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

(11) EP 2 325 570 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.05.2011 Bulletin 2011/21

(21) Application number: **10009569.4**

(22) Date of filing: **14.09.2010**

(51) Int Cl.:
F24D 19/10 *(2006.01)* ***F24F 11/00*** *(2006.01)*
F24F 3/06 *(2006.01)* ***F25B 13/00*** *(2006.01)*
F25B 49/02 *(2006.01)*

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

(30) Priority: **24.11.2009 JP 2009266361**

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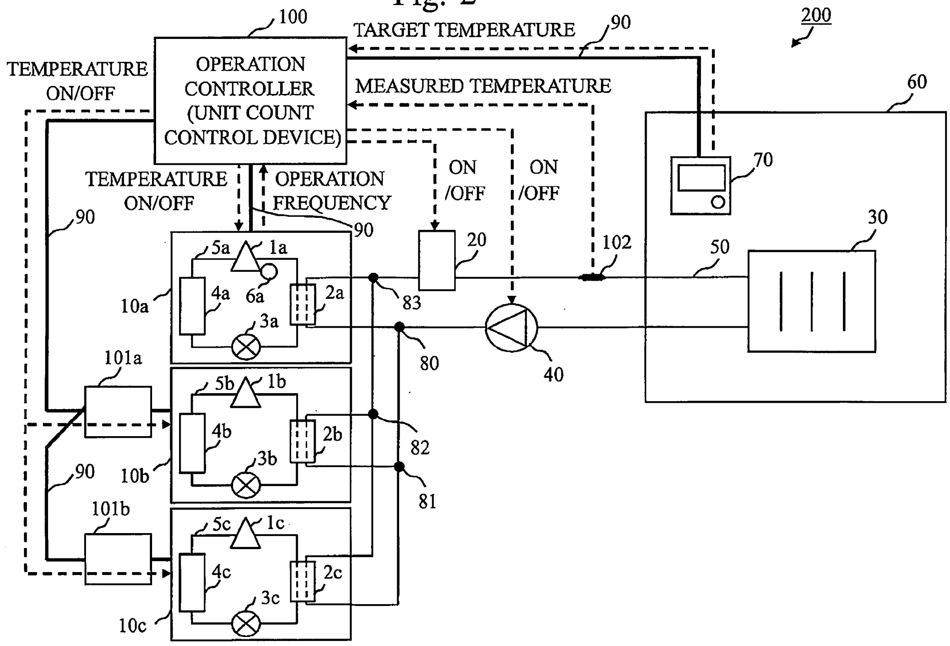
(54) Unit count control device, unit count control method, and fluid supply system

(57) [Object] In a fluid supply system which includes a plurality of heat pump units having a compressor and which supplies a fluid heated or cooled by the heat pump units to a fluid-using device, to control the operation unit count of heat pump units efficiently without grasping the air-conditioning capacities of the heat pump units.

[Means of Solution] The operation frequency of the compressor provided to a predetermined heat pump unit of the plurality of heat pump units is acquired. Whether or not to operate, other than the predetermined heat pump unit of the plurality of heat pump units, remaining heat pump units is determined depending on the operation frequency acquired.

Fig. 2



EP 2 325 570 A2

Description

[Technical Field]

[0001] The present invention relates to a technique for controlling the operation unit count of heat pump units in, for example, a fluid supply system that uses a plurality of heat pump units.

[Background Art]

[0002] In an air conditioning system provided with a plurality of heat source machines such as heat pump units, the count of heat source machines to be operated may be controlled based on the air-conditioning load to be removed from the building and the air-conditioning capacity (characteristics) of the heat source machines. Patent document 1 includes a description on measurement of air-conditioning load data and determination of the count of heat source machines to be operated, based on the measured air-conditioning load data.

[Prior Art Document]

[Patent Document]

[0003]

> [Patent Document 1]
> Japanese Unexamined Patent Publication No. 2009-127936

[Summary of the Invention]

[Problems to be Solved by the Invention]

[0004] When a unit count control device that controls the count of heat source machines to be operated is to grasp the air-conditioning load, a measurement instrument (e.g., apIurality of pipe temperature measurement thermistors, flowmeters, or the like) must be installed, and the air-conditioning load must be detected by it. In general, the measurement instrument is not installed in a building that is not under constant energy management (e.g., a small-scale house, an apartment, and the like). It is costly to install a measurement instrument in such a building.
When the unit count control device is to grasp the air-conditioning capacity of the heat source machines, the air-conditioning capacity must be input to the unit count control device in advance, or the unit control device must acquire information on the air-conditioning capacity from the heat source machines via a communication circuit. A person in charge of installation of the heat source machines may install arbitrarily selected heat source machines. In this case, since the air-conditioning capacity of the heat source machines to be connected cannot be known in advance,the air-conditioning capacity cannot be input to the unit count control device in advance. Depending on how the heat source machines are installed, the unit count control device cannot acquire information on the air-conditioning capacity from the heat source machines via the communication circuit.
It is an object of the present invention to control the operation unit count of heat pump units efficiently without grasping the air-conditioning capacity of the heat pump units.

[Means to Solve the Problems]

[0005] For example, according to the present invention, in a fluid supply system which includes a plurality of heat pump units having a compressor and which supplies a fluid that has undergone one of heating and cooling by the heat pump units to a fluid-using device, a unit count control device serves to control an operation unit count of the plurality of heat pump units, and includes
a frequency acquisition part which acquires an operation frequency of the compressor provided to a predetermined heat pump unit of the plurality of heat pump units; and
a unit count control part which determines whether or not to operate, other than the predetermined heat pump unit of the plurality of heat pump units, remaining heat pump units depending on the operation frequency acquired by the frequency acquisition part.

[Effect of the Invention]

[0006] A unit count control device according to the present invention controls the operation unit count depending on the operation frequency of the compressor provided to a certain heat pump unit. Hence, the operation unit count of heat pump units can be controlled efficiently without grasping the air-conditioning capacities of the heat pump units.

