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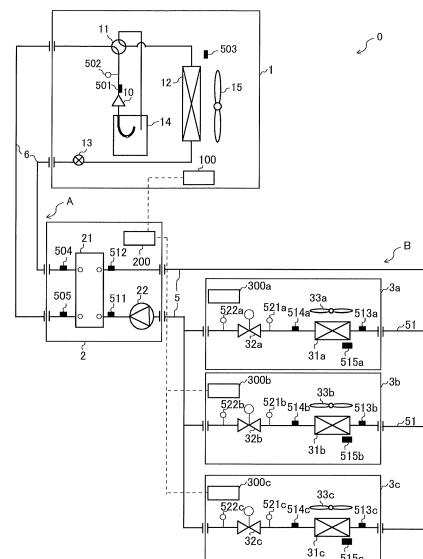
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(54) **AIR CONDITIONING DEVICE**

(57) An air-conditioning apparatus of the present disclosure includes a heat medium circulation circuit and a heat-source-side refrigerant circulation circuit. In the heat medium circulation circuit, a pump configured to pressurize a heat medium that contains water or brine and transfers heat, an indoor heat exchanger configured to exchange heat between an indoor air of an air-conditioned space and the heat medium, and a flow control device installed corresponding to the indoor heat exchanger and configured to control a flow rate of the heat medium passing through the indoor heat exchanger are connected by a pipe to circulate the heat medium therein. In the heat-source-side refrigerant circulation circuit, a compressor configured to compress a heat-source-side refrigerant, a heat-source-side heat exchanger configured to exchange heat between the heat-source-side refrigerant and an outdoor air, an expansion device configured to decompress the heat-source-side refrigerant, and a heat medium heat exchanger configured to exchange heat between the heat-source-side refrigerant and the heat medium are connected by a pipe. A plurality of the indoor heat exchangers are installed in respective indoor units. Each of the indoor units includes a detection device configured to detect a physical quantity related to a heat quantity involved in heat exchange of the indoor heat

exchanger, and is configured to perform communication by a signal containing data on detection of the detection device.

FIG. 2



Description

Technical Field

[0001] The present disclosure relates to an air-conditioning apparatus. The present disclosure relates more particularly to an air-conditioning apparatus that circulates a heat medium, such as water, which is different from a refrigerant, to perform air-conditioning.

Background Art

[0002] An air-conditioning apparatus is known that includes a heat-source-side refrigerant, a refrigerant circulation circuit in which an outdoor unit and a relay unit are connected by pipes to circulate the heat-source-side refrigerant therein, and a heat medium circulation circuit in which the relay unit and an indoor unit are connected by pipes to circulate a heat medium (indoor-side refrigerant) therein (see, for example, Patent Literature 1). In the heat-source-side refrigerant circulation circuit, the outdoor unit and the relay unit are connected by pipes, and, in the heat medium circulation circuit, the relay unit and a plurality of indoor units are connected by pipes. Through heat exchange between the heat-source-side refrigerant and the heat medium at a heat medium heat exchanger provided in the relay unit, the heat medium supplies heating energy or cooling energy to an indoor side, whereby air-conditioning is performed.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2017-101855

Summary of Invention

Technical Problem

[0004] However, in the air-conditioning apparatus of Patent Literature 1, the temperature of the heat medium supplied to an indoor unit is controlled according to an indoor set temperature of the indoor unit. In controlling the temperature of the heat medium, no data on indoor space in which air-conditioning is performed by the indoor unit is used. Consequently, in the air-conditioning apparatus of Patent Literature 1, even when a condition of the indoor space is changed, the temperature of the heat medium supplied to the indoor unit is not changed, and as a result, control suitable to the condition of the indoor space cannot be performed.

[0005] The present disclosure has been made to solve the above problem, and an object thereof is to provide an air-conditioning apparatus capable of saving energy by utilizing data relating to indoor units.

Solution to Problem

[0006] An air-conditioning apparatus of an embodiment of the present disclosure includes a heat medium circulation circuit and a heat-source-side refrigerant circulation circuit. In the heat medium circulation circuit, a pump configured to pressurize a heat medium that contains water or brine and transfers heat, an indoor heat exchanger configured to cause heat exchange to be performed between an indoor air of an air-conditioned space and the heat medium, and a flow control device installed in correspondence with the indoor heat exchanger and configured to control a flow rate of the heat medium passing through the indoor heat exchanger are connected by a pipe to circulate the heat medium therein. In the heat-source-side refrigerant circulation circuit, a compressor configured to compress a heat-source-side refrigerant, a heat-source-side heat exchanger configured to cause heat exchange to be performed between the heat-source-side refrigerant and an outdoor air, an expansion device configured to decompress the heat-source-side refrigerant, and a heat medium heat exchanger configured to exchange heat between the heat-source-side refrigerant and the heat medium are connected by a pipe. A plurality of the indoor heat exchangers are installed in respective indoor units. Each of the indoor units includes a detection device configured to detect a physical quantity related to a heat quantity involved in heat exchange of the indoor heat exchanger, and is configured to perform communication by a signal containing data on detection of the detection device.

Advantageous Effects of Invention

[0007] According to an embodiment of the present disclosure, because each indoor unit is provided with a detection device that detects a heat quantity involved in heat exchange of the indoor heat exchanger, data obtained by detection in the indoor unit can be utilized in operation of the heat-source-side refrigerant circulation circuit. As a result, energy saving can be achieved.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a schematic diagram illustrating an installation example of an air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure.

[Fig. 2] Fig. 2 is a diagram illustrating an example of a configuration of the air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure.

[Fig. 3] Fig. 3 is a diagram illustrating a configuration of a relay unit control device 200 according to Embodiment 1 of the present disclosure.

[Fig. 4] Fig. 4 is a flowchart illustrating a control per-

formed by the relay unit control device 200 according to Embodiment 1 of the present disclosure.

[Fig. 5] Fig. 5 includes graphs illustrating as a whole an example of an operation result of the air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure.

[Fig. 6] Fig. 6 is a diagram illustrating an example of a configuration of an air-conditioning apparatus 0 according to Embodiment 2 of the present disclosure.

[Fig. 7] Fig. 7 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 3 of the present disclosure.

[Fig. 8] Fig. 8 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 4 of the present disclosure.

[Fig. 9] Fig. 9 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 5 of the present disclosure.

Description of Embodiments

[0009] Now, embodiments of an air-conditioning apparatus according to the present disclosure will be described with reference to the drawings. In the drawings referred to below, components that are denoted by the same reference symbols are the same or corresponding components, and this applies to the entire embodiments described below. Moreover, in the drawings, a relationship of sizes of components may be different from that of actual ones. Further, modes of components described in the entire description are mere examples, and the components are not limited to the modes given in the description. In particular, combinations of the components are not limited to the combinations in embodiments, and components described in one embodiment may be applied to another embodiment. In addition, in terms of pressures and temperatures, the states of "high" and "low" are not determined by comparing with any specific absolute values, but are relatively determined based on the conditions or operations in the apparatus. Further, with regard to a plurality of devices of the same type that are distinguished by suffixes, in the case where the devices are not particularly required to be distinguished or specified, the suffixes are omitted in some cases.

Embodiment 1

[0010] Fig. 1 is a schematic diagram illustrating an installation example of an air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure. Based on Fig. 1, an installation example of an air-conditioning apparatus 0 according to Embodiment 1 will be described. The air-conditioning apparatus 0 includes a heat-source-side refrigerant circulation circuit A in which a heat-source-side refrigerant is circulated and a heat medium circulation circuit B in which a heat medium, such as water, which stores and transfers heat is circulated. The air-conditioning apparatus 0 performs air-condition-

ing by performing cooling/heating operation or other operation. The heat-source-side refrigerant circulation circuit A functions as a heat-source-side device that heats or cools the heat medium in the heat medium circulation circuit B.

[0011] In Fig. 1, the air-conditioning apparatus 0 according to Embodiment 1 includes one outdoor unit 1 as a heat source apparatus, a plurality of indoor units 3 (indoor units 3a to 3c) as indoor devices, and a relay unit 2. The relay unit 2 is a unit that intermediates heat transfer between the heat-source-side refrigerant circulating in the heat-source-side refrigerant circulation circuit A and the heat medium circulating in the heat medium circulation circuit B. The outdoor unit 1 and the relay unit 2 are connected by a refrigerant pipe 6 that serves as a flow path of the heat-source-side refrigerant. Here, a plurality of relay units 2 may be connected to one outdoor unit 1 in parallel.

[0012] Each of the indoor units 3 is connected to the relay unit 2 by way of a heat medium main pipe 5 that serves as a flow path of the heat medium. Here, each of the indoor units 3 is connected to the heat medium main pipe 5 via the heat medium branch pipe 51.

[0013] As the heat-source-side refrigerant to be circulated in the heat-source-side refrigerant circulation circuit A, a single refrigerant such as R-22 or R-134a, a pseudo-azeotropic refrigerant mixture such as R-410A or R-404A, or a non-azeotropic refrigerant mixture such as R-407C may be used, for example. In addition, a refrigerant, or a mixture thereof, having a double bond in the chemical formula, such as $\text{CF}_3\text{CF}=\text{CH}_2$, which has a relatively low global warming potential, or a natural refrigerant, such as CO_2 or propane, may be used.

[0014] As the heat medium to be circulated in the heat medium circulation circuit B, brine (antifreeze liquid), water, a mixture of brine and water, or a mixture of water and an additive having a high anticorrosive effect may be used, for example. Thus, in the air-conditioning apparatus 0 of Embodiment 1, a substance having high safety can be used as the heat medium.

[0015] Fig. 2 is a diagram illustrating an example of a configuration of the air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure. Based on Fig. 2, a configuration of devices provided in the air-conditioning apparatus 0 will be described. As described above, the outdoor unit 1 is connected to the relay unit 2 by the refrigerant pipe 6. Also, the indoor units 3 are connected to the relay unit 2 by the heat medium main pipe 5. In Fig. 2, three indoor units 3 are connected to the relay unit 2 via the heat medium main pipe 5. Note that the number of the indoor units 3 to be connected is not limited to three.

<Outdoor Unit 1 >

[0016] The outdoor unit 1 is configured to transfer heat by circulating the heat-source-side refrigerant in the heat-source-side refrigerant circulation circuit A and cause the

heat-source-side refrigerant to exchange heat with the heat medium at a heat medium heat exchanger 21 of the relay unit 2. In Embodiment 1, cooling energy is transferred by the heat-source-side refrigerant. The outdoor unit 1 includes, in the casing, a compressor 10, a heat-source-side heat exchanger 12, an expansion device 13, and an accumulator 14. The compressor 10, a refrigerant flow passage switching device 11, the heat-source-side heat exchanger 12, and the accumulator 14 are connected by the refrigerant pipe 6 and are installed in the outdoor unit 1. The compressor 10 is configured to suck and compress the heat-source-side refrigerant and discharge the refrigerant in a high-temperature, high-pressure state. Here, the compressor 10 may be, for example, an inverter compressor, or a similar device, capable of controlling capacity. The refrigerant flow passage switching device 11 is configured to switch flow paths of the heat-source-side refrigerant depending on whether operation is in a cooling operation mode or a heating operation mode. The refrigerant flow passage switching device 11 is not required to be installed if only a cooling operation or a heating operation is performed.

[0017] The heat-source-side heat exchanger 12 is configured to cause heat exchange to be performed between an outdoor air supplied by a heat-source-side fan 15 and the heat-source-side refrigerant. In a heating operation mode, the heat-source-side heat exchanger 12 functions as an evaporator, and causes the heat-source-side refrigerant to receive heat. In a cooling operation mode, the heat-source-side heat exchanger 12 functions as a condenser or radiator, and causes the heat-source-side refrigerant to reject heat. The expansion device 13 functions as a pressure reducing valve and an expansion valve, and is configured to decompress and expand the heat-source-side refrigerant. Here, the expansion device 13 may be, for example, an electronic expansion valve, or similar other devices, whose opening degree can be variably controlled to arbitrarily adjust the flow rate of the heat-source-side refrigerant. The accumulator 14 is installed on the sucking side of the compressor 10. The accumulator 14 is configured to store excessive refrigerant that is generated when, for example, the amount of refrigerant used in a heating operation and that in a cooling operation is different or when operation changes and is in a transition period. Note that there is a case where the accumulator 14 is not installed in the heat-source-side refrigerant circulation circuit A.

