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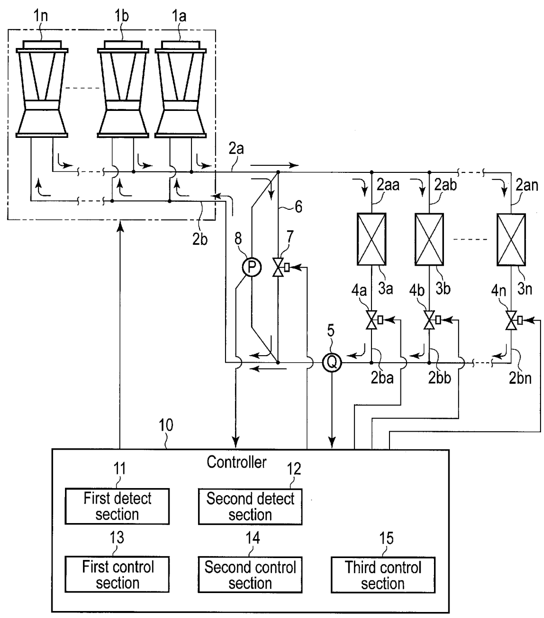
(54) **HEAT SOURCE DEVICE**

(57) A controller controls the number of the heat source units to be operated and an amount of the heat-transfer medium which flows to the load side in accordance with required capability from the load side. The controller detects the flow rate of the heat-transfer medium flowing to the load side, and controls an amount of the heat-transfer medium which bypass flowing to the load side in accordance with the detected flow rate. The controller divides the detected flow rate and allocates the divided flow rate to each of the heat source units in operation, thereby controlling a power of the pump in each of the heat source units in operation in accordance with the allocated amount.



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Description

Technical Field

[0001] Embodiments described herein relate generally to a heat source apparatus comprising a plurality of heat source units.

Background Art

[0002] A heat source apparatus which comprises a plurality of heat source units, and supplies heat or cold energy which can be obtained by the operation of these heat source units to a load side (a use side) is known.

[0003] The heat source unit takes in a heat-transfer medium (water or brine) by the operation of a pump, and heats or cools the taken-in heat-transfer medium by the operation of a heat-pump-type refrigerating cycle.

[0004] The heat source units are connected in parallel with each other via a heat-transfer medium pipe, and the number of these heat source units to be operated is controlled in accordance with the load.

Citation List

Patent Literature

Patent Literature 1

[0005] JP 2008-224182 A

Summary of Invention

Technical Problem

[0006] When a plurality of heat source units are to be operated, the power of a pump of each of the heat source units is controlled in accordance with required capability from the load side.

[0007] However, if pipe resistances of the heat source units to be operated are different from each another, there will be a difference in the flow rate of the heat-transfer medium flowing into each of the heat source units, and a pump of the heat source unit on the side having a lower flow rate may slow down and stop abnormally.

[0008] The present embodiment aims to provide a reliable heat source apparatus which does not cause the pump of a heat source unit to stop abnormally, and which can supply an appropriate amount of heat or cold energy to the load side.

Means for Solving Problem

[0009] An open showcase of claim 1 comprising; a plurality of heat source units which supply a heat-transfer medium to a load side; a first flow control valve which controls an amount of the heat-transfer medium which flows to the load side; a flow detect section which detects the amount of the heat-transfer medium flowing to the load side; a bypass pipe for allowing the heat-transfer medium flowing to the load side to be diverted; a second flow control valve which controls an amount of the heat-transfer medium which flows into the bypass pipe; and a controller which is configured to control the number of the heat source units to be operated and the amount of adjustments of the first flow control valve in accordance with required capability from the load side, to control the amount of adjustments of the second flow control valve in accordance with a flow rate detected by the flow detect section, and to divide the flow rate detected by the flow detect section and allocate the divided flow rate to each of the heat source units in operation, thereby controlling a capability of supplying the heat-transfer medium in each of the heat source units in operation in accordance with the allocated amount.

Brief Description of Drawings

[0010]

FIG. 1 is a diagram showing the entire structure of an embodiment.

FIG. 2 is a diagram showing the structure of a refrigerating cycle of each heat source unit according to the embodiment.

FIG. 3 is a flowchart showing control of a controller according to the embodiment.

FIG. 4 is a graph showing a load-side pipe resistance characteristic of the embodiment.

FIG. 5 is a graph showing the relationship between a flow rate of water and a pumping power in each heat source unit of the embodiment.

Mode for Carrying Out the Invention

[0011] An embodiment of a heat source apparatus of the present embodiment will be described hereinafter with reference to the accompanying drawings.

[0012] As shown in FIG. 1, a plurality of air heat exchangers 3a, 3b, ... 3n, for example, which are the units on a load side, are connected to a plurality of heat source units 1a, 1b, ... 1n via a heat-transfer medium pipe (hereinafter referred to as a water pipe) 2a and a heat-transfer medium pipe (hereinafter referred to as a water pipe) 2b. The heat source units 1a, 1b, ... 1n are connected in parallel with each other via the water pipes 2a and 2b. The air heat exchangers 3a, 3b, ... 3n are also connected in parallel with each other via the water pipes 2a and 2b.

[0013] The water pipe 2a includes a plurality of branch pipes 2aa, 2ab, ... 2an which are connected to water inlets of the air heat exchangers 3a, 3b, ... 3n, respectively. The water pipe 2b includes a plurality of branch pipes 2ba, 2bb, ... 2bn which are connected to water outlets of the air heat exchangers 3a, 3b, ... 3n, respectively.

[0014] The heat source units 1a, 1b, ... 1n each comprise a heat-transfer medium heat exchanger (water heat exchangers 60, 30 which will be described later), a heat-pump-type refrigerating cycle, and a pump (a pump 80 which will be described later). Water (a heat-transfer medium) within the water pipe 2b which has passed through the load side is introduced into the heat-transfer medium heat exchanger by the inlet pressure of the pump, the water within the heat-transfer medium heat exchanger is heated or cooled by an operation of the heat-pump-type refrigerating cycle, and the heated or cooled water is supplied to the water pipe 2a by a discharge pressure of the pump.

[0015] Each of the air heat exchangers 3a, 3b, ... 3n exchanges the heat of the water flowing from the water pipe 2a with the heat of indoor air sent from an indoor fan, and discharges the water after this heat exchange to the water pipe 2b.

[0016] Flow control valves (first flow control valves) 4a, 4b, ... 4n, the respective degrees of opening of which are variable, are provided in the branch pipes 2ba, 2bb, ... 2bn of the water pipe 2b, respectively. The flow control valves 4a, 4b, ... 4n control the amounts of water which flow into the air heat exchangers 3a, 3b, ... 3n by changes in the degrees of opening of the flow control valves 4a, 4b, ... 4n, respectively.