[Brief Explanation of the Drawings]

[0007]

> Fig. 1 is a view showing the basic configuration of a fluid supply system 200;
> Fig. 2 is a view showing the configuration of the fluid supply system 200 according to the first embodiment;
> Fig. 3 is a function block diagram showing the function of an operation controller 100;
> Fig. 4 includes conceptual illustrations and graphs showing the effect on the operation efficiency of the heat source machines in unit count control; and
> Fig. 5 is a flowchart showing the flow of a unit count control process by a unit count control part 122.

[Embodiments for Carrying out the Invention]

Embodiment 1

[0008] Fig. 1 is a view showing the basic configuration of a fluid supply system 200.
The fluid supply system 200 is provided with a heat pump unit 10, an auxiliary heat source 20, a heat dissipator 30 (an example of a fluid-using device) installed in an indoor space 60, and a pump 40, which are connected sequentially with a fluid pipe 50. In particular, the fluid pipe 50 is connected to a first heat exchanger 2 provided to the heat pump unit 10. Water (an example of the fluid) flows through the fluid pipe 50.
The indoor space 60 where the heat dissipator 30 is installed is provided with a remote controller 70 to input a preset temperature and the like.
[0009] The heat pump unit 10 has a heat pump cycle formed by connecting a compressor 1, the first heat exchanger 2, an expansion mechanism 3, and a second heat exchanger 4 in series with a refrigerant pipe 5. As the refrigerant circulates in the heat pump cycle through the compressor 1, first heat exchanger 2, expansion mechanism 3, and second heat exchanger 4 sequentially, the refrigerant absorbs heat from air or the like at the second heat exchanger 4 and dissipates heat to water flowing in the fluid pipe 50 at the first heat exchanger 2. In other words, the water flowing in the fluid pipe 50 is heated by the heat pump unit 10 into hot water.
The auxiliary heat source 20 further heats the hot water heated by the heat pump unit 10. For example, the auxiliary heat source 20 is an electric heater.
The heat dissipator 30 dissipates the heat of the hot water heated by the heat pump unit 10 and auxiliary heat source 20 to air in the indoor space 60. Consequently, the interior of the indoor space 60 becomes warm, and the hot water is cooled into coldwater. For example, the heat dissipator 30 is a floor-heating panel or radiator which causes hot water and air to exchange heat by heat exchange of natural convection of radiation heat, a fan coil unit which causes hot water and air to exchange heat by heat exchange of forced convection by an internal fan, or the like.
The pump 40 circulates water in the fluid pipe 50. In other words, as the pump 40 operates, water circulates through the heat pump unit 10, auxiliary heat source 20, and heat dissipator 30 sequentially. As described above, repeatedly, water is heated by the heat pump unit 10, further heated by the auxiliary heat source 20, and cooled by the heat dissipator 30. This repetition heats the indoor space 60.
[0010] Fig. 2 is a view showing the configuration of the fluid supply system 200 according to the first embodiment.
The fluid supply system 200 shown in Fig. 2 is provided with three heat pump units 10a, 10b, and 10c. The respective heat pump units 10 are connected in parallel through the fluid pipe 50. In other words, water flowing out from the pump 40 branches at a first branch point 80 and second branch point 81 to flow to the heat pump units 10a 10b, and 10c. The hot water heated by the heat pump units 10a, 10b, and 10c merge at a first merge point 82 and second merge point 83. The merged hot water is further heated by the auxiliary heat source 20 and supplied to the heat dissipator 30. The water cooled by the heat dissipator 30 flows to the heat pump units 10a 10b, and 10c again through the pump 40.
[0011] The fluid supply system 200 shown in Fig. 2 includes an operation controller 100 (unit count control device) . The operation controller 100 controls the operation of the heat pump units 10a, 10b, and 10c, the auxiliary heat source 20, and the pump 40.
The operation controller 100 and the heat pump unit 10a are directly connected to each other by a network 90. The operation controller 100 and the heat pump units 10b and 10c are connected to each other by the network 90 through relays 101a and 101b. Note that the heat pump unit 10a will be referred to as a master heat pump unit and that the heat pump units 10b and 10c will be referred to as slave heat pump units.
[0012] Fig. 3 is a function block diagram showing the function of the operation controller 100.
The operation controller 100 includes a data collection part 110, an operation control part 120, and a data storage unit 130.
[0013] The data collection part 110 includes a frequency acquisition part 111, a measured temperature detection part 112, a target temperature acquisition part 113, and an operation information acquisition part 114.
The frequency acquisition part 111 acquires the operation frequency of a compressor 1a of the master heat pump unit (heat pump unit 10a) by receiving, via the network 90, the operation frequency detected by a frequency detector 6a provided to the compressor 1a of the master heat pump unit.
The measured temperature detection part 112 acquires, as the measured temperature, the water temperature detected by a temperature sensor 102 provided between the auxiliary heat source 20 and heat dissipator 30 in the fluidpipe 50. Namely, the measured temperature detection part 112 acquires, as the measured temperature, the temperature of the water to be supplied to the heat dissipator 30. The temperature sensor 102 is, e.g., a temperature thermistor.
The target temperature acquisition part 113 acquires the target temperature input by the remote controller 70, by receiving it from the remote controller 70 via the network 90. The target temperature is the target temperature of the water to be supplied to the heat dissipator 30.
The operation information acquisition part 114 acquires the ON/OFF information of the fluid supply system 200 input by the remote controller 70, by receiving it from the remote controller 70 via the network 90.
[0014] The operation control part 120 includes an air-conditioning control part 121 and a unit count control part 122.
The air-conditioning control part 121 turns on/off the