<Indoor Unit 3>

[0018] The indoor units 3 are configured to supply air-conditioned air to indoor spaces. Each indoor unit 3 of Embodiment 1 includes, in the casing, an indoor heat exchanger 31 (indoor heat exchangers 31 a to 31 c), an indoor flow control device 32 (indoor flow control devices 32a to 32c) and an indoor-side fan 33 (indoor-side fans 33a to 33c). The indoor heat exchangers 31 and the indoor flow control devices 32 form part of the heat medium

circulation circuit B.

[0019] The indoor flow control device 32 is, for example, a two-way valve whose opening degree (opening area) can be controlled. By adjusting the opening degree, the indoor flow control device 32 controls the flow rate of the heat medium flowing into and out from the indoor heat exchanger 31. Then, the indoor flow control device 32 adjusts the flow rate of the heat medium to be passed through the indoor heat exchanger 31 based on the temperature of the heat medium flowing into the indoor unit 3 and the temperature of the heat medium flowing out from the indoor unit 3, so that the indoor heat exchanger 31 can cause heat exchange to be performed with an appropriate quantity of heat for a heat load of the indoor space. When the indoor heat exchanger 31 does not need to cause heat exchange to be performed with a heat load, such as when operation is stopped or in a thermos-off state, the indoor flow control device 32 can close the valve completely to stop supply of the heat medium to the indoor heat exchanger 31. In Fig. 2, the indoor flow control device 32 is installed on the pipe on the outlet side to which the indoor heat exchanger 31 discharges the heat medium, but the configuration is not limited thereto. For example, the indoor flow control device 32 may be installed on the inlet side from which the indoor heat exchanger 31 incorporates the heat medium.

[0020] Furthermore, the indoor heat exchanger 31 has, for example, heat-transfer tubes and fins. The heat medium passes through the heat-transfer tubes of the indoor heat exchanger 31. The indoor heat exchanger 31 is configured to cause heat exchange to be performed between air of the indoor space supplied from the indoor-side fan 33 and the heat medium. When the heat medium having a temperature cooler than the air passes through the heat-transfer tubes, the air is cooled, and the indoor space is thus cooled. The indoor-side fan 33 is configured to cause the air of the indoor space to pass through the indoor heat exchanger 31 and generate an air flow that causes the air to return to the indoor space.

<Relay Unit 2>

[0021] Next, a configuration of the relay unit 2 will be described. The relay unit 2 includes devices that are used to transfer heat between the heat-source-side refrigerant circulating in the heat-source-side refrigerant circulation circuit A and the heat medium circulating in the heat medium circulation circuit B. The relay unit 2 includes a heat medium heat exchanger 21 and a pump 22.

[0022] The heat medium heat exchanger 21 is configured to cause heat exchange to be performed between the heat-source-side refrigerant and the heat medium to transfer heat to the heat medium from the heat-source-side refrigerant. The heat medium heat exchanger 21 functions as a condenser or a radiator, and is configured to reject heat to the heat-source-side refrigerant when heating the heat medium. When cooling the heat medium, the heat medium heat exchanger 21 functions as an

evaporator, and is configured to cause the heat-source-side refrigerant to receive heat. The pump 22 is configured to suck the heat medium and apply pressure thereto to cause the heat medium to circulate in the heat medium circulation circuit B. Here, the pump 22 can control capacity, and can thus adjust the flow rate of the heat medium circulating (volume of the heat medium flowing per unit time) in the heat medium circulation circuit B according to the magnitude of a heat load in each indoor unit 3.

[0023] Now, operations of the devices on the heat-source-side refrigerant circulation circuit A side of the air-conditioning apparatus 0 will be described based on the flow of the heat-source-side refrigerant circulating in the heat-source-side refrigerant circulation circuit A. First, a case where the heat medium is cooled will be described. The compressor 10 sucks and compresses the heat-source-side refrigerant, and then discharges the refrigerant in a high-temperature, high-pressure state. The discharged heat-source-side refrigerant flows into the heat-source-side heat exchanger 12 via the refrigerant flow passage switching device 11. The heat-source-side heat exchanger 12 causes heat exchange to be performed between air supplied by the heat-source-side fan 15 and the heat-source-side refrigerant, and condenses and liquefies the heat-source-side refrigerant. The condensed and liquefied heat-source-side refrigerant passes through the expansion device 13. When the condensed and liquefied heat-source-side refrigerant passes through the expansion device 13, the expansion device 13 decompresses the refrigerant. The decompressed heat-source-side refrigerant then flows out from the outdoor unit 1, passes through the refrigerant pipe 6, and flows into the heat medium heat exchanger 21 of the relay unit 2. The heat medium heat exchanger 21 causes heat exchange to be performed between the heat-source-side refrigerant passing therein and the heat medium to evaporate and gasify the heat-source-side refrigerant. At this time, the heat medium is cooled. The heat-source-side refrigerant flowed out of the heat medium heat exchanger 21 flows out from the relay unit 2, passes through the refrigerant pipe 6, and flows into the outdoor unit 1. Then, after passing through the refrigerant flow passage switching device 11 again, the heat-source-side refrigerant, which has been evaporated and gasified, is sucked into the compressor 10.

[0024] Next, a case where the heat medium is heated will be described. The compressor 10 sucks and compresses the heat-source-side refrigerant, and then discharges the refrigerant in a high-temperature, high-pressure state. The discharged heat-source-side refrigerant flows out from the outdoor unit 1 via the refrigerant flow passage switching device 11, passes through the refrigerant pipe 6, and flows into the heat medium heat exchanger 21 of the relay unit 2. The heat medium heat exchanger 21 causes heat exchange to be performed between the heat-source-side refrigerant passing therein and the heat medium to condense and liquefy the heat-source-side refrigerant. At this time, the heat medium is

heated. The condensed and liquefied heat-source-side refrigerant flowed out of the heat medium heat exchanger 21 flows out from the relay unit 2, passes through the refrigerant pipe 6, and passes through the expansion device 13 of the outdoor unit 1. When the condensed and liquefied heat-source-side refrigerant passes through the expansion device 13, the expansion device 13 decompresses the refrigerant. The decompressed heat-source-side refrigerant then flows into the heat-source-side heat exchanger 12. The heat-source-side heat exchanger 12 causes heat exchange to be performed between air supplied by the heat-source-side fan 15 and the heat-source-side refrigerant to evaporate and gasify the heat-source-side refrigerant. Then, after passing through the refrigerant flow passage switching device 11 again, the heat-source-side refrigerant, which has been evaporated and gasified, is sucked into the compressor 10.

[0025] In the air-conditioning apparatus 0, various sensors are provided as detection devices to detect physical quantities. In the heat-source-side refrigerant circulation circuit A, a discharge temperature sensor 501, a discharge pressure sensor 502, and an outdoor temperature sensor 503 are installed on the outdoor unit 1 side. The discharge temperature sensor 501 is configured to detect the temperature of the refrigerant discharged from the compressor 10 and output a discharge temperature detection signal. An outdoor unit control device 100, which will be described later, receives the discharge temperature detection signal output from the discharge temperature sensor 501. Here, the discharge temperature sensor 501 includes a thermistor or other similar devices. Other temperature sensors, which will be described below, are assumed to also include thermistors or other similar devices. The discharge pressure sensor 502 is configured to detect the pressure of the refrigerant discharged from the compressor 10 and output a discharge pressure detection signal. The outdoor unit control device 100, which will be described later, receives the discharge pressure detection signal output from the discharge pressure sensor 502. The outdoor temperature sensor 503 is installed in an air inflow portion of the heat-source-side heat exchanger 12 in the outdoor unit 1. The outdoor temperature sensor 503 is configured to detect, for example, an outdoor temperature, which is the temperature of air around the outdoor unit 1, and output an outdoor temperature detection signal. The outdoor unit control device 100, which will be described later, receives the outdoor temperature detection signal output from the outdoor temperature sensor 503.

[0026] Furthermore, in the heat-source-side refrigerant circulation circuit A, a first refrigerant temperature sensor 504 and a second refrigerant temperature sensor 505 are installed on the relay unit 2 side. The first refrigerant temperature sensor 504 is installed in a pipe on the refrigerant inflow side of the heat medium heat exchanger 21 in the flow of the refrigerant in the heat-source-side refrigerant circulation circuit A generated when the heat medium is cooled. The first refrigerant temperature sen-

sor 504 and the second refrigerant temperature sensor 505 are configured to detect the temperature of the refrigerant flowing into the heat medium heat exchanger 21 and that of the refrigerant flowing out from the heat medium heat exchanger 21, and output refrigerant-side detection signals. A relay unit control device 200, which will be described later, receives the refrigerant-side detection signals output from the first refrigerant temperature sensor 504 and the second refrigerant temperature sensor 505.

[0027] Meanwhile, in the heat medium circulation circuit B, a heat medium inflow port side temperature sensor 511 and a heat medium outflow port side temperature sensor 512 are installed on the relay unit 2 side. The heat medium inflow port side temperature sensor 511 is installed in a pipe on the heat medium inflow side of the heat medium heat exchanger 21 in the flow of the heat medium in the heat medium circulation circuit B. The heat medium inflow port side temperature sensor 511 is configured to detect the temperature of the heat medium flowing into the heat medium heat exchanger 21 and output a heat medium inflow side detection signal. The relay unit control device 200, which will be described later, receives the heat medium inflow-side detection signal output from the heat medium inflow port side temperature sensor 511. The heat medium outflow port side temperature sensor 512 is installed in a pipe on the heat medium outflow side of the heat medium heat exchanger 21 in the flow of the heat medium in the heat medium circulation circuit B. The heat medium outflow port side temperature sensor 512 is configured to detect the temperature of the heat medium flowing out from the heat medium heat exchanger 21 and output a heat medium outflow side detection signal. The relay unit control device 200, which will be described later, receives the heat medium outflow side detection signal output from the heat medium outflow port side temperature sensor 512. Detection sensors, such as a pressure sensor and a flow rate sensor, may be installed on the relay unit 2 side in the heat medium circulation circuit B, although the air-conditioning apparatus 0 of Embodiment 1 is not provided with such detection units.

[0028] In the heat medium circulation circuit B, an indoor inflow port side temperature sensor 513 (indoor inflow port side temperature sensors 513a to 513c) is installed on each indoor unit 3 side. In addition, an indoor outflow port side temperature sensor 514 (indoor outflow port side temperature sensors 514a to 514c) is also installed. The indoor inflow port side temperature sensor 513 is configured to detect the temperature of the heat medium flowing into the indoor heat exchanger 31 and output an inflow side detection signal. An indoor unit control device 300, which will be described later, installed in each indoor unit 3 receives the inflow side detection signal output from the corresponding indoor outflow port side temperature sensor 514. Each indoor outflow port side temperature sensor 514 is configured to detect the temperature of the heat medium flowing out from the in-

door heat exchanger 31 and output an outflow side detection signal. The indoor unit control device 300, which will be described later, receives the inflow side detection signal output from the corresponding indoor outflow port side temperature sensor 514.

[0029] Furthermore, in the heat medium circulation circuit B, an indoor inflow side pressure sensor 521 (indoor inflow side pressure sensors 521a to 521c) is installed on the indoor unit 3 side. In addition, an indoor outflow side pressure sensor 522 (indoor outflow side pressure sensors 522a to 522c) is also installed. The indoor inflow side pressure sensor 521 and the indoor outflow side pressure sensor 522 are installed on the heat medium inflow side and the heat medium outflow side, respectively, of the indoor flow control device 32 in each indoor unit 3, and are configured to output signals corresponding to the detected pressure values. The indoor unit control device 300, which will be described later, provided in each indoor unit 3 receives the signals corresponding to the pressure values output from the indoor inflow side pressure sensor 521 and the indoor outflow side pressure sensor 522.

[0030] Here, when the relay unit 2 is provided with, for example, a pressure sensor that detects the entire pressure of the heat medium circulating in the heat medium circulation circuit B, the indoor inflow side pressure sensor 521 may be omitted. Further, a flow rate detection device that detects flow rate may be installed in place of a pressure sensor. Furthermore, a heat quantity detection device capable of detecting a quantity of heat involved in heat exchange with air of the indoor space, in which a heat load is present, may be installed.

[0031] Each indoor unit control device 300 is configured to obtain, by calculation or other similar operation, a quantity of heat involved in heat exchange at the indoor heat exchanger 31. Each indoor unit control device 300 is configured to send signals containing the obtained heat quantity to the relay unit control device 200.

