



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.06.2013 Bulletin 2013/23

(51) Int Cl.:
F25B 13/00 (2006.01) **F25B 30/02** (2006.01)
F25B 49/02 (2006.01)

(21) Application number: **12194517.4**

(22) Date of filing: **28.11.2012**

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

- **Yamaguchi, Toru**
Tokyo, 108-8215 (JP)
- **Mori, Takachika**
Tokyo, 108-8215 (JP)
- **Fuchimoto, Takeshi**
Tokyo, 108-8215 (JP)

(30) Priority: **30.11.2011 JP 2011262439**

(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(71) Applicant: **Mitsubishi Heavy Industries**
Tokyo 108-8215 (JP)

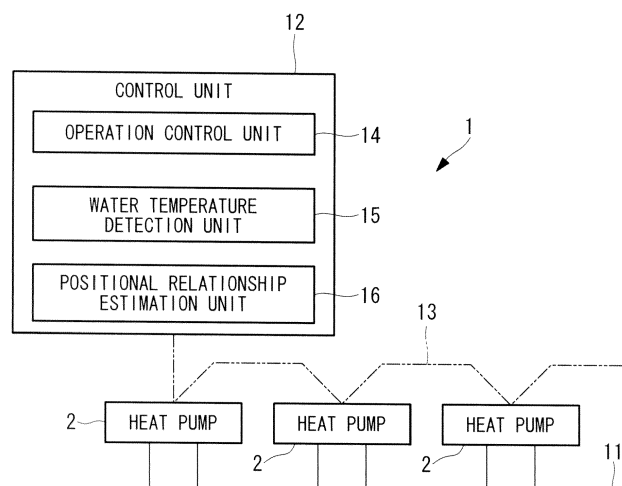
(72) Inventors:
• **Akatsuka, Kei**
Tokyo, 108-8215 (JP)

(54) **Heat pump position checking method in heat pump system and heat pump system**

(57) There is provided a heat pump position checking method in a heat pump system capable of correctly checking the positional relationship among heat pumps and achieving efficient operation and improvement in reliability and a heat pump system. A heat pump system (1) is a heat pump system in which a plurality of heat pumps (2) are connected to a water pipe (11), and a water heat exchanger of each heat pump (2) exchanges heat with water flowing through the water pipe (11). The heat

pump system (1) includes an operation control unit (14) which puts one heat pump (2) into cooling operation or heating operation, a water temperature detection unit (15) which detects the temperatures of water in the water pipe (11) flowing into the plurality of heat pumps (2), and a positional relationship estimation unit (16) which estimates the positional relationship among the plurality of heat pumps (2) on the basis of the heat pump (2) in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps (2).

FIG. 1



Description

Technical Field

[0001] The present invention relates to a heat pump position checking method in a heat pump system in which a plurality of heat pumps are connected via a water pipe and a heat pump system.

Background Art

[0002] In a heat pump system using a plurality of heat pumps (e.g., an air-cooled heat pump chiller), the plurality of heat pumps are connected to a water pipe, and a water heat exchanger of each heat pump exchanges heat with water flowing through the water pipe. With this configuration, water in the water pipe is heated or cooled. There is also known a module chiller in which two heat pumps are connected and act as one unit.

[0003] PTL 1 discloses a technique for preventing low-load operation of an absorption cold/warm water generator by integrating an air-cooled heat pump chiller with the absorption cold/warm water generator and improving the operating efficiency of the entire system under low-load conditions.

Citation List

Patent Literature

PTL 1

[0004] Japanese Unexamined Patent Application, Publication No. 2002-195684

Summary of Invention

Technical Problem

[0005] In a module chiller as described above, when a plurality of heat pumps are to be connected to the same water pipe, the heat pumps are generally arranged in parallel. Additionally, connection of the water pipe in the module chiller is performed in, e.g., a factory and is not performed on the spot at an installation location. For this reason, the module chiller does not include means for determining whether the heat pumps are connected in series or in parallel, means for determining the order of the heat pumps from the upstream side to the downstream side in the case of series connection, means for checking the connection status of the heat pumps, and the like.

[0006] In contrast, there is proposed a module chiller which allows selection of a method for connecting a water pipe and execution of work on the spot, i.e., a module chiller which allows selection of whether to connect a plurality of heat pumps in parallel or in series. In the case of the module chiller, it is conceivable that an installer or

the like of the module chiller manually sets whether the plurality of heat pumps are to be connected in series or in parallel, the order of the heat pumps from the upstream side to the downstream side in the case of series connection, and the like in a microcomputer.

[0007] The manual setting, however, can cause an inputting error. If the module chiller is operated with improper settings, inefficient operation is continued, which may impair reliability.

[0008] The present invention has been made in consideration of the above-described circumstances, and has as its object to provide a heat pump position checking method in a heat pump system capable of correctly checking the positional relationship among heat pumps and achieving efficient operation and improvement in reliability and a heat pump system.

Solution to Problem

[0009] A heat pump position checking method in a heat pump system according to a first aspect of the present invention is a heat pump position checking method in a heat pump system in which a plurality of heat pumps are connected to a water pipe, and a water heat exchanger of each of the heat pumps exchanges heat with water flowing through the water pipe, including a first step of putting one heat pump into cooling operation or heating operation, a second step of detecting temperatures of water in the water pipe flowing into the plurality of heat pumps, and a third step of estimating a positional relationship among the plurality of heat pumps on the basis of the heat pump in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps.