[0017] In the water pipe 2b, at a point downstream from the branch pipes 2ba, 2bb, ... 2bn, a flow sensor (a flow detect section) 5 is arranged. The flow sensor 5 detects the amount (total volume) of water flowing from the air heat exchangers 3a, 3b, ... 3n as an amount (total volume) of water Qt which flows into the air heat exchangers 3a, 3b, ... 3n.

[0018] At a point between where the heat source units 1a, 1b, ... 1n are connected in the water pipe 2a and where the air heat exchangers 3a, 3b, ... 3n are connected in the water pipe 2a, an end of a bypass pipe 6 is connected. 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 air heat exchangers 3a, 3b, ... 3n to bypass the air heat exchangers 3a, 3b, ... 3n, and be returned to the heat source units 1a, 1b, ... 1n. At a midstream portion of the bypass pipe 6, a flow control valve (a second flow control valve) 7, the degree of opening of which is variable, is provided. The flow control valve 7 is also called a bypass valve, and the amount of water which flows into the bypass pipe 6 can be controlled by a change in the degree of opening of the flow control valve 7.

[0019] When the flow control valve 7 is fully closed, water within the pipe 2a does not flow into the bypass pipe 6, but flows to the load side. When the flow control valve 7 is opened, of the water within the pipe 2a, an amount of water in proportion to the degree of opening of the flow control valve 7 flows into the pipe 2b through the bypass pipe 6. Water which did not flow into the bypass pipe 6 of the water within the pipe 2a flows to the load side.

[0020] At a point between both ends of the bypass pipe 6, a differential pressure sensor 8, which is a first differential pressure detect section, is connected. The differential pressure sensor 8 detects a difference P between the pressure of water on one end of the bypass pipe 6 and the pressure of water on the other end of the same (i.e., a difference P between water pressures at both ends of the bypass pipe 6).

[0021] As described above, the heat source units 1a, 1b, ... 1n each comprise a heat-transfer medium heat exchanger (the water heat exchangers 60, 30 which will be described later) and a pump (the pump 80 which will be described later) which circulates water between the heat-transfer medium heat exchanger and the load side. The heat source units 1a, 1b, ... 1n heat or cool water which passes through the heat-transfer medium heat exchanger by the operation of the heat-pump-type refrigerating cycle.

[0022] FIG. 2 shows the structure of a heat-pump-type refrigerating cycle mounted in the heat source unit 1a. Note that each of the heat-pump-type refrigerating cycles mounted in the heat source units 1b, ... 1n also has a similar structure.

[0023] A refrigerant discharged from a compressor 21 flows into air heat exchangers 23a and 23b via a four-way valve 22, and the refrigerant which has passed through the air heat exchangers 23a and 23b flows into a first refrigerant channel 30a of the water 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 30a is suctioned into the compressor 21 through the four-way valve 22 and an accumulator 25. The direction in which the refrigerant flows as above corresponds to one at the time of a cooling operation (a cold-water generation operation), and the air heat exchangers 23a and 23b serve as condensers, and the first refrigerant channel 30a of the water 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. That is, the first refrigerant channel 30a of the water heat exchanger 30 serves as the condenser, and the air heat exchangers 23a and 23b serve as the evaporators.

[0024] A first heat-pump-type refrigerating 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 30a of the water heat exchanger 30, and the accumulator 25.

[0025] A refrigerant discharged from a compressor 41 flows into air heat exchangers 43a and 43b via a four-way valve 42, and the refrigerant which has passed through the air heat exchangers 43a and 43b flows into a second refrigerant channel 30b of the water heat exchanger 30 via electronic expansion valves 44a and 44b. The refrigerant which has passed through the second refrigerant channel 30b is suctioned into the compressor 41 through the four-way valve 42 and an accumulator 45. The direction in which the refrigerant flows as above corresponds to one at the time of a cooling operation (a cold-water generation operation), and the air heat exchangers 43a and 43b serve as condensers, and the second refrigerant channel 30b of the water 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 42 is switched and the flowing direction of the refrigerant is reversed. That is, the second refrigerant channel 30b of the water heat exchanger 30 serves as the condenser, and the air heat exchangers 43a and 43b serve as the evaporators.

[0026] A second heat-pump-type refrigerating cycle is constituted by the compressor 41, the four-way valve 42, the air heat exchangers 43a and 43b, the electronic expansion valves 44a and 44b, the second refrigerant channel 30b of the water heat exchanger 30, and the accumulator 45.

[0027] A refrigerant discharged from a compressor 51 flows into air heat exchangers 53a and 53b via a four-way valve 52, and the refrigerant which has passed through the air heat exchangers 53a and 53b flows into a first refrigerant channel 60a of the water heat exchanger (heat-transfer medium heat exchanger) 60 via electronic expansion valves 54a and 54b. The refrigerant which has passed through the first refrigerant channel 60a is suctioned into the compressor 51 through the four-way valve 52 and an accumulator 55. The direction in which the refrigerant flows as above corresponds to one at the time of a cooling operation (a cold-water generation operation), and the air heat exchangers 53a and 53b serve as condensers, and the first refrigerant channel 60a of the water heat exchanger 60 serves as an evaporator. At the time of a heating operation (a hot-water generation operation), the channel of the four-way valve 52 is switched and the flowing direction of the refrigerant is reversed. That is, the first refrigerant channel 60a of the water heat exchanger 60 serves as the condenser, and the air heat exchangers 53a and 53b serve as the evaporators.

[0028] A third heat-pump-type refrigerating cycle is constituted by the compressor 51, the four-way valve 52, the air heat exchangers 53a and 53b, the electronic expansion valves 54a and 54b, the first refrigerant channel 60a of the water heat exchanger 60, and the accumulator 55.

[0029] A refrigerant discharged from a compressor 71 flows into air heat exchangers 73a and 73b via a four-way valve 72, and the refrigerant which has passed through the air heat exchangers 73a and 73b flows into a second refrigerant channel 60b of the water heat exchanger 60 via electronic expansion valves 74a and 74b. The refrigerant which has passed through the second refrigerant channel 60b is suctioned into the compressor 71 through the four-way valve 72 and an accumulator 75. The direction in which the refrigerant flows as above corresponds to one at the time of a cooling operation (a cold-water generation operation), and the air heat exchangers 73a and 73b serve as condensers, and the second refrigerant channel 60b of the water heat exchanger 60 serves as an evaporator. At the time of a heating operation (a hot-water generation operation), the channel of the four-way valve 72 is switched and the flowing direction of the refrigerant is reversed. That is, the second refrigerant channel 60b of the water heat exchanger 60 serves as the condenser, and the air heat exchangers 73a and 73b serve as the evaporators.

