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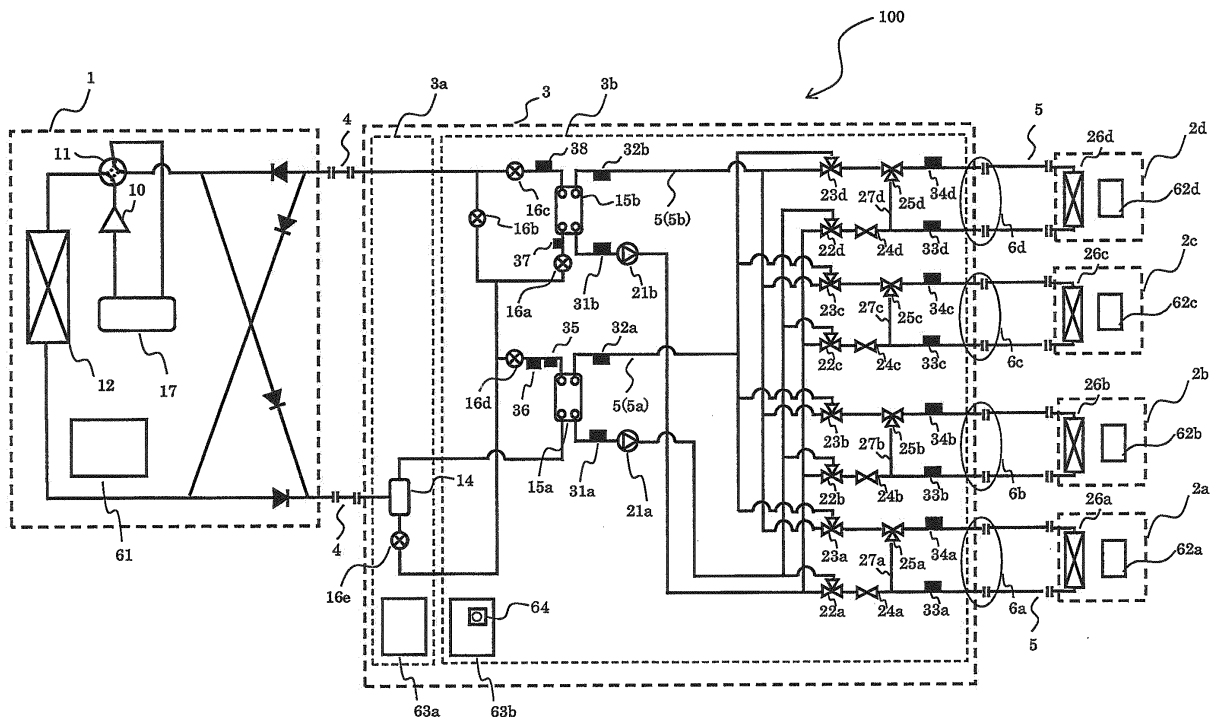
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(54) **REFRIGERATION AND AIR-CONDITIONING DEVICE**

(57) A refrigerating and air-conditioning apparatus that achieves reduced limitations with respect to the communication of indoor units and can identify which indoor unit is connected to each branch port is obtained.

Indoor units 2 are made to operate on a one-by-one basis, and it is identified which indoor unit 2 is connected to each branch port 6 on the basis of the difference between an inlet temperature and an outlet temperature at the branch port 6 at that time.

FIG. 1



Description

Technical Field

- 5 **[0001]** The present invention relates to refrigerating and air-conditioning apparatuses, and particularly, to a refrigerating and air-conditioning apparatus equipped with a plurality of use-side heat exchangers.

Background Art

- 10 **[0002]** In the conventional art, for example, there has been proposed a matter "detecting a first temperature of a heat exchanger in each indoor unit when all of flow control valves in a branch kit 30 are opened in a case where a refrigerant is supplied to each outdoor-unit-side refrigerant-pipe connection port connected to the branch kit 30; then detecting a second temperature of each indoor heat exchanger when the flow control valves in the branch kit are closed on a one-by-one basis; identifying an indoor unit corresponding to a heat exchanger in which a predetermined change in the
15 second temperature with reference to the first temperature is obtained as an indoor unit that is connected to the refrigerant-pipe connection port corresponding to one of the closed flow control valves, and setting a specific identification address for the identified indoor unit." (for example, see Patent Literature 1).

Citation List

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Patent Literature

- [0003]** Patent Literature 1: Japanese Unexamined Patent Application Publication No. 9-229457 (Abstract)

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Summary of Invention

Technical Problem

- 30 **[0004]** In a refrigerating and air-conditioning apparatus in the related art that can simultaneously perform cooling and heating, a relay unit is provided with a plurality of branch ports for a refrigerant pipe, and indoor units are connected to the respective branch ports. Because the relay unit needs to control flow switching valves and the like based on whether the indoor units are in operation or are stopped or whether the indoor units are operating in a cooling mode or a heating mode, it is necessary to perform the control by identifying which indoor unit is connected to which branch port. Therefore, connected-branch-port numbers or connected-indoor-unit numbers need to be set at the indoor units or the relay unit
35 by using DIP switches or the like.

- [0005]** However, when setting the connected-branch-port numbers or the connected-indoor-unit numbers at the indoor units or the relay unit by using DIP switches or the like, each indoor unit or the relay unit requires setting means, such as a DIP switch, which involves a problem in that the component cost is increased and a troublesome task is required in the setting process. In addition, there is another problem in that the operation cannot be performed properly if this
40 setting means is set incorrectly.

- [0006]** Furthermore, if the connections are to be automatically determined by controlling the flow control valves and measuring temperature changes in the indoor heat exchangers, as in Patent Literature 1 described above, the temperature data of each indoor heat exchanger needs to be transmitted to the relay unit by communication. In order to allow for exchanging of such temperature data, programs that use the same communication protocol need to be provided for a
45 transmission process performed by microcomputers of controllers in the indoor units and a reception analysis process performed by a microcomputer of a controller in the relay unit. This is a problem in that there are limitations with respect to indoor units that can be connected to the relay unit.

- [0007]** An example of limitations with respect to indoor units that can be connected to the relay unit, as mentioned above, will be described below.

- 50 Fig. 8 is a schematic diagram illustrating the configuration of an indoor-unit controller and a relay-unit controller in the related art provided with a function for controlling a flow control valve and measuring a temperature change in an indoor heat exchanger so as to automatically determine the connection. In Fig. 8, a relay-unit controller 63b and an indoor-unit controller 62 are connected by transmission lines 71. The transmission lines 71 connect transmission circuits and reception circuits of the relay-unit controller 63b and the indoor-unit controller 62. The transmission circuit and the
55 reception circuit in each controller are connected to a microcomputer in the controller, and the microcomputer performs a transmission process and a reception analysis process.

- [0008]** Fig. 9 illustrates the flow of data when transmitting temperature data of an indoor heat exchanger from the indoor-unit controller 62 to the relay-unit controller 63b in the related art. First, the temperature data is converted into a

transmittable digital signal by a transmission process performed by the indoor-unit controller 62. Furthermore, the digital signal is converted into a signal waveform by the transmission circuit, and the signal waveform is transmitted to the relay unit via the transmission line. In the relay-unit controller 63b, the reception circuit reversely-converts the signal waveform into a digital signal. Furthermore, the digital signal is reversely-converted into temperature data by a reception analysis process so that the temperature data can be received.

Accordingly, in the related art, programs that use the same communication protocol need to be provided for both of the transmission process performed by the microcomputer in the indoor-unit controller 62 and the reception analysis process performed by the microcomputer in the relay-unit controller 63b in order to perform transmission and reception of the temperature data.

Moreover, expensive circuit configurations are necessary because the reception circuit in the relay-unit controller 63b and the transmission circuit in the indoor-unit controller 62 need to be connectable to each other and also need to satisfy limiting conditions with respect to the operating speed.

[0009] In the related art, the relay unit and each indoor unit are connectable only if the combination thereof satisfies the limiting conditions thereof. This is a problem in that the units cannot be readily connected if they are products provided by different manufacturers.

[0010] In addition, there is another problem in that the configuration for the communication between the relay unit and each indoor unit is complicated.

[0011] The present invention has been made to solve the aforementioned problems, and a first object thereof is to provide a refrigerating and air-conditioning apparatus that achieves reduced limitations with respect to the communication of indoor units and can identify which indoor unit is connected to each branch port.

[0012] A second object is to provide a refrigerating and air-conditioning apparatus that can detect a setting error with respect to the connection between each branch port and each indoor unit.

Solution to Problem

[0013] A refrigerating and air-conditioning apparatus according to the present invention includes a refrigeration cycle that makes a refrigerant circulate therethrough by connecting a compressor, a heat-source-side heat exchanger, at least one expansion valve, and at least one intermediate heat exchanger; and a heat-medium circuit that makes a heat medium circulate therethrough by connecting at least one pump, a plurality of use-side heat exchangers, and the intermediate heat exchanger. The at least one intermediate heat exchanger and the pump are accommodated in a relay unit. The plurality of use-side heat exchangers are accommodated in respective indoor units. Each indoor unit includes an indoor-unit controller that performs on-off control for operation performed by the use-side heat exchanger for exchanging heat between the heat medium and a thermal load. The relay unit includes a plurality of branch ports that are connected to the plurality of use-side heat exchangers and make the heat medium circulate to the use-side heat exchangers, outlet temperature sensors that are provided for the respective branch ports and each detect an outlet temperature of the heat medium flowing out of the branch port to the corresponding use-side heat exchanger, inlet temperature sensors that are provided for the respective branch ports and each detect an inlet temperature of the heat medium flowing into the branch port from the corresponding use-side heat exchanger, and a relay-unit controller that is connected to the indoor-unit controllers by a transmission line and controls operation of each indoor-unit by transmitting an operation command or a stop command thereto via the transmission line. The relay-unit controller makes the indoor units operate on a one-by-one basis and identifies which of the indoor units is connected to each branch port on the basis of a difference between the inlet temperature and the outlet temperature at the branch port. Advantageous Effects of Invention

[0014] The present invention can achieve reduced limitations with respect to the communication of indoor units and can identify which indoor unit is connected to each branch port.

Brief Description of Drawings

[0015]

[Fig. 1] Fig. 1 is a schematic circuit diagram illustrating the configuration of a refrigerating and air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a schematic diagram illustrating the configuration of a relay-unit controller and an indoor-unit controller according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a flowchart illustrating the flow of an process of automatic determination of connected branch ports to indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a schematic circuit diagram illustrating the configuration of a refrigerating and air-conditioning apparatus according to Embodiment 2 of the present invention.

[Fig. 5] Fig. 5 is a flowchart illustrating the flow of an process of automatic determination of connected branch ports

to indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 2 of the present invention.

[Fig. 6] Fig. 6 is a schematic circuit diagram illustrating the configuration of a refrigerating and air-conditioning apparatus according to Embodiment 3 of the present invention.

[Fig. 7] Fig. 7 is a flowchart illustrating the flow of an process of automatic determination of connected branch ports to indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 3 of the present invention.

[Fig. 8] Fig. 8 is a schematic diagram illustrating the configuration of an indoor-unit controller and a relay-unit controller in the related art provided with a function for controlling a flow control valve and measuring a temperature change in an indoor heat exchanger so as to automatically determine the connection.

[Fig. 9] Fig. 9 illustrates the flow of data when transmitting temperature data of the indoor heat exchanger from an indoor-unit controller 62 to a relay-unit controller 63b in the related art.

Description of Embodiments

Embodiment 1

[0016] Embodiment 1 relates to a refrigerating and air-conditioning apparatus that performs an process of automatic determination of connected branch ports to indoor units during trial operation performed after installation of the apparatus.

[0017] Fig. 1 is a schematic circuit diagram illustrating the configuration of the refrigerating and air-conditioning apparatus according to Embodiment 1 of the present invention. As shown in Fig. 1, the refrigerating and air-conditioning apparatus includes a single heat source device 1 serving as a heat source unit, a plurality of indoor units 2, and a relay unit 3 interposed between the heat source device 1 and the indoor units 2.

[0018] The heat source device 1 accommodates a compressor 10, a four-way valve 11, a heat-source-side heat exchanger 12, and an accumulator 17 that are connected in series by a refrigerant pipe 4, and serves as a system that supplies required heat by means of a refrigerant.

[0019] The indoor units 2 are individually equipped with use-side heat exchangers 26. The use-side heat exchangers 26 are connected to stop valves 24 and flow control valves 25 in a second relay unit 3b via pipes 5. The indoor units 2 transfer heat from a heat medium circulated by the use-side heat exchangers 26 to indoor air by heat exchange. The heat medium used may be water, an antifreeze, or the like. In Embodiment 1, water is used as the heat medium.

[0020] The relay unit 3 is constituted of a first relay unit 3a and the second relay unit 3b that are accommodated in separate housings. The first relay unit 3a is provided with a gas-liquid separator 14 and an expansion valve 16e, and separates a transported refrigerant into three, that is, high-pressure gas, intermediate-pressure liquid, and low-pressure gas and supplies the refrigerant as a heat source for cooling and heating. The second relay unit 3b is provided with two intermediate heat exchangers 15, four expansion valves 16, two pumps 21, four flow switching valves 22, four flow switching valves 23, four stop valves 24, and four flow control valves 25. The second relay unit 3b transfers required heat from a cooling or heating refrigerant to water and causes the water storing a required amount of heat to circulate to a heat-medium circuit (water circuit).

[0021] The second relay unit 3b is further provided with two first temperature sensors 31, two second temperature sensors 32, four third temperature sensors 33, four fourth temperature sensors 34, a fifth temperature sensor 35, a pressure sensor 36, a sixth temperature sensor 37, and a seventh temperature sensor 38. The four third temperature sensors 33 (third temperature sensors 33a to 33d) are provided at the inlet side of heat-medium passages of the use-side heat exchangers 26, are configured to detect the temperature of the heat medium flowing into the use-side heat exchangers 26, and may be formed of thermistors or the like. The number of third temperature sensors 33 provided corresponds the number of (four, in this case) indoor units 2 installed. In line with the indoor units 2, the third temperature sensor 33a, the third temperature sensor 33b, the third temperature sensor 33c, and the third temperature sensor 33d are shown in that order from the lower side of the drawing.