[0032] In addition, an indoor temperature sensor 515 (indoor temperature sensors 515a to 515c) is installed on each indoor unit 3 side. The indoor temperature sensor 515 is configured to detect a suction temperature, which is the temperature of air that is caused to flow into the indoor heat exchanger 31 by an air flow generated by driving the indoor-side fan 33, and output a suction temperature detection signal. Here, the suction temperature may be the temperature of indoor air in the indoor space, in which a heat load is present.

[0033] Next, a configuration of control system devices in the air-conditioning apparatus 0 of Embodiment 1 of the present disclosure will be described. As shown in Fig. 2, each unit includes a controller that controls devices in the unit. Each controller is configured to perform processing based on data on physical quantities included in the signals sent from various sensors and based on the signals of instructions and settings sent from input devices (not shown) or other similar devices. Here, each of the controllers is connected to other controllers via wired

communication connection or wireless communication connection and is capable of communicating with other control units via signals containing various data. The outdoor unit 1 includes the outdoor unit control device 100. The relay unit 2 includes the relay unit control device 200. Each of the indoor units 3 includes the indoor unit control device 300 (indoor unit control devices 300a to 300c).

[0034] For communication in Embodiment 1, each indoor unit control device 300 can send, to the relay unit control device 200 of the relay unit 2, signals, which contain data on pressure, temperature and other variables detected by the sensors in the corresponding indoor unit 3. In addition, each indoor unit control device 300 can also send, to the relay unit control device 200 of the relay unit 2, data on indoor set temperature input from a remote control (now shown), and data obtained by arithmetic processing as described later, such as a flow rate of the heat medium passing through the corresponding indoor heat exchanger 31 and a heat quantity involved in heat exchange in the indoor heat exchanger 31 with air of the indoor space.

[0035] Now, calculations of the indoor unit control device 300 for a flow rate of the heat medium passing through the indoor heat exchanger 31 and for a heat quantity involved in heat exchange at the indoor heat exchanger 31 with air of the indoor space will be described. By using pressure values detected by the indoor inflow side pressure sensor 521 and the indoor outflow side pressure sensor 522, the indoor unit control device 300 can calculate a pressure difference between the pressure of the heat medium before passing through the indoor flow control device 32 and that after passing through the indoor flow control device 32. The indoor unit control device 300 can also calculate a flow rate of the heat medium passing through the indoor heat exchanger 31 by using, at least, the pressure difference and a Cv value that represents features of the valve of the indoor flow control device 32. Here, the Cv value is a value determined by the type and the port diameter of the valve of a flow control device, and is a capacity coefficient of the valve. The Cv value is a numerical value representing a flow rate of fluid passing through a valve with a certain pressure difference. Furthermore, from temperatures detected by the indoor inflow port side temperature sensor 513 and the indoor outflow port side temperature sensor 514 and the flow rate of the heat medium passing through the indoor heat exchanger 31, a heat quantity involved in heat exchange in the indoor heat exchanger 31 with air of the indoor space can be calculated.

[0036] Calculation of a heat quantity at each indoor unit control device 300 will be described. First, each controller obtains the Cv value based on the opening degree of the valve of the corresponding flow control device. Based on the Cv value and the pressure difference between the pressure of the heat medium before passing through the flow control device and that of after passing through the flow control device, a flow rate of the heat medium passing through the heat exchanger and the flow

control device is calculated. Here, the flow rate of the heat medium increases as the Cv value increases. In addition, the flow rate of the heat medium also increases when the pressure difference of the heat medium is large.

5 Then, based on the flow rate of the heat medium flowing in the corresponding heat exchanger and a temperature difference between the temperature of the heat medium flowing into the heat exchanger and that of the heat medium flowing out from the heat exchanger, a heat quantity supplied to a heat load through heat exchange is calculated. The supplied heat quantity increases as the flow rate of the heat medium passing through the heat exchanger increases. In addition, the supplied heat quantity increases when the temperature difference of the heat medium before and after the heat exchange is large. Then, the controller of each unit compares the calculated heat quantity supplied to the heat load with a required capacity (a heat quantity required for supplying to the heat load), and when the required capacity is larger, the opening degree of the corresponding flow control device is increased. Furthermore, when the total of the calculated heat quantities is less than the total of the required capacities of all the indoor units 3, output of the pump 22 of the relay unit 2 is increased, driving frequency of the compressor 10 of the outdoor unit 1 is increased, or other operations for increasing the heat quantities are performed.

[0037] Fig. 3 is a diagram illustrating a configuration of the relay unit control device 200 according to Embodiment 1 of the present disclosure. As described above, processing associated with controls in Embodiment 1 is performed by the relay unit control device 200. The relay unit control device 200 includes a control processing device 210, a memory device 220, a clocking device 230, and a communication device 240.

[0038] The memory device 220 stores data that the control processing device 210 uses in processing. The memory device 220 includes a volatile memory device (not shown), such as a random access memory (RAM), which can temporarily store data and a non-volatile auxiliary memory device (not shown), such as a flash memory, which can store data for a long time. In addition, the memory device 220 stores programs. The control processing device 210 performs processing based on the programs to achieve processing in each unit of the control processing device 210.

[0039] The clocking device 230 includes a timer and measures a time period that the control processing device 210 uses for calculation or other operation. The communication device 240 is an interface between the control processing device 210 and controllers of other units, and is configured to convert signals containing data when performing communication by the signals therebetween. Hereinafter, communication between the control processing device 210 and controllers of other units is assumed to be performed via the communication device 240.

[0040] The control processing device 210 includes a

temperature gradient setting processing unit 211, a calculation processing unit 212, a determination processing unit 213, and a heat-source-side control processing unit 214. The temperature gradient setting processing unit 211 is configured to generate a target temperature gradient for each indoor unit 3 from data, which are data on a suction temperature at start of operation of the indoor unit 3 and data on an indoor set temperature of the indoor unit 3 sent from the indoor unit control device 300 of the indoor unit 3. Then, one of the generated target temperature gradients is set as a reference (hereinafter referred to as reference temperature gradient). In controlling the heat-source-side refrigerant circulation circuit A, the reference temperature gradient is used to determine the temperature of heat medium involved in heat exchange in the heat medium heat exchanger 21. As described above, the suction temperature is detected by the indoor temperature sensor 515 and is the temperature of air in the indoor space. The calculation processing unit 212 is configured to calculate a temperature difference of suction temperatures in each indoor unit 3 at a predetermined time interval. Based on a condition of air of the indoor space, in which a heat load is present, in each indoor unit 3, the condition of air being obtained from the calculated temperature difference, the determination processing unit 213 determines whether or not the temperature of the heat medium is changed. Then, the heat-source-side control processing unit 214 provides an instruction based on the processing performed by the determination processing unit 213 to a device on the heat-source-side refrigerant circulation circuit A side to control the heat-source-side refrigerant circulation circuit A. More specifically, processing such as control processing is performed by sending a signal of an instruction to change the driving frequency of the compressor 10 or other signal to the outdoor unit control device 100 of the outdoor unit 1. Then, by changing an evaporation temperature or a condensation temperature of the heat-source-side refrigerant in the heat medium heat exchanger 21, the temperature of the heat medium flowing out from the heat medium heat exchanger 21 is changed. Here, the control processing device 210 includes, for example, a microcomputer having a control arithmetic processing device such as a central processing unit (CPU).

[0041] In Embodiment 1, the relay unit control device 200 performs processing based on data sent from the indoor unit control device 300 and sends an instruction to the outdoor unit control device 100 to control the heat-source-side refrigerant circulation circuit A. In this description, processing in Embodiment 1 is performed mainly by the relay unit control device 200, but the processing may be performed by other device. One or a plurality of controllers among the outdoor unit control device 100 and the indoor unit control devices 300 may perform control or other processing. A controller provided outside the units may perform control or other processing. In addition, for example, the processing to be per-

formed by the calculation processing unit 212 may be performed by each of the indoor unit control devices 300, and the processing to be performed by the heat-source-side control processing unit 214 may be performed by the outdoor unit control device 100.

[0042] Next, operation of the air-conditioning apparatus 0 will be described. The outdoor unit 1 causes the heat-source-side refrigerant to circulate between the outdoor unit 1 and the relay unit 2 via the refrigerant pipe 6. At this time, the heat-source-side refrigerant exchanges heat with the heat medium when passing through the heat medium heat exchanger 21 in the relay unit 2, which will be described later. The heat medium is heated or cooled through the heat exchange. In Embodiment 1, the heat-source-side refrigerant is assumed to be heated and the heat medium is assumed to be cooled.

[0043] By using the pump 22, which will be described later, the heat medium cooled in the relay unit 2 is circulated by passing through the heat medium main pipes 5 and the indoor units 3. At this time, the heat medium exchanges heat with air supplied by a fan at the indoor heat exchanger 31 in the indoor unit 3, which will be described later. The air having been subjected to the heat exchange with the heat medium is supplied for air-conditioning in the indoor space.

[0044] Fig. 4 is a flowchart illustrating a control performed by the relay unit control device 200 according to Embodiment 1 of the present disclosure. Based on Fig. 4, the control of the air-conditioning apparatus 0 in Embodiment 1 will be described. Here, the control processing device 210 of the relay unit control device 200 performs control related processing.

[0045] The temperature gradient setting processing unit 211 of the control processing device 210 generates a target temperature gradient as data for each indoor unit 3 based on the data of suction temperature and indoor set temperature sent from the indoor unit control device 300 of the indoor unit 3 (step S1). A method or formula for calculating a target temperature gradient are not particularly limited. For example, a formula for target temperature gradient is represented by $(T_p - T_0)/t_a$ when a suction temperature T_0 at start of operation is brought to an indoor set temperature T_p in a predetermined time period t_a . Here, target temperature gradients for the indoor units 3 are calculated by using the same method or formula so that process does not become complicated. At this time, because a suction temperature and an indoor set temperature may be different for each indoor unit 3, a target temperature gradient may be different for each indoor unit 3. In addition, the time period t_a represents an ideal time period for making the temperature of air in an indoor space reach the set temperature. For example, the time period t_a is such a time period that a person in an indoor space does not feel uncomfortable when the air temperature reaches the set temperature within the time period t_a .

[0046] Among the temperature gradients of the indoor units 3, the temperature gradient with the largest slope

is set as a reference temperature gradient by the temperature gradient setting processing unit 211 (step S2). Therefore, by setting the reference temperature gradient regarding a largest heat load, a sufficient quantity of heat is supplied to cover the heat loads of all the indoor units 3.

[0047] The temperature gradient setting processing unit 211 determines the temperature of the heat medium involved in heat exchange in the heat medium heat exchanger 21 based on the set target temperature gradient (step S3). For example, in a cooling operation, the temperature gradient setting processing unit 211 sets the temperature of the heat medium to decrease as the temperature gradient increases. Thus, a target evaporation temperature for the heat-source-side refrigerant in the heat medium heat exchanger 21 is set to a low temperature. In a heating operation, the temperature gradient setting processing unit 211 sets the temperature of the heat medium so to increase as the temperature gradient increases. Thus, a target condensation temperature for the heat-source-side refrigerant in the heat medium heat exchanger 21 is set to be a high temperature.

[0048] To make the heat medium reach the temperature determined by the temperature gradient setting processing unit 211, the heat-source-side control processing unit 214 provides an instruction to a device on the heat-source-side refrigerant circulation circuit A side to control and operate the heat-source-side refrigerant circulation circuit A (step S4).

[0049] Then, the calculation processing unit 212 of the control processing device 210 determines whether or not a set time period has elapsed (step S5). In Embodiment 1, a temperature difference is calculated with a set time period of one minute, but the set time period is not limited to one minute.

[0050] Furthermore, the calculation processing unit 212 calculates a temperature difference between suction temperatures for each indoor unit 3 at a predetermined time interval (step S6). At this time, a temperature T at a time t is represented by a liner function (1).

$$T = ((T_p - T_0) / t_a) t + T_0 \quad (1)$$

[0051] Then, the determination processing unit 213 determines whether or not to change the temperature of the heat medium involved in heat exchange in the heat medium heat exchanger 21 based on the change in temperature of the indoor air obtained from the temperature difference calculated by the calculation processing unit 212 (step S7).

[0052] When, for example, determining that the temperature difference is out of a temperature difference threshold range, the determination processing unit 213 determines the temperature of the heat medium involved in heat exchange in the heat medium heat exchanger 21 (step S8). Here, in Embodiment 1, an upper limit and a lower limit for the temperature difference threshold range

are set to be plus or minus one degree Celsius. However, the upper and lower limits are not limited to these values. For example, the upper and lower limits of the temperature difference threshold range may be set within a range of plus or minus 0.5 to one degree Celsius.