pump 40 depending on the ON/OFF information of the fluid supply system 200. The air-conditioning control part 121 turns on/off the auxiliary heat source 20 depending on the temperature difference between the target temperature and the measured temperature when all the heat pump units 10 are operating. Namely, the air-conditioning control part 121 starts operation of the auxiliary heat source 20 when all the heat pump units 10 are operating and the temperature difference between the target temperature and the measured temperature is large, and stops operation of the auxiliary heat source 20 when the temperature difference decreases. When the air-conditioning control part 121 turns on/off the auxiliary heat source 20, the time elapsed since the heat pump unit 10a, 10b, or 10c is started is taken into consideration. For example, if the heat pump unit 10c has just started operation, the heat pump unit 10c may not be functioning sufficiently. Therefore, even if there is a temperature difference between the target temperature and the measured temperature, the air-conditioning control part 121 does not start operation of the auxiliary heat source 20 immediately. Furthermore, the air-conditioning control part 121 transmits the target temperature and measured temperature to the heat pump units 10a, 10b, and 10c via the network so that the heat pump units 10a, 10b, and 10c determine their capacities (operation frequencies). If the temperature difference between the target temperature and the measured temperature is large, the heat pump units 10a, 10b, and 10c increase the operation frequencies; when the temperature difference is small, they decrease the operation frequencies.
When the operationof the auxiliaryheat source 20 is stopped, the unit count control part 122 turns on/off the slave heat pump units (heat pump units 10b and 10c) depending on the operation frequency of the compressor 1 of the master heat pump unit and the temperature difference between the target temperature and the measured temperature.

[0015] The data storage unit 130 stores information necessary for the operation control part 120 to perform operation control, e.g., the operation status of the heat pump units 10a, 10b, and 10c (whether they are operating or stopped) , in a storage device.

[0016] Fig. 4 includes conceptual illustrations showing the effect on the operation efficiency of the heat source machines in unit count control.
In general, a heat pump unit has a high efficiency when it operates at a frequency near the rated frequency, and a low efficiency when it operates at a frequency far from the rated frequency. For example, assuming that frequency control of the heat source machine is practiced within the range of 30 Hz to 100 Hz, the heat source machine has the worst efficiencywhen it operates at a frequency near 30 Hz (low-frequency range), and the best efficiency when it operates at a frequency of almost 50 Hz to 70 Hz (rated frequency range) which is close to the rated frequency.
For this reason, as shown in Fig. 4, to operate the two heat pump units 10a and 10b with high capacities and at frequencies within the rated frequency range is more efficient than to operate the three heat pump units 10a, 10b, and 10c with low capacities and at frequencies within the low-frequency range.

[0017] When the temperature difference between the target temperature and the measured temperature is small and the operation frequency of the compressor 1 of the master heat pump unit is within the low-frequency range, it can be judged that the capacity of the heat pump unit 10 satisfies the air-conditioning load and that the heat pump unit 10 operates with a low efficiency. Hence, when the temperature difference between the target temperature and the measured temperature is small and the operation frequency of the compressor 1 of the master heat pump unit is within the low-frequency range, one slave heat pump unit (the heat pump unit 10c in Fig. 4) is stopped.
Then, the unit count of heat pump units 10 decreases, the capacity becomes insufficient temporarily, and the temperature difference between the target temperature and the measured temperature increases. As described above, the heat pump unit 10 determines its operation frequency depending on the temperature difference between the target temperature and the measured temperature. Therefore, when the temperature difference between the target temperature and the measured temperature increases, the heat pump unit 10 (the heat pump units 10a, 10b) in operation increases the operation frequency. Consequently, the operation frequency becomes close to the rated frequency, and the efficiency of the heat pump unit 10 is improved.

[0018] Fig. 5 is a flowchart showing the flow of the unit count control process by the unit count control part 122. As a premise, assume that the operation of the auxiliary heat source 20 has been stopped.
In (S1), the unit count control part 122 judges whether or not the efficiency of the heat pump unit 10a as the master heat pump unit decreases. More specifically, the unit count control part 122 judges whether or not the operation frequency of the compressor 1a of the heat pump unit 10a is equal to or lower than the predetermined first frequency and whether or not the temperature difference between the target temperature and the measured temperature is equal to or smaller than the predetermined first temperature (whether the temperature difference is small) . If these conditions are satisfied, the flow advances to (S2); if not, the flow advances to (S3).
In (S2) , as the efficiency of the heat pump unit 10a decreases, the unit count control part 122 stops (turns off) operation of one of the slave heat pump units that are operating.

[0019] In (S3), the unit count control part 122 judges whether or not the air-conditioning capacity is insufficient. More specifically, the unit count control part 122 judges whether or not the operation frequency of the compressor 1a of the heat pump unit 10a is equal to or higher than the predetermined second frequency which is higher than the first frequency and whether or not the temperature difference between the target temperature and the measured temperature is equal to or larger than the predetermined second temperature which is larger than the first temperature (whether the temperature difference is large). If these conditions are satisfied, the flow advances to (S4) ; if not, the flow advances to (S5). The second frequency can be, e.g., the maximum operation frequency of the compressor la.

In (S4), as the air-conditioning capacity is insufficient, the unit count control part 122 starts (turns on) operation of one of the slave heat pump units that have been currently stopped.

In (S5), as the efficiency of the heat pump unit 10a does not decrease nor is the air-conditioning capacity insufficient, the status quo is maintained. Namely, the unit count control part 122 does not turn on/off the slave heat pump units.

[0020] When the unit count control part 122 has performed count control in (S2) or (S4), it stands by for a predetermined period of time in (S6), and does not perform unit count control for a predetermined period of time. This is because the time lag with which the operation start or stop of the heat pump unit 10 is reflected in change of the water temperature is taken into consideration. This is also to prevent hunching operation in which switching on/off of the heat pump unit 10 is repeated during a short period of time. The time taken until the result of unit count control is reflected in change of water temperature may differ between a case in which the operation unit count is decreased in (S2) and a case in which the operation unit count is increased in (S4). In these cases, the standby time may be differed between the case in which the operation unit count is decreased in (S2) (that is, when the flow advances from (S2) to (S6)) and the case in which the operation unit count is increased in (S4) (that is, when the flow advances from (S4) to (S6).