[0022] The third temperature sensors 33 correspond to "inlet temperature sensors" in the present invention.

[0023] The four fourth temperature sensors 34 (fourth temperature sensors 34a to 34d) are provided at the outlet side of the heat-medium passages of the use-side heat exchangers 26, are configured to detect the temperature of the heat medium flowing out of the use-side heat exchangers 26, and may be formed of thermistors or the like. The number of fourth temperature sensors 34 provided corresponds to the number of (four, in this case) indoor units 2 installed. In line with the indoor units 2, the fourth temperature sensor 34a, the fourth temperature sensor 34b, the fourth temperature sensor 34c, and the fourth temperature sensor 34d are shown in that order from the lower side of the drawing.

[0024] The fourth temperature sensors 34 correspond to "outlet temperature sensors" in the present invention.

[0025] The pipes 5 that guide the water serving as a heat medium include a pipe (referred to as "pipe 5a" hereinafter) that is connected to the intermediate heat exchanger 15a and a pipe (referred to as "pipe 5b" hereinafter) that is connected to the intermediate heat exchanger 15b. The pipe 5a and the pipe 5b each branch off into pipe segments (four pipe segments, in this case) in accordance with the number of indoor units 2 connectable to the relay unit 3. Combinations of branch pipe segments of the pipes 5a and 5b that are connectable to the indoor units 2a to 2d will be referred to as

branch ports 6a to 6d. The branch ports 6a to 6d are connected to each other by the flow switching valves 22, the flow switching valves 23, and the flow control valves 25. By controlling the flow switching valves 22 and the flow switching valves 23, the heat medium guided through the pipe 5a can be made to flow into the use-side heat exchangers 26, or the heat medium guided through the pipe 5b can be made to flow into the use-side heat exchangers 26.

[0026] The heat source device 1 is provided with a controller 61 that controls the operation of each of the devices included in the heat source device 1. The indoor units 2a to 2d are respectively provided with indoor-unit controllers 62a to 62d that control the operation of each of the devices included in each of the indoor units 2a to 2d. The relay units 3a and 3b are respectively provided with relay-unit controllers 63a and 63b that control the operation of each of the devices included in the relay units 3a and 3b. The relay-unit controller 63b is provided with a switch 64 that is to be operated when commencing the automatic determination process for branch ports.

[0027] The controller 61, the indoor-unit controllers 62a to 62d, and the relay-unit controllers 63a and 63b are capable of exchanging signals with each other.

[0028] The number of connected heat source devices 1, indoor units 2, and relay units 3 is not limited to that shown in the drawing.

[0029] The indoor units 2 are not limited to air-conditioning units, and may alternatively be hot-water-supply units.

[0030] Operation modes executed by the refrigerating and air-conditioning apparatus 100 will now be described.

[0031] The refrigerating and air-conditioning apparatus 100 can perform cooling operation or heating operation in each indoor unit 2. Specifically, the refrigerating and air-conditioning apparatus 100 can perform the same operation in all of the indoor units 2 or perform different operations among the indoor units 2. Four operation modes executable by the refrigerating and air-conditioning apparatus 100, that is, a cooling only operation mode in which all of the driven indoor units 2 perform the cooling operation, a heating only operation mode in which all of the driven indoor units 2 perform the heating operation, a cooling main operation mode in which the cooling load is the greater, and a heating main operation mode in which the heating load is the greater, will be described below together with the flow of the refrigerant.

Cooling Only Operation Mode

[0032] The following description relates to an example of a cooling only operation mode in a case where a cooling load is generated only in a use-side heat exchanger 26a and a use-side heat exchanger 26b.

[0033] In the case of the cooling only operation mode, the four-way valve 11 in the heat source device 1 is switched so that the refrigerant discharged from the compressor 10 flows into the heat-source-side heat exchanger 12. In the relay unit 3, the pump 21 a is stopped, the pump 21 b is driven, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed, so that the heat medium circulates between the intermediate heat exchanger 15b and the corresponding use-side heat exchangers 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). In this state, the operation of the compressor 10 commences.

[0034] First, the flow of the refrigerant in a refrigeration cycle will be described.

[0035] A low-temperature low-pressure gas refrigerant is compressed by the compressor 10 and is discharged therefrom as a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 travels through the four-way valve 11 so as to flow into the heat-source-side heat exchanger 12. Then, the refrigerant condenses and liquefies while transferring heat to outdoor air at the heat-source-side heat exchanger 12, thereby becoming a high-pressure liquid refrigerant. The high-pressure liquid refrigerant flowing out of the heat-source-side heat exchanger 12 flows out of the heat source device 1 via a check valve, and then travels through the refrigerant pipe 4 so as to flow into the first relay unit 3a. The high-pressure liquid refrigerant flowing into the first relay unit 3a flows into the gas-liquid separator 14 and then travels through the expansion valve 16e before flowing into the second relay unit 3b.

[0036] The refrigerant flowing into the second relay unit 3b is expanded by being throttled by an expansion valve 16a, thereby becoming a low-temperature low-pressure two-phase gas-liquid refrigerant. This two-phase gas-liquid refrigerant flows into the intermediate heat exchanger 15b functioning as an evaporator and cools the heat medium circulating through the heat-medium circuit by receiving heat from the heat medium, thereby becoming a low-temperature low-pressure gas refrigerant. The gas refrigerant flowing out of the intermediate heat exchanger 15b flows out of the second relay unit 3b and the first relay unit 3a after traveling through an expansion valve 16c, and then travels through the refrigerant pipe 4 so as to flow into the heat source device 1. The refrigerant flowing into the heat source device 1 travels through a check valve and is suctioned into the compressor 10 again via the four-way valve 11 and the accumulator 17. The expansion valve 16b and the expansion valve 16d are set to small opening degrees so as to prevent the refrigerant from flowing therethrough, whereas the expansion valve 16c is completely opened so as to prevent the occurrence of pressure loss.

[0037] Next, the flow of the heat medium in the heat-medium circuit will be described.

[0038] In the cooling only operation mode, the heat medium circulates via the pipe 5b since the pump 21 a is stopped. The heat medium cooled by the refrigerant at the intermediate heat exchanger 15b is made to flow through the pipe 5b

by the pump 21 b. The heat medium pressurized by and flowing out of the pump 21 b travels through the stop valves 24 (the stop valve 24a and the stop valve 24b) via the flow switching valves 22 (the flow switching valve 22a and the flow switching valve 22b) so as to flow into the use-side heat exchangers 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). Then, the heat medium receives heat from indoor air (thermal load) at the use-side heat exchangers 26, thereby cooling an air-conditioning target area, such as an indoor area, where the indoor units 2 are installed.

[0039] Subsequently, the heat medium flowing out of the use-side heat exchangers 26 flows into the flow control valves 25 (the flow control valve 25a and the flow control valve 25b). In this case, with the functions of the flow control valves 25, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area, such as an indoor area, flows into the use-side heat exchangers 26, whereas the remaining heat medium bypasses the use-side heat exchangers 26 by flowing through bypass pipes 27 (a bypass pipe 27a and a bypass pipe 27b).

[0040] The heat medium traveling through the bypass pipes 27 does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchangers 26. Then, the heat medium flows into the intermediate heat exchanger 15b via the flow switching valves 23 (the flow switching valve 23a and the flow switching valve 23b), and is suctioned into the pump 21 b again. The air-conditioning load required in the air-conditioning target area, such as an indoor area, can be covered by performing control such that a temperature difference between the third temperature sensors 33 and the fourth temperature sensors 34 is maintained at a target value.

[0041] In this case, since the heat medium does not need to flow into use-side heat exchangers 26 with no thermal load (including those in a thermostat-off state), the passages therefor are closed by the corresponding stop valves 24, thereby preventing the heat medium from flowing toward the use-side heat exchangers 26. Since there is a thermal load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow into these heat exchangers. In contrast, since there is no thermal load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valves 24c and 24d are closed. If a cooling load is generated at the use-side heat exchanger 26c or the use-side heat exchanger 26d, the stop valve 24c or the stop valve 24d may be opened so as to circulate the heat medium.

Heating Only Operation Mode

[0042] The following description relates to an example of a heating only operation mode in a case where a heating load is generated only in the use-side heat exchanger 26a and the use-side heat exchanger 26b.

[0043] In the case of the heating only operation mode, the four-way valve 11 in the heat source device 1 is switched so that the refrigerant discharged from the compressor 10 flows into the relay unit 3 without traveling through the heat-source-side heat exchanger 12. In the relay unit 3, the pump 21 a is driven, the pump 21 b is stopped, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed, so that the heat medium circulates between the intermediate heat exchanger 15a and the corresponding use-side heat exchangers 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). In this state, the operation of the compressor 10 commences.

[0044] First, the flow of the refrigerant in the refrigeration cycle will be described.

[0045] A low-temperature low-pressure gas refrigerant is compressed by the compressor 10 and is discharged therefrom as a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 travels through the four-way valve 11, is guided through the refrigerant pipe 4, and then passes through a check valve so as to flow out of the heat source device 1. The high-temperature high-pressure gas refrigerant flowing out of the heat source device 1 travels through the refrigerant pipe 4 so as to flow into the first relay unit 3a. The high-temperature high-pressure gas refrigerant flowing into the first relay unit 3a flows into the gas-liquid separator 14 and subsequently flows into the intermediate heat exchanger 15a. The high-temperature high-pressure gas refrigerant flowing into the intermediate heat exchanger 15a condenses and liquefies while transferring heat to the heat medium circulating through the heat-medium circuit, thereby becoming a high-pressure liquid refrigerant.

[0046] The high-pressure liquid refrigerant flowing out of the intermediate heat exchanger 15a is expanded by being throttled by the expansion valve 16d, thereby turning into a low-temperature low-pressure two-phase gas-liquid state. The two-phase gas-liquid refrigerant throttled by the expansion valve 16d travels through the expansion valve 16b and is guided through the refrigerant pipe 4 so as to flow into the heat source device 1 again. The refrigerant flowing into the heat source device 1 flows into the heat-source-side heat exchanger 12 functioning as an evaporator via a check valve. Then, the refrigerant flowing into the heat-source-side heat exchanger 12 receives heat from outdoor air at the heat-source-side heat exchanger 12, thereby becoming a low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant flowing out of the heat-source-side heat exchanger 12 returns to the compressor 10 via the four-way valve 11 and the accumulator 17. The expansion valve 16a, the expansion valve 16c, and the expansion valve 16e are set to small opening degrees so as to prevent the refrigerant from flowing therethrough.

[0047] Next, the flow of the heat medium in the heat-medium circuit will be described.

[0048] In the heating only operation mode, the heat medium circulates via the pipe 5a since the pump 21 b is stopped. The heat medium heated by the refrigerant at the intermediate heat exchanger 15a is made to flow through the pipe 5a by the pump 21 a. The heat medium pressurized by and flowing out of the pump 21 a travels through the stop valves 24 (the stop valve 24a and the stop valve 24b) via the flow switching valves 22 (the flow switching valve 22a and the flow switching valve 22b) so as to flow into the use-side heat exchangers 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). Then, the heat medium transfers heat to indoor air (thermal load) at the use-side heat exchangers 26, thereby heating the air-conditioning target area, such as an indoor area, where the indoor units 2 are installed.

[0049] Subsequently, the heat medium flowing out of the use-side heat exchangers 26 flows into the flow control valves 25 (the flow control valve 25a and the flow control valve 25b). In this case, with the functions of the flow control valves 25, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area, such as an indoor area, flows into the use-side heat exchangers 26, whereas the remaining heat medium bypasses the use-side heat exchangers 26 by flowing through the bypass pipes 27 (the bypass pipe 27a and the bypass pipe 27b).

[0050] The heat medium traveling through the bypass pipes 27 does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchangers 26. Then, the heat medium flows into the intermediate heat exchanger 15a via the flow switching valves 23 (the flow switching valve 23a and the flow switching valve 23b), and is suctioned into the pump 21 a again. The air-conditioning load required in the air-conditioning target area, such as an indoor area, can be covered by performing control such that a temperature difference between the third temperature sensors 33 and the fourth temperature sensors 34 is maintained at a target value.

[0051] In this case, since the heat medium does not need to flow into use-side heat exchangers 26 with no thermal load (including those in a thermostat-off state), the passages therefor are closed by the corresponding stop valves 24, thereby preventing the heat medium from flowing toward the use-side heat exchangers 26. Since there is a thermal load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow into these heat exchangers. In contrast, since there is no thermal load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valves 24c and 24d are closed. If a heating load is generated at the use-side heat exchanger 26c or the use-side heat exchanger 26d, the stop valve 24c or the stop valve 24d may be opened so as to circulate the heat medium.

Cooling Main Operation Mode

[0052] The following description relates to an example of a cooling main operation mode in a case where a heating load is generated at the use-side heat exchanger 26a and a cooling load is generated at the use-side heat exchanger 26b.

[0053] In the case of the cooling main operation mode, the four-way valve 11 in the heat source device 1 is switched so that the refrigerant discharged from the compressor 10 flows into the heat-source-side heat exchanger 12. In the relay unit 3, the pump 21 a and the pump 21 b are driven, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed, so that the heat medium circulates between the intermediate heat exchanger 15a and the use-side heat exchanger 26a as well as between the intermediate heat exchanger 15b and the use-side heat exchanger 26b. In this state, the operation of the compressor 10 commences.

[0054] First, the flow of the refrigerant in the refrigeration cycle will be described.

[0055] A low-temperature low-pressure gas refrigerant is compressed by the compressor 10 and is discharged therefrom as a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 travels through the four-way valve 11 so as to flow into the heat-source-side heat exchanger 12. Then, the refrigerant condenses by transferring heat to outdoor air at the heat-source-side heat exchanger 12, thereby becoming a two-phase gas-liquid refrigerant. The two-phase gas-liquid refrigerant flowing out of the heat-source-side heat exchanger 12 flows out of the heat source device 1 via a check valve, and then travels through the refrigerant pipe 4 so as to flow into the first relay unit 3a. The two-phase gas-liquid refrigerant flowing into the first relay unit 3a flows into the gas-liquid separator 14 where the refrigerant is separated into a gas refrigerant and a liquid refrigerant, which then flow into the second relay unit 3b.