[0053] Then, to make the temperature of the heat medium reach the temperature determined by the determination processing unit 213, the heat-source-side control processing unit 214 provides an instruction to a device on the heat-source-side refrigerant circulation circuit A side to control and operate the heat-source-side refrigerant circulation circuit A (step S9). Here, the determination processing unit 213 in Embodiment 1 determines to change the temperature of the heat medium by two degrees Celsius. However, the change of the temperature is not limited to two degrees Celsius, and the temperature to be determined may be changed. For example, based on the horsepower of the compressor 10 of the outdoor unit 1, an interval of the temperature of the heat medium to be changed may be determined.

[0054] Meanwhile, when it is determined that the temperature difference is equal to or larger than the temperature difference threshold value, the temperature of the heat medium is not changed (step S10).

[0055] The calculation processing unit 212 and the determination processing unit 213 continue the processing of steps S5 to S10 until it is determined that the temperatures of the air of the indoor spaces of all the indoor units 3 involving in operation reach the indoor set temperatures (step S11).

[0056] Fig. 5 shows graphs illustrating an example of an operation result of the air-conditioning apparatus 0 according to Embodiment 1 of the present disclosure. Fig. 5 illustrates a case where the indoor units 3 of the air-conditioning apparatus 0 perform cooling operation. In Fig. 5, the target temperature gradient of the indoor unit 3a is set as a reference temperature gradient. As illustrated in Fig. 5, when the temperature of the indoor space approaches the set temperature, the temperature of the indoor space is controlled in such a manner that the temperature of the indoor space changes along the target temperature gradient by increasing an evaporation temperature and thus changing the temperature of the heat medium.

[0057] As described above, the target temperature gradient for the largest load is set as a reference temperature gradient, and the temperature of the heat medium supplied to the indoor units 3 is determined based on the gradient. As a result, in the indoor unit 3 having a small heat load, the temperature reaches the set temperature faster than the indoor unit 3 that supplies heat to a largest heat load. In Fig. 5, in the indoor spaces of the indoor units 3b and 3c, in which heat loads are required, the temperatures reach the set temperatures faster than the indoor space of the indoor unit 3a, which is subjected to air-conditioning. Thus, in the indoor units 3 in which the temperatures of the air of the indoor spaces, in which heat load are present, reach the set tempera-

tures, the indoor unit control device 300 controls to close the indoor flow control devices 32. By closing the indoor flow control devices 32, the heat medium is not allowed to pass through the indoor heat exchangers 31, and thus supply of heat is stopped and the temperatures of the air of the indoor spaces are controlled not to decrease below the set temperatures.

[0058] In a related art chiller, indoor conditions are not reflected in control of heat supply to a heat medium, such as water. Thus, heat is supplied while the temperature of the heat medium is maintained at a constant level. According to the air-conditioning apparatus 0 of Embodiment 1, among the indoor units 3, the outdoor unit 1 and the relay unit 2, signals containing data on the detected physical quantities, such as temperatures, flow rates, and heat quantities, can be exchanged. In addition, data indicating indoor conditions of the indoor units 3 can be sent to other units. Thus, in the air-conditioning apparatus 0, based on the conditions of air-conditioning in the indoor units 3 and the conditions of the indoor spaces, control such as change of temperature of the heat medium can be performed in cooperation with devices on the heat-source-side refrigerant circulation circuit A side. Consequently, the air-conditioning apparatus 0 can achieve energy saving.

[0059] For example, target temperature gradients of the indoor units 3 are obtained by using the temperatures of air of the indoor spaces detected by the indoor temperature sensors 515, which are installed in the respective indoor units 3, and the set temperatures set for the respective indoor units 3, and among the target temperature gradients, a reference temperature gradient is set. Based on the set target temperature gradient, the temperature of the heat medium involved in heat exchange in the heat medium heat exchanger 21 is determined and the heat-source-side refrigerant circulation circuit A is operated to obtain the determined temperature. Then, based on the detected changes in the indoor temperatures in the indoor units 3, it is determined whether or not to change the temperature of the heat medium. As described above, by changing the temperature of the heat medium, the temperatures of air of the indoor spaces, in which heat loads are present, are controlled. As a result, power consumption can be reduced, and thus energy saving can be achieved. Here, it is preferred that a target temperature gradient have such a gradient that the temperature of the indoor air is slowly brought to the indoor set temperature. The reason is because a slow temperature adjustment is easy to control and saves energy. In addition, by controlling the heat-source-side refrigerant circulation circuit A based on the temperature changes of indoor air, the temperatures of the indoor spaces and the temperature of the heat medium can be controlled with certain widths.

Embodiment 2

[0060] Fig. 6 is a diagram illustrating an example of a

configuration of an air-conditioning apparatus 0 according to Embodiment 2 of the present disclosure. Now, the air-conditioning apparatus 0 according to Embodiment 2 of the present disclosure will be described. Here, the devices having the same functions and operations as those of Embodiment 1 are denoted by the same reference symbols.

[0061] In Embodiment 2, the outdoor unit 1 and the relay unit 2 are connected by using two refrigerant pipes 6, and the relay unit 2 and each of the indoor units 3a to 3c are connected by using two heat medium branch pipes 51. Because, as described above, two pipes are used to connect between the outdoor unit 1 and the relay unit 2, and between the relay unit 2 and each of the indoor units 3a to 3c, installation of the air-conditioning apparatus 0 can be facilitated.

<Outdoor Unit 1 >

[0062] Similarly to Embodiment 1, the outdoor unit 1 includes the compressor 10, the refrigerant flow passage switching device 11, the heat-source-side heat exchanger 12, the accumulator 14, and the heat-source-side fan 15. The outdoor unit 1 of Embodiment 2 further includes a first connection pipe 16, a second connection pipe 17, and first backflow prevention devices 18a to 18d. Here, as the backflow prevention devices 18a to 18d, check valves are used. The first backflow prevention device 18a is configured to prevent backflow of the refrigerant, which is in a high-temperature, high-pressure gaseous state, from the first connection pipe 16 toward the heat-source-side heat exchanger 12 in a heating-only operation mode and a heating-main operation mode. The first backflow prevention device 18b is configured to prevent backflow of the refrigerant, which is in a high-pressure liquid or gas-liquid two-phase state, from the first connection pipe 16 toward the accumulator 14 in a cooling-only operation mode and a cooling main operation mode. The first backflow prevention device 18c is configured to prevent backflow of the refrigerant, which is in a high-pressure liquid or gas-liquid two-phase state, from the second connection pipe 17 toward the accumulator 14 in a cooling-only operation mode and a cooling main operation mode. The first backflow prevention device 18d is configured to prevent backflow of the refrigerant, which is in a high-temperature, high-pressure gaseous state, from the flow path on the discharge side of the compressor 10 toward the second connection pipe 17 in a heating-only operation mode and a heating-main operation mode.

[0063] As described above, because the first connection pipe 16, the second connection pipe 17 and the first backflow prevention devices 18a to 18d are provided, the flow of the refrigerant into the relay unit 2 is maintained in a constant direction regardless of any operation that the indoor unit 3 requests. Although check valves are used as the first backflow prevention devices 18a to 18d, other device capable of preventing backflow of refrigerant may be used. For example, as the first backflow preven-

tion devices 18a to 18d, opening and closing devices, expansion devices having a complete closing function, or other similar devices may be used.

<Relay Unit 2>

[0064] The relay unit 2 of Embodiment 2 includes two heat medium heat exchangers 21 and two pumps 22, both of which are described in Embodiment 1. In addition, the relay unit 2 includes two relay-side expansion devices 23, two opening and closing devices 24, and two relay-side refrigerant flow passage switching devices 25. The relay unit 2 also includes three first heat medium flow passage switching devices 26, three second heat medium flow passage switching devices 27, and three heat medium flow control devices 28 for each indoor unit 3.

[0065] The two heat medium heat exchangers 21 (a heat medium heat exchanger 21a and a heat medium heat exchanger 21b) of Embodiment 2 are configured to function as condensers (radiators) or evaporators. The heat medium heat exchanger 21a is installed between a relay-side expansion device 23a and a relay-side refrigerant flow passage switching device 25a in the heat-source-side refrigerant circulation circuit A, and serves as a heat exchanger that heats the heat medium in a cooling and heating mixed operation mode. The heat medium heat exchanger 21b is installed between a relay-side expansion device 23b and a relay-side refrigerant flow passage switching device 25b in the heat-source-side refrigerant circulation circuit A, and serves as a heat exchanger that cools the heat medium in a cooling and heating mixed operation mode.

[0066] The two relay-side expansion devices 23 (the relay-side expansion device 23a and the relay-side expansion device 23b) are configured to function as pressure reducing valves and expansion valves, and decompress and expand the heat-source-side refrigerant. The relay-side expansion device 23a is provided on an upstream side of the heat medium heat exchanger 21a in the direction of flow of the heat-source-side refrigerant in a cooling operation. The relay-side expansion device 23b is provided on an upstream side of the heat medium heat exchanger 21b in the direction of flow of the heat-source-side refrigerant in a cooling operation. The two relay-side expansion devices 23 may be, for example, electronic expansion valves, or other similar devices, whose opening degrees can be controlled.

[0067] The two opening and closing devices 24 (an opening and closing device 24a and opening and closing device 24b) are formed of two-way valves or other similar devices, and are configured to open and close the refrigerant pipes 6. The opening and closing device 24a is installed on the refrigerant pipe 6 on the inflow side of the heat-source-side refrigerant. The opening and closing device 24b is installed on a pipe that connects the refrigerant pipe 6 on an inlet side of the heat-source-side refrigerant and the refrigerant pipe 6 on an outlet side thereof. The two relay-side refrigerant flow passage

switching devices 25 (a relay-side refrigerant flow passage switching device 25a and a relay-side refrigerant flow passage switching device 25b) are formed of four-way valves or other similar devices, and are configured to switch the flows of the heat-source-side refrigerant based on the operation mode. The relay-side refrigerant flow passage switching device 25a is installed on a downstream side of the heat medium heat exchanger 21a in the direction of flow of the heat-source-refrigerant in a cooling operation. The relay-side refrigerant flow passage switching device 25b is installed on a downstream side of the heat medium heat exchanger 21b in the direction of flow of the heat-source-refrigerant in a cooling-only operation.

[0068] The two pumps 22 (a pump 22a and a pump 22b) are configured to pressurize the heat medium flowing in the heat medium main pipe 5 to cause the heat medium to be circulated in the heat medium circulation circuit B. The pump 22a is installed on the heat medium main pipe 5 between the heat medium heat exchanger 21a and the second heat medium flow passage switching device 27. The pump 22b is installed on the heat medium main pipe 5 between the heat medium heat exchanger 21b and the second heat medium flow passage switching device 27.

[0069] The three first heat medium flow passage switching devices 26 (the first heat medium flow passage switching devices 26a to 26c) are formed of three-way valves or other similar devices, and are configured to switch the flow paths of the heat medium. The number of the first heat medium flow passage switching devices 26 to be provided corresponds to the number of the installed indoor units 3 (three in this embodiment). One of the three flow paths of the first heat medium flow passage switching device 26 is connected to the heat medium heat exchanger 21a. Another thereof is connected to the heat medium heat exchanger 21b. The other thereof is connected to the heat medium flow control device 28. The first heat medium flow passage switching devices 26 are installed on the heat medium flow paths on the outlet sides of the indoor heat exchangers 31. In Fig. 6, the first heat medium flow passage switching devices 26a, 26b, and 26c are illustrated in this order from the bottom of the sheet in correspondence with the indoor units 3.

[0070] The three second heat medium flow passage switching devices 27 (the second heat medium flow passage switching devices 27a to 27c) are formed of three-way valves or other similar devices, and are configured to switch the flow paths of the heat medium. The number of the second heat medium flow passage switching devices 27 to be provided corresponds to the number of the installed indoor units 3 (three in this embodiment). One of the three flow paths of the second heat medium flow passage switching device 27 is connected to the heat medium heat exchanger 21a. Another thereof is connected to the heat medium heat exchanger 21b. The other thereof is connected to the indoor heat exchanger

31. The second heat medium flow passage switching devices 27 are installed on the heat medium flow paths on the inlet sides of the indoor heat exchangers 31. In Fig. 6, the second heat medium flow passage switching devices 27a, 27b, and 27c are illustrated in this order from the bottom of the sheet in correspondence with the indoor units 3.