[0010] According to this configuration, the one heat pump performs cooling operation or heating operation, which changes the temperature of water flowing through the water pipe. If a different heat pump is connected downstream of the heat pump in operation, the temperature of water in the water pipe flowing into the heat pump changes. From this, it can be seen that the heat pump, for which a change in the temperature of water is detected, is located downstream of the heat pump in operation. If a change in the temperature of water is not detected, the heat pump is installed upstream of or in parallel with the heat pump in operation. For this reason, the positional relationship among the heat pumps, i.e., the order in which the plurality of heat pumps are connected via the water pipe can be checked.

[0011] The first aspect may further include a fourth step of stopping the heat pump in cooling operation or heating operation after the temperatures of water are detected in the second step and putting one heat pump which is different from the heat pump already operated in the first step into cooling operation or heating operation and a fifth step of integrating the newly estimated positional relationship among the plurality of heat pumps with an already estimated positional relationship among the plu-

rality of heat pumps, and the first to fifth steps may be repeated until positions of all of the plurality of heat pumps are determined.

[0012] According to this configuration, the one heat pump is put into cooling operation or heating operation, and the heat pump in cooling operation or heating operation is stopped after the temperatures of water are detected. The one different heat pump is then put into cooling operation or heating operation. With the operation, a positional relationship among the heat pumps is newly estimated, in addition to an already estimated positional relationship among the heat pumps. The newly estimated positional relationship among the heat pumps is integrated with the already estimated positional relationship among the heat pumps. The integration results in obtaining of detailed information on the positional relationship among the heat pumps. Repetition of the first to fifth steps of the present invention reveals the positional relationship among the heat pumps and determines positions of all the heat pumps.

[0013] A heat pump position checking method in a heat pump system according to a second aspect of the present invention is a heat pump position checking method in a heat pump system in which a plurality of heat pumps are connected to a water pipe, and a water heat exchanger of each of the heat pumps exchanges heat with water flowing through the water pipe, including a first step of simultaneously putting one first heat pump into cooling operation and putting one different second heat pump into heating operation, a second step of detecting temperatures of water in the water pipe flowing into the plurality of heat pumps, and a third step of estimating a positional relationship among the plurality of heat pumps on the basis of the first heat pump in cooling operation, the second heat pump in heating operation, and the temperatures of water detected at the plurality of heat pumps.

[0014] According to this configuration, the one first heat pump performs cooling operation, and the one different second heat pump performs heating operation, which changes the temperature of water flowing through the water pipe. If a different heat pump is connected downstream of the first or second heat pump in operation, the temperature of water in the water pipe flowing into the heat pump changes. From this, it can be seen that the heat pump, for which a change in the temperature of water is detected, is located downstream of the first or second heat pump in operation. If a change in the temperature of water is not detected, it can be seen that the heat pump is installed upstream of or in parallel with the first or second heat pump in operation. For this reason, the positional relationship among the heat pumps, i.e., the order in which the plurality of heat pumps are connected via the water pipe can be checked.

[0015] A heat pump system according to a third aspect of the present invention is a heat pump system in which a plurality of heat pumps are connected to a water pipe, and a water heat exchanger of each of the heat pumps exchanges heat with water flowing through the water

pipe, including an operation control unit which puts one heat pump into cooling operation or heating operation, a water temperature detection unit which detects temperatures of water in the water pipe flowing into the plurality of heat pumps, and a positional relationship estimation unit which estimates a positional relationship among the plurality of heat pumps on the basis of the heat pump in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps.

[0016] A heat pump system according to a fourth aspect of the present invention is a heat pump system in which a plurality of heat pumps are connected to a water pipe, and a water heat exchanger of each of the heat pumps exchanges heat with water flowing through the water pipe, including an operation control unit which puts one first heat pump into cooling operation and puts one different second heat pump into heating operation, a water temperature detection unit which detects temperatures of water in the water pipe flowing into the plurality of heat pumps, and a positional relationship estimation unit which estimates a positional relationship among the plurality of heat pumps on the basis of the first heat pump in cooling operation, the second heat pump in heating operation, and the temperatures of water detected at the plurality of heat pumps.

{Advantageous Effects of Invention}

[0017] According to the present invention, when a plurality of heat pumps are connected via a water pipe, the positional relationship among the heat pumps can be correctly checked, which allows efficient operation and improvement in reliability.

Brief Description of Drawings

[0018]

{Fig. 1}

Fig. 1 is a block diagram showing a heat pump system according to a first embodiment of the present invention.

{Fig. 2}

Fig. 2 is a configuration diagram showing a heat pump according to the first embodiment.

{Fig. 3}

Fig. 3 is a flow chart showing heat pump position checking operation in the heat pump system according to the first embodiment.

{Fig. 4}

Fig. 4 is a schematic diagram showing how heat pumps are connected in series via water pipes.

{Fig. 5}

Fig. 5 is a schematic diagram showing how the heat pumps are connected in series via water pipes.

{Fig. 6}

Fig. 6 is a chart showing the relationship between a heat pump to be operated and a change (changes)

in the temperature of water at inlets of the heat pumps in the heat pump position checking operation according to the first embodiment of the present invention.

{Fig. 7}

Fig. 7 is a chart showing the relationship between a heat pump to be operated and a change (changes) in the temperature of water at inlets of the heat pumps in the heat pump position checking operation according to the first embodiment.

{Fig. 8}

Fig. 8 is a chart showing the relationship between heat pumps to be operated and a change (changes) in the temperature of water at inlets of the heat pumps in heat pump position checking operation according to a modification of the first embodiment.