[0030] A fourth heat-pump-type refrigerating cycle is constituted by the compressor 71, the four-way valve 72, the air heat exchangers 73a and 73b, the electronic expansion valves 74a and 74b, the second refrigerant channel 60b of the water heat exchanger 60, and the accumulator 75.

[0031] Water in the water pipe 2b flows into a water channel 60c of the water heat exchanger 60 through a water pipe 101. The water flowing from the water channel 60c flows into a water channel 30c of the water heat exchanger 30 through a water pipe 102. The water flowing from the water channel 30c flows into the water pipe 2a. The water channel 60c of the water heat exchanger 60 and the water channel 30c of the water heat exchanger 30 are connected in series via the water pipe 102.

[0032] A pump 80 is provided in the water pipe 101. The pump 80 draws the water within the water pipe 2b into the water pipe 101, and sends the drawn water to the water pipe 2b through the water heat exchanger 60, the water pipe 102, the water heat exchanger 30, and a water pipe 103. The pump 80 has a motor which operates by an alternating voltage supplied from an inverter 81, and the power (lifting height) is changed in accordance with a speed of rotation of the motor. The inverter 81 rectifies a voltage of a commercial alternating-current power supply 82, converts a direct-current voltage after the rectification into an alternating voltage of a predetermined frequency by switching, and supplies the converted alternating voltage as power to drive the motor of the pump 80. By changing a frequency (output frequency) F of an output voltage of the inverter 81, the speed of rotation of the motor of the pump 80 is changed.

[0033] At a point between the water pipe 101 and the water pipe 103 (i.e., between an end of the water heat exchanger 60 and an end of the water heat exchanger 30), a differential pressure sensor 90, which is a second differential pressure detect section, is connected. The differential pressure sensor 90 detects a difference Pw between the pressure of water which flows into the water heat exchanger 60 and the pressure of water which flows out of the water heat exchanger 30. The amount of water which flows into the water heat exchangers 60 and 30, that is, an amount of water Wa which flows into the heat source unit 1a, can be detected based on the pressure difference Pw detected by the differential pressure sensor 90.

[0034] Meanwhile, a controller 10 is connected to the heat source units 1a, 1b, ... 1n, the flow control valves 4a, 4b, ... 4n, the flow sensor 5, the flow control valve 7, and the differential pressure sensor 8. A heat source apparatus is constituted by the heat source units 1a, 1b, ...

1n, the water pipes 2a and 2b, the flow control valves 4a, 4b, ... 4n, the flow sensor 5, the bypass pipe 6, the flow control valve 7, the differential pressure sensor 8, and the controller 10.

[0035] The controller 10 controls the operation of the heat source units 1a, 1b, ... 1n, the degree of opening of the flow control valves 4a, 4b, ... 4n, and the degree of opening of the flow control valve 7. As the main function, the controller 10 includes a first detect section 11, a second detect section 12, a first control section 13, a second control section 14, a third control section 15, and a memory 16.

[0036] At the time of a test operation after the heat source apparatus has been installed (i.e., after installation), the first detect section 11 detects a load-side pipe resistance characteristic (also referred to as a secondary pipe resistance characteristic) representing the relationship between an amount Q of water which flows to the load side and a difference P between water pressures at both ends of the bypass pipe 6 while operating each of the pumps 80 of the heat source units 1a, 1b, ... 1n at their rated power (a predetermined operating frequency F).

[0037] The second detect section 12 detects an amount of water W which flows into each of the heat source units in operation by a computation based on the pressure difference Pw detected by each of the differential pressure sensors 90 of the heat source units 1a, 1b, ... 1n, and a heat exchanger resistance characteristic in each of the heat source units 1a, 1b, ... 1n. The heat exchanger resistance characteristic is specific to the water heat exchangers 60 and 30, and is measured in advance and stored in the memory 16 of the controller 10.

[0038] In accordance with a total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n on the load side (i.e., a difference between an indoor air temperature Ta and a preset temperature Ts), the first control section 13 controls the number of heat source units 1a, 1b, ... 1n to be operated, and the degree of opening of each of the flow control valves 4a, 4b, ... 4n.

[0039] The second control section 14 controls the degree of opening of the flow control valve (bypass valve) 7 in accordance with the flow rate Qt detected by the flow sensor 5, and the load-side pipe resistance characteristic detected by the first detect section 11, so that an optimum amount of water which is commensurate with the total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n flows into the air heat exchangers 3a, 3b, ... 3n.

[0040] The third control section 15 divides (for example, equally divides) the flow rate Qt detected by the flow sensor 5 and allocates the divided flow rate to the heat source units in operation of the heat source units 1a, 1b, ... 1n as a necessary flow rate Wt. In this way, the third control section 15 controls the power of the pump 80 (the capability of supplying the heat-transfer medium) of each of the heat source units in operation so that each of the flow rates W detected by the second detect section 12 agrees with the allocated flow rate Wt.

[0041] Next, referring to a flowchart of FIG. 3, the control executed by the controller 10 will be described.

[0042] At the time of a test operation after the heat source apparatus has been installed (Yes in step S1), the controller 10 detects the load-side pipe resistance characteristic by a next process (step S2).

[0043] First, the controller 10 fully closes the flow control valve 7 of the bypass pipe 6, and fully opens only the flow control valve corresponding to an air heat exchanger having the greatest pipe resistance of the flow control valves 4a, 4b, ... 4n and fully closes the rest of the flow control valves. In this state, the controller 10 operates each of the pumps 80 of the heat source units 1a, 1b, ... 1n at the rated power (a predetermined operating frequency F), and stores a corresponding point (an intersection point) of a value (minimum flow rate) Qn of the flow rate Qt detected by the flow sensor 5 and a value Pn of the pressure difference P detected by the differential pressure sensor 8 at this time as a first characteristic point Sn as shown in FIG. 4 in the memory 16. In this case, since the flow control valve 7 is fully closed, all of the water which flows out from the heat source units 1a, 1b, ... 1n is directly transmitted to the load side without being diverted.

[0044] As the air heat exchanger having the greatest pipe resistance, the air heat exchangers 3n, for example, which is located at a distal end position where the distance of the pipe from the heat source units 1a, 1b, ... 1n is the greatest, is selected in advance. Alternatively, the air heat exchanger 3b, for example, which is closer to the heat source units 1a, 1b, ... 1n than from the air heat exchanger 3n at the distal end position, may be selected in advance as the air heat exchanger having the greatest pipe resistance for the fact that the branch pipes 2ab and 2bb connected to the water pipes 2a and 2b are narrower than the branch pipes of the other air heat exchangers. Selection of the air heat exchanger having the greatest pipe resistance is carried out based on an empirical rule or measurement of an operator in the installation of the heat source apparatus. A result of this selection is stored in the memory 16 of the controller 10.

