2013), paragraphs [0057] to [0076], [0104] to [0106]; fig. 6 to 8 & US 2012/0125033 A1 & US 2013/0333409 A1 & WO 2011/013672 A1 & EP 2461111 A1 & CN 102472536 A & KR 10-2012-0031227 A & KR 10-2013-0100223 A & CN 103822394 A	1-7
Y	JP 62-225856 A (Toshiba Corp.), 03 October 1987 (03.10.1987), claims; page 3, lower left column, lines 16 to 19; page 4, upper left column, lines 10 to 15 (Family: none)	1-7

☒ 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
22 July 2015 (22.07.15)

Date of mailing of the international search report
04 August 2015 (04.08.15)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/066750

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 62-166245 A (Toshiba Corp.), 22 July 1987 (22.07.1987), claims (Family: none)	1-7
Y	WO 2004/088212 A1 (Toshiba Carrier Corp.), 14 October 2004 (14.10.2004), claims; page 13, line 14 to page 18, line 2 & EP 1610070 A1 & KR 10-2005-0114692 A & CN 1764809 A	1-7
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A	WO 2010/092916 A1 (Toshiba Carrier Corp.), 19 August 2010 (19.08.2010), entire text; all drawings & US 2012/0055665 A1 & EP 2397786 A1 & CN 102308155 A & KR 10-2011-0126688 A & RU 2011137550 A	1-7
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REFERENCES CITED IN THE DESCRIPTION

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