[0071] The three heat medium flow control devices 28 (heat medium flow control devices 28a to 28c) are provided on the relay unit 2 side in place of the indoor flow control devices 32 of Embodiment 1. The heat medium flow control devices 28 are formed of two-way valves, or similar other devices, capable of controlling the opening areas, and are configured to control flow rates of the heat medium flowing in the heat medium branch pipes 51. The number of the heat medium flow control devices 28 to be provided corresponds to the number of the installed indoor units 3 (three in this embodiment). One end of the heat medium flow control device 28 is connected to the indoor heat exchanger 31. The other end thereof is connected to the first heat medium flow passage switching device 26. Here, the heat medium flow control devices 28 are installed on the heat medium flow paths on the outlet sides of the indoor heat exchangers 31. However, the heat medium flow control devices 28 may be installed on the heat medium flow paths on the inlet sides of the indoor heat exchangers 31. In Fig. 6, the heat medium flow control devices 28a, 28b, and 28c are illustrated in this order from the bottom of the sheet in correspondence with the indoor units 3.

[0072] Now, various sensors to be installed will be described. As in the case of Embodiment 1, on the heat-source-side refrigerant circulation circuit A, the discharge temperature sensor 501, the discharge pressure sensor 502, and the outdoor temperature sensor 503 are installed on the outdoor unit 1 side. On the relay unit 2 side on the heat-source-side refrigerant circulation circuit A, as the first refrigerant temperature sensor 504, a first refrigerant temperature sensor 504a and a first refrigerant temperature sensor 504b are installed to correspond to the two heat medium heat exchangers 21. Similarly, as the second refrigerant temperature sensor 505, a second refrigerant temperature sensor 505a and a second refrigerant temperature sensor 505b are installed in correspondence with the two heat medium heat exchangers 21.

[0073] In Embodiment 2, heat-source-side refrigerant pressure sensors 506 (a heat-source-side refrigerant pressure sensor 506a and a heat-source-side refrigerant pressure sensor 506b) are installed. The heat-source-side refrigerant pressure sensor 506a is configured to detect the pressure of the heat-source-side refrigerant flowing into and flowing out from the heat medium heat exchanger 21a. The heat-source-side refrigerant pressure sensor 506b is configured to detect the pressure of the heat-source-side refrigerant flowing between the heat medium heat exchanger 21b and the relay-side expansion device 23b.

[0074] Meanwhile, on the relay unit 2 side of the heat medium circulation circuit B, the heat medium inflow port side temperature sensors 511 (a heat medium inflow port side temperature sensor 511a and a heat medium inflow port side temperature sensor 511b) and the heat medium outflow port side temperature sensors 512 (a heat medium outflow port side temperature sensor 512a and a heat medium outflow port side temperature sensor 512b) are installed.

[0075] In Embodiment 1, the indoor inflow side pressure sensor 521 (the indoor inflow side pressure sensors 521a to 521c) and the indoor outflow side pressure sensor 522 (the indoor outflow side pressure sensors 522a to 522c) are installed on the indoor unit 3 side. In the air-conditioning apparatus 0 of Embodiment 2, the indoor inflow side pressure sensor 521 and the indoor outflow side pressure sensor 522 are installed, respectively, on the heat medium inflow side and the heat medium outflow side of the heat medium flow control device 28, which is installed in the relay unit 2 as the indoor flow control device 32 in Embodiment 1, and are configured to send signals corresponding to detected pressures.

[0076] Furthermore, similarly to Embodiment 1, on each indoor unit 3 side, the indoor inflow port side temperature sensor 513 (indoor inflow port side temperature sensors 513a to 513c), the indoor outflow port side temperature sensor 514 (indoor outflow port side temperature sensors 514a to 514c), and the indoor temperature sensor 515 (indoor temperature sensors 515a to 515c) are installed.

[0077] As operation modes of the air-conditioning apparatus 0 in Embodiment 2, there are a cooling only mode, in which all operating indoor units 3 perform cooling operation, and a heating only mode, in which all operating indoor units 3 perform heating operation. In addition, there are a cooling-main operation mode, which is executed when cooling load in the operating indoor units 3 is larger than heating load, and a heating-main operation mode, which is executed when heating load in the operating indoor units 3 is larger than cooling load.

<Cooling-only operation Mode>

[0078] In a cooling-only operation mode, the refrigerant in a high-temperature, high-pressure gaseous state discharged from the compressor 10 flows into the heat-source-side heat exchanger 12 via the refrigerant flow passage switching device 11. In the heat-source-side heat exchanger 12, the refrigerant is condensed and liquefied by rejecting heat to ambient air, thereby changing into a high-pressure liquid state, and flows out from the outdoor unit 1 via the first backflow prevention device 18a. Then, the refrigerant flows into the relay unit 2 via the refrigerant pipe 6. The refrigerant flowed into the relay unit 2 passes through the opening and closing device 24a, and is expanded at the relay-side expansion device 23a or the relay-side expansion device 23b, thereby changing into a low-temperature, low-pressure two-

phase state. The two-phase refrigerant flows into the heat medium heat exchanger 21a or the heat medium heat exchanger 21b and, in the heat medium heat exchanger 21a or the heat medium heat exchanger 21b, receives heat from the heat medium circulating in the heat medium circulation circuit B, thereby changing into a low-temperature, low-pressure gaseous state. The gaseous refrigerant flows out from the relay unit 2 via the relay-side refrigerant flow passage switching device 25a or the relay-side refrigerant flow passage switching device 25b. Then, the gaseous refrigerant flows into the outdoor unit 1 again via the refrigerant pipe 6. The refrigerant flowed into the outdoor unit 1 passes through the first backflow prevention device 18d and is sucked into the compressor 10 again via the refrigerant flow passage switching device 11 and the accumulator 14.

[0079] In the heat medium circulation circuit B, the heat medium is cooled by the refrigerant at both the heat medium heat exchanger 21a and the heat medium heat exchanger 21b. The cooled heat medium flows in the heat medium main pipe 5 and the heat medium branch pipes 51 by means of the pump 22a and pump 22b. The heat medium, which has flowed into the indoor heat exchanger 31a, 31b or 31c via the second heat medium flow passage switching device 27a, 27b or 27c, receives heat from indoor air at the indoor heat exchanger. The indoor air is thus cooled, and cooling of air-conditioned space is performed. The refrigerant flowed out from the indoor heat exchanger 31a, 31b or 31c flows into the heat medium flow control device 28a, 28b or 28c. Then, the refrigerant passes through the first heat medium flow passage switching device 26a, 26b or 26c and flows into the heat medium heat exchanger 21a or the heat medium heat exchanger 21b, and the refrigerant is cooled there and then is sucked into the pump 22a or the pump 22b again. Note that when there is no heat load for the indoor heat exchanger 31a, 31b or 31c, the corresponding heat medium flow control device 28a, 28b or 28c is completely closed. In addition, when heat load is present for the indoor heat exchanger 31a, 31b or 31c, the opening degree of the corresponding heat medium flow control device 28a, 28b or 28c is adjusted so that the heat load in the indoor heat exchanger 31a, 31b or 31c is controlled.

<Cooling-main operation Mode>

[0080] In a cooling-main operation mode, the refrigerant in a high-temperature, high-pressure gaseous state discharged from the compressor 10 flows into the heat-source-side heat exchanger 12 via the refrigerant flow passage switching device 11. In the heat-source-side heat exchanger 12, the refrigerant is condensed by rejecting heat to ambient air and changes into a two-phase state, and flows out from the outdoor unit 1 via the first backflow prevention device 18a. Then, the refrigerant flows into the relay unit 2 via the refrigerant pipe 6. The refrigerant flowed into the relay unit 2 passes through the relay-side refrigerant flow passage switching device 25b

and then flows into the heat medium heat exchanger 21b, which functions as a condenser. In the heat medium heat exchanger 21b, the refrigerant rejects heat to the heat medium circulating in the heat medium circulation circuit B, thereby changing into a high-pressure liquid state. The high-pressure liquid refrigerant is expanded at the relay-side expansion device 23b and changes into a low-temperature, low-pressure two-phase state. The two-phase refrigerant flows into the heat medium heat exchanger 21a, which functions as an evaporator, via the relay-side expansion device 23a. In the heat medium heat exchanger 21a, the refrigerant receives heat from the heat medium circulating in the heat medium circulation circuit B, thereby changing into a low-pressure gaseous state, and then flows out from the relay unit 2 via the relay-side refrigerant flow passage switching device 25a. Then, the refrigerant flows into the outdoor unit 1 again via the refrigerant pipe 6. The refrigerant flowed in to the outdoor unit 1 passes through the first backflow prevention device 18d and is sucked into the compressor 10 again via the refrigerant flow passage switching device 11 and the accumulator 14.

[0081] In the heat medium circulation circuit B, heating energy of the refrigerant is transferred to the heat medium at the heat medium heat exchanger 21b. Then, the heated heat medium flows in the heat medium main pipe 5 and the heat medium branch pipes 51 by means of the pump 22b. By operating the first heat medium flow passage switching devices 26a to 26c and the second heat medium flow passage switching devices 27a to 27c, the heat medium is caused to flow into the indoor heat exchangers 31a, 31b and/or 31c to which a heating operation is requested, and rejects heat to the indoor air. The indoor air is thus heated, and heating of air-conditioned space is performed. Meanwhile, cooling energy of the refrigerant is transferred to the heat medium at the heat medium heat exchanger 21a. Then, the cooled heat medium flows in the heat medium main pipe 5 and the heat medium branch pipes 51 by means of the pump 22a. By operating the first heat medium flow passage switching devices 26a to 26c and the second heat medium flow passage switching devices 27a to 27c, the heat medium is caused to flow into the indoor heat exchangers 31a, 31b and/or 31c to which a cooling operation is requested, and receives heat from the indoor air. The indoor air is thus cooled, and cooling of air-conditioned space is performed. Note that when there is no heat load for the indoor heat exchanger 31a, 31b or 31c, the corresponding heat medium flow control device 28a, 28b or 28c is completely closed. In addition, when heat load is present for the indoor heat exchanger 31a, 31b or 31c, the opening degree of the corresponding heat medium flow control device 28a, 28b or 28c is adjusted so that the heat load in the indoor heat exchanger 31a, 31b or 31c is controlled.

<Heating-only operation Mode>

[0082] In a heating-only operation mode, the refriger-

ant in a high-temperature, high-pressure gaseous state discharged from the compressor 10 passes through, via the refrigerant flow passage switching device 11, the first connection pipe 16 and the first backflow prevention device 18b and flows out from the outdoor unit 1. Then, the refrigerant flows into the relay unit 2 via the refrigerant pipe 6. The refrigerant flowed into the relay unit 2 passes through the relay-side refrigerant flow passage switching device 25a or the relay-side refrigerant flow passage switching device 25b and flows into the corresponding heat medium heat exchanger 21a or 21b. In the heat medium heat exchanger 21a or 21b, the refrigerant rejects heat to the heat medium circulating in the heat medium circulation circuit B, thereby changing into a high-pressure liquid state. The high-pressure liquid refrigerant is expanded at the relay-side expansion device 23a or the relay-side expansion device 23b, thereby changing into a low-temperature, low-pressure two-phase state, and then passes through the opening and closing device 24b and flows out from the relay unit 2. Then, the refrigerant passes through the refrigerant pipe 6 and flows into the outdoor unit 1 again. The refrigerant flowed into the outdoor unit 1 passes through the second connection pipe 17 and the first backflow prevention device 18c and flows into the heat-source-side heat exchanger 12, which functions as an evaporator. In the heat-source-side heat exchanger 12, the refrigerant receives heat from ambient air, thereby changing into a low-temperature, low-pressure gaseous state. The gaseous refrigerant is sucked into the compressor 10 again via the refrigerant flow passage switching device 11 and the accumulator 14. Note that the movement of the heat medium in the heat medium circulation circuit B is the same as that in the cooling-only operation mode. In the heating-only operation mode, the heat medium is heated by the refrigerant at the heat medium heat exchanger 21a or the heat medium heat exchanger 21b and rejects heat to the indoor air at the indoor heat exchanger 31a or the indoor heat exchanger 31b, and heating of air-conditioned space is thus performed.