[0045] Next, the controller 10 fully opens all of the flow control valves 4a, 4b, ... 4n while fully closing the flow control valve 7 of the bypass pipe 6. In this state, the controller 10 operates each of the pumps 80 of the heat source units 1a, 1b, ... 1n at the rated power, and stores a corresponding point (an intersection point) of a value (maximum flow rate) Qm of the flow rate Qt detected by the flow sensor 5 and a value Pm of the pressure difference P detected by the differential pressure sensor 8 at this time as a second characteristic point Sm as shown in FIG. 4 in the memory 16.

[0046] Further, the controller 10 detects a quadratic approximation curve which approximately represents the relationship between the amount of water Q which flows to the load side and the difference P between water pressures at both ends of the bypass pipe 6 by connecting the stored first characteristic point Sn and second characteristic point Sm as the load-side pipe resistance characteristic. The controller 10 stores it in the memory 16 as the detected load-side pipe resistance characteristic.

[0047] Meanwhile, at the time of a normal operation after the test operation has been finished (No in step S1), in accordance with a total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n on the load side (i.e., a difference between an indoor air temperature Ta and a preset temperature Ts), the controller 10 controls the number of heat source units 1a, 1b, ... 1n to be operated, and the degree of opening of each of the flow control valves 4a, 4b, ... 4n (step S3).

[0048] That is, the greater the total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n is, the more the controller 10 increases the number of heat source units 1a, 1b, ... 1n to be operated. In contrast, the smaller the total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n is, the less the number of heat source units 1a, 1b, ... 1n to be operated is. Further, the greater the required power of the air heat exchanger 3a is, the more the controller 10 increases the degree of opening of the flow control valve 4a (i.e., increases the flow). In contrast, the smaller the required power of the air heat exchanger 3a is, the smaller the degree of opening of the flow control valve 4a is (i.e., the flow is reduced). The degree of opening of each of the flow control valves 4b, ... 4n corresponding to the air heat exchangers 3b, ... 3n is also similarly controlled.

[0049] In accordance with execution of the control of the number of heat source units to be operated and the control of the degree of opening, the amount (total volume) of water Qt which actually flows into the air heat exchangers 3a, 3b, ... 3n is detected by the flow sensor 5.

[0050] The controller 10 obtains a target pressure difference Pt which is the target difference between water pressures at both ends of the bypass pipe 6 corresponding to the flow rate Qt detected by the flow sensor 5 from the load-side pipe resistance characteristic shown in FIG. 4 which has been detected and stored at the time of test operation (step S4). Further, the controller 10 controls the degree of opening of the flow control valve 7 (the bypass amount of water) such that the pressure difference P detected by the differential pressure sensor 8 (difference P between water pressures at both ends of the bypass pipe 6) is equivalent to the target pressure difference Pt obtained as described above (step S5).

[0051] By setting the pressure difference P detected by the differential pressure sensor 8 to the target pressure difference Pt, an optimum amount of water which is commensurate with the total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n flows into the air heat exchangers 3a, 3b, ... 3n. Water which is excessive for the air heat exchangers 3a, 3b, ... 3n returns to one or more heat source units in operation through the bypass pipe 6.

[0052] The controller 10 equally divides the flow rate Qt detected by the flow sensor 5, and allocates the divided flow rate to one or more heat source units in operation as the necessary flow rate Wt (step S6). For example, if the flow rate Qt detected by the flow sensor 5 is 1000 1/hr, and the number of heat source units in operation of the heat source units 1a, 1b, ... 1n is five, the flow rate of 200 (=1000/5) 1/hr is allocated as the necessary flow rate Wt per heat source unit. If the flow rate Qt detected by the flow sensor 5 is 1200 1/hr, and the number of heat source units in operation of the heat source units 1a, 1b, ... 1n is four, the flow rate of 300 (=1200/4) 1/hr is allocated as the necessary flow rate Wt per heat source unit.

[0053] By a computation based on the pressure difference Pw detected by the differential pressure sensor 90 of one or more heat source units in operation and the heat exchanger resistance characteristic of the water heat exchangers (the water heat exchangers 60 and 30) of the one or more heat source units in operation, the amount of water W which flows into the one or more heat source units in operation individually is detected (step S7).

[0054] For example, when two heat source units, i.e., the heat source units 1a and 1b, are in operation, the controller 10 reads a pressure difference Pwa detected by the differential pressure sensor 90 of the heat source unit 1a and a pressure difference Pwb detected by the differential pressure sensor 90 of the heat source unit 1b, and also reads the heat exchanger resistance characteristic of the heat source unit 1a and the heat exchanger resistance characteristic of the heat source unit 1b from the memory 16. Then, the controller 10 detects an amount of water Wa which flows into the heat source unit 1a and an amount of water Wb which flows into the heat source unit 1b by a computation based on the detected pressure differences Pwa and Pwb and each of the heat exchanger resistance characteristics.

[0055] The controller 10 controls the output frequency F of each of the inverters 81 of the heat source units 1a and 1b such that each of the detected flow rates Wa and Wb agrees with the necessary flow rates Wt allocated to the heat source units 1a and 1b (step S8).

[0056] More specifically, when the detected flow rate Wa is less than the necessary flow rate Wt allocated to the heat source unit 1a, the controller 10 increases the output frequency F of the inverter 81 of the heat source unit 1a. As a result, the power of the pump 80 of the heat source unit 1a is increased, and the amount of water Wa which flows into the heat source unit 1a changes to be increased. When the detected flow rate Wa is more than the necessary flow rate Wt allocated to the heat source unit 1a, the controller 10 reduces the output frequency F of the inverter 81 of the heat source unit 1a. As a result, the power of the pump 80 of the heat source unit 1a is reduced, and the amount of water Wa which flows into the heat source unit 1a changes to be reduced. When the detected flow rate Wa is equal to the necessary flow rate Wt allocated to the heat source unit 1a, the controller 10 maintains the output frequency F of the inverter 81 of the heat source unit 1a at that time.

[0057] Similarly, when the detected flow rate Wb is less than the necessary flow rate Wt allocated to the heat source unit 1b, the controller 10 increases the output frequency F of the inverter 81 of the heat source unit 1b. When the detected flow rate Wb is more than the necessary flow rate Wt allocated to the heat source unit 1b, the controller 10 reduces the output frequency F of the inverter 81 of the heat source unit 1b. When the detected flow rate Wb is equal to the necessary flow rate Wt allocated to the heat source unit 1b, the controller 10 maintains the output frequency F of the inverter 81 of the heat source unit 1b at that time.