At a lapse of predetermined period of time, the unit count control part 122 performs the process again starting with (S1).

[0021] If a slave heat pump unit is operating, the air-conditioning control part 121 turns on/off the auxiliary heat source 20. Namely, if the temperature difference between the target temperature and the measured temperature is equal to or larger than the predetermined temperature, the air-conditioning control part 121 starts operation of the auxiliary heat source 20. If the temperature difference between the target temperature and the measured temperature is equal to or smaller than the predetermined temperature, the air-conditioning control part 121 stops operation of the auxiliary heat source 20.

[0022] If it is determined in (S1) that the operation frequency of the heat pump unit 10a is equal to or lower than the third frequency which is lower than the first frequency, in (S2) , the unit count control part 122 may stop operation of the two slave heat pump units that are operating currently.

Similarly, if it is determined in (S3) that the temperature difference between the target temperature and the measured temperature is equal to or larger than the third temperature which is larger than the second temperature, in (S4), the unit count control part 122 may start operation of the two heat pump units that have been stopped currently.

In other words, the unit count control part 122 may turn on/off a plurality of slave heat pump units at once depending on the operation frequency of the compressor 1 of the master heat pump unit and the temperature difference between the target temperature and the measured temperature. Namely, the unit count control part 122 controls the operation unit count of heat pump units 10 depending on the operation frequency of the compressor 1 of the master heat pump unit and the temperature difference between the target temperature and the measured temperature.

[0023] As described above, the operation controller 100 according to the first embodiment can control the operation unit count of heat pump units 10 without grasping the capacities of the heat pump units 10, so that the operation efficiency is improved.

If the heat pump units 10a, 10b, and 10c are selected and installed by a person specializedin installation,their capacities may not always be the same (e.g., 5 kW, 5 KW, and 5 kW, respectively) but may differ (e.g., 5 kW, 3 kW, and 7 kW, respectively). In either case, the operation controller 100 according to the first embodiment can control the operation unit count appropriately, so that the operation efficiency is improved.

[0024] In the above description, the fluid supply system 200 provided with the three heat pump unit 10 is described as an example. However, the number of heat pump units 10 may be two, or four or more.

In the above description, the heat dissipator 30 exemplifies the fluid supply device. However, in place of the heat dissipator 30, a water heater or the like may be used as a fluid supply device.

Also, in place of the heat dissipator 30, a heat absorber or a cold water supply machine may be used as the fluid supply device. In this case, the heat pump unit 10 circulates the refrigerant in the heat pump cycle through the compressor 1, second heat exchanger 4, expansion mechanism 3, and first heat exchanger 2 sequentially. As a result, the refrigerant absorbs heat from water flowing through the fluidpipe 50 in the first heat exchanger 2 and dissipates heat to the air at the second heat exchanger 4. In other words, water flowing in the fluid pipe 50 is cooled by the heat pump unit 10 into cold water. This cold water may be supplied to the heat absorbingmachine or coldwater supplymachine, thereby cooling the room or supplying cold water.

In the above description, water flows in the fluid pipe 50. Alternatively, a fluid other than water may flow in the fluid pipe 50.

In the above description, the fluid supply system 200 is provided with only one heat dissipator 30. However, the fluid supply system 200 may be provided with a plurality of heat dissipation units 30.

Explanation of Signs

[0025]

1	compressor
2	first heat exchanger
3	expansion mechanism
4	second heat exchanger
5	refrigerant pipe
6a	frequency detector
10	heat pump unit
20	auxiliary heat source
30	heat dissipator
40	pump
50	fluid pipe
60	indoor space
70	remote controller
80	first branch point
81	second branch point
82	first merge point
83	second merge point
90	network
100	operation controller
101	relay
102	temperature sensor
110data	collection part
111	frequency acquisition part
112	measured temperature detection part
113	target temperature acquisition part
114	operation information acquisition part
120	operation control part
121	air-conditioning control part
122unit	count control part
130data	storage unit
200fluid	supply system

Claims

1. A unit count control device, in a fluid supply system (200) which includes a plurality of heat pump units (10) having a compressor (1) and which supplies a fluid that has undergone one of heating and cooling by the heat pump units to a fluid-using device, the unit count control device serving to control an operation unit count of the plurality of heat pump units, the unit count control device comprising:

a frequency acquisition part (111) which acquires an operation frequency of the compressor provided to a predetermined heat pump unit of the plurality of heat pump units; and
a unit count control part (122) which determines whether or not to operate, other than the predetermined heat pump unit of the plurality of heat pump units, remaining heat pump units (10) depending on the operation frequency acquired by the frequency acquisition part.

2. The unit count control device according to claim 1, wherein when the operation frequency is not more than a first predetermined frequency, the unit count control part (122) stops operation of, among the remaining heat pump units (10), at least one heat pump unit of heat pump units that are operating.

3. The unit count control device according to either one of claims 1 and 2,
wherein when the operation frequency is not less than a second predetermined frequency, the unit count control part (122) starts operation of, among the remaining heat pump units (10), at least one heat pump unit of heat pump units that have been stopped.

4. The unit count control device according to any one of claims 1 to 3, further comprising:

a target temperature acquisition part (113) which acquires a target temperature of a fluid to be supplied to the fluid-using device; and
a measured temperature detection part (112) which detects as a measured temperature a temperature of a fluid to be supplied to the fluid-

using device,
wherein the unit count control part (122) determines whether or not to operate the remaining heat pump units (10) depending on the operation frequency and a temperature difference between a target temperature acquired by the target temperature acquisition part and a measured temperature detected by the measured temperature detection part.

5. The unit count control device according to claim 4, wherein when the temperature difference is not more than a first predetermined temperature and the operation frequency is not more than the first predetermined frequency, the unit count control part (122) stops operation of, among the remaining heat pump units (10), at least one heat pump unit of the heat pump units that are operating.