[0056] The gas refrigerant separated at the gas-liquid separator 14 flows into the intermediate heat exchanger 15a. The gas refrigerant flowing into the intermediate heat exchanger 15a condenses and liquefies while transferring heat to the heat medium circulating through the heat-medium circuit, thereby becoming a liquid refrigerant. The liquid refrigerant flowing out of the intermediate heat exchanger 15b travels through the expansion valve 16d. On the other hand, the liquid refrigerant separated at the gas-liquid separator 14 travels through the expansion valve 16e, merges with the liquid refrigerant condensed and liquefied at the intermediate heat exchanger 15a and having traveled through the expansion valve 16d, and is expanded by being throttled by the expansion valve 16a so as to flow into the intermediate heat exchanger 15b as a low-temperature low-pressure two-phase gas-liquid refrigerant.

[0057] At the intermediate heat exchanger 15b functioning as an evaporator, this two-phase gas-liquid refrigerant receives heat from the heat medium circulating through the heat-medium circuit so as to become a low-temperature

low-pressure gas refrigerant while cooling the heat medium. The gas refrigerant flowing out of the intermediate heat exchanger 15b travels through the expansion valve 16c and then flows out of the second relay unit 3b and the first relay unit 3a so as to flow into the heat source device 1 via the refrigerant pipe 4. The refrigerant having flowed into the heat source device 1 travels through a check valve and is suctioned into the compressor 10 again via the four-way valve 11 and the accumulator 17. The expansion valve 16b is set to a small opening degree so as to prevent the refrigerant from flowing therethrough, whereas the expansion valve 16c is completely opened so as to prevent the occurrence of pressure loss.

[0058] Next, the flow of the heat medium in the heat-medium circuit will be described.

[0059] In the cooling main operation mode, the heat medium circulates via both the pipe 5a and the pipe 5b since the pump 21 a and the pump 21 b are both driven. The heat medium heated by the refrigerant at the intermediate heat exchanger 15a is made to flow through the pipe 5a by the pump 21 a. The heat medium cooled by the refrigerant at the intermediate heat exchanger 15b is made to flow through the pipe 5b by the pump 21 b.

[0060] The heat medium pressurized by and flowing out of the pump 21 a travels through the stop valve 24a via the flow switching valve 22a so as to flow into the use-side heat exchanger 26a. Then, the heat medium transfers heat to indoor air (thermal load) at the use-side heat exchanger 26a, thereby heating the air-conditioning target area, such as an indoor area, where the indoor unit 2 is installed. The heat medium pressurized by and flowing out of the pump 21 b travels through the stop valve 24b via the flow switching valve 22b so as to flow into the use-side heat exchanger 26b. Then, the heat medium receives heat from indoor air (thermal load) at the use-side heat exchanger 26b, thereby cooling the air-conditioning target area, such as an indoor area, where the indoor unit 2 is installed.

[0061] The heat medium having performed the heating flows into the flow control valve 25a. In this case, with the function of the flow control valve 25a, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area flows into the use-side heat exchanger 26a, whereas the remaining heat medium bypasses the use-side heat exchanger 26a by flowing through the bypass pipe 27a. The heat medium traveling through the bypass pipe 27a does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchanger 26a. Then, the heat medium flows into the intermediate heat exchanger 15a via the flow switching valve 23a, and is suctioned into the pump 21 a again.

[0062] Likewise, the heat medium having performed the cooling flows into the flow control valve 25b. In this case, with the function of the flow control valve 25b, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area flows into the use-side heat exchanger 26b, whereas the remaining heat medium bypasses the use-side heat exchanger 26b by flowing through the bypass pipe 27b. The heat medium traveling through the bypass pipe 27b does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchanger 26b. Then, the heat medium flows into the intermediate heat exchanger 15b via the flow switching valve 23b, and is suctioned into the pump 21 b again.

[0063] During this time, the warm heat medium (the heat medium to be used for the heating load) and the cool heat medium (the heat medium to be used for the cooling load) respectively flow into the use-side heat exchanger 26a with the heating load and the use-side heat exchanger 26b with the cooling load without mixing with each other due to the functions of the flow switching valves 22 (the flow switching valve 22a and the flow switching valve 22b) and the flow switching valves 23 (the flow switching valve 23a and the flow switching valve 23b). The air-conditioning load required in the air-conditioning target area, such as an indoor area, can be covered by performing control such that a temperature difference between the third temperature sensors 33 and the fourth temperature sensors 34 is maintained at a target value.

[0064] In this case, since the heat medium does not need to flow into use-side heat exchangers 26 with no thermal load (including those in a thermostat-off state), the passages therefor are closed by the corresponding stop valves 24, thereby preventing the heat medium from flowing toward the use-side heat exchangers 26. Referring to Fig. 6, since there is a thermal load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow into these heat exchangers. In contrast, since there is no thermal load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valves 24c and 24d are closed. If a heating load or a cooling load is generated at the use-side heat exchanger 26c or the use-side heat exchanger 26d, the stop valve 24c or the stop valve 24d may be opened so as to circulate the heat medium.

Heating Main Operation Mode

[0065] The following description relates to an example of a heating main operation mode in a case where a heating load is generated at the use-side heat exchanger 26a and a cooling load is generated at the use-side heat exchanger 26b.

[0066] In the case of the heating main operation mode, the four-way valve 11 in the heat source device 1 is switched so that the refrigerant discharged from the compressor 10 flows into the relay unit 3 without traveling through the heat-source-side heat exchanger 12. In the relay unit 3, the pump 21 a and the pump 21 b are driven, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed, so that the heat medium circulates between the intermediate heat exchanger 15a and the use-side heat exchanger 26a as well as between the

intermediate heat exchanger 15b and the use-side heat exchanger 26b. In this state, the operation of the compressor 10 commences.

[0067] First, the flow of the refrigerant in the refrigeration cycle will be described.

[0068] A low-temperature low-pressure refrigerant is compressed by the compressor 10 and is discharged therefrom as a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 travels through the four-way valve 11, is guided through the refrigerant pipe 4, and then passes through a check valve so as to flow out of the heat source device 1. The high-temperature high-pressure gas refrigerant flowing out of the heat source device 1 travels through the refrigerant pipe 4 so as to flow into the first relay unit 3a. The high-temperature high-pressure gas refrigerant having flowed into the first relay unit 3a flows into the gas-liquid separator 14 and subsequently flows into the intermediate heat exchanger 15a. The high-temperature high-pressure gas refrigerant having flowed into the intermediate heat exchanger 15a condenses and liquefies while transferring heat to the heat medium circulating through the heat-medium circuit, thereby becoming a high-pressure liquid refrigerant.

[0069] The high-pressure liquid refrigerant flowing out of the intermediate heat exchanger 15a is expanded by being throttled by the expansion valve 16d, thereby turning into a low-temperature low-pressure two-phase gas-liquid state. The two-phase gas-liquid refrigerant throttled by the expansion valve 16d is distributed to a passage extending through the expansion valve 16a and a passage extending through the expansion valve 16b. The refrigerant traveling through the expansion valve 16a is further expanded by the expansion valve 16a so as to become a low-temperature low-pressure two-phase gas-liquid refrigerant, which then flows into the intermediate heat exchanger 15b functioning as an evaporator. Then, the refrigerant having flowed into the intermediate heat exchanger 15b receives heat from the heat medium at the intermediate heat exchanger 15b, thereby becoming a low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant flowing out of the intermediate heat exchanger 15b travels through the expansion valve 16c.

[0070] On the other hand, the refrigerant throttled by the expansion valve 16d and flowing to the expansion valve 16b merges with the refrigerant traveling through the intermediate heat exchanger 15b and the expansion valve 16c, thereby becoming a low-temperature low-pressure refrigerant with a greater quality. Then, the merged refrigerant flows out of the second relay unit 3b and the first relay unit 3a and then travels through the refrigerant pipe 4 so as to flow into the heat source device 1. The refrigerant having flowed into the heat source device 1 flows into the heat-source-side heat exchanger 12 functioning as an evaporator via a check valve. Then, the refrigerant having flowed into the heat-source-side heat exchanger 12 receives heat from outdoor air at the heat-source-side heat exchanger 12, thereby becoming a low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant flowing out of the heat-source-side heat exchanger 12 returns to the compressor 10 via the four-way valve 11 and the accumulator 17. The expansion valve 16e is set to a small opening degree so as to prevent the refrigerant from flowing therethrough.

[0071] Next, the flow of the heat medium in the heat-medium circuit will be described.

[0072] In the heating main operation mode, the heat medium circulates via both the pipe 5a and the pipe 5b since the pump 21 a and the pump 21 b are both driven. The heat medium heated by the refrigerant at the intermediate heat exchanger 15a is made to flow through the pipe 5a by the pump 21 a. The heat medium cooled by the refrigerant at the intermediate heat exchanger 15b is made to flow through the pipe 5b by the pump 21 b.

[0073] The heat medium pressurized by and flowing out of the pump 21 a travels through the stop valve 24a via the flow switching valve 22a so as to flow into the use-side heat exchanger 26a. Then, the heat medium transfers heat to indoor air (thermal load) at the use-side heat exchanger 26a, thereby heating the air-conditioning target area, such as an indoor area, where the indoor unit 2 is installed. The heat medium pressurized by and flowing out of the pump 21 b travels through the stop valve 24b via the flow switching valve 22b so as to flow into the use-side heat exchanger 26b. Then, the heat medium receives heat from indoor air (thermal load) at the use-side heat exchanger 26b, thereby cooling the air-conditioning target area, such as an indoor area, where the indoor unit 2 is installed.

[0074] The heat medium flowing out of the use-side heat exchanger 26a flows into the flow control valve 25a. In this case, with the function of the flow control valve 25a, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area, such as an indoor area, flows into the use-side heat exchanger 26a, whereas the remaining heat medium bypasses the use-side heat exchanger 26a by flowing through the bypass pipe 27a. The heat medium traveling through the bypass pipe 27a does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchanger 26a. Then, the heat medium flows into the intermediate heat exchanger 15a via the flow switching valve 23a, and is suctioned into the pump 21 a again.

[0075] Likewise, the heat medium flowing out of the use-side heat exchanger 26b flows into the flow control valve 25b. In this case, with the function of the flow control valve 25b, only an amount of heat medium sufficient to cover the air-conditioning load required in the air-conditioning target area, such as an indoor area, flows into the use-side heat exchanger 26b, whereas the remaining heat medium bypasses the use-side heat exchanger 26b by flowing through the bypass pipe 27b. The heat medium traveling through the bypass pipe 27b does not contribute to heat exchange and merges with the heat medium having traveled through the use-side heat exchanger 26b. Then, the heat medium flows into the intermediate heat exchanger 15b via the flow switching valve 23b, and is suctioned into the pump 21 b again.

[0076] During this time, the warm heat medium and the cool heat medium respectively flow into the use-side heat exchanger 26a with the heating load and the use-side heat exchanger 26b with the cooling load without mixing with each other due to the functions of the flow switching valves 22 (the flow switching valve 22a and the flow switching valve 22b) and the flow switching valves 23 (the flow switching valve 23a and the flow switching valve 23b). The air-conditioning load required in the air-conditioning target area, such as an indoor area, can be covered by performing control such that a temperature difference between the third temperature sensors 33 and the fourth temperature sensors 34 is maintained at a target value.

[0077] In this case, since the heat medium does not need to flow into use-side heat exchangers 26 with no thermal load (including those in a thermostat-off state), the passages therefor are closed by the corresponding stop valves 24, thereby preventing the heat medium from flowing toward the use-side heat exchangers 26. Referring to Fig. 7, since there is a thermal load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow into these heat exchangers. In contrast, since there is no thermal load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valves 24c and 24d are closed. If a heating load or a cooling load is generated at the use-side heat exchanger 26c or the use-side heat exchanger 26d, the stop valve 24c or the stop valve 24d may be opened so as to circulate the heat medium.

[0078] Accordingly, when a heating load is generated at the use-side heat exchangers 26a to 26d, the corresponding flow switching valves 22a to 22d and the corresponding flow switching valves 23a to 23d are switched to passages that are connected to the intermediate heat exchanger 15a for heating. If a cooling load is generated at the use-side heat exchangers 26a to 26d, the corresponding flow switching valves 22a to 22d and the corresponding flow switching valves 23a to 23d are switched to passages that are connected to the intermediate heat exchanger 15b for cooling. Consequently, heating operation or cooling operation can be performed freely in each indoor unit 2.

[0079] The flow switching valves 22a to 22d and the flow switching valves 23a to 23d may each be a device that can switch passages, such as a device that can switch a three-way passage, like a three-way valve, or a combination of two devices, like two on-off valves, which can open and close a two-way passage. Alternatively, the flow switching valves 22a to 22d and the flow switching valves 23a to 23d may each be a device that can change the flow rate in a three-way passage, such as a stepping-motor-driven mixing valve, or a combination of two devices, such as electronic expansion valves, which can change the flow rate in a two-way passage. In this case, the occurrence of water hammer caused by sudden opening or closing of a passage can also be prevented.

Configuration of Controllers

[0080] Fig. 2 is a schematic diagram illustrating the configuration of a relay-unit controller and an indoor-unit controller according to Embodiment 1 of the present invention.

[0081] As shown in Fig. 2, the relay-unit controller 63b includes a control unit 300 within a microcomputer 300a, an output circuit 301, an input circuit 302, an input circuit 303, and an input circuit 304. Each of the indoor-unit controllers 62 (the indoor-unit controllers 62a to 62d) includes a control unit 200, an input circuit 201, an output circuit 202, and an output circuit 203.

[0082] The relay-unit controller 63b and each indoor-unit controller 62 are connected by three transmission lines 71. A transmission line 71 a connects the output circuit 301 of the relay-unit controller 63b to the input circuit 201 of the indoor-unit controller 62. A transmission line 71 b connects the input circuit 302 of the relay-unit controller 63b to the output circuit 202 of the indoor-unit controller 62. A transmission line 71 c connects the input circuit 303 of the relay-unit controller 63b to the output circuit 203 of the indoor-unit controller 62.

[0083] Although only one indoor-unit controller 62 is shown in Fig. 2, the indoor-unit controllers 62a of the indoor units have the same configuration and are each connected to the relay-unit controller 63b by three transmission lines 71. Furthermore, the number of output circuits 301, input circuits 302, and input circuits 303 provided in the relay-unit controller 63b correspond to the number of indoor-unit controllers 62 connected thereto.