<Heating-main operation Mode>

[0083] In a heating-main operation mode, the refrigerant in a high-temperature, high-pressure gaseous state discharged from the compressor 10 passes through, via the refrigerant flow passage switching device 11, the first connection pipe 16 and the first backflow prevention device 18b and flows out from the outdoor unit 1. Then, the refrigerant passes through the refrigerant pipe 6 and flows into the relay unit 2. The refrigerant flowed into the relay unit 2 passes through the relay-side refrigerant flow passage switching device 25b and flows into the heat medium heat exchanger 21b, which functions as a condenser. In the heat medium heat exchanger 21b, the refrigerant rejects heat to the heat medium circulating in the heat medium circulation circuit B, thereby changing into a high-pressure liquid state. The high-pressure liquid

refrigerant is expanded at the relay-side expansion device 23b, thereby changing into a low-temperature, low-pressure two-phase state. The two-phase refrigerant flows into the heat medium heat exchanger 21a, which functions as an evaporator, via the relay-side expansion device 23a. In the heat medium heat exchanger 21a, the refrigerant receives heat from the heat medium circulating in the heat medium circulation circuit B and flows out from the relay unit 2 via the relay-side refrigerant flow passage switching device 25a. Then, the refrigerant flows into the outdoor unit 1 again via the refrigerant pipe 6. The refrigerant flowed into the outdoor unit 1 passes through the second connection pipe 17 and the first backflow prevention device 18c, and flows into the heat-source-side heat exchanger 12, which functions as an evaporator. In the heat medium heat exchanger 21, the refrigerant receives heat from ambient air, thereby changing into a low-temperature, low-pressure gaseous state. The gaseous refrigerant is sucked into the compressor 10 again via the refrigerant flow passage switching device 11 and the accumulator 14. Note that the movement of the heat medium in the heat medium circulation circuit B and the operations of the first heat medium flow passage switching devices 26a to 26c, the second heat medium flow passage switching devices 27a to 27c, the heat medium flow control devices 28a to 28c, and the indoor heat exchangers 31a to 31c are the same as those in the cooling-main operation mode.

[0084] Next, control of the air-conditioning apparatus 0 of Embodiment 2 will be described. In the air-conditioning apparatus 0 of Embodiment 1, the heat medium heat exchanger 21 functions as an evaporator or a condenser, and either cooling or heating of the heat medium is performed. Therefore, on the heat-source-side refrigerant circulation circuit A side, either one of the evaporation temperature and the condensation temperature in the heat medium heat exchanger 21 is controlled.

[0085] Here, in the air-conditioning apparatus 0 of Embodiment 2, in the cooling-only operation mode, the heat medium heat exchanger 21a and the heat medium heat exchanger 21b function as evaporators. In the heating-only operation mode, the heat medium heat exchanger 21a and the heat medium heat exchanger 21b function as condensers. Thus, the same control as that in Embodiment 1 can be performed.

[0086] Meanwhile, in the cooling-main operation mode and the heating-main operation mode, in the heat-source-side refrigerant circulation circuit A, the heat medium heat exchanger 21 that functions as an evaporator and the heat medium heat exchanger 21 that functions as a condenser are present at the same time, as described above. At this time, it is difficult to perform optimal control based on both a target temperature gradient for cooling an indoor space and a target temperature gradient for heating an indoor space. In the cooling-main operation mode, the heat load for cooling is large. Thus, the control processing device 210 of the relay unit control device 200 sets a reference temperature gradient among

the target temperature gradients of the indoor units 3 operating under a cooling mode, and the control is performed by executing the processing described in Embodiment 1. Meanwhile, in the heating-main operation mode, the heat load for heating is large. Thus, the control processing device 210 sets a reference temperature gradient among the target temperature gradients of the indoor units 3 operating under a heating mode, and the control is performed by executing the processing described in Embodiment 1.

[0087] As described above, the control described in Embodiment 1 can be performed also in the air-conditioning apparatus 0 of Embodiment 2 capable of performing cooling and heating simultaneous operations. Therefore, according to the temperatures of indoor spaces in which heat loads are present, supply of heat from the heat-source-side refrigerant circulation circuit A side can be controlled and thus the temperatures of the heat medium circulating in the heat medium circulation circuit B can be changed.

Embodiment 3

[0088] Fig. 7 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 3 of the present disclosure. In Fig. 7, the devices denoted by the same reference symbols as those in Fig. 1 perform the same operations as those of Embodiment 1. In the air-conditioning apparatus 0 of Embodiment 3, a plurality of the relay units 2 described in Embodiment 1 or Embodiment 2 are connected to the outdoor unit 1 in parallel by using the refrigerant pipe 6, to thereby form the heat-source-side refrigerant circulation circuit A.

[0089] As described above, according to the air-conditioning apparatus 0 of Embodiment 3, even in the air-conditioning apparatus 0 of Embodiment 3 in which a plurality of relay units 2 are provided and connected to the outdoor unit 1 in parallel, communication can be performed between units. Thus, the controls described in Embodiment 1 and Embodiment 2 can be performed.

Embodiment 4

[0090] Fig. 8 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 4 of the present disclosure. In Fig. 8, the devices denoted by the same reference symbols as those in Fig. 2 perform the same operations as those of Embodiment 1. In the air-conditioning apparatus 0 of Embodiment 4, the devices of the relay unit 2 described in Embodiment 1 or Embodiment 2 are housed and integrated in the outdoor unit 1. Thus, in the air-conditioning apparatus 0 of Embodiment 4, the outdoor unit 1 and the indoor units 3 are connected by the heat medium main pipes 5 and the heat medium branch pipes 51. Because the outdoor unit 1 houses all the devices of heat-source-side refrigerant circulation circuit A, the amount of the refrigerant can be reduced. In addition, only connection of the outdoor unit

1 and the indoor units 3 by pipes is required, piping work can be facilitated. Furthermore, without providing the relay unit 2 independently, the controls described in Embodiment 1 and Embodiment 2 can be performed.

Embodiment 5

[0091] Fig. 9 is a diagram illustrating a configuration of an air-conditioning apparatus 0 according to Embodiment 5 of the present disclosure. In Fig. 9, the devices denoted by the same reference symbols as those in Fig. 2 perform the same operations as those of Embodiment 1. As illustrated in Fig. 9, in the air-conditioning apparatus 0 of Embodiment 5, a flow control unit 4 including a plurality of flow control devices 41 (flow control devices 41a to 41c) are installed, in place of the indoor flow control devices 32 installed in the indoor units 3. The flow control unit 4 includes a flow adjustment control device 400. The flow adjustment control device 400 can communicate with controllers of other units. By providing the flow control unit 4 and consolidating a plurality of flow control devices 41 in air-conditioning apparatus 0 of Embodiment 5, maintenance of the air-conditioning apparatus 0 can be facilitated. Because the flow control unit 4 is configured to be capable of communicating signals containing various data, the air-conditioning apparatus 0 capable of performing efficient operations can be provided also in Embodiment 5.

Embodiment 6

[0092] In the embodiments described above, the relay unit control device 200 determines whether or not to change the temperature of the heat medium based on a change in a temperature difference of the suction temperature, which is the temperature of an indoor space, however, the determination method is not limited thereto. The determination for the temperature of the heat medium may be performed based on, for example, a relationship between a target temperature gradient and a temperature difference of the suction temperature. Furthermore, the determination of the temperature of the heat medium may be performed based on a heat quantity.

Reference Signs List

[0093] 0 air-conditioning apparatus 1 outdoor unit 2 relay unit 3, 3a, 3b, 3c indoor unit 4 flow control unit 5 heat medium main pipe 6 refrigerant pipe 10 compressor 11 refrigerant flow passage switching device 12 heat-source-side heat exchanger 13 expansion device 14 accumulator 15 heat-source-side fan 16 first connection pipe 17 second connection pipe 18a, 18b, 18c, 18d first backflow prevention device 21, 21a, 21b heat medium heat exchanger 22, 22a, 22b pump 23, 23a, 23b relay-side expansion device 24, 24a, 24b opening and closing device 25, 25a, 25b relay-side refrigerant flow passage switching device 26, 26a, 26b, 26c first heat medium flow

passage switching device 27, 27a, 27b, 27c second heat
 medium flow passage switching device 28, 28a, 28b, 28c
 heat medium flow control device 31, 31a, 31b, 31c indoor
 heat exchanger 32, 32a, 32b, 32c indoor flow control de-
 vice 33, 33a, 33b, 33c indoor-side fan 41, 41a, 41b, 41c 5
 flow control device 51 heat medium branch pipe 100 out-
 door unit control device 200 relay unit control device 210
 control processing device 211 temperature gradient set-
 ting processing unit 212 calculation processing unit 213
 determination processing unit 214 heat-source-side con- 10
 trol processing unit 220 memory device 230 clocking de-
 vice 240 communication device 300, 300a, 300b, 300c
 indoor unit control device 400 flow adjustment control
 device 501 discharge temperature sensor 502 discharge
 pressure sensor 503 outdoor temperature sensor 504, 15
 504a, 504b first refrigerant temperature sensor 505,
 505a, 505b second refrigerant temperature sensor 506,
 506a, 506b heat-source-side refrigerant pressure sensor
 511, 511a, 511b heat medium inflow port side tempera-
 ture sensor 512, 512a, 512b heat medium outflow port 20
 side temperature sensor 513, 513a, 513b, 513c indoor
 inflow port side temperature sensor 514, 514a, 514b,
 514c indoor outflow port side temperature sensor 515,
 515a, 515b, 515c indoor temperature sensor 521, 521a, 25
 521b, 521c indoor inflow side pressure sensor 522, 522a,
 522b, 522c indoor outflow side pressure sensor

Claims

1. An air-conditioning apparatus comprising:

a heat medium circulation circuit, in which

a pump configured to pressurize a heat me- 35
 dium that contains water or brine, and trans-
 fers heat,
 an indoor heat exchanger configured to
 cause heat exchange to be performed be- 40
 tween an indoor air of an air-conditioned
 space and the heat medium, and
 a flow control device installed in corre-
 spondence with the indoor heat exchanger
 and configured to control a flow rate of the 45
 heat medium passing through the indoor
 heat exchanger

are connected by a pipe to circulate the heat medium therein; and

a heat-source-side refrigerant circulation circuit, 50
 in which

a compressor configured to compress a 55
 heat-source-side refrigerant,
 a heat-source-side heat exchanger config-
 ured to cause heat exchange to be per-
 formed between the heat-source-side re-
 frigerant and an outdoor air,

an expansion device configured to decom-
 press the heat-source-side refrigerant, and
 a heat medium heat exchanger configured
 to cause heat exchange to be performed
 between the heat-source-side refrigerant
 and the heat medium

are connected by a pipe,
 wherein a plurality of the indoor heat exchangers
 are installed in respective indoor units, and
 each of the indoor units includes a detection de-
 vice configured to detect a physical quantity re-
 lated to a heat quantity involved in heat ex-
 change of the indoor heat exchanger and per-
 forms communication by a signal containing da-
 ta on detection of the detection device.

2. The air-conditioning apparatus of claim 1 further comprising a controller,

wherein each of the indoor units further includes an
 indoor temperature sensor configured to detect a
 temperature of the indoor air, and
 the controller is configured to set a target tempera-
 ture gradient as a reference among target tempera-
 ture gradients each of which is calculated from a set
 temperature for the indoor air of each indoor unit and
 a temperature of the indoor air thereof at start of op-
 eration, and, based on the set target temperature
 gradient, determine a temperature of the heat me-
 dium flowing out from passing through the indoor heat
 exchanger, and control the heat-source-side refrig-
 erant circulation circuit so that the heat medium hav-
 ing a determined temperature is obtained through
 heat exchange.

3. The air-conditioning apparatus of claim 2, wherein the controller controls a temperature of the heat medium involved in heat exchange with the heat-source-side refrigerant in the heat medium heat exchanger by controlling a temperature of the heat-source-side refrigerant passing through the heat medium heat exchanger, based on a temperature change of the indoor air at a predetermined time interval.

4. The air-conditioning apparatus of any one of claims 1 to 3, wherein the compressor and the heat-source-side heat exchanger are installed in the outdoor unit, and the heat medium heat exchanger and the pump are installed in a relay unit configured to transfer heat between the outdoor unit and the indoor unit.

5. The air-conditioning apparatus of claim 4, wherein a plurality of the relay units are connected in parallel to the outdoor unit by a pipe.

6. The air-conditioning apparatus of any one of claims

1 to 3, wherein a component of the heat-source-side refrigerant circulation circuit and the pump are installed in the outdoor unit.