[0058] Note that the amounts of water Wa, Wb, ... Wn which flow into the heat source units 1a, 1b, ... 1n, respectively, vary depending on the pipe resistance between heat source unit side (i.e., where the heat source units 1a, 1b, ... 1n are arranged) and the load side. That is, the pipe resistance of the heat source unit 1n located at a distal end position that is farthest from the load side is great, and the amount of water Wn which flows into the heat source unit 1n is therefore somewhat reduced. The pipe resistance of the heat source unit 1a which is closer to the load side is small, and thus, the amount of water Wa which flows into the heat source unit 1a is somewhat increased.

[0059] FIG. 5 shows the relationship between the amounts of water Wa and Wn which flow into the heat source units 1a and 1n and the power (pumping power) of each of the pumps 80 of the heat source units 1a and 1n, when, for example, two heat source units 1a and 1n are operated, with the heat exchanger resistances Ra and Rn of the heat source units 1a and 1n given as the parameters. In order to make the amount of water Wa which flows into the heat source unit 1a agree with the necessary flow rate Wt allocated to the heat source unit 1a, the operating frequency F of the pump 80 of the heat source unit 1a may be set to a predetermined value Fa. In order to make the amount of water Wn which flows into the heat source unit 1n at the distal end position agree with the necessary flow rate Wt allocated to the heat source unit 1n, the operating frequency F of the pump 80 of the heat source unit 1n may be set to a predetermined value Fn (> Fa).

[0060] Accordingly, as described above, by detecting the amount (total volume) of water Qt which flows into the air heat exchangers 3a, 3b, ... 3n on the load side, dividing the detected flow rate Qt and allocating the divided flow rate to each of the heat source units in operation, for example, the heat source units 1a and 1n, as the necessary flow rate Wt, and controlling the operating frequency F of each of the pumps 80 of the heat source units 1a and 1n such that the amounts of water Wa and Wn which flow into the heat source units 1a and 1n agree with the necessary flow rate Wt, the amounts of water Wa and Wn which flow into the heat source units 1a and 1n can be made the same even if the pipe resistance of the heat source unit 1a is different from the pipe resistance of the heat source unit 1n.

[0061] Since the amounts of water Wa and Wn which flow into the heat source units 1a and 1n are even, it is possible to prevent each of the pumps 80 of the heat source units 1a and 1n from slowing down and stopping abnormally. Thereby, an appropriate amount of hot water or cold water, which is commensurate with the total sum of the required power of each of the air heat exchangers 3a, 3b, ... 3n, can be supplied to the air heat exchangers 3a, 3b, ... 3n at all times.

[0062] Since the operating frequency F of each of the pumps 80 needs only to be increased or reduced so as to obtain the necessary flow rate Wt, there is no need to detect the so-called heat-source-unit-side pipe resistance characteristic (a primary pipe resistance characteristic) or the characteristic of each of the pumps 80 in advance. Even in an installation environment in which the heat source units 1a, 1b, ... 1n are intricately arranged, stopgap steps such as header construction and reverse turn piping for equalizing the pipe resistance do not need to be taken.

[Modifications]

[0063] The above embodiment was described by referring to the heat source units 1a, 1b, ... 1n each comprising four heat-pump-type refrigerating cycles and two water heat exchangers as an example. However, the numbers of heat-pump-type refrigerating cycles and water heat exchangers of each heat source unit can be selected as required.

[0064] The above embodiment was described by referring to a case where the unit on the load side is an air heat exchanger. However, the present embodiment can similarly be put into practice in a case where the unit on the load side is, for example, a hot-water storage tank.

[0065] In the above embodiment, an amount of water which flows to the load side is detected, the detected flow rate is evenly divided, and the divided flow rate is allocated to each of the heat source units in operation. However, the division may not necessarily be even, but may be such a division that each of the pumps 80 can operate continuously without slowing down.

[0066] In the above embodiment, the load-side pipe resistance characteristic is detected through a test operation after installation of the heat source apparatus. However, detecting the load-side pipe resistance characteristic is not limited to the above occasion, and may be carried out at the time of a test operation which takes place after the air heat exchangers on the load side have been increased or decreased.

[0067] The embodiment and modifications described herein 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 embodiment described herein may be made without departing from the spirit of the invention. 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.

Industrial Applicability

[0068] The heat source apparatus of the present embodiment can be used for an air conditioner, a hot-water supply apparatus, etc.

Reference Signs List

[0069] 1a, 1b, ... 1n···heat source unit, 2a, 2b···water pipe (heat-transfer medium pipe), 3a, 3b, ... 3n··· air heat exchanger (unit on a load side), 4a, 4b, ... 4n ···flow control valve (first flow control valve), 5··· flow sensor (flow detect section), 6··· bypass pipe, 7···flow control valve (second flow control valve), 8··· differential pressure sensor (first differential pressure detect section), 10··· controller, 11···first detect section, 12···second detect section, 13···first control section, 14···second control section, 15···third control section, 21, 41, 51, 71··· compressor, 30, 60···water heat exchanger (heat-transfer medium heat exchanger), 80···pump, 81···inverter, 82···commercial alternating-current power supply, 90··· differential pressure sensor (second differential pressure detect section)

Claims

1. A heat source apparatus **characterized by** comprising:

   a plurality of heat source units which supply a heat-transfer medium to a load side;
   a first flow control valve which controls an amount of the heat-transfer medium which flows to the load side;
   a flow detect section which detects the amount of the heat-transfer medium flowing to the load side;
   a bypass pipe for allowing the heat-transfer medium flowing to the load side to be diverted;
   a second flow control valve which controls an amount of the heat-transfer medium which flows into the bypass pipe; and
   a controller which is configured to control the number of the heat source units to be operated and the amount of adjustments of the first flow control valve in accordance with required capability from the load side, to control the amount of adjustments of the second flow control valve in accordance with a flow rate detected by the flow detect section, and to divide the flow rate detected by the flow detect section and allocate the divided flow rate to each of the heat source units in operation, thereby controlling a capability of supplying the heat-transfer medium in each of the heat source units in operation in accordance with the allocated amount.

2. The heat source apparatus of Claim 1, **characterized in that** each of the heat source units includes:

   a heat-transfer medium heat exchanger through which the heat-transfer medium flows;
   a heat-pump-type refrigerating cycle which heats or cools the heat-transfer medium within the heat-transfer medium heat exchanger; and
   a pump which draws in the heat-transfer medium which has passed through the load side and sends the drawn heat-transfer medium to the load side through the heat-transfer medium heat exchanger.