6. The unit count control device according to either one of claims 4 and 5,
wherein when the temperature difference is not less than a second predetermined temperature and the operation frequency is not less than the second predetermined frequency, the unit count control part (122) stops operation of, among the remaining heat pump units (10), at least one heat pump unit of the heat pump units that are operating.

7. The unit count control device according to any one of claims 1 to 6,
wherein the unit count control part (122) refrains from determining whether to operate the remaining heat pump units (10) during a predetermined period of time, after having done one of stopping and starting of the remaining heat pump units.

8. A unit count control method, in a fluid supply system (200) which includes a plurality of heat pump units (10) having a compressor (1) and which supplies a fluid that has undergone one of heating and cooling by the heat pump units to a fluid-using device, the unit count control method serving to control an operation unit count of the plurality of heat pump units, the unit count control method comprising:

receiving an operation frequency of the compressor provided to a predetermined heat pump unit of the plurality of heat pump units; and
determining whether or not to operate, other than the predetermined heat pump unit of the plurality of heat pump units, remaining heat pump units (10) depending on the operation frequency received.

9. A fluid supply system (200) including
a plurality of heat pump units (10) having a compressor (1), and
a unit count control device which controls an operation unit count of the plurality of heat pump units,
the fluid supply system serving to supply a fluid that has undergone one of heating and cooling by the heat pump units to a fluid-using device,
wherein the unit count control device comprises:

a frequency acquisition part (111) which acquires an operation frequency of the compressor provided to a predetermined heat pump unit of the plurality of heat pump units; and
a unit count control part (122) which determines whether or not to operate, other than the predetermined heat pump unit of the plurality of heat pump units, remaining heat pump units (10) depending on the operation frequency acquired by the frequency acquisition part.