7. The air-conditioning apparatus of any one of claims 1 to 6, wherein the flow control device is installed in the indoor unit. 5
8. The air-conditioning apparatus of any one of claims 1 to 6, wherein a plurality of the flow control devices are installed in a flow control unit. 10

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FIG. 1

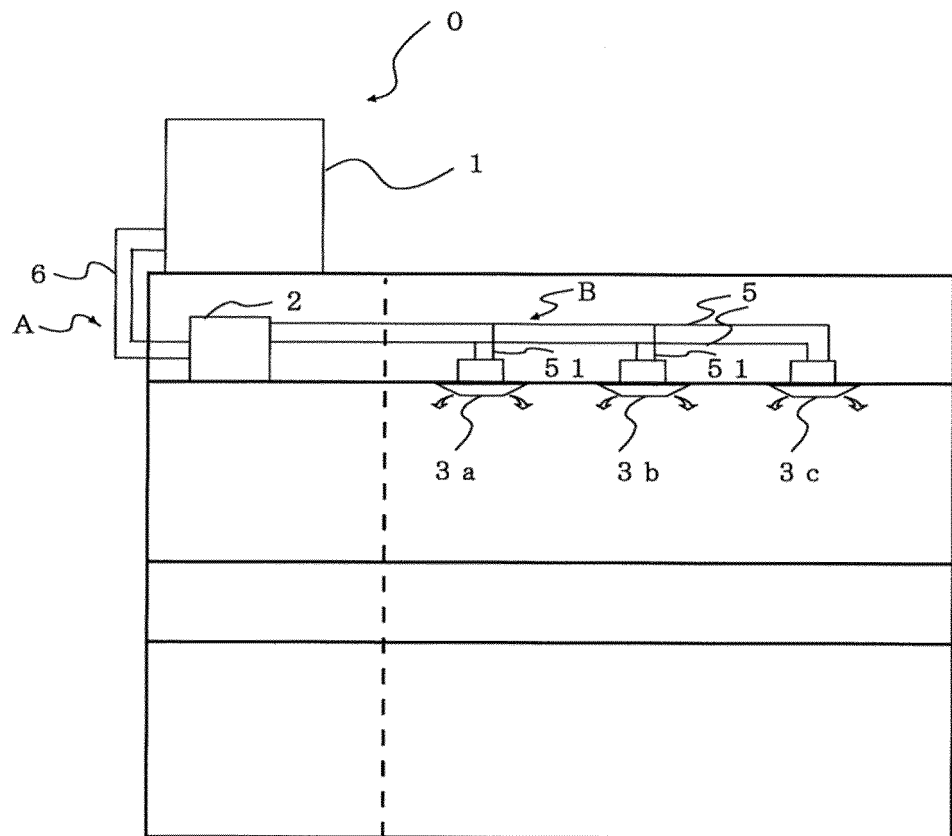
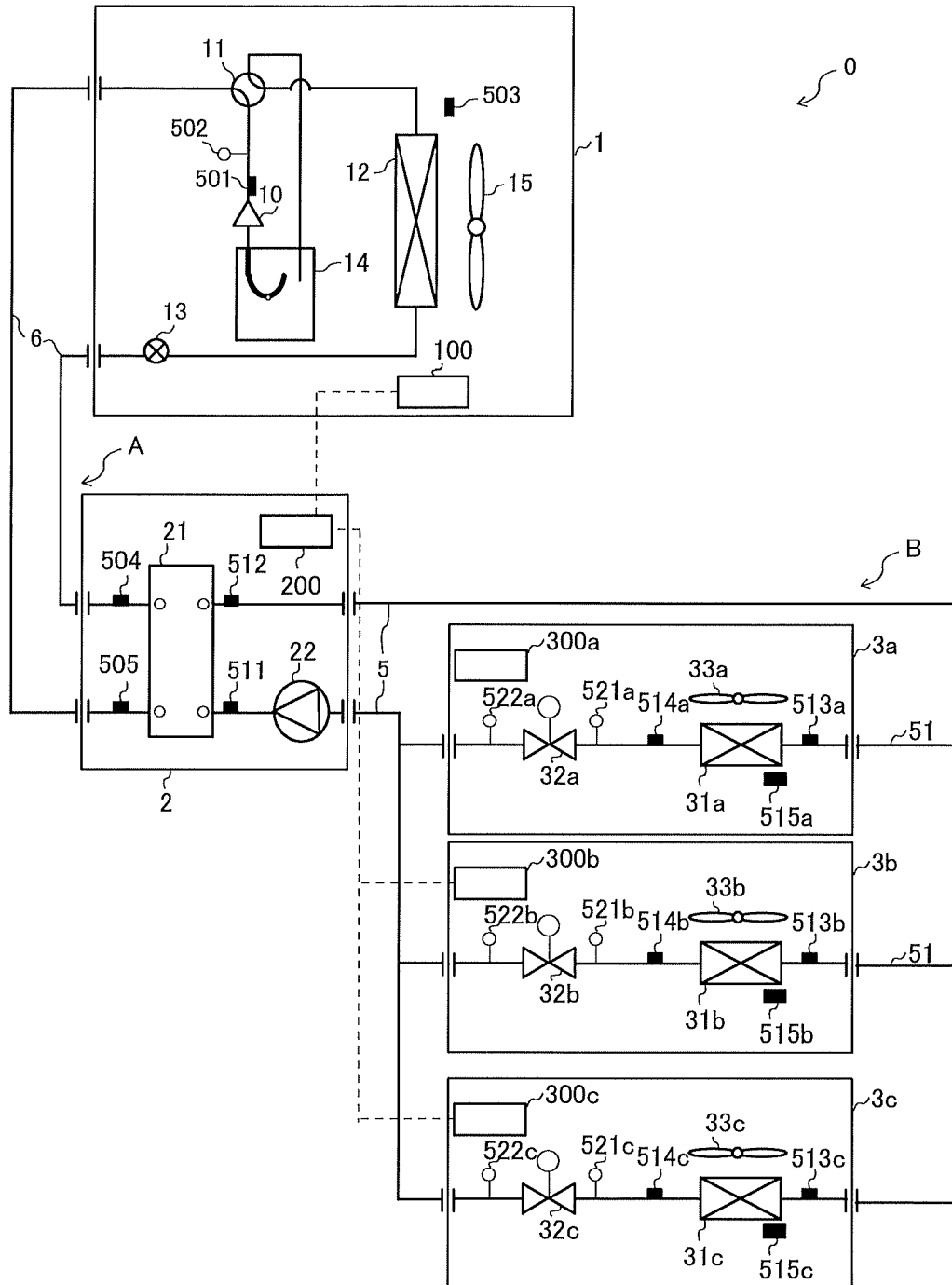