[0084] The output circuit 301 of the relay-unit controller 63b transmits a binary signal corresponding to an operation command and a stop command via the transmission line 71 a in accordance with output processing from the control unit 300. The binary signal is, for example, an on/off signal that sets the operation command to a predetermined voltage value and the stop command to an output value of zero. The input circuit 201 of each indoor-unit controller 62 receives the binary signal via the transmission line 71 a and inputs the binary signal to the control unit 200. The control unit 200 starts or stops the operation of the indoor unit 2 on the basis of the input binary signal. The expression "start the operation of the indoor unit 2" refers to, for example, a state (thermostat-on state) in which a fan and the like within the indoor unit 2 are driven so as to facilitate heat exchange between the heat medium and indoor air (thermal load) by the use-side heat exchanger 26. The expression "stop the operation" refers to, for example, a state (thermostat-off state) in which the driving of the fan and the like within the indoor unit 2 is stopped so as not to facilitate heat exchange between the heat medium and indoor air (thermal load) by the use-side heat exchanger 26.

[0085] The output circuit 202 of the indoor-unit controller 62 transmits a binary signal corresponding to an operating

state and a stopped state of the indoor unit via the transmission line 71 b in accordance with output processing from the control unit 200. This binary signal is, for example, an on/off signal that sets the operating state to a predetermined voltage value and the stopped state to an output value of zero. The input circuit 302 of the relay-unit controller 63b receives the binary signal via the transmission line 71 b and inputs the binary signal to the control unit 300. The control unit 300 determines whether the indoor unit 2 is in the operating state or the stopped state on the basis of the input binary signal.

[0086] The output circuit 203 of the indoor-unit controller 62 transmits a binary signal corresponding to a heating mode and a cooling mode of the indoor unit via the transmission line 71 c in accordance with output processing from the control unit 200. This binary signal is, for example, an on/off signal that sets the heating mode to a predetermined voltage value and the cooling mode to an output value of zero. The input circuit 303 of the relay-unit controller 63b receives the binary signal via the transmission line 71 c and inputs the binary signal to the control unit 300. The control unit 300 determines whether the indoor unit 2 is operating in the heating mode or the cooling mode on the basis of the input binary signal.

[0087] The input circuit 304 of the relay-unit controller 63b inputs detection values of the third temperature sensors 33a to 33d and the fourth temperature sensors 34a to 34d provided in the relay unit 3 to the control unit 300. The control unit 300 performs a process of automatic determination of connected branch ports on the basis of input temperature data.

[0088] The control unit 300 may be achieved by software executed on the microcomputer 300a but not limited to this. The control unit 300 may be achieved with hardware, such as a circuit device that achieves the function of the control unit 300.

[0089] In each indoor-unit controller 62, the control unit 200 may similarly be achieved by software executed on a microcomputer. Alternatively, a relay circuit or the like may be used in place of a microcomputer.

[0090] With the above configuration, the relay-unit controller 63b and each indoor-unit controller 62 can exchange information by inputting and outputting binary signals (on/off signals).

[0091] Therefore, as compared with the configuration in Fig. 8, which is a related-art technology, the need for performing digital-signal conversion during a transmission process and a reception analysis process during reception can be eliminated, so that a program of the microcomputer 300a in the relay-unit controller 63b is simplified, thereby reducing limitations with respect to connectable devices.

[0092] Furthermore, the input circuits and the output circuits can be achieved at a lower cost, as compared with the configuration in Fig. 8, which is a related-art technology. Moreover, the indoor-unit controllers 62 can also be achieved at a lower cost since microcomputers are not used therein.

[0093] In normal operation performed after the process of automatic determination of connected branch ports, to be described later, the indoor-unit controllers 62 may start or stop the operation of the indoor units 2 in response to commands from remote controllers or the like provided in the indoor units 2.

[0094] In this case, the relay-unit controller 63b sets the operation mode to be executed by the refrigerating and air-conditioning apparatus 100 and switches the passages extending to the use-side heat exchangers 26 by controlling the stop valves 24, the flow switching valves 22, the flow switching valves 23, and the like so that hot water or cold water is supplied from the corresponding branch ports 6 in accordance with the binary signals corresponding to the operating/stopped states and the binary signals corresponding to the heating/cooling modes received from the indoor-unit controllers 62.

[0095] Accordingly, even during the normal operation, the relay-unit controller 63b and the indoor-unit controllers 62 communicate with each other only by input and output of binary signals (on/off signals), so that limitations with respect to the communication of the indoor units 2 that can be connected to the relay unit 3 can be reduced.

[0096] The refrigerating and air-conditioning apparatus 100 having the above configuration performs the process of automatic determination of connected branch ports in which to identify which indoor unit 2 is connected to which branch port 6 during trial operation performed after installation of the apparatus.

[0097] Next, the operation of the process of automatic determination of connected branch ports will be described.

Process of automatic determination of connected branch ports

[0098] Fig. 3 is a flowchart illustrating the flow of the process of automatic determination of connected branch ports of the indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 1 of the present invention.

[0099] The refrigerating and air-conditioning apparatus 100 commences the automatic determination process when, for example, the switch 64 provided in the relay unit 3 is operated.

[0100] In Fig. 3, step 101 to step 113 correspond to a process performed by the relay unit 3.

[0101] In step 102, the relay unit 3 transmits a trial heating only operation command to the heat source device 1 and the process proceeds to step 103.

[0102] In step 103, the heat source device 1 receives the trial heating only operation command from the relay unit 3 and starts operating in the heating only operation mode described above.

[0103] Furthermore, the relay unit 3 starts operating in the heating only operation mode and supplies hot water (heated

heat medium) to all of the branch ports 6a to 6d regardless of the operation modes (heating/cooling) of the indoor units 2. Subsequently, the process proceeds to step 104.

[0104] In step 104, an operation command is transmitted to indoor units 2 to which an operation command is not transmitted yet. Here, no operation command has been transmitted yet, and an operation command is transmitted to the first indoor unit 2a via the transmission line 71 a so that the indoor unit 2a begins to operate. Subsequently, the process proceeds to step 105. Thus, the hot water and indoor air exchange heat with each other in the use-side heat exchanger 26a of the indoor unit 2a, thereby heating the indoor area or the like in which the indoor unit 2a is installed (heating mode).

[0105] In step 105, after waiting for a predetermined time to elapse, the process proceeds to step 106.

[0106] In step 106, current water-temperature data of all of the branch ports 6a to 6d are acquired. In this case, temperatures T33a to T33d of the four third temperature sensors 33a to 33d and temperatures T34a to T34d of the four fourth temperature sensors 34a to 34d are acquired. The process then proceeds to step 107.

[0107] In step 107, the branch-port determination process is performed. In this case, changes in the data of the temperatures T33a to T33d of the four third temperature sensors 33a to 33d and the temperatures T34a to T34d of the four fourth temperature sensors 34a to 34d are checked.

[0108] The temperatures detected by the third temperature sensors 33a to 33d are temperatures (outlet temperatures) of hot water supplied to the use-side heat exchangers 26a to 26d from the branch ports 6a to 6d.

[0109] The temperatures detected by the fourth temperature sensors 34a to 34d are temperatures (inlet temperatures) of hot water returning to the branch ports 6a to 6d from the use-side heat exchangers 26a to 26d.

[0110] If a temperature difference between the inlet temperature and the outlet temperature at each of the branch ports 6a to 6d is defined as ΔT_i ($i = a, b, c, \text{ or } d$), the following expression stands:

$$\text{temperature difference } \Delta T_i = T33i - T34i \quad (i = a, b, c, \text{ or } d)$$

[0111] In the indoor unit 2a operating in the heating mode, because heat is transferred from the hot water at the use-side heat exchanger 26a, the temperature difference ΔT at the branch port 6 connected to the indoor unit 2a is a positive value.

[0112] On the other hand, in the indoor units 2b to 2d that are in a stopped state, because there is little receiving or transferring of heat to the hot water at the use-side heat exchangers 26b to 26d, the temperature difference ΔT at each of the branch ports 6 connected to the indoor units 2b to 2d is a value whose absolute value is small.

[0113] Accordingly, if a certain temperature difference ΔT is a positive value that is larger than a predetermined determination value, the relay unit 3 determines that an indoor unit 2 currently in operation is connected to the branch port 6 at which the aforementioned temperature difference ΔT is detected. On the other hand, if the value of a temperature difference ΔT is a positive value smaller than the predetermined determination value or is a negative value, it is determined that an indoor unit 2 currently in a stopped state or no indoor unit 2 is connected to the branch port 6 at which the aforementioned temperature difference ΔT is detected.

[0114] In this case, because a temperature difference ΔT_a of the indoor unit 2a operating in the heating mode is larger than the predetermined value, the relay unit 3 determines that the indoor unit 2a is connected to the branch port 6a.

[0115] Accordingly, the relay unit 3 can determine which one of the branch ports 6 is connected to an indoor unit 2 currently in operation.

[0116] If none of the temperature differences ΔT is larger than the predetermined value and the relay unit 3 cannot determine a branch port 6 to which an indoor unit 2 currently performing heating is connected after a specific time period, the relay unit 3 determines there is a setting error.

[0117] Subsequently, the relay unit 3 proceeds to step 108.

[0118] In step 108, the relay unit 3 transmits a stop command to the indoor unit 2a in operation via the transmission line 71 a so as to stop the operation of the indoor unit 2a. Subsequently, the process proceeds to step 109.

[0119] In step 109, it is determined whether there are indoor units 2 to which an operation command has not been transmitted yet. If yes, the process proceeds to step 104. If no, the process proceeds to step 110.

[0120] In this case, since an operation command has not been transmitted to the indoor units 2b to 2d yet, the process proceeds to step 104, and the same process is repeated.

[0121] Accordingly, the relay unit 3 makes all of the connected indoor units 2 operate on a one-by-one basis and performs the connected-branch-port determination process for identifying which indoor unit 2 is connected to each branch port 6 on the basis of the temperature difference ΔT at that time.

[0122] When the determination process is completed for all of the indoor units 2, the relay unit 3 proceeds to step 110.

[0123] In step 110, the relay unit 3 stops the heating only operation mode and proceeds to step 111.

[0124] In step 111, a stop command is transmitted to the heat source device 1, and the process proceeds to step 112.

[0125] In step 112, if a setting error is detected during the determination process in step 107, the process proceeds to step 113. If a setting error is not detected, the process ends.

[0126] In this case, the term "setting error" refers to a case where, for example, a connector that connects a wire extending from a temperature sensor to a substrate is not connected or is improperly connected, a connector that connects a wire extending from an actuator, such as a flow control valve, to a substrate is not connected or is improperly connected, or a normal temperature change cannot be detected during a failure in an input-output circuit.

[0127] In step 113, an abnormal-state notification process is performed by, for example, displaying an abnormal state on display means provided in a remote controller or the like or turning on an error lamp provided in the heat source device 1. Subsequently, the process ends.

[0128] Although the process of automatic determination of connected branch ports shown in Fig. 3 is performed in the heating only operation mode, the process can be performed similarly in the cooling only operation mode. For example, hot water may be supplied to an indoor unit 2 and may exchange heat with the cooling load in the heating only operation mode during wintertime, and cold water may be supplied to an indoor unit 2 and may exchange heat with the heating load in the cooling only operation mode during summertime. By identifying each branch port based on the temperature difference ΔT , the process of automatic determination of connected branch ports can be performed year-round.

[0129] Accordingly, in Embodiment 1, the indoor units 2 are made to operate on a one-by-one basis, and it is identified which indoor unit 2 is connected to each branch port 6 on the basis of the temperature difference ΔT between the inlet temperature and the outlet temperature of the branch port 6 at that time.

[0130] Therefore, it is not necessary to set connected branch ports by using setting means, such as a DIP switch, in the indoor units 2 or the relay unit 3, so that the need for such setting means is eliminated, whereby the component cost can be reduced. In addition, the troublesome task involved in the setting process is not necessary, thereby achieving enhanced user-friendliness.

[0131] Because the process of automatic determination of connected branch ports is performed based on the detection values of the third temperature sensors 33a to 33d and the fourth temperature sensors 34a to 34d provided in the relay unit 3, it is not necessary to transmit temperature data between the relay unit 3 and the indoor units 2. Therefore, limitations with respect to the communication of the indoor units 2 that can be connected to the relay unit 3 can be reduced.

[0132] Furthermore, the interface between the relay unit 3 and each indoor unit 2 can be controlled based on simple transmission of information, which only includes the operation/stop commands, the operating/stopped states, and the heating/cooling modes.

[0133] Thus, the interface between the relay unit 3 and each indoor unit 2 can be achieved by inexpensive transmission means.

[0134] Moreover, other manufacturers' products, such as fan coil units, can be readily connected.

[0135] With regard to the communication between the relay-unit controller 63b and each indoor-unit controller 62, information can be exchanged therebetween by input and output of binary signals (on/off signals). Therefore, as compared with the configuration of the related art shown in Fig. 8, the need for performing digital-signal conversion during a transmission process and a reception analysis process during reception can be eliminated. Consequently, the program of the microcomputer 300a in the relay-unit controller 63b is simplified, thereby reducing limitations with respect to connectable indoor units 2. Furthermore, the input-output circuits 302 and 303 can be achieved with a simple configuration at a lower cost. Moreover, the indoor-unit controllers 62 can also be achieved at a lower cost since microcomputers are not used therein.

[0136] Because a setting error can be detected during the automatic determination process, a determination error can be prevented in advance. Moreover, improper connections, connection leak, and defects in the connectors on the substrates in the relay-unit controller 63b and the indoor-unit controllers 62 can be detected at an early stage.

Embodiment 2

[0137] In Embodiment 2 described below, the time required for the process of automatic determination of connected branch ports of the indoor units 2 is shortened.

[0138] The process of automatic determination of connected branch ports is desirably performed within a shorter period of time.

[0139] In Embodiment 2, a refrigerating and air-conditioning apparatus is obtained that can shorten the time required for the automatic determination process, as compared with the case where the determination process is performed by making the indoor units 2 operate on a one-by-one basis.