Fig. 1

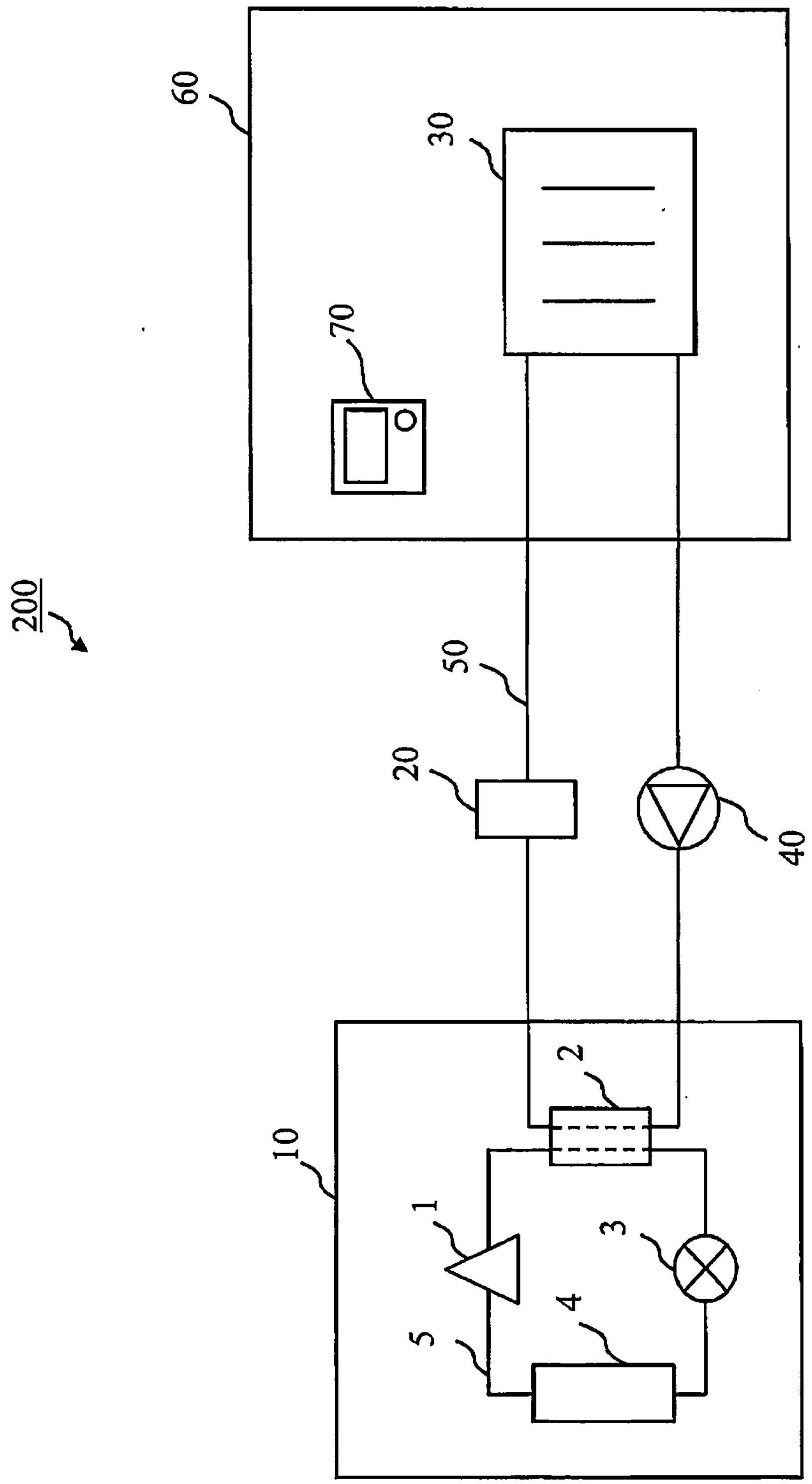


Fig. 2

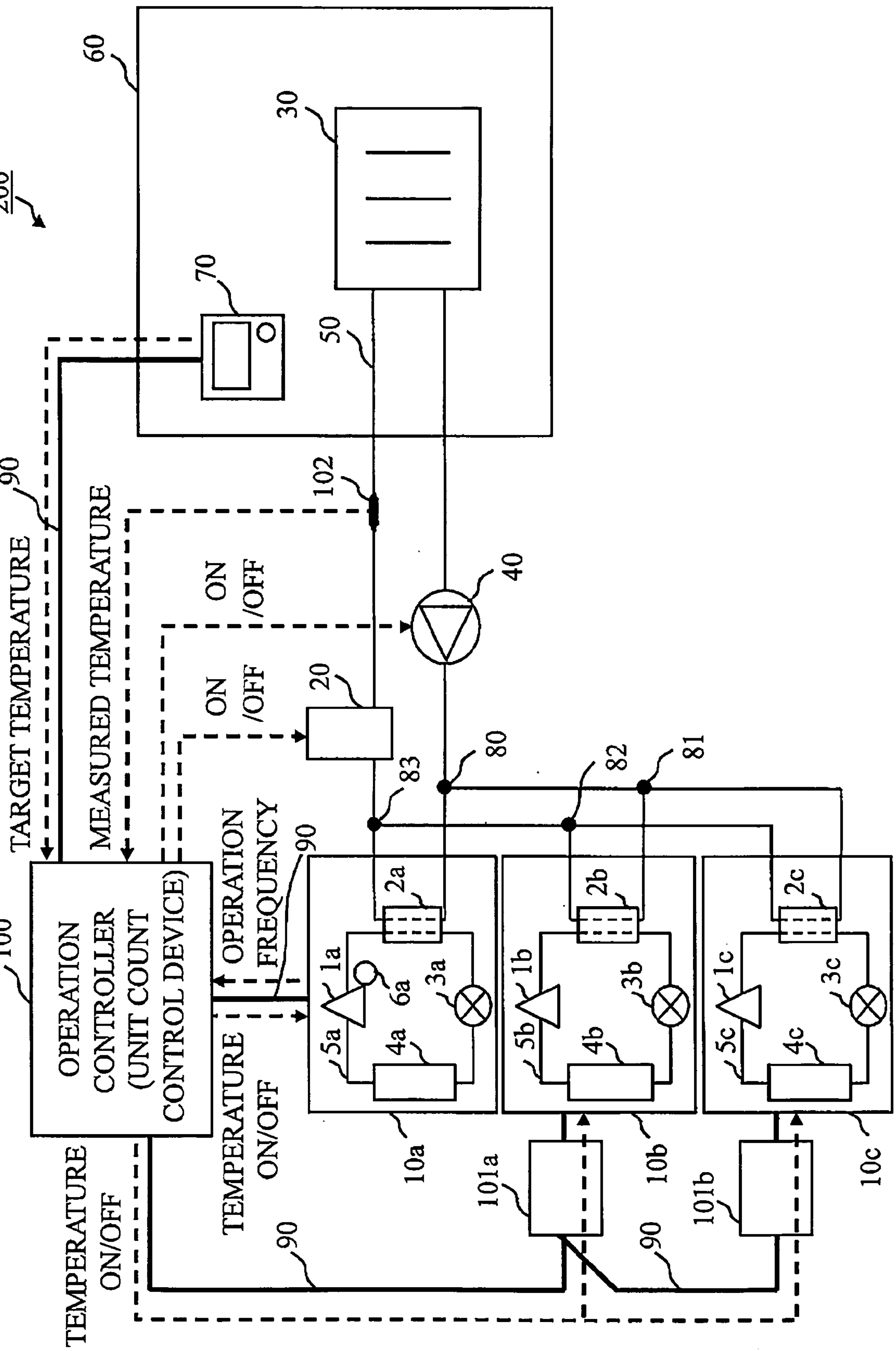
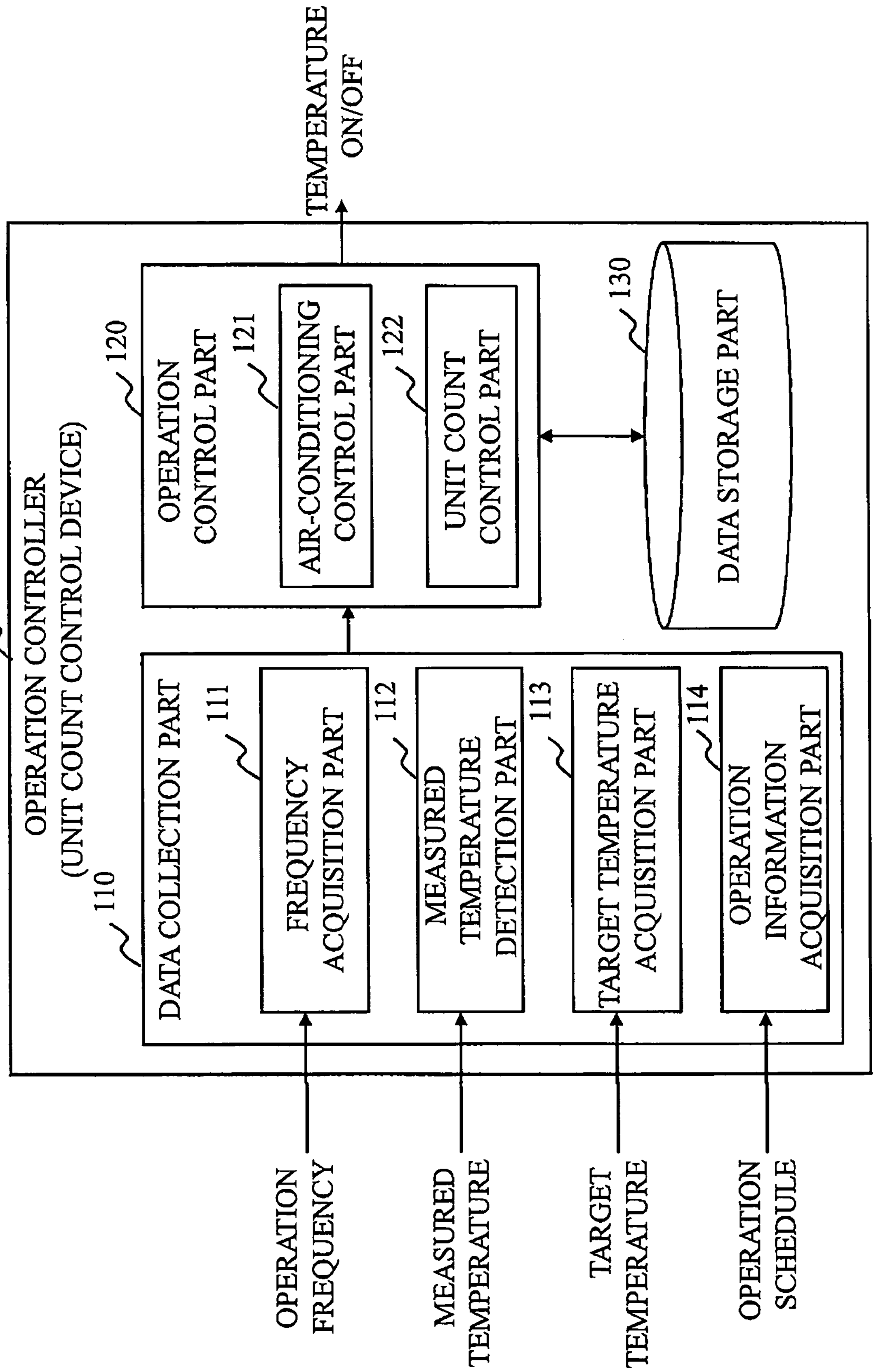