{Fig. 9}

Fig. 9 is a chart showing the relationship between heat pumps to be operated and a change (changes) in the temperature of water at inlets of the heat pumps in heat pump position checking operation according to the modification of the first embodiment.

Description of Embodiments

[0019] An embodiment of the present invention will be described below with reference to the drawings.

The configuration of a heat pump system 1 will first be described with reference to Fig. 1.

The heat pump system 1 according to the present embodiment is composed of a plurality of heat pumps 2, water pipes 11 connected to the heat pumps 2, and the like. The heat pumps 2 are, for example, air-cooled heat pump chillers and can generate chilled water or warm water by exchanging heat with water flowing through the water pipes 11. The heat pump system 1 may be a module chiller in which the plurality of heat pumps 2 act as one unit.

[0020] As shown in Fig. 2, the heat pump 2 comprises a compressor 5, a four-way valve 6, a water heat exchanger 7, an expansion valve 8, an air heat exchanger 9, an accumulator 10, and the like. The compressor 5, four-way valve 6, water heat exchanger 7, expansion valve 8, air heat exchanger 9, and accumulator 10 are coupled by refrigerant piping 3 and constitute a refrigerant circuit.

[0021] A motor of the compressor 5 is driven by an inverter. In the compressor 5, the speed of the motor, i.e., the discharge rate of a refrigerant is adjusted by the output frequency of the inverter.

[0022] The air heat exchanger 9 causes outside air and the refrigerant to exchange heat, and the water heat exchanger 7 causes water and the refrigerant to exchange heat. The accumulator 10 prevents some of the refrigerant that has failed to be gasified by an evaporator (the water heat exchanger 7 or air heat exchanger 9) from being sucked into the compressor 5 while being liquid. A temperature sensor 4 is provided at an inlet of the water

heat exchanger 7 where the water pipe 11 is connected. A temperature detected by the temperature sensor 4 is sent as the temperature of water in the water pipe 11 to a water temperature detection unit 15 of a control unit 12.

[0023] The heat pump 2 switches between heating operation and cooling (or defrosting) operation in response to a change in refrigerant flow direction caused by switching of the four-way valve 6. During heating operation, the refrigerant discharged from the compressor 5 flows through the water heat exchanger 7, expansion valve 8, air heat exchanger 9, and accumulator 10 in this order. The water heat exchanger 7 acts as a condenser, and the air heat exchanger 9 acts as an evaporator. Warm water heated by the water heat exchanger 7 is supplied to the next heat pump 2 or the outside via the water pipe 11.

[0024] During cooling (defrosting) operation, the refrigerant discharged from the compressor 5 flows through the air heat exchanger 9, expansion valve 8, water heat exchanger 7, and accumulator 10 in this order. The air heat exchanger 9 acts as a condenser, and the water heat exchanger 7 acts as an evaporator. Chilled water cooled by the water heat exchanger 7 is supplied to the next heat pump 2 or the outside via the water pipe 11.

[0025] In the present embodiment, after the heat pumps 2 are connected by the water pipes 11, the positional relationship among the plurality of heat pumps 2, i.e., whether the heat pumps 2 are connected in series or in parallel, the order in which the heat pumps 2 are connected from the upstream side to the downstream side in the case of series connection, and the like are automatically checked. With the automatic checking, setting errors caused by manual input can be avoided, which allows efficient operation and improvement in reliability. The present embodiment is performed, for example, during trial operation after the heat pump system 1 is installed at an installation location, and connection of the water pipes 11 is completed. The present embodiment may also be performed after reconnection of the water pipes 11 of the heat pump system 1.

[0026] The heat pump system 1 according to the present embodiment includes the control unit 12 that operates the plurality of heat pumps 2, detects the temperature of water in the water heat exchanger 7 of each heat pump 2, and estimates the positional relationship among the heat pumps 2. As shown in Fig. 1, the control unit 12 and the heat pumps 2 are connected by, for example, a control cable 13, and control signals are transmitted and received therebetween. Note that Fig. 1 shows a case where three heat pumps 2 are connected in series via the water pipes 11.

[0027] The control unit 12 includes, for example, an operation control unit 14, the water temperature detection unit 15, and a positional relationship estimation unit 16. The control unit 12 may be provided separately from the heat pumps 2 or may be provided at any one of the heat pumps 2.

[0028] At the time of position checking operation ac-

According to the present embodiment, the operation control unit 14 puts the heat pump 2 into cooling operation or heating operation. For example, in the case of cooling operation, operating conditions are set such that cooled water at a fixed temperature (e.g., 7°C) is supplied from an outlet of the water heat exchanger 7 to the outside when water at a fixed temperature (e.g., 12°C) is supplied to the inlet of the water heat exchanger 7 connected to the water pipe 11. At the time of the position checking operation, the operation control unit 14 stops the heat pump 2 in cooling operation or heating operation after the temperature of water at the inlet of the water heat exchanger 7 of the heat pump 2 is detected.

[0029] The water temperature detection unit 15 detects the temperature of water in the water pipe 11 flowing into the heat pump 2 or the surface temperature of the water heat exchanger 7 that reflects the temperature of water (hereinafter referred to as "temperature of water") on the basis of a measurement value obtained from the temperature sensor 4. The water temperature detection unit 15 detects the temperature of water for each of all the heat pumps 2 of the heat pump system 1. Detected temperatures of water are associated one-to-one with the identifiers of the heat pumps 2. The transition of temperature that changes according to operating conditions (e.g., the temperature of the heat pump 2 before cooling (heating) operation and the temperature during steady operation) is also stored in a memory of the control unit 12 or the like.