3. The heat source apparatus of Claim 2, **characterized in that**:

   the first flow control valve controls the amount of the heat-transfer medium which flows to the load side by a change in a degree of opening;
   the bypass pipe which allows the heat-transfer medium flowing from each of the heat source units toward the load side to be diverted, and returns the diverted heat-transfer medium to each of the heat source units; and
   the second flow control valve controls the amount of the heat-transfer medium which flows into the bypass pipe by a change in a degree of opening.

4. The heat source apparatus of Claim 3, **characterized in that** the controller includes:

   a first control section which controls the number of the heat source units to be operated and the degree of opening of the first flow control valve in accordance with the required capability from the load side;
   a second control section which controls the degree of opening of the second flow control valve in accordance with the flow rate detected by the flow detect section; and
   a third control section which divides the flow rate detected by the flow detect section and allocates the divided flow rate to each of the heat source units in operation, thereby controlling a power of the pump in each of the heat source units in operation in accordance with the allocated amount.

5. The heat source apparatus of Claim 2, **characterized in that** the heat source units are connected in parallel with each other by a pipe.

6. The heat source apparatus of Claim 5, further comprising:

a first differential pressure detect section which detects a pressure difference P, which is a difference between pressures of the heat-transfer medium at both ends of the bypass pipe; and
a second differential pressure detect section which detects a pressure difference Pw, which is a difference between pressures of the heat-transfer medium at both ends of each of the heat-transfer medium heat exchangers,
characterized in that the controller includes:

a first detect section which detects a load-side pipe resistance characteristic representing a relationship between an amount Q of the heat-transfer medium which flows to the load side and the pressure difference P, which is the difference between pressures of the heat-transfer medium at both ends of the bypass pipe;
a first control section which controls the number of the heat source units to be operated and a degree of opening of the first flow control valve in accordance with the required capability from the load side;
a second detect section which detects an amount W of the heat-transfer medium which flows into each of the heat source units in operation, on the basis of the pressure difference Pw detected by the second differential pressure detect section;
a second control section which controls a degree of opening of the second flow control valve in accordance with a flow rate Qt detected by the flow detect section and the load-side pipe resistance characteristic detected by the first detect section; and
a third control section which divides the flow rate Qt detected by the flow detect section and allocates the divided flow rate to each of the heat source units in operation as a necessary flow rate Wt, and controls a power of the pump in each of the heat source units in operation such that each flow rate W detected by the second detect section agrees with the necessary flow rate Wt.

7. The heat source apparatus of Claim 6, **characterized in that** the first detect section detects the load-side pipe resistance characteristic at a test operation.

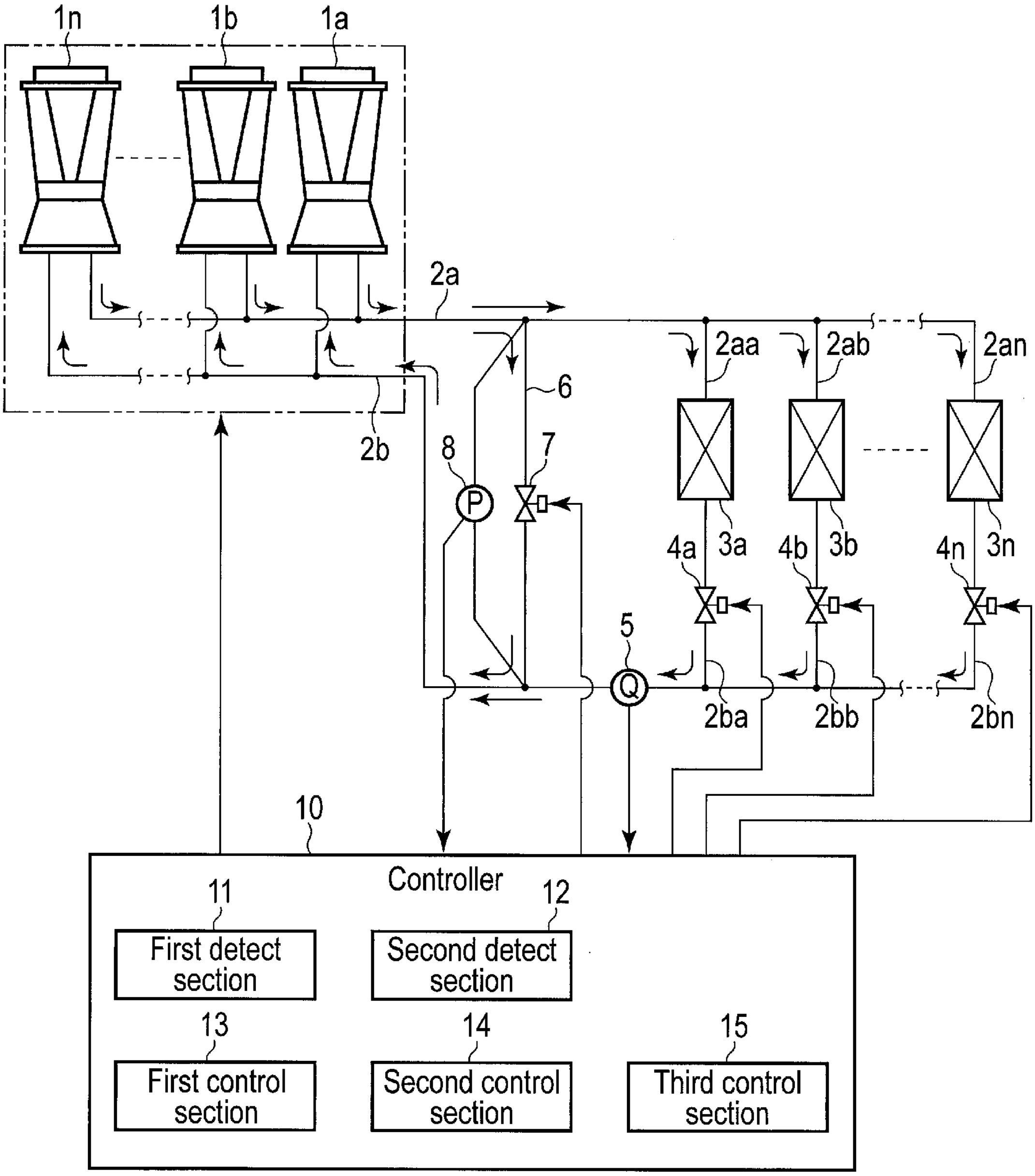
8. The heat source apparatus of Claim 6, **characterized in that** the second detect section detects the amount W of the heat-transfer medium which flows into each of the heat source units in operation, on the basis of the pressure difference Pw detected by the second differential pressure detect section and a heat exchanger resistance characteristic of each of the heat source units.