200
60
30
70
50
102
40
20
80
81
82
83
90
TARGET TEMPERATURE
MEASURED TEMPERATURE
ON /OFF
ON /OFF
OPERATION FREQUENCY
100
OPERATION CONTROLLER (UNIT COUNT CONTROL DEVICE)
TEMPERATURE ON/OFF
TEMPERATURE ON/OFF
1a
2a
3a
4a
5a
6a
1b
2b
3b
4b
5b
1c
2c
3c
4c
5c
10a
10b
10c
101a
101b

Fig. 3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OPERATION CONTROLLER
(UNIT COUNT CONTROL DEVICE)
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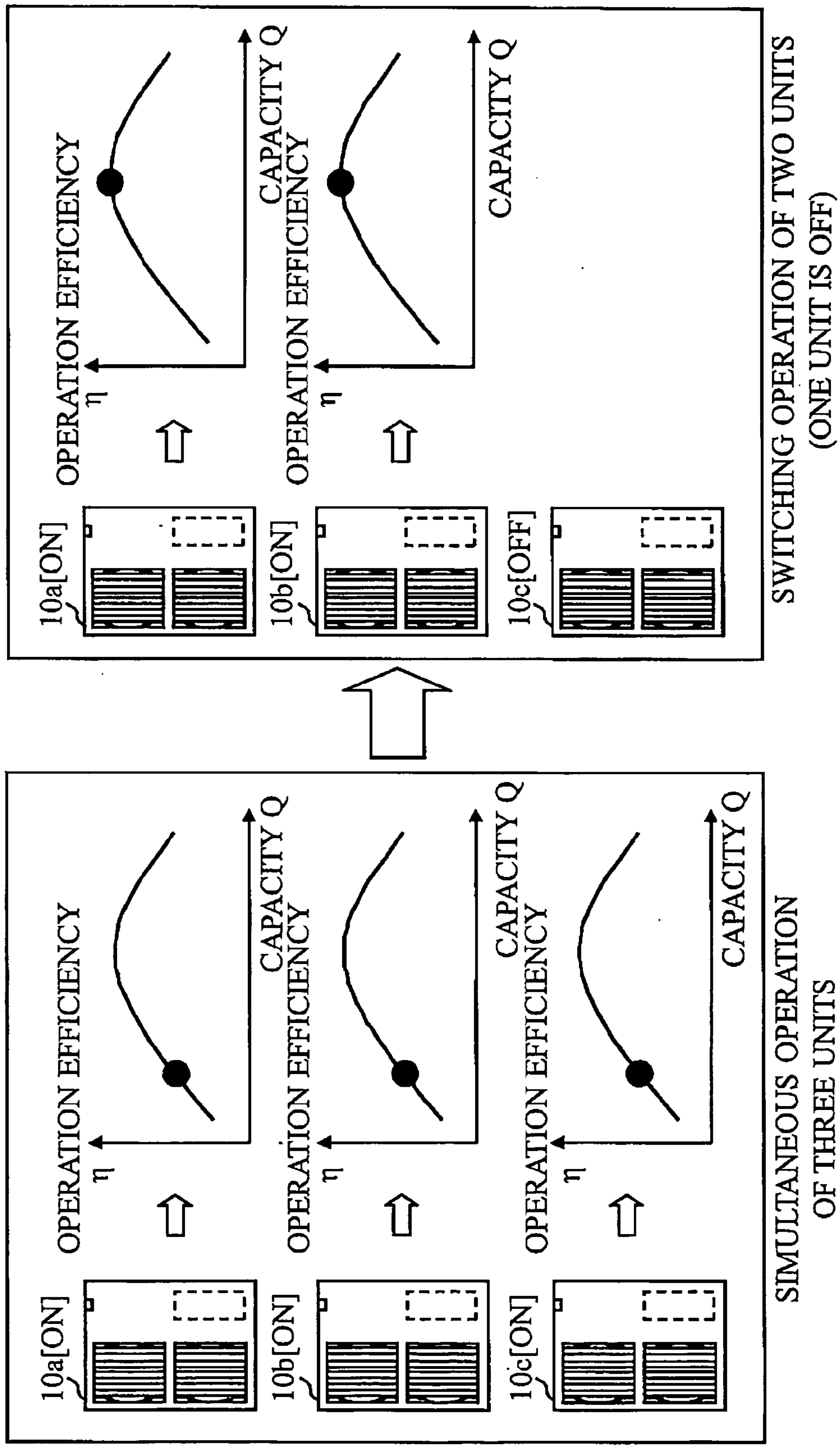
DATA COLLECTION PART
111
FREQUENCY ACQUISITION PART
112
MEASURED TEMPERATURE DETECTION PART
113
TARGET TEMPERATURE ACQUISITION PART
114
OPERATION INFORMATION ACQUISITION PART
120
OPERATION CONTROL PART
121
AIR-CONDITIONING CONTROL PART
122
UNIT COUNT CONTROL PART
130
DATA STORAGE PART
TEMPERATURE ON/OFF
OPERATION FREQUENCY
MEASURED TEMPERATURE
TARGET TEMPERATURE
OPERATION SCHEDULE