[0140] Fig. 4 is a schematic circuit diagram illustrating the configuration of the refrigerating and air-conditioning apparatus according to Embodiment 2 of the present invention.

[0141] The following description mainly relates to points different from Embodiment 1. Components that are the same as those in Embodiment 1 are given the same reference numerals.

[0142] As shown in Fig. 4, the indoor units 2 in Embodiment 2 are each provided with a ninth temperature sensor 39

and a tenth temperature sensor 40.

[0143] The four ninth temperature sensors 39 (ninth temperature sensors 39a to 39d) are provided at the inlet side of the heat-medium passages of the use-side heat exchangers 26, are configured to detect the temperature of the heat medium flowing into the use-side heat exchangers 26, and may be formed of thermistors or the like. The number of ninth temperature sensors 39 provided corresponds to the number of (four, in this case) indoor units 2 installed.

[0144] In line with the indoor units 2, the ninth temperature sensor 39a, the ninth temperature sensor 39b, the ninth temperature sensor 39c, and the ninth temperature sensor 39d are shown in that order from the lower side of the drawing.

[0145] The four tenth temperature sensors 40 (tenth temperature sensors 40a to 40d) are provided at the outlet side of the heat-medium passages of the use-side heat exchangers 26, are configured to detect the temperature of the heat medium flowing out of the use-side heat exchangers 26, and may be formed of thermistors or the like. The number of tenth temperature sensors 40 provided corresponds to the number of (four, in this case) indoor units 2 installed. In line with the indoor units 2, the tenth temperature sensor 40a, the tenth temperature sensor 40b, the tenth temperature sensor 40c, and the tenth temperature sensor 40d are shown in that order from the lower side of the drawing.

[0146] The number of connected heat source devices 1, indoor units 2, and relay units 3 is not limited to that shown in the drawing.

[0147] Detection values of the ninth temperature sensors 39 and the tenth temperature sensors 40 in the indoor units 2 are transmitted to the relay-unit controller 63b from the indoor-unit controllers 62 via the transmission lines 71. For example, temperature data is converted into a transmittable digital signal by signal processing performed by a micro-computer provided in each indoor-unit controller 62, and the digital signal is converted into a signal waveform by a transmission circuit before being transmitted via the corresponding transmission line 71.

[0148] The refrigerating and air-conditioning apparatus 100 having the above configuration performs the process of automatic determination of connected branch ports so as to identify which indoor unit 2 is connected to which branch port 6 during trial operation performed after installation of the apparatus.

[0149] Next, the operation of the process of automatic determination of connected branch ports in Embodiment 2 will be described.

Process of Automatic Determination of Connected Branch Ports

[0150] Fig. 5 is a flowchart illustrating the flow of the process of automatic determination of connected branch ports of the indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 2 of the present invention.

[0151] The refrigerating and air-conditioning apparatus 100 commences the automatic determination process when, for example, the switch 64 provided in the relay unit 3 is operated.

[0152] In Fig. 5, step 201 to step 217 correspond to a process performed by the relay unit 3.

[0153] In step 202, the relay unit 3 transmits a trial heating main operation command to the heat source device 1 and proceeds to step 203.

[0154] In step 203, the heat source device 1 receives the trial heating main operation command from the relay unit 3 and starts operating in the heating main operation mode described above.

[0155] Furthermore, the relay unit 3 starts operating in the heating main operation mode. In this case, all of the stop valves 24a to 24d are closed. Subsequently, the process proceeds to step 204.

[0156] In step 204, an operation command is transmitted to all of the indoor units 2a to 2d so that all of the indoor units 2 begin to operate. Subsequently, the process proceeds to step 205.

[0157] In step 205, hot water is supplied to the next branch port 6. In this case, the stop valve 24a corresponding to the branch port 6a is opened so as to switch the flow switching valve 22a and the flow switching valve 23a to the passage connected to the intermediate heat exchanger 15a for heating. Thus, hot water is supplied from the branch port 6a. Subsequently, the process proceeds to step 206.

[0158] In step 206, it is determined whether there are branch ports 6 that are not supplied with hot water or cold water yet. If yes, the process proceeds to step 207. If no, the process proceeds to step 208. In this case, since the branch ports 6b to 6d are not supplied with hot water or cold water yet, the process proceeds to step 207.

[0159] In step 207, cold water is supplied to the next branch port 6. In this case, the stop valve 24b corresponding to the branch port 6b is opened so as to switch the flow switching valve 22b and the flow switching valve 23b to the passage connected to the intermediate heat exchanger 15b for cooling. Thus, cold water is supplied from the branch port 6b. Subsequently, the process proceeds to step 208.

[0160] In step 208, after waiting for a predetermined time to elapse, the process proceeds to step 209.

[0161] In step 209, current water-temperature data of all of the indoor units 2a to 2d are acquired. In this case, temperatures T39a to T39d of the four ninth temperature sensors 39a to 39d are acquired. Subsequently, the process proceeds to step 210.

[0162] In step 210, the branch-port determination process is performed. In this case, changes in the data of the temperatures T39a to T39d of the four ninth temperature sensors 39a to 39d are checked.

[0163] In the indoor unit 2a connected to the branch port 6a supplying hot water thereto, the temperature T39a of the ninth temperature sensor 39a is substantially equal to the temperature of the hot water. In the indoor unit 2b connected to the branch port 6b supplying cold water thereto, the temperature T39b of the ninth temperature sensor 39b is substantially equal to the temperature of the cold water.

[0164] Accordingly, if a certain temperature T39 is a value close to the temperature of the hot water, the relay unit 3 determines that the branch port 6a is connected to the indoor unit 2 at which the aforementioned temperature T39 is detected. For example, the temperature of the hot water is detected by the first temperature sensor 31 a. The determination of whether or not a certain temperature T39 is a value close to the temperature of the hot water is performed by determining whether or not a temperature difference between the temperature of the hot water and the temperature T39 is within a predetermined temperature range.

[0165] If a certain temperature T39 is a value close to the temperature of the cold water, the relay unit 3 determines that the branch port 6b is connected to the indoor unit 2 at which the aforementioned temperature T39 is detected. For example, the temperature of the cold water is detected by the first temperature sensor 31 b. The determination of whether or not a certain temperature T39 is a value close to the temperature of the cold water is performed by determining whether or not a temperature difference between the temperature of the cold water and the temperature T39 is within a predetermined temperature range.

[0166] If neither of the above, the relay unit 3 determines that the indoor unit 2 at which the aforementioned temperature T39 is detected is connected to one of the remaining branch ports 6c and 6d or is not connected to any of the branch ports 6.

[0167] Accordingly, the relay unit 3 can determine the indoor units 2 connected to the branch port 6a supplying hot water and the branch port 6b supplying cold water.

[0168] If, after a specific time period of operation, the relay unit 3 cannot determine the indoor units 2 connected to the branch port 6 supplying hot water and the branch port 6 supplying cold water or cannot determine neither of the indoor units 2, the relay unit 3 determines a setting error.

[0169] Subsequently, the relay unit 3 proceeds to step 211.

[0170] In step 211, the water supply to the branch ports supplying hot water and cold water is stopped. Subsequently, the process proceeds to step 212.

[0171] In step 212, it is determined whether there are branch ports 6 not supplied with hot water or cold water yet. If yes, the process proceeds to step 205. If no, the process proceeds to step 213.

[0172] In this case, since the branch ports 6c and 6d are not supplied with hot water or cold water yet, the process proceeds to step 205, and the same process is repeated.

[0173] Accordingly, the relay unit 3 performs the determination process for all of the branch ports 6 by determining the indoor units 2 connected to the branch ports 6 simultaneously and on a two-by-two basis.

[0174] When the last one of the branch ports 6 remains, hot water is supplied to that branch port 6, and the determination process for the indoor unit 2 connected to that branch port 6 is performed.

[0175] When the determination process is completed for all of the branch ports 6, the relay unit 3 proceeds to step 213.

[0176] In step 213, the relay unit 3 transmits a stop command to all of the indoor units 2 and proceeds to step 214.

[0177] In step 214, the relay unit 3 stops the heating main operation mode and proceeds to step 215.

[0178] In step 215, a stop command is transmitted to the heat source device 1, and the process proceeds to step 216.

[0179] In step 216, if a setting error is detected during the determination process in step 210, the process proceeds to step 217. If no setting error is detected, the process ends.

[0180] In this case, the term "setting error" refers to a case where, for example, a connector that connects a wire extending from a temperature sensor to a substrate is not connected or is improperly connected, a connector that connects a wire extending from an actuator, such as a flow control valve, to a substrate is not connected or is improperly connected, or where a normal temperature change cannot be detected during a failure in an input-output circuit.

[0181] In step 217, an abnormal-state notification process is performed by, for example, displaying an abnormal state on display means provided in a remote controller or the like or turning on an error lamp provided in the heat source device 1. Subsequently, the process ends.

[0182] Accordingly, in Embodiment 2, hot water and cold water are simultaneously supplied to two branch ports 6 so that two indoor units 2 connected to these branch ports 6 are simultaneously identified on the basis of the temperatures of the heat medium flowing into the corresponding use-side heat exchangers 26.

[0183] Therefore, the time required for the automatic determination process can be shortened, as compared with the case where the branch ports 6 are determined on a one-by-one basis. Moreover, a setting error can be detected during the automatic determination process.

Embodiment 3

[0184] In Embodiment 3 described below, the time required for the process of automatic determination of connected branch ports of the indoor units 2 is shortened.

[0185] The process of automatic determination of connected branch ports is desirably performed within a shorter period of time.

[0186] In Embodiment 3, a refrigerating and air-conditioning apparatus is obtained that can shorten the time required for the automatic determination process, as compared with the case where the determination process is performed by making the indoor units 2 operate on a one-by-one basis.

[0187] Fig. 6 is a schematic circuit diagram illustrating the configuration of the refrigerating and air-conditioning apparatus according to Embodiment 3 of the present invention.

[0188] The following description mainly relates to points different from Embodiment 1. Components that are the same as those in Embodiment 1 are given the same reference numerals.

[0189] As shown in Fig. 6, the indoor units 2 in Embodiment 3 are each provided with an eleventh temperature sensor 41 and a twelfth temperature sensor 42.

[0190] The four eleventh temperature sensors 41 (eleventh temperature sensors 41 a to 41 d) are provided near air inlets of the indoor units 2, are configured to detect the temperature of indoor air, and may be formed of thermistors or the like. The number of eleventh temperature sensors 41 provided corresponds to the number of (four, in this case) indoor units 2 installed. In line with the indoor units 2, the eleventh temperature sensor 41 a, the eleventh temperature sensor 41 b, the eleventh temperature sensor 41 c, and the eleventh temperature sensor 41 d are shown in that order from the lower side of the drawing.

[0191] The four twelfth temperature sensors 42 (twelfth temperature sensors 42a to 42d) are provided near air outlets of the indoor units 2, are configured to detect the temperature of discharged air, and may be formed of thermistors or the like. The number of twelfth temperature sensors 42 provided corresponds to the number of (four, in this case) indoor units 2 installed. In line with the indoor units 2, the twelfth temperature sensor 42a, the twelfth temperature sensor 42b, the twelfth temperature sensor 42c, and the twelfth temperature sensor 42d are shown in that order from the lower side of the drawing.

[0192] The number of connected heat source devices 1, indoor units 2, and relay units 3 is not limited to that shown in the drawing.

[0193] Detection values of the eleventh temperature sensors 41 and the twelfth temperature sensors 42 in the indoor units 2 are transmitted to the relay-unit controller 63b from the indoor-unit controllers 62 via the transmission lines 71. For example, temperature data is converted into a transmittable digital signal by signal processing performed by a microcomputer provided in each indoor-unit controller 62, and the digital signal is converted into a signal waveform by a transmission circuit and transmitted via the corresponding transmission line 71.

[0194] The refrigerating and air-conditioning apparatus 100 having the above configuration performs the process of automatic determination of connected branch ports so as to identify which indoor unit 2 is connected to which branch port 6 during trial operation performed after installation of the apparatus.

[0195] Next, the operation of the process of automatic determination of connected branch ports in Embodiment 3 will be described.

Process of automatic determination of connected branch ports

[0196] Fig. 7 is a flowchart illustrating the flow of the process of automatic determination of connected branch ports of the indoor units in the refrigerating and air-conditioning apparatus according to Embodiment 3 of the present invention.

[0197] The refrigerating and air-conditioning apparatus 100 commences the automatic determination process when, for example, the switch 64 provided in the relay unit 3 is operated.

[0198] In Fig. 7, step 301 to step 315 correspond to a process performed by the relay unit 3.

[0199] In step 302, the relay unit 3 transmits a trial heating main operation command to the heat source device 1 and proceeds to step 303.

[0200] In step 303, when the heat source device 1 receives the trial heating main operation command from the relay unit 3, it starts operating in the heating main operation mode described above.

[0201] Furthermore, the relay unit 3 starts operating in the heating main operation mode. In this case, all of the stop valves 24a to 24d are opened. Subsequently, the process proceeds to step 304.

[0202] In step 304, an operation command is transmitted to all of the indoor units 2a to 2d so that all of the indoor units 2 begin to operate. Subsequently, the process proceeds to step 305.

[0203] In step 305, the amount of hot water to be supplied, the amount of cold water to be supplied, and the flow rates thereof are calculated for the individual branch ports 6.

[0204] First, hot water is supplied to the first half of the branch ports 6, whereas cold water is supplied to the second half of the branch ports 6. In this case, hot water is supplied to the branch ports 6a and 6b, whereas cold water is supplied to the branch ports 6c and 6d.

[0205] If the number of branch ports 6 is an odd number N, hot water is supplied to a first group of branch ports 6 defined by a maximum integer ($2/N$) that does not exceed $2/N$, whereas cold water is supplied to the second remaining

group.

[0206] Then, the flow rates are calculated with L as the number of branch ports 6 in the first half and M as the number of branch ports 6 in the second half.

[0207] The flow rate at an A-th ($A = 1$ to L) branch port 6 in the first half is defined as $A/L \times 100\%$. The flow rate at a B-th ($B = 1$ to M) branch port 6 in the second half is defined as $B/L \times 100\%$.

[0208] In this case, the flow rate at the branch port 6a is 50%, the flow rate at the branch port 6b is 100%, the flow rate at the branch port 6c is 50%, and the flow rate at the branch port 6d is 100%.