9. The heat source apparatus of Claim 6, **characterized in that**:

the flow detect section detects a total amount of the heat-transfer medium which flows into a plurality of units connected in parallel with each other by a pipe on the load side; and
a plurality of first flow control valves, each of which is identical to the first flow control valve, control the amount of the heat-transfer medium which flows into the plurality of units individually by changes in their degrees of opening.

10. The heat source apparatus of Claim 9, **characterized in that** the first detect section is configured to:

fully close the second flow control valve in a test operation of the heat source apparatus, fully open only one of the first flow control valves corresponding to a unit having the greatest pipe resistance of the plurality of units and fully close the other one or more first flow control valves, operate the pumps of the respective heat source units at their rated power in this state, and store a corresponding point of a value Qn of the flow rate Qt detected by the flow detect section and a value Pn of the pressure difference P detected by the first differential pressure detect section at this time as a first characteristic point Sn;
have all of first flow control valves opened subsequently while having the second flow control valve fully closed, operate the pumps of the respective heat source units at their rated power in this state, and store a corresponding point of a value Qm of the flow rate Qt detected by the flow detect section and a value Pm of the pressure difference P detected by the first differential pressure detect section at this time as a second characteristic point Sm; and
detect a quadratic approximation curve which approximately represents a relationship between an amount of water Q which flows to the load side and a difference P between water pressures at both ends of the bypass pipe 6 by connecting the stored first characteristic point Sn and second characteristic point Sm as the load-side pipe resistance characteristic.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8
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P
3a
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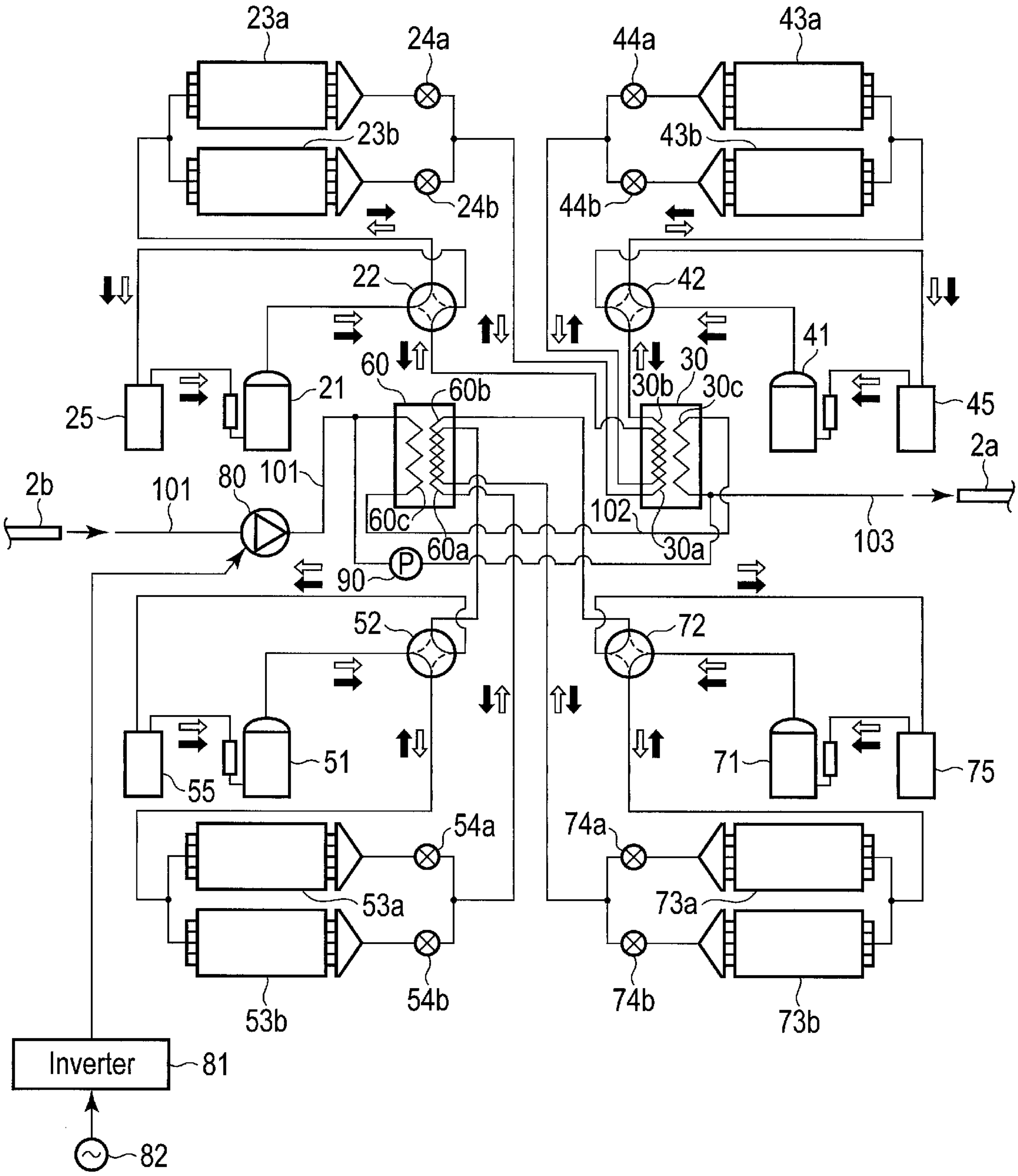
4b
4n
5
Q
2ba
2bb
2bn
10
Controller
11
First detect section
12
Second detect section
13
First control section
14
Second control section
15
Third control section