Fig. 4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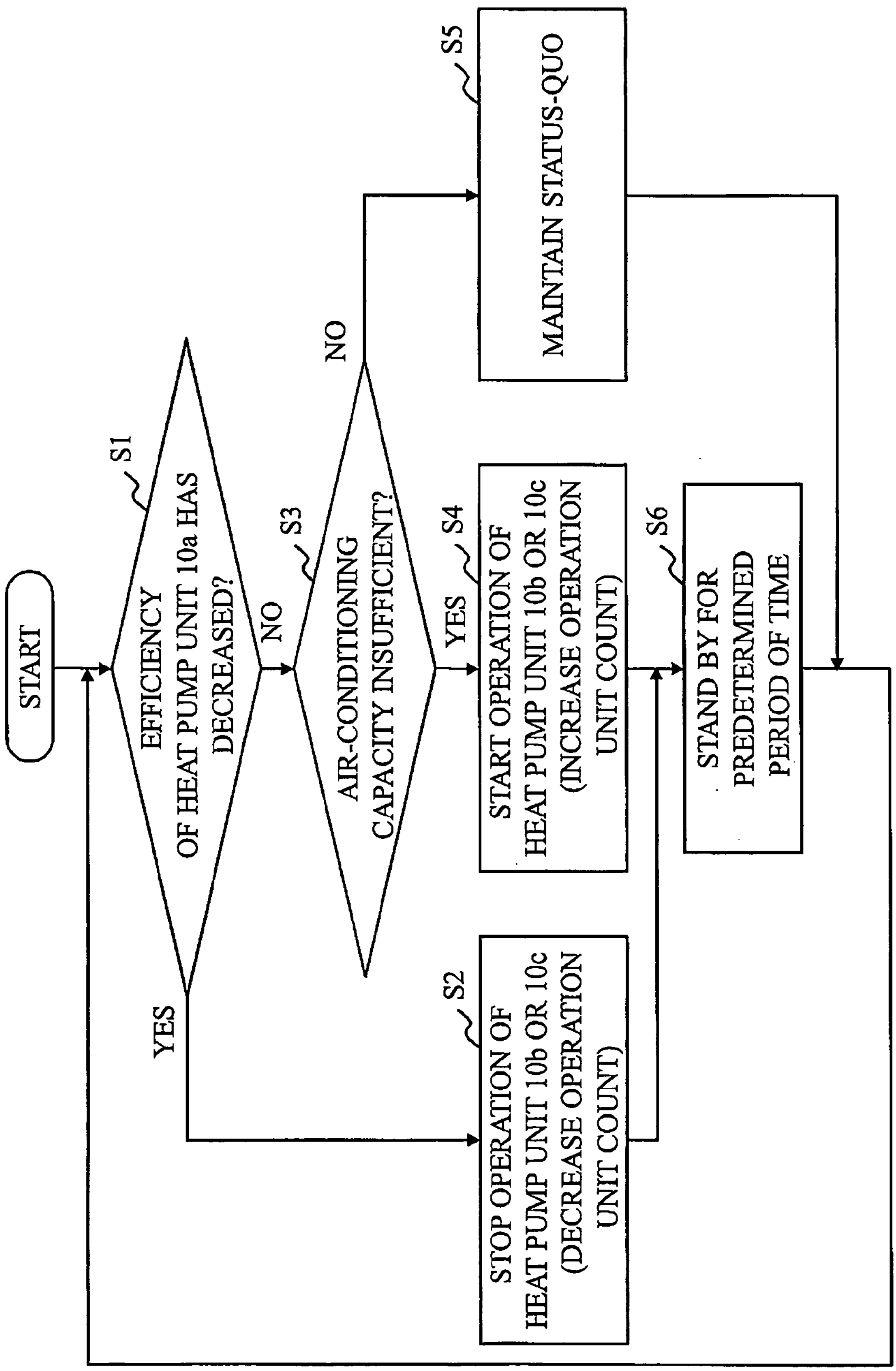
10b[ON]
10c[ON]
OPERATION EFFICIENCY
η
CAPACITY Q
SIMULTANEOUS OPERATION
OF THREE UNITS
10a[ON]
10b[ON]
10c[OFF]
SWITCHING OPERATION OF TWO UNITS
(ONE UNIT IS OFF)

Fig. 5


START
S1
EFFICIENCY OF HEAT PUMP UNIT 10a HAS DECREASED?
YES
NO
S2
STOP OPERATION OF HEAT PUMP UNIT 10b OR 10c (DECREASE OPERATION UNIT COUNT)
S3
AIR-CONDITIONING CAPACITY INSUFFICIENT?
YES
NO
S4
START OPERATION OF HEAT PUMP UNIT 10b OR 10c (INCREASE OPERATION UNIT COUNT)
S5
MAINTAIN STATUS-QUO
S6
STAND BY FOR PREDETERMINED PERIOD OF TIME

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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