[0030] The positional relationship estimation unit 16 estimates a positional relationship among the plurality of heat pumps 2 on the basis of one heat pump 2 in cooling operation or heating operation and temperatures of water detected at the plurality of heat pumps 2. The positional relationship estimation unit 16 integrates the newly estimated positional relationship among a plurality of heat pumps 2 with an already estimated positional relationship among the plurality of heat pumps 2. When the positional relationship among all the heat pumps 2 is apparent from a result of the integration, the control unit 12 judges that the positional relationship is determined and performs address setting.

[0031] A method for estimating a positional relationship is, for example, as follows. One heat pump 2 performs cooling operation or heating operation, which changes the temperature of water flowing through the water pipe 11. If one different heat pump 2 is connected downstream of the heat pump 2 in operation, the temperature of water in the water pipe 11 flowing into the downstream heat pump 2 changes. The change shows the heat pump 2, for which a change in the temperature of water has been detected, is located downstream of the heat pump 2 in operation. If a change in the temperature of water is not detected, it is apparent that the heat pump 2 in question is installed upstream of or in parallel with the heat pump 2 in operation. For this reason, the positional relationship among the heat pumps 2, i.e., the order in which the plurality of heat pumps 2 are connected via the water pipes 11 can be checked.

[0032] The operation of checking the positions of the heat pumps 2 will be described with reference to Fig. 3. First, one of the plurality of heat pumps 2 in the heat pump system 1 is put into cooling operation or heating operation (step S1).

[0033] The temperature of water at the inlet of each water heat exchanger 7 where the water pipe 11 is connected before the cooling (heating) operation is detected. The operation of the heat pump 2 stabilizes the temperature of water in the water pipe 11 supplied from each water heat exchanger 7. The temperature of water at the inlet of each water heat exchanger 7 at this time is also detected (step S2).

[0034] When the stabilized temperatures of water are sensed, the heat pump 2 in cooling operation or heating operation is stopped (step S3). A positional relationship among the plurality of heat pumps 2 is estimated on the basis of the one heat pump 2 in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps 2 (step S4). The newly estimated positional relationship among the plurality of heat pumps 2 is integrated with an already estimated positional relationship among the plurality of heat pumps 2 (step S5). Note that if steps S1 to S4 have been performed for the first time, there is no already estimated positional relationship among the plurality of heat pumps 2, and step S5 is skipped.

[0035] It is determined (step S6) whether the positional relationship among all the heat pumps 2 is determined in step S5. Steps S1 to S5 described above are repeated until the positions of all the heat pumps 2 are determined. In this case, the heat pump 2 to be operated is changed, and one different heat pump 2 is put into cooling operation or heating operation (step S8).

[0036] When the positions of all the heat pumps 2 are determined, whether the heat pumps 2 are connected in series or in parallel is recorded, and in the case of series connection, the order in which the heat pumps 2 are connected is also recorded. The addresses of the heat pumps 2 are set in, for example, the control unit 12 on the basis of the determined positional relationship (step S7).

[0037] With the above-described operation, the positional relationship among the heat pumps 2 in the heat pump system 1 is not manually but automatically set. Accordingly, a human error such as incorrect input can be prevented, and efficient operation and improvement in reliability can be achieved.

[0038] Examples of the position checking operation will be described. First, a case will be described where heat pumps A, B, C, and D are connected in series, as shown in Fig. 4. Initially, a control unit 12 is unaware of what positional relationship the heat pumps A to D of a heat pump system 1 have and in which order the heat pumps A to D are connected.

[0039] Position checking operation is performed with the processes shown in Fig. 6. First, only the heat pump A is put into cooling operation (step S11). As a result, the

temperature of water at an inlet of a water heat exchanger 7 of the heat pump A does not change, and the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps B, C, and D fall. It is thus estimated (1) that the heat pump A is installed upstream of the heat pumps B, C, and D, i.e., most upstream.

[0040] Only the heat pump B is then put into cooling operation (step S12). As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A and B do not change, and the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps C and D fall. It is thus estimated (2) that the heat pump B is installed upstream of the heat pumps C and D. It is also estimated from the fact (1) that the heat pumps A and B are installed in this order.

[0041] Only the heat pump C is further put into cooling operation (step S13). As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A, B, and C do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump D falls. It is thus estimated (3) that the heat pump C is installed upstream of the heat pump D.

[0042] With the above-described steps S11 to S13, it can be seen from the facts (1) to (3) that the heat pumps A, B, C, and D are installed in this order.

[0043] A case will be described where heat pumps A and B are connected in series, heat pumps C and D are connected in series, and the heat pumps A and B connected in this order and the heat pumps C and D connected in this order are connected in parallel, as shown in Fig. 5. Initially, a control unit 12 is unaware of what positional relationship the heat pumps A to D of a heat pump system 1 have and in which order the heat pumps A to D are connected.

[0044] Accordingly, position checking operation is performed with the processes shown in Fig. 7. First, only the heat pump A is put into cooling operation (step S21). As a result, the temperatures of water at inlets of water heat exchangers 7 of the heat pumps A, C, and D do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump B falls. It is thus estimated (1) that the heat pump A is installed upstream of the heat pump B, i.e., most upstream and (2) that the heat pump A is installed downstream of or in parallel with the heat pumps C and D.

[0045] Only the heat pump B is then put into cooling operation (step S22). As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A, B, C, and D do not change. It is thus estimated (3) that the heat pump B is installed downstream of or in parallel with the heat pumps A, C, and D.