[0209] When the calculation is completed, the process proceeds to step 306.

[0210] In step 306, hot water or cold water is supplied to each branch port 6 based on the calculation results obtained in step 305, and the flow rate at each branch port 6 is set.

[0211] In this case, the flow switching valve 22a and the flow switching valve 23a corresponding to the branch port 6a are switched to the passage connected to the intermediate heat exchanger 15a for heating so that hot water is supplied from the branch port 6a. Furthermore, the opening degree of the flow control valve 25a is adjusted so that the flow rate at the branch port 6a is set to 50%.

[0212] Furthermore, the flow switching valve 22b and the flow switching valve 23b corresponding to the branch port 6b are switched to the passage connected to the intermediate heat exchanger 15a for heating so that hot water is supplied from the branch port 6b. Moreover, the opening degree of the flow control valve 25b is adjusted so that the flow rate at the branch port 6b is set to 100%.

[0213] Furthermore, the flow switching valve 22c and the flow switching valve 23c corresponding to the branch port 6c are switched to the passage connected to the intermediate heat exchanger 15b for cooling so that cold water is supplied from the branch port 6b. Moreover, the opening degree of the flow control valve 25c is adjusted so that the flow rate at the branch port 6c is set to 50%.

[0214] Furthermore, the flow switching valve 22d and the flow switching valve 23d corresponding to the branch port 6d are switched to the passage connected to the intermediate heat exchanger 15b for cooling so that cold water is supplied from the branch port 6d. Moreover, the opening degree of the flow control valve 25d is adjusted so that the flow rate at the branch port 6b is set to 100%.

[0215] Subsequently, the process proceeds to step 307.

[0216] In step 307, after waiting for a predetermined time to elapse, the process proceeds to step 308.

[0217] In step 308, current suction temperature data and current discharge temperature data of all of the indoor units 2a to 2d are acquired. In this case, temperatures T41 a to T41 d of the four eleventh temperature sensors 41 a to 41 d and temperatures T42a to T42d of the four twelfth temperature sensors 42a to 42d are acquired. Subsequently, the process proceeds to step 309.

[0218] In step 309, the branch-port determination process is performed. In this case, changes in the data of the temperatures T41a to T41d of the four eleventh temperature sensors 41 a to 41 d and the temperatures T42a to T42d of the four twelfth temperature sensors 42a to 42d are checked.

[0219] If a temperature difference between the discharge temperature and the suction temperature in each of the indoor units 2 is defined as ΔT_i ($i = a, b, c, \text{ or } d$), the following expression stands:

$$\text{temperature difference } \Delta T_i = T_{42i} - T_{41i} \quad (i = a, b, c, \text{ or } d)$$

[0220] In the indoor unit 2a connected to the branch port 6a supplying hot water thereto, the temperature difference ΔT_a is a positive value since heat is transferred from the hot water to air at the use-side heat exchanger 26a of the indoor unit 2a. Likewise, in the indoor unit 2b connected to the branch port 6b supplying hot water thereto, the temperature difference ΔT_b is a positive value. Because the flow rate at the branch port 6a is 50% and the flow rate at the branch port 6b is 100%, the temperature difference ΔT_b is a value larger than the temperature difference ΔT_a .

[0221] In the indoor unit 2c connected to the branch port 6c supplying cold water thereto, the temperature difference ΔT_c is a negative value since the cold water receives heat from air at the use-side heat exchanger 26c of the indoor unit 2c. Likewise, also in the indoor unit 2d connected to the branch port 6d supplying cold water thereto, the temperature difference ΔT_d is a negative value. Because the flow rate at the branch port 6c is 50% and the flow rate at the branch port 6d is 100%, the temperature difference ΔT_d is a negative value whose absolute value is larger than that of the temperature difference ΔT_c .

[0222] Accordingly, if a certain temperature difference ΔT is a positive value that is smaller than a predetermined determination value, the relay unit 3 determines that the indoor unit 2a supplied with hot water at a flow rate of 50% is connected to the branch port 6 at which the aforementioned temperature difference ΔT is detected.

[0223] If a certain temperature difference ΔT is a positive value that is larger than the predetermined determination value, it is determined that the indoor unit 2b supplied with hot water at a flow rate of 100% is connected to the branch

port 6 at which the aforementioned temperature difference ΔT is detected.

[0224] If a certain temperature difference ΔT is a negative value and the absolute value thereof is smaller than the predetermined determination value, it is determined that the indoor unit 2c supplied with cold water at a flow rate of 50% is connected to the branch port 6 at which the aforementioned temperature difference ΔT is detected.

[0225] If a certain temperature difference ΔT is a negative value and the absolute value thereof is larger than the predetermined determination value, it is determined that the indoor unit 2d supplied with cold water at a flow rate of 100% is connected to the branch port 6 at which the aforementioned temperature difference ΔT is detected.

[0226] Accordingly, the relay unit 3 can determine the indoor units connected to the branch ports.

[0227] If there are differences in the sizes (heat exchanger capacities) of the use-side heat exchangers 26a to 26d in the indoor units 2a to 2d or differences in the amount of air from fans provided in the indoor units 2, the values of the temperature differences ΔT_a to ΔT_d are affected by such differences. Therefore, it is necessary to perform a correction process based on such data.

[0228] If the relay unit 3 cannot determine the indoor units 2 connected to all of the branch ports 6 after a specific time period of operation, the relay unit 3 determines there is a setting error.

[0229] Subsequently, the relay unit 3 proceeds to step 310.

[0230] In step 310, the water supply to the branch ports supplying hot water and cold water is stopped. Subsequently, the process proceeds to step 311.

[0231] In step 311, the relay unit 3 transmits a stop command to all of the indoor units 2 and proceeds to step 312.

[0232] In step 312, the relay unit 3 stops the heating main operation mode and proceeds to step 313.

[0233] In step 313, a stop command is transmitted to the heat source device 1, and the process proceeds to step 314.

[0234] In step 314, if a setting error is detected during the determination process in step 309, the process proceeds to step 315. If a setting error is not detected, the process ends.

[0235] In this case, the term "setting error" refers to a case where, for example, a connector that connects a wire extending from a temperature sensor to a substrate is not connected or is improperly connected, a connector that connects a wire extending from an actuator, such as a flow control valve, to a substrate is not connected or is improperly connected, or a normal temperature change cannot be detected during a failure in an input-output circuit.

[0236] In step 315, an abnormal-state notification process is performed by, for example, displaying an abnormal state on display means provided in a remote controller or the like or turning on an error lamp provided in the heat source device 1. Subsequently, the process ends.

[0237] Accordingly, in Embodiment 3, hot water and cold water are simultaneously supplied to the branch ports 6, and the flow rate at each branch port 6 is adjusted, so that a plurality of indoor units 2 connected to the branch ports 6 are simultaneously identified on the basis of the temperature differences between the discharge temperatures and the suction temperatures in the indoor units 2.

[0238] Therefore, the time required for the automatic determination process can be shortened, as compared with the case where the branch ports 6 are determined on a one-by-one basis. Moreover, a setting error can be detected during the automatic determination process.

Reference Signs List

[0239]

1 heat source device 2a indoor unit 2b indoor unit 2c indoor unit 2d indoor unit 3 relay unit 3a first relay unit 3b second relay unit 4 refrigerant pipe 5a refrigerant pipe 5b refrigerant pipe 6a branch port 6b branch port 6c branch port 6d branch port 10 compressor 11 four-way valve 12 heat-source-side heat exchanger 14 gas-liquid separator 15a intermediate heat exchanger 15b intermediate heat exchanger 16a expansion valve 16b expansion valve 16c expansion valve 16d expansion valve 16e expansion valve 17 accumulator 21 a pump 21 b pump 22a flow switching valve 22b flow switching valve 22c flow switching valve 22d flow switching valve 23a flow switching valve 23b flow switching valve 23c flow switching valve 23d flow switching valve 24a stop valve 24b stop valve 24c stop valve 24d stop valve 25a flow control valve 25b flow control valve 25c flow control valve 25d flow control valve 26a use-side heat exchanger 26b use-side heat exchanger 26c use-side heat exchanger 26d use-side heat exchanger 27a bypass pipe 27b bypass pipe 27c bypass pipe 27d bypass pipe 31 a first temperature sensor 31 b first temperature sensor 32a second temperature sensor 32b second temperature sensor 33a third temperature sensor 33b third temperature sensor 33c third temperature sensor 33d third temperature sensor 34a fourth temperature sensor 34b fourth temperature sensor 34c fourth temperature sensor 34d fourth temperature sensor 35 fifth temperature sensor 36 pressure sensor 37 sixth temperature sensor 38 seventh temperature sensor 39a ninth temperature sensor 39b ninth temperature sensor 39c ninth temperature sensor 39d ninth temperature sensor 40a tenth temperature sensor 40b tenth temperature sensor 40c tenth temperature sensor 40d tenth temperature sensor 41 a eleventh temperature sensor 41 b eleventh temperature sensor 41 c eleventh temperature sensor 41 d eleventh temperature sensor 42a

twelfth temperature sensor 42b twelfth temperature sensor 42c twelfth temperature sensor 42d twelfth temperature
 sensor 61 controller 62a indoor-unit controller 62b indoor-unit controller 62c indoor-unit controller 62d indoor-unit
 controller 63a relay-unit controller 63b relay-unit controller 64 switch 71a transmission line 71b transmission line 71
 c transmission line 100 refrigerating and air-conditioning apparatus 200 controller 200 control unit 201 input circuit
 202 output circuit 203 output circuit 300 control unit 300a microcomputer 301 output circuit 302 input-output circuit
 302 input circuit 303 input circuit 304 input circuit

Claims

1. A refrigerating and air-conditioning apparatus comprising:

a refrigeration cycle that makes a refrigerant circulate therethrough by connecting a compressor, a heat-source-
 side heat exchanger, at least one expansion valve, and at least one intermediate heat exchanger; and
 a heat-medium circuit that makes a heat medium circulate therethrough by connecting at least one pump, a
 plurality of use-side heat exchangers, and the intermediate heat exchanger,
 wherein the at least one intermediate heat exchanger and the at least one pump are accommodated in a relay unit,
 wherein the plurality of use-side heat exchangers are accommodated in respective indoor units,
 wherein each indoor unit includes an indoor-unit controller that performs on-off control for operation performed
 by the use-side heat exchanger for exchanging heat between the heat medium and a thermal load,
 wherein the relay unit includes
 a plurality of branch ports that are connected to the plurality of use-side heat exchangers and make the heat
 medium circulate to the use-side heat exchangers,
 outlet temperature sensors that are provided for the respective branch ports and each detect an outlet temper-
 ature of the heat medium flowing out of the branch port to the corresponding use-side heat exchanger,
 inlet temperature sensors that are provided for the respective branch ports and each detect an inlet temperature
 of the heat medium flowing into the branch port from the corresponding use-side heat exchanger, and
 a relay-unit controller that is connected to the indoor-unit controllers by a transmission line and controls operation
 of each indoor-unit by transmitting an operation command or a stop command thereto via the transmission line,
 and
 wherein the relay-unit controller makes the indoor units operate on a one-by-one basis and identifies which of
 the indoor units is connected to each branch port on the basis of a difference between the inlet temperature
 and the outlet temperature at the branch port.

2. The refrigerating and air-conditioning apparatus of claim 1,

wherein, in a state where the heat medium heated or cooled by performing a heating only operation mode, in which
 the heat medium is heated by causing a high-temperature high-pressure refrigerant discharged from the compressor
 to flow to the intermediate heat exchanger, or a cooling only operation mode, in which the heat medium is cooled
 by causing a low-temperature low-pressure refrigerant to flow to the intermediate heat exchanger, circulates to the
 plurality of use-side heat exchangers,
 the relay-unit controller
 makes each indoor unit operate on a one-by-one basis, acquires the inlet temperature and the outlet temperature
 at each branch port, and
 identifies that the operating indoor unit is connected to the branch port at which the difference between the inlet
 temperature and the outlet temperature is larger than a predetermined value.

3. The refrigerating and air-conditioning apparatus of claim 1 or 2,

wherein, in a state where the heat medium heated or cooled by performing a heating only operation mode, in which
 the heat medium is heated by causing a high-temperature high-pressure refrigerant discharged from the compressor
 to flow to the intermediate heat exchanger, or a cooling only operation mode, in which the heat medium is cooled
 by causing a low-temperature low-pressure refrigerant to flow to the intermediate heat exchanger, circulates to the
 plurality of use-side heat exchangers,
 the relay-unit controller
 makes each indoor unit operate on a one-by-one basis, acquires the inlet temperature and the outlet temperature
 at each branch port, and
 determines there is a setting error if at none of the branch ports the difference between the inlet temperature and
 the outlet temperature is larger than a predetermined value.

4. The refrigerating and air-conditioning apparatus of any one of claims 1 to 3,
wherein the relay-unit controller transmits a binary signal corresponding to the operation command and the stop
command via the transmission line, and
wherein each indoor-unit controller performs on-off control for the operation of the indoor unit in accordance with
the binary signal received via the transmission line.
5. The refrigerating and air-conditioning apparatus of any one of claims 1 to 4,
wherein only a binary signal is transmitted via the transmission line.