F I G. 1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45
2a
2b
101
80
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102
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60a
30a
90
P
52
72
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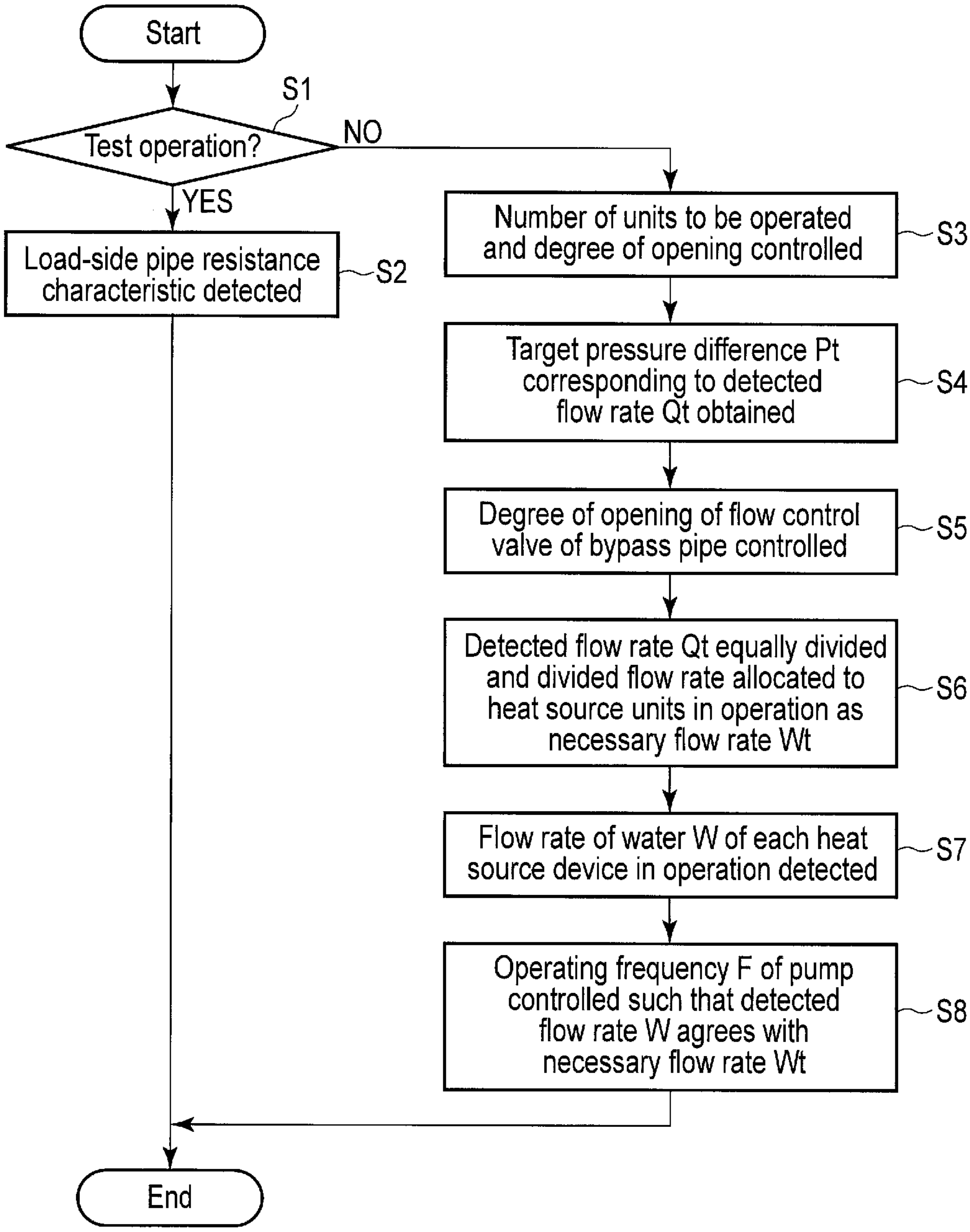
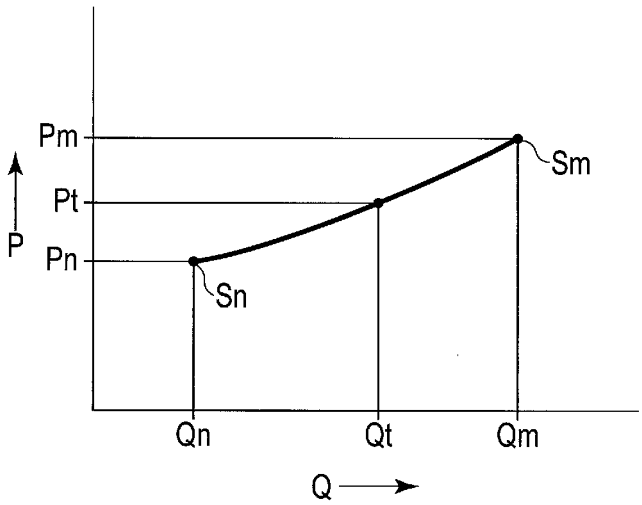
74b
53b
73b
Inverter
81
82

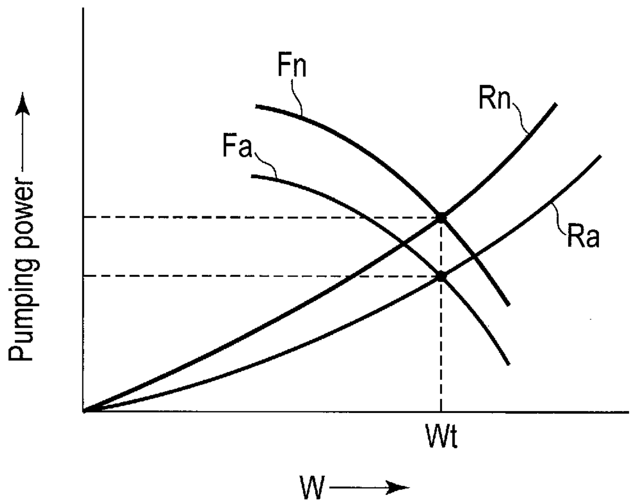
F I G. 2


Start
S1
Test operation?
NO
YES
Load-side pipe resistance characteristic detected
S2
Number of units to be operated and degree of opening controlled
S3
Target pressure difference Pt corresponding to detected flow rate Qt obtained
S4
Degree of opening of flow control valve of bypass pipe controlled
S5
Detected flow rate Qt equally divided and divided flow rate allocated to heat source units in operation as necessary flow rate Wt
S6
Flow rate of water W of each heat source device in operation detected
S7
Operating frequency F of pump controlled such that detected flow rate W agrees with necessary flow rate Wt
S8
End

F I G. 3



F I G. 4



F I G. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/054612

A. CLASSIFICATION OF SUBJECT MATTER
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)
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.
Y A	JP 2011-58660 A (Hitachi Cable, Ltd.), 24 March 2011 (24.03.2011), paragraphs [0034] to [0085]; fig. 1 to 3 (Family: none)	1-5 6-10
Y A	JP 2013-181673 A (Mitsubishi Heavy Industries, Ltd.), 12 September 2013 (12.09.2013), paragraphs [0027] to [0030]; fig. 1 & US 2014/0358253 A & WO 2013/129464 A1 & EP 2821725 A & KR 10-2014-0108556 A & CN 104246381 A	1-5 6-10

☒ 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
19 May 2015 (19.05.15)

Date of mailing of the international search report
26 May 2015 (26.05.15)

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

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/054612

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2010-270970 A (Mitsubishi Heavy Industries, Ltd.), 02 December 2010 (02.12.2010), paragraphs [0020] to [0053]; fig. 1 to 4 (Family: none)	1-5 6-10

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REFERENCES CITED IN THE DESCRIPTION

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