[0046] Consequently, it can be seen (4) that the fact (1) shows that the heat pumps A and B are installed in this order and the facts (1) and (3) show that the heat pump B is installed in parallel with the heat pumps C and D.

[0047] Only the heat pump C is further put into cooling operation (step S23). As a result, the temperatures of

water at the inlets of the water heat exchangers 7 of the heat pumps A, B, and C do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump D falls. It is thus estimated (5) that the heat pump C is installed upstream of the heat pump D, i.e., most upstream and (6) that the heat pump C is installed downstream of or in parallel with the heat pumps A and B. It is estimated from the fact (5) that the heat pumps C and D are installed in this order.

[0048] With the above-described steps S21 to S23, it can be seen that the heat pumps A and B are connected in series, the heat pumps C and D are connected in series, and that the heat pumps A and B connected in this order and the heat pumps C and D connected in this order are connected in parallel.

[0049] Position checking operation according to a modification of the present embodiment will be described. In the present modification, one heat pump 2 is put into cooling operation, and at the same time, one different heat pump 2 is put into heating operation. This method can save more time than a method in which only one heat pump is put into cooling operation or heating operation.

[0050] Examples of the position checking operation according to the present modification will be described below. First, a case will be described where heat pumps A, B, C, and D are connected in series, as shown in Fig. 4. Initially, a control unit 12 is unaware of what positional relationship the heat pumps A to D of a heat pump system 1 have and in which order the heat pumps A to D are connected.

[0051] Position checking operation is performed with the processes shown in Fig. 8. First, the heat pump A is put into cooling operation, and at the same time, the heat pump B is put into heating operation (step S31). Note that the difference in temperature between an inlet and an outlet of a water heat exchanger 7 caused by heating operation is assumed to be, for example, twice the difference in temperature between the inlet and the outlet of the water heat exchanger 7 caused by cooling operation. As a result, the temperature of water at the inlet of the water heat exchanger 7 of the heat pump A does not change, the temperature of water at the inlet of the water heat exchanger 7 of the heat pump B falls, and the temperatures of water rise for the heat pumps C and D. It can thus be seen (1) that the heat pump A is installed upstream of the heat pump B and that the heat pumps A and B are installed in this order. Additionally, it is estimated (2) that the heat pump B is installed upstream of the heat pumps C and D.

[0052] Then, the heat pump C is put into cooling operation, and at the same time, the heat pump D is put into heating operation (step S32). As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A, B, and C do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump D falls. Combined with the fact (1), it can thus be seen that the heat pumps A, B, C,

and D are installed in this order.

[0053] A case will be described where heat pumps A and B are connected in series, heat pumps C and D are connected in series, and the heat pumps A and B connected in this order and the heat pumps C and D connected in this order are connected in parallel, as shown in Fig. 5. Initially, a control unit 12 is unaware of what positional relationship the heat pumps A to D of a heat pump system 1 have and in which order the heat pumps A to D are connected.

[0054] Position checking operation is performed with the processes shown in Fig. 9. First, the heat pump A is put into cooling operation, and at the same time, the heat pump B is put into heating operation (step S41). Note that the difference in temperature between an inlet and an outlet of a water heat exchanger 7 caused by heating operation is assumed to be, for example, twice the difference in temperature between the inlet and the outlet of the water heat exchanger 7 caused by cooling operation. As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A, C, and D do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump B falls. Additionally, it can thus be seen (1) that the heat pump A is installed upstream of the heat pump B and that the heat pumps A and B are installed in this order. Additionally, it is estimated (2) that the heat pumps C and D are installed upstream of or in parallel with the heat pumps A and B.

[0055] Then, the heat pump C is put into cooling operation, and at the same time, the heat pump D is put into heating operation (step S42). As a result, the temperatures of water at the inlets of the water heat exchangers 7 of the heat pumps A, B, and C do not change, and the temperature of water at the inlet of the water heat exchanger 7 of the heat pump D falls. It can thus be seen (3) that the heat pump C is installed upstream of the heat pump D and that the heat pumps C and D are installed in this order. It can also be seen (4) that the heat pumps A and B are installed in parallel with the heat pumps C and D.

[0056] Consequently, it can be seen from the facts (3) and (4) that the heat pumps A and B are connected in series, the heat pumps C and D are connected in series, and that the heat pumps A and B connected in this order and the heat pumps C and D connected in this order are connected in parallel. Examples of the modification of the present embodiment illustrated in Figs. 8 and 9 are smaller in the number of processes than Examples illustrated in Figs. 6 and 7, and the modification can be said to achieve time saving.

[0057] As has been described above, according to the present embodiment, whether heat pumps are to be connected in series or in parallel, the order of the heat pumps from the upstream side to the downstream side in the case of series connection, and the like are automatically set in a microcomputer, which allows prevention of incorrect manual input. This results in efficient operation and

improvement in reliability. Additionally, even if the water pipes 11 are erroneously connected or if the water pipes 11 are reconnected, whether heat pumps are to be connected in series or in parallel, the order from the upstream side to the downstream side in the case of series connection, and the like can be acquired by executing the method for checking the positions of the heat pumps 2 according to the present embodiment.