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FIG. 1

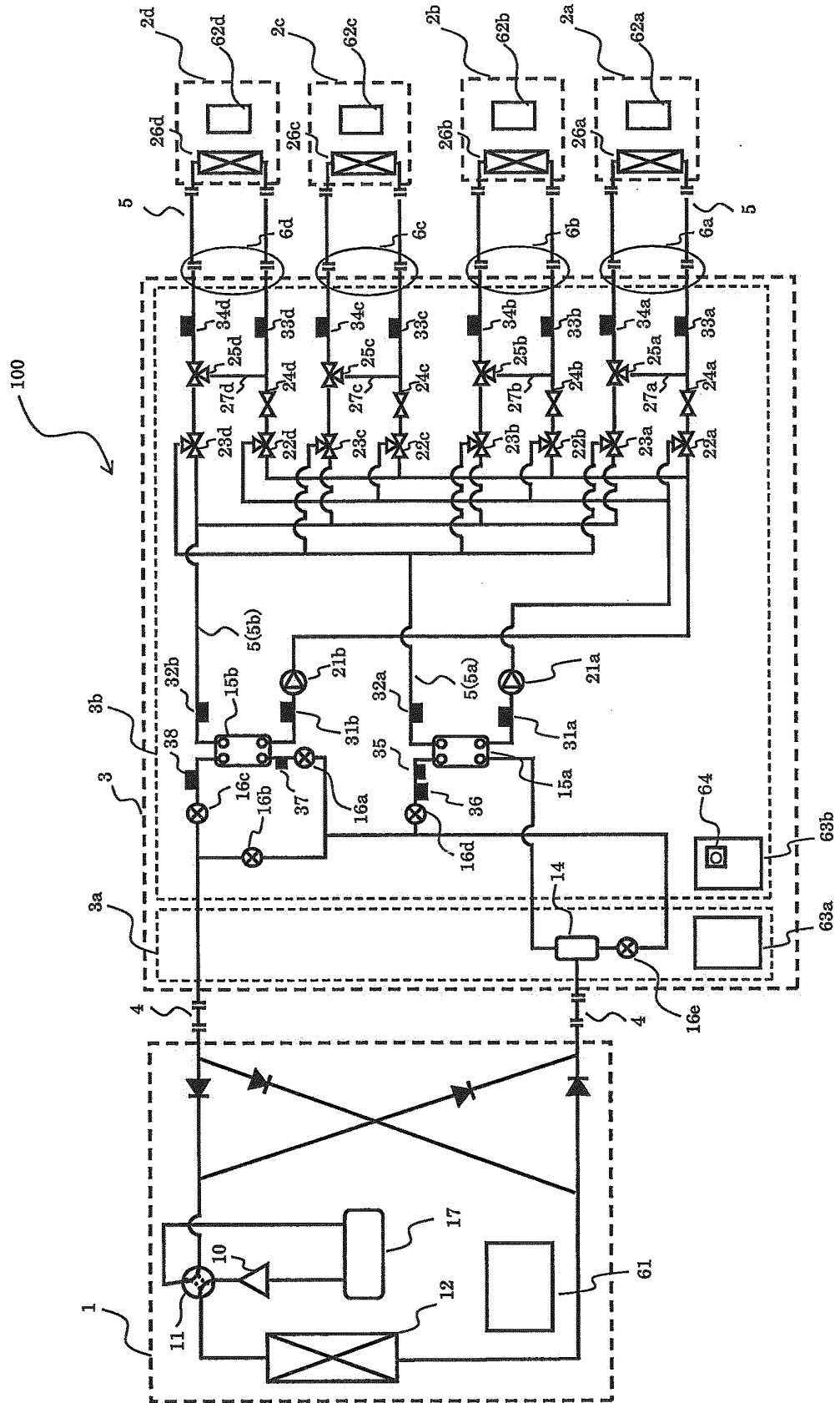


FIG. 2

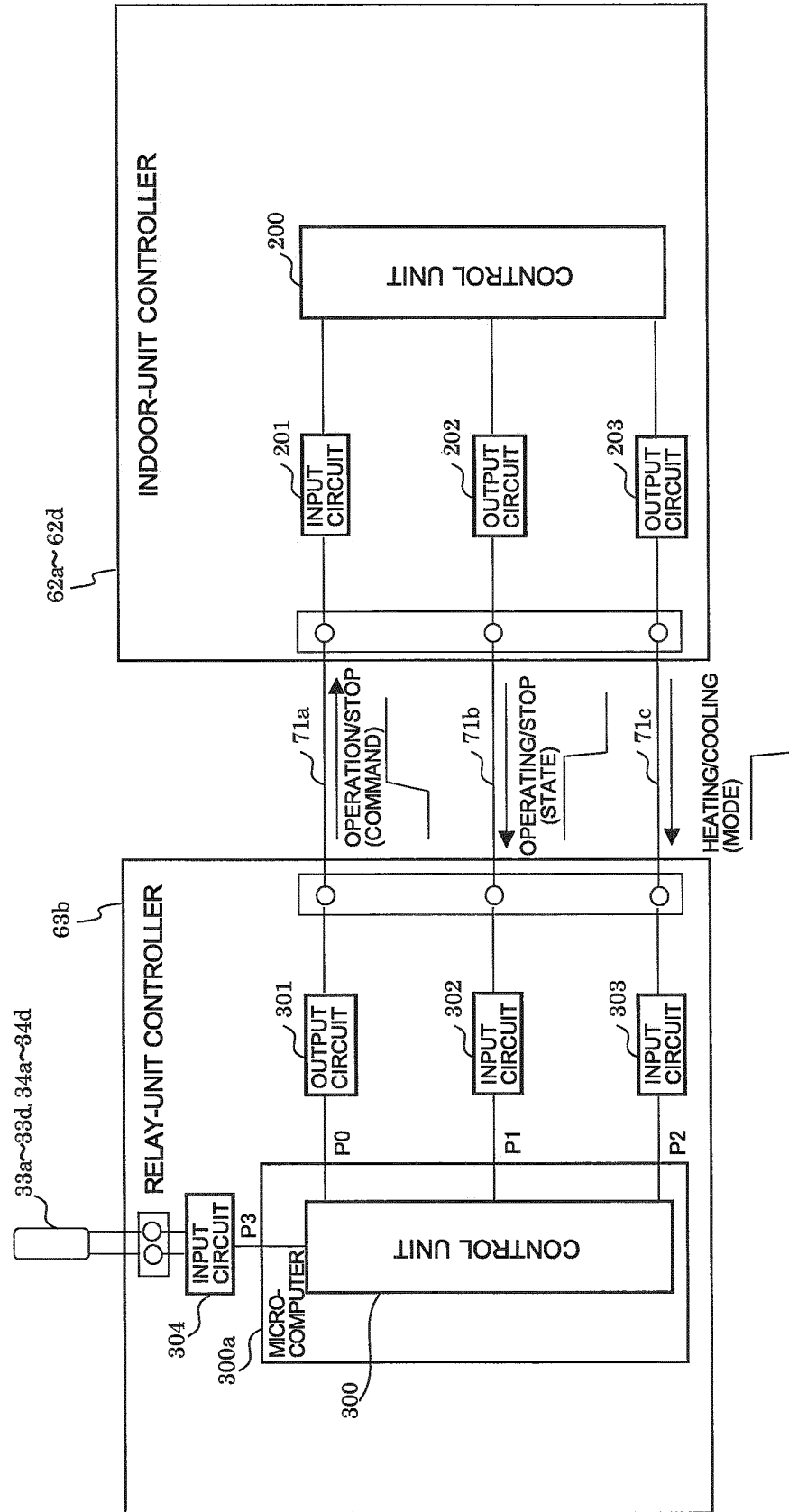


FIG. 3

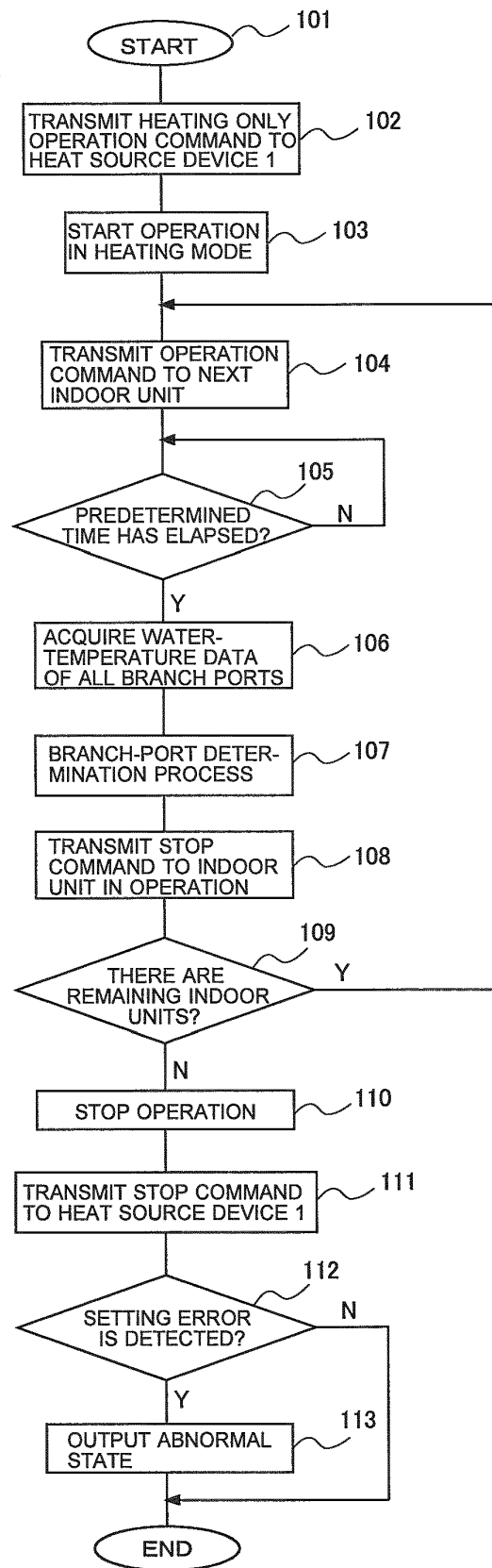


FIG. 4

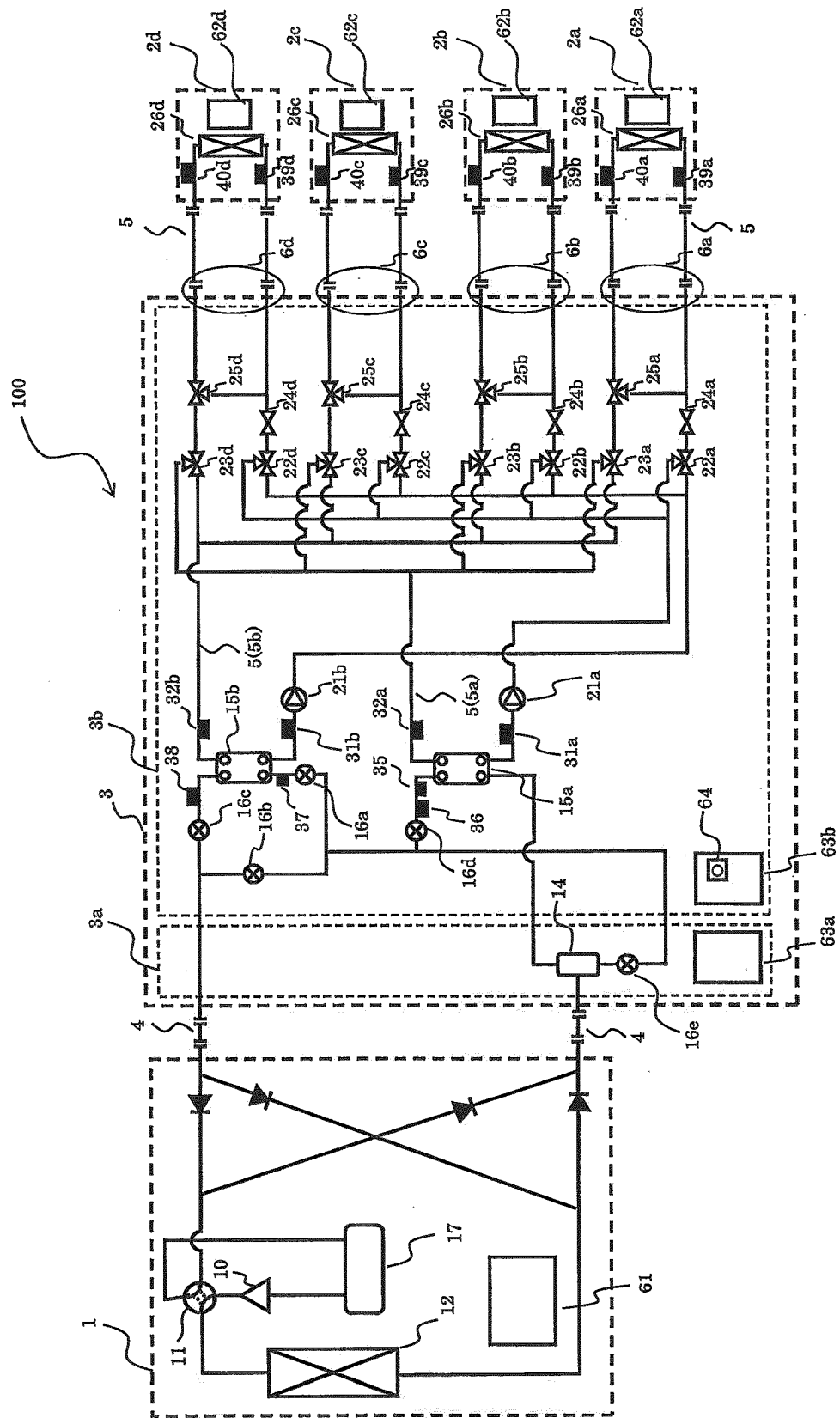


FIG. 5

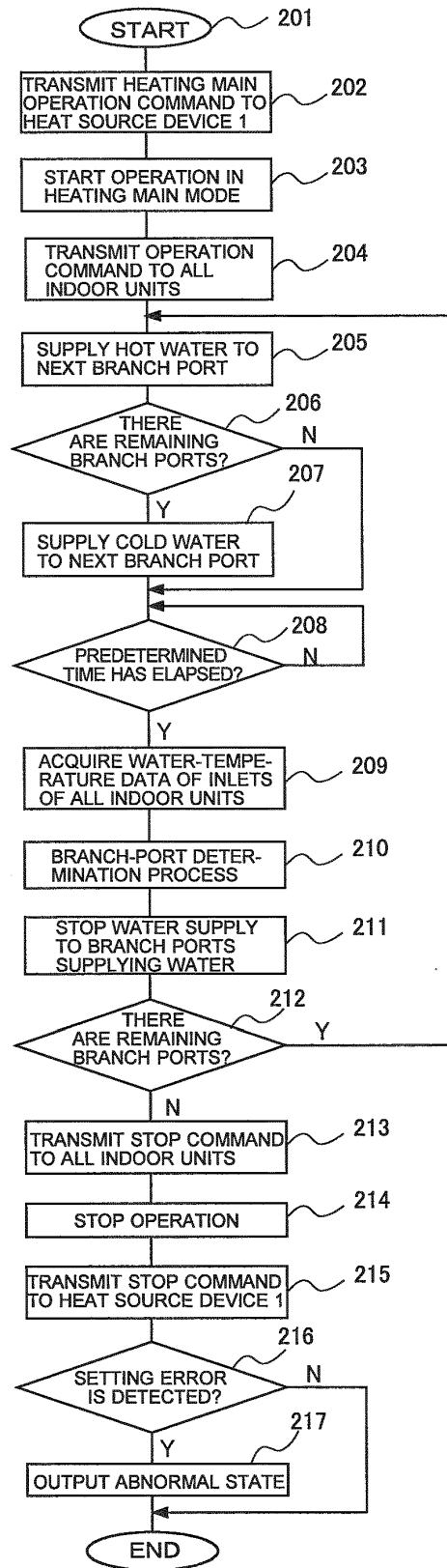


FIG. 6

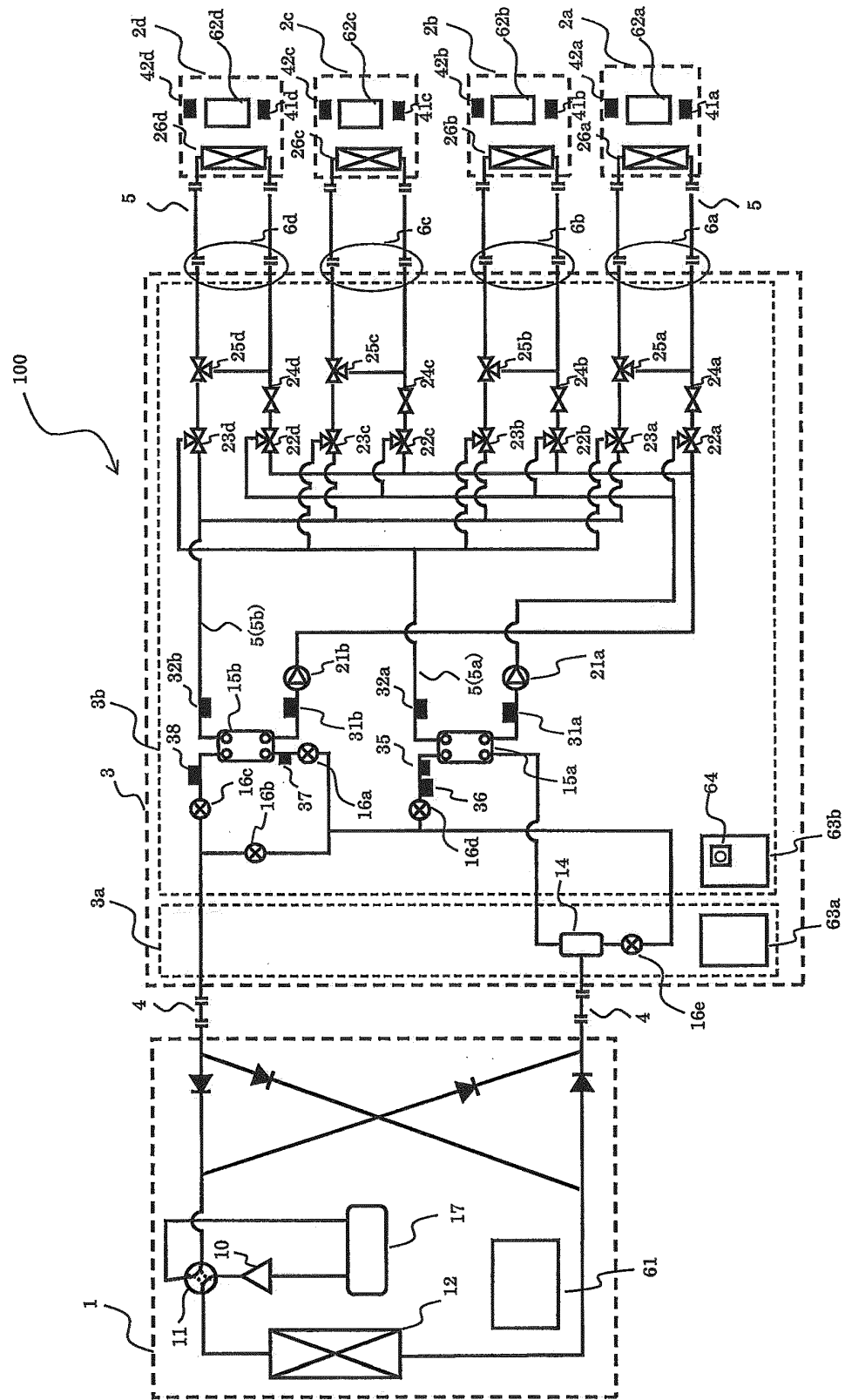


FIG. 7

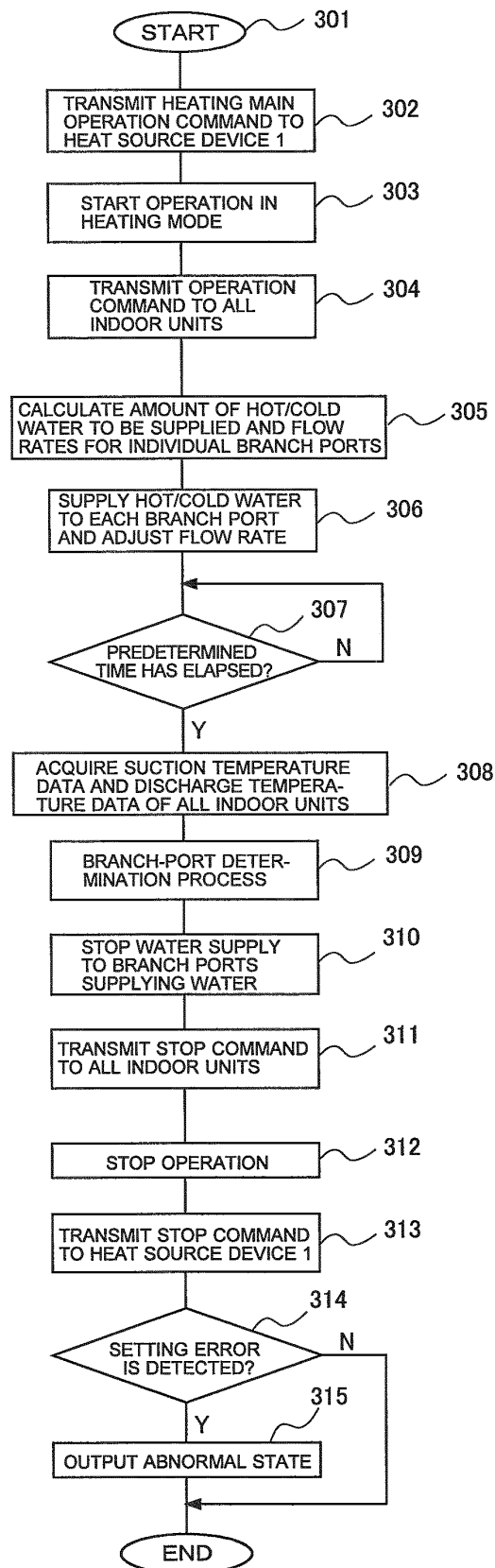


FIG. 8

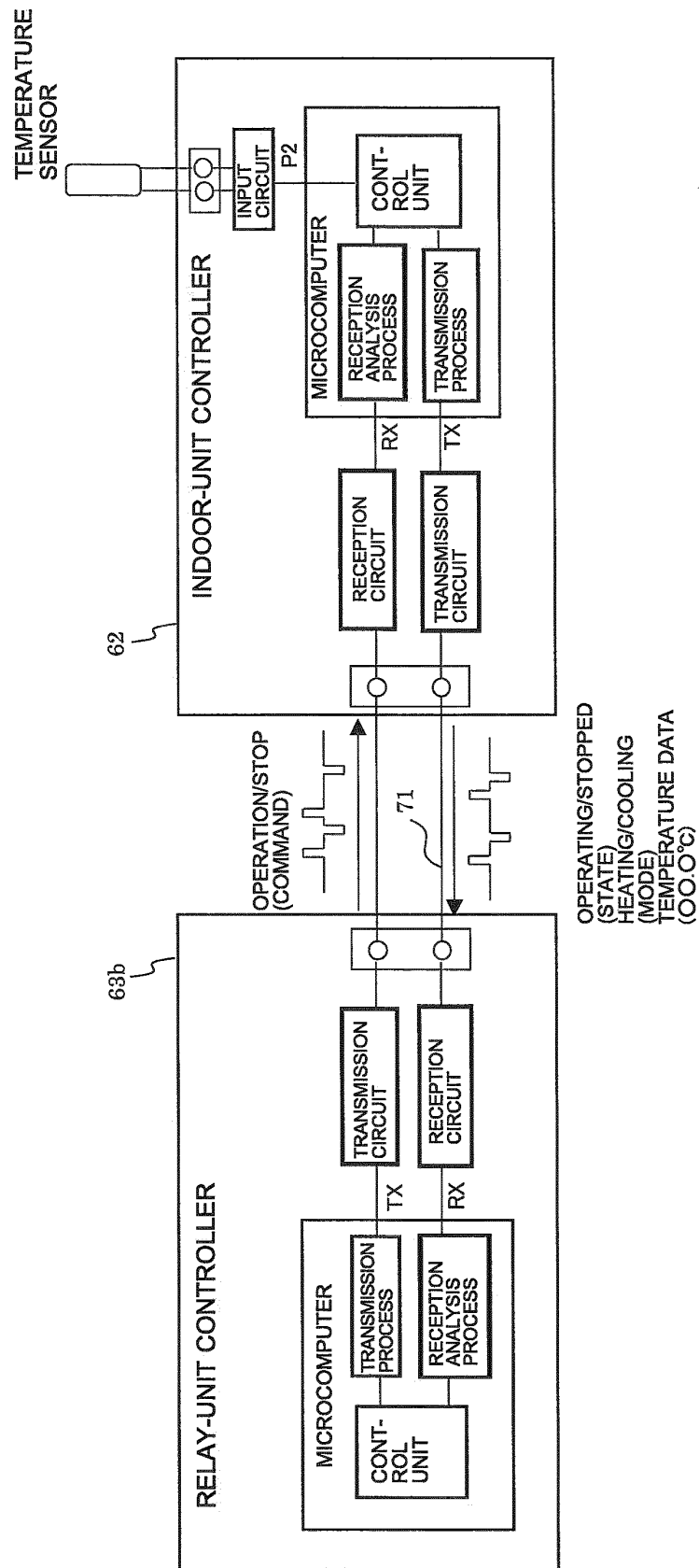
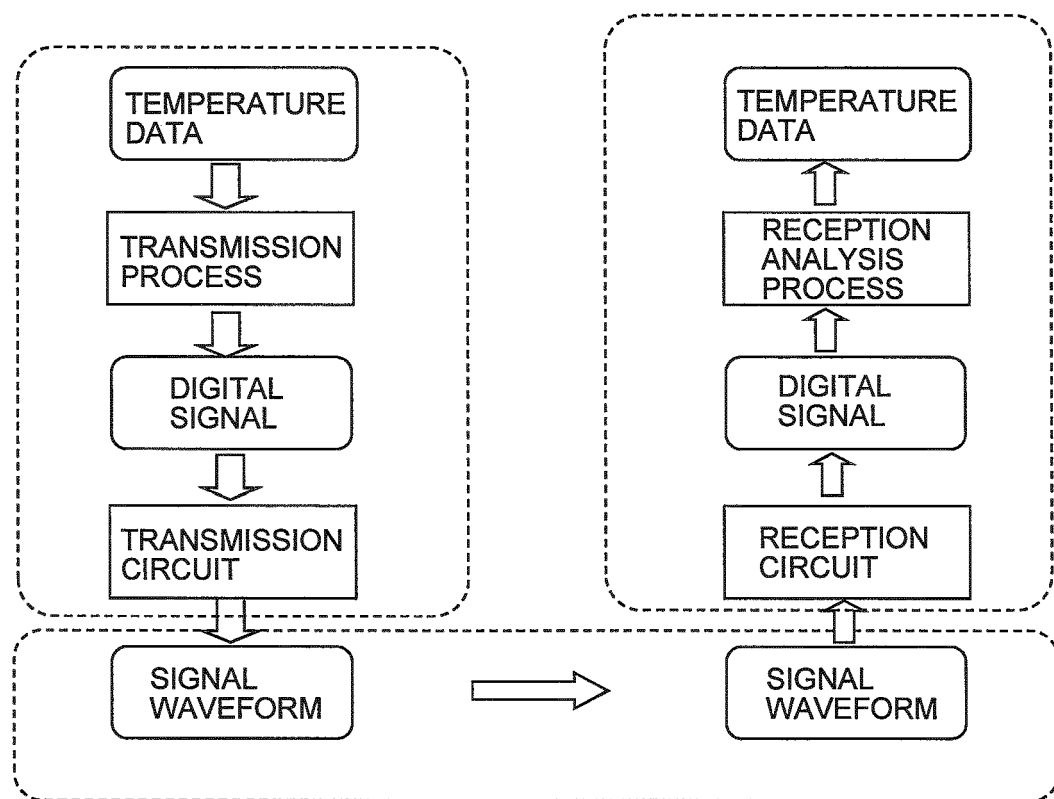


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/001174

A. CLASSIFICATION OF SUBJECT MATTER <i>F24F11/02 (2006.01) i, F24F1/32 (2011.01) i</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, F24F1/32		
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 1996-2011 Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2010/109571 A1 (Mitsubishi Electric Corp.), 30 September 2010 (30.09.2010), entire text; all drawings (Family: none)	1-5
A	JP 9-229458 A (Sanyo Electric Co., Ltd.), 05 September 1997 (05.09.1997), entire text; all drawings (Family: none)	1-5
A	JP 2006-118765 A (Matsushita Electric Industrial Co., Ltd.), 11 May 2006 (11.05.2006), entire text; all drawings (Family: none)	1-5
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 18 April, 2011 (18.04.11)		Date of mailing of the international search report 17 May, 2011 (17.05.11)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/001174

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-90585 A (Fujitsu General Ltd.), 28 March 2003 (28.03.2003), entire text; all drawings (Family: none)	1-5

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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