FIG. 2



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FIG. 3

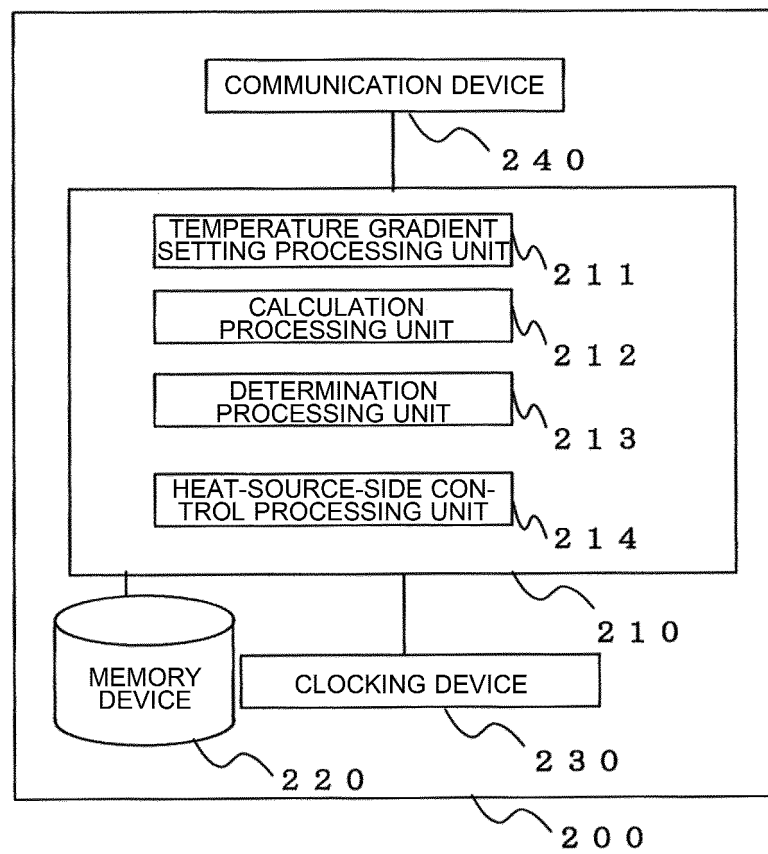


FIG. 4

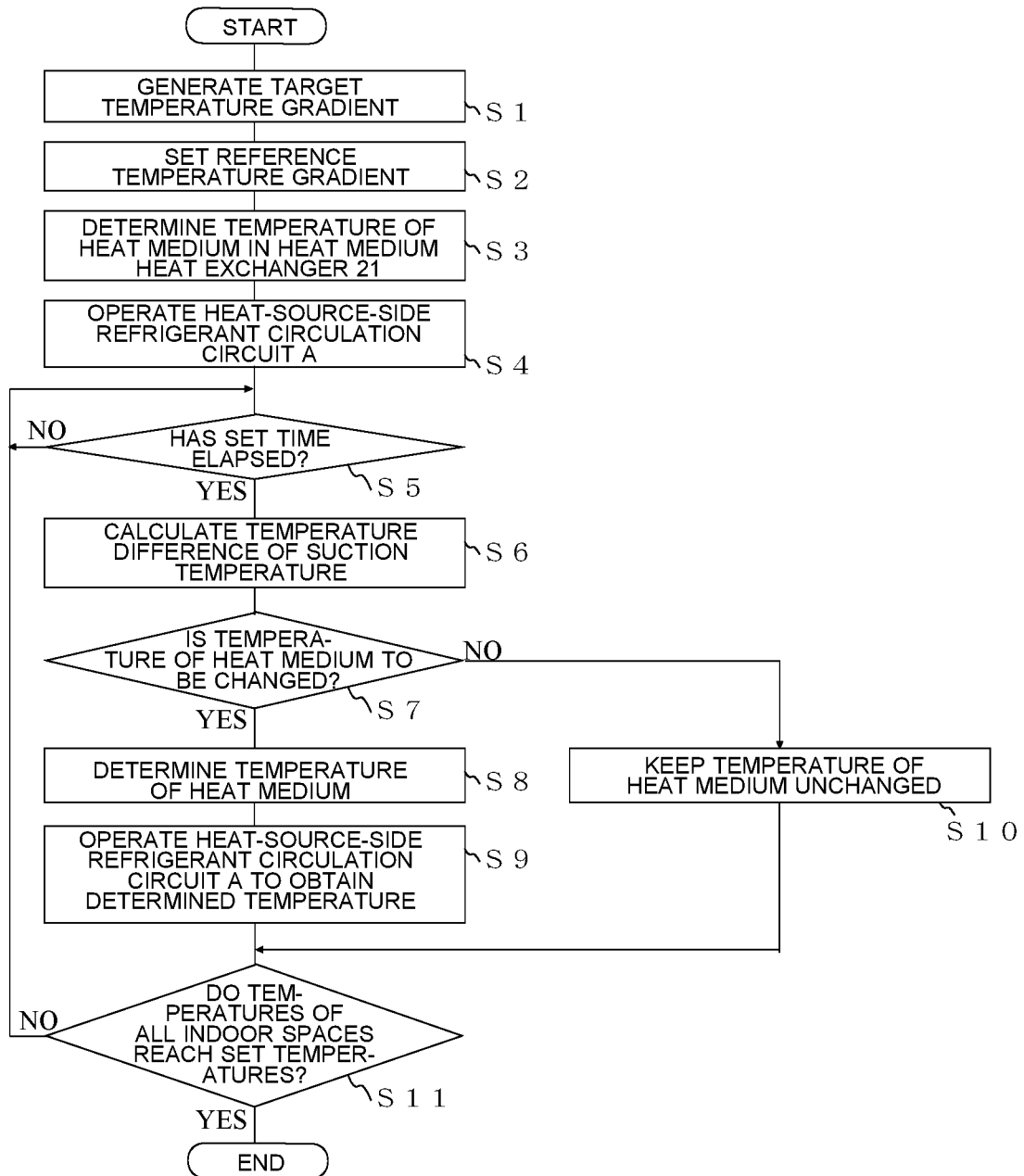


FIG. 5

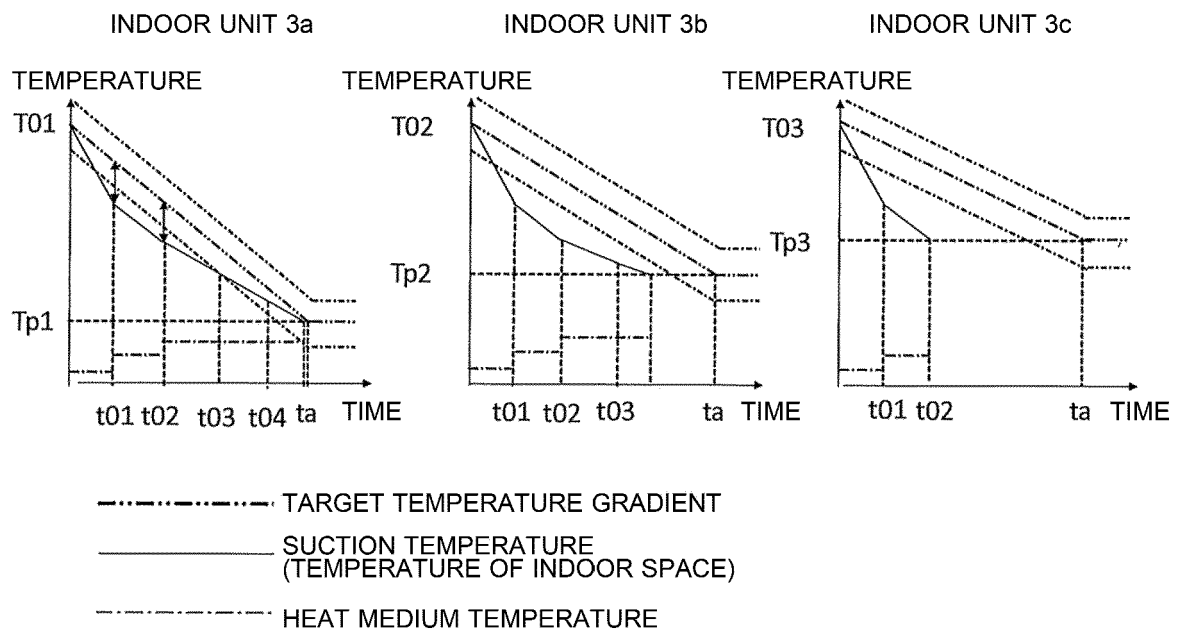
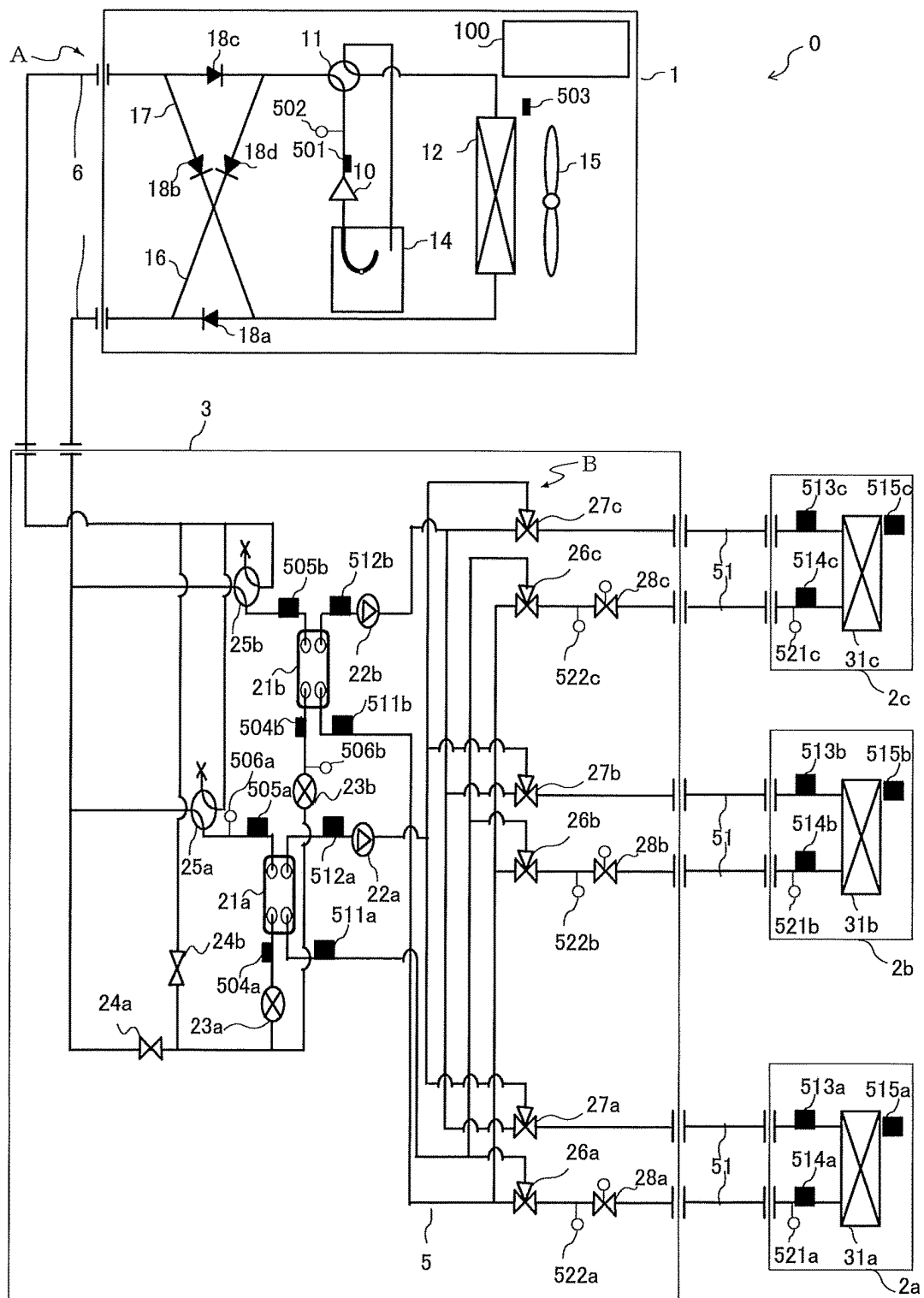


FIG. 6



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FIG. 7

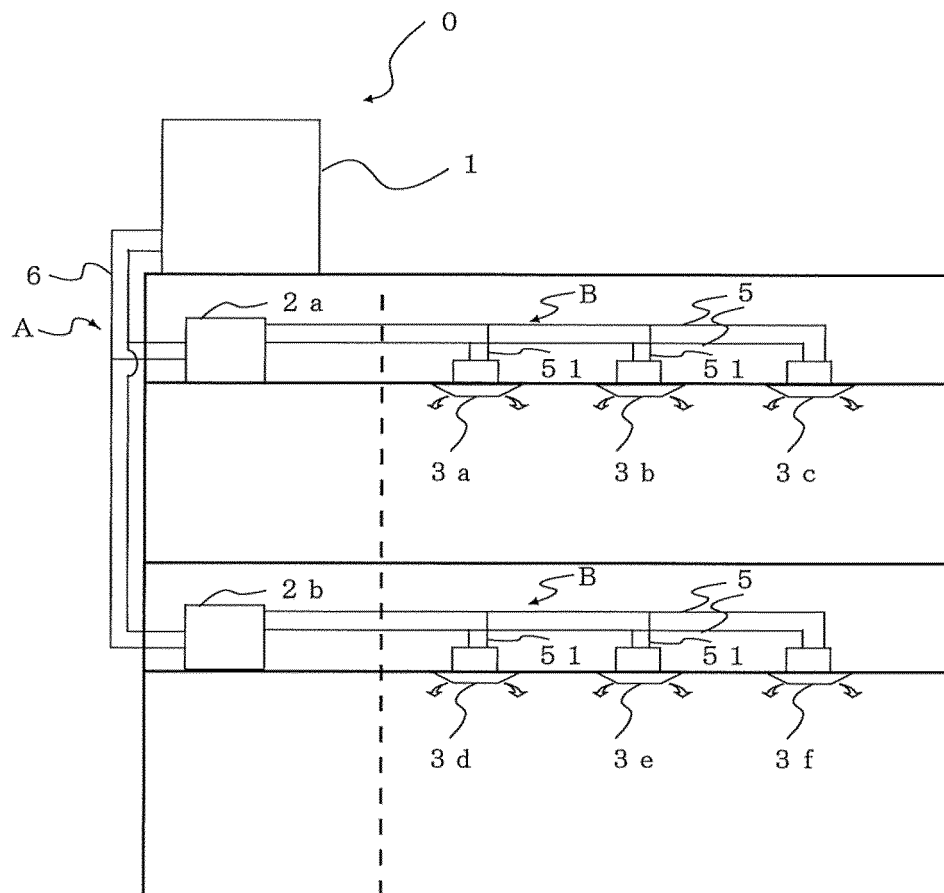


FIG. 8

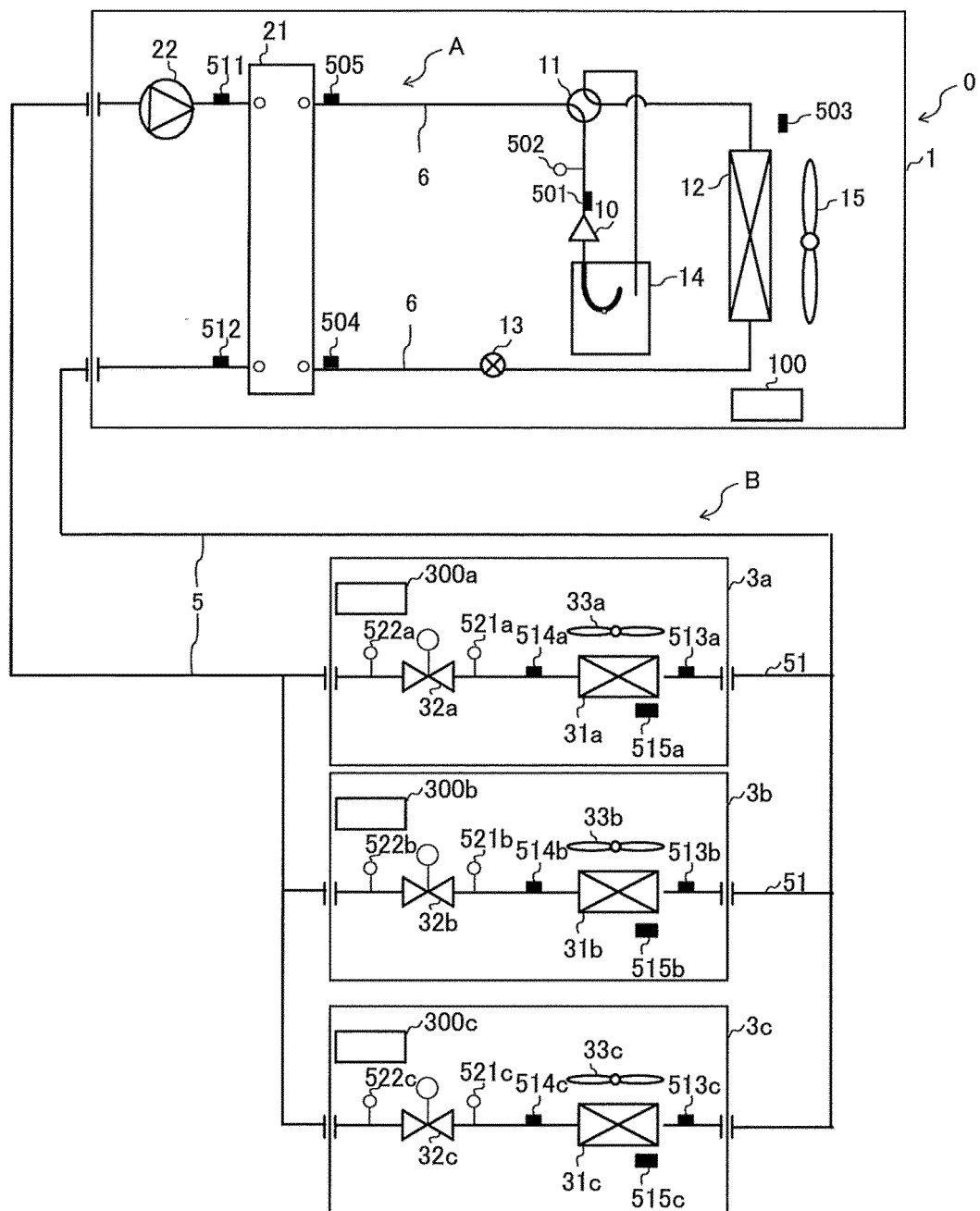