10 {Reference Signs List}

[0058]

- | | |
|----|----------------------|
| 1 | heat pump system |
| 2 | heat pump |
| 3 | refrigerant piping |
| 4 | temperature sensor |
| 5 | compressor |
| 6 | four-way valve |
| 7 | water heat exchanger |
| 8 | expansion valve |
| 9 | air heat exchanger |
| 10 | accumulator |
| 11 | water pipe |

Claims

1. A heat pump position checking method in a heat pump system (1) in which a plurality of heat pumps (2) are connected to a water pipe (11), and a water heat exchanger (7) of each of the heat pumps (2) exchanges heat with water flowing through the water pipe (11), the method being **characterized in that** it comprises:

a first step (S1) of putting one heat pump (2) into cooling operation or heating operation;
a second step (S2) of detecting temperatures of water in the water pipe (11) flowing into the plurality of heat pumps (2); and
a third step (S4) of estimating a positional relationship among the plurality of heat pumps (2) on the basis of the heat pump (2) in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps (2).

2. The heat pump position checking method in the heat pump system according to claim 1, further comprising:

a fourth step (S3) of stopping the heat pump (2) in cooling operation or heating operation after the temperatures of water are detected in the second step and putting one heat pump (2) which is different from the heat pump (2) already operated in the first step into cooling operation

or heating operation; and
 a fifth step (S5) of integrating the newly estimated positional relationship among the plurality of heat pumps (2) with an already estimated positional relationship among the plurality of heat pumps (2), wherein
 the first to fifth steps are repeated until positions of all of the plurality of heat pumps (2) are determined.

3. A heat pump position checking method in a heat pump system (1) in which a plurality of heat pumps (2) are connected to a water pipe (11), and a water heat exchanger (7) of each of the heat pumps (2) exchanges heat with water flowing through the water pipe (11), the method being **characterized in that** it comprises:

a first step (S31, S32, S41, S42) of simultaneously putting one first heat pump (2) into cooling operation and putting one different second heat pump (2) into heating operation;
 a second step of detecting temperatures of water in the water pipe (11) flowing into the plurality of heat pumps (2); and
 a third step of estimating a positional relationship among the plurality of heat pumps (2) on the basis of the first heat pump (2) in cooling operation, the second heat pump (2) in heating operation, and the temperatures of water detected at the plurality of heat pumps (2).

4. A heat pump system (1) in which a plurality of heat pumps (2) are connected to a water pipe (11), and a water heat exchange (7) of each of the heat pumps (2) exchanges heat with water flowing through the water pipe (11), the heat pump system being **characterized in that** it comprises:

an operation control unit (14) which puts one heat pump (2) into cooling operation or heating operation;
 a water temperature detection unit (15) which detects temperatures of water in the water pipe (11) flowing into the plurality of heat pumps (2); and
 a positional relationship estimation unit (16) which estimates a positional relationship among the plurality of heat pumps (2) on the basis of the heat pump (2) in cooling operation or heating operation and the temperatures of water detected at the plurality of heat pumps (2).

5. A heat pump system (1) in which a plurality of heat pumps (2) are connected to a water pipe (11), and a water heat exchanger (7) of each of the heat pumps (2) exchanges heat with water flowing through the water pipe (11), the heat pump system being **char-**

acterized in that it comprises:

an operation control unit (14) which puts one first heat pump (2) into cooling operation and puts one different second heat pump (2) into heating operation;
 a water temperature detection unit (15) which detects temperatures of water in the water pipe flowing into the plurality of heat pumps (2); and
 a positional relationship estimation unit (16) which estimates a positional relationship among the plurality of heat pumps (2) on the basis of the first heat pump (2) in cooling operation, the second heat pump (2) in heating operation, and the temperatures of water detected at the plurality of heat pumps (2).

FIG. 1

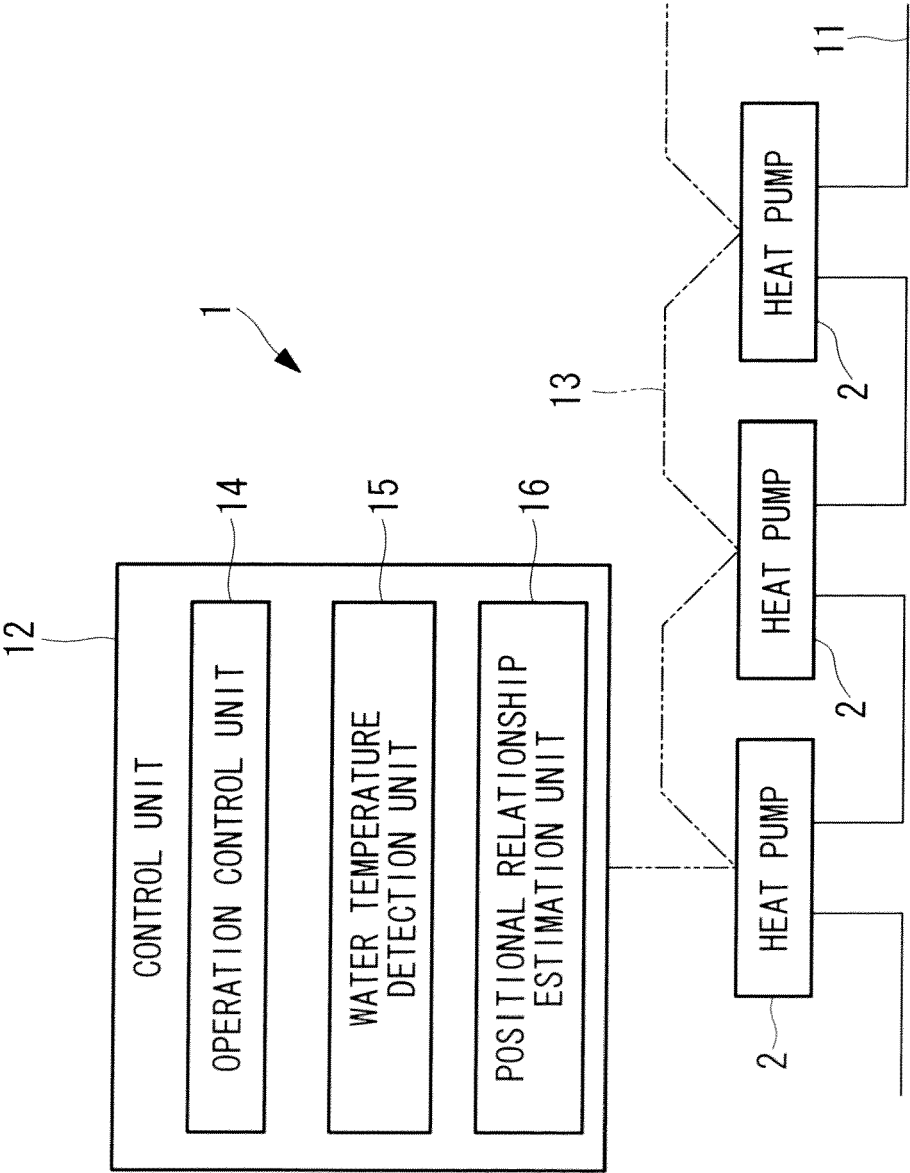


FIG. 2

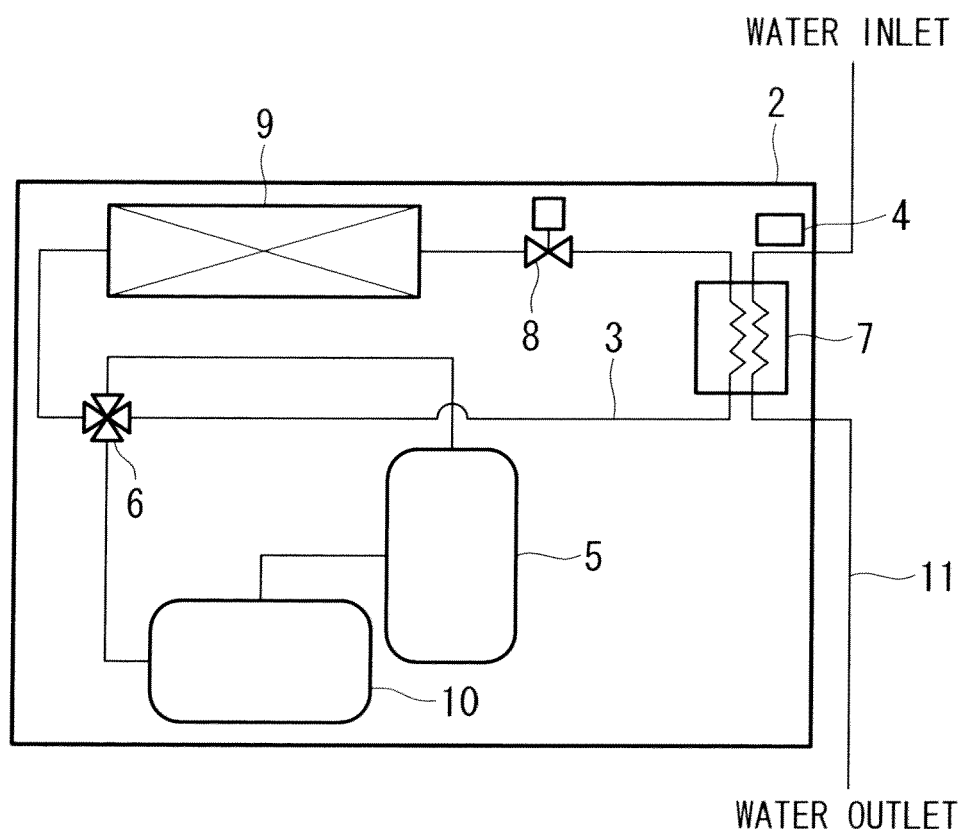


FIG. 3

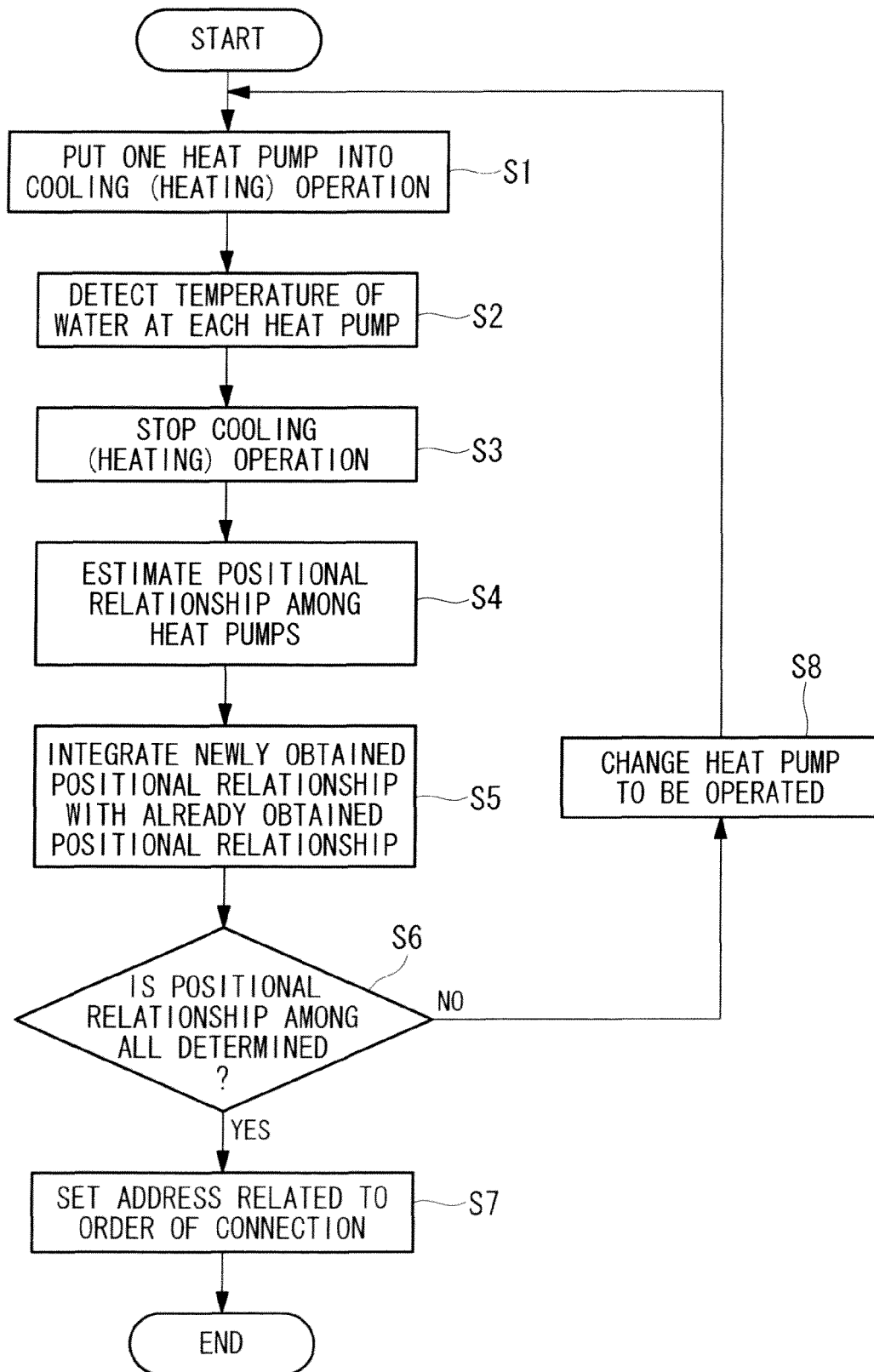


FIG. 4

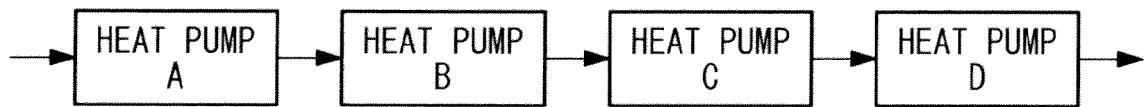


FIG. 5

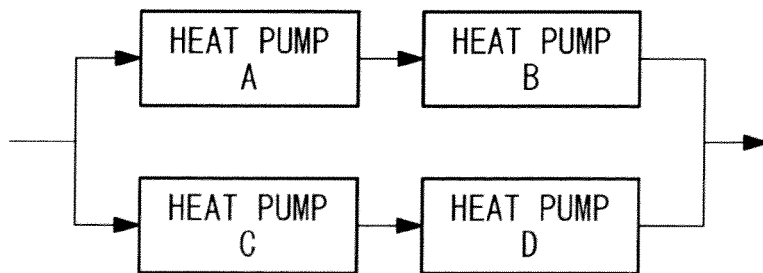


FIG. 6

	HEAT PUMP TO PERFORM COOLING OPERATION	TEMPERATURE OF WATER AT INLET OF A	TEMPERATURE OF WATER AT INLET OF B	TEMPERATURE OF WATER AT INLET OF C	TEMPERATURE OF WATER AT INLET OF D
S11	A	—	FALL	FALL	FALL
S12	B	—	—	FALL	FALL
S13	C	—	—	—	FALL

FIG. 7

	HEAT PUMP TO PERFORM COOLING OPERATION	TEMPERATURE OF WATER AT INLET OF A	TEMPERATURE OF WATER AT INLET OF B	TEMPERATURE OF WATER AT INLET OF C	TEMPERATURE RE OF WATER AT INLET OF D
S21	A	—	FALL	—	—
S22	B	—	—	—	—
S23	C	—	—	—	FALL

FIG. 8

	HEAT PUMP TO PERFORM COOLING OPERATION	HEAT PUMP TO PERFORM HEATING OPERATION	TEMPERATURE OF WATER AT INLET OF A	TEMPERATURE OF WATER AT INLET OF B	TEMPERATURE OF WATER AT INLET OF C	TEMPERATURE OF WATER AT INLET OF D
S31	A	B	—	FALL	RISE	RISE
S32	C	D	—	—	—	FALL

FIG. 9

	HEAT PUMP TO PERFORM COOLING OPERATION	HEAT PUMP TO PERFORM HEATING OPERATION	TEMPERATURE OF WATER AT INLET OF A	TEMPERATURE OF WATER AT INLET OF B	TEMPERATURE OF WATER AT INLET OF C	TEMPERATURE OF WATER AT INLET OF D
S41	A	B	—	FALL	—	—
S42	C	D	—	—	—	FALL

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2002195684 A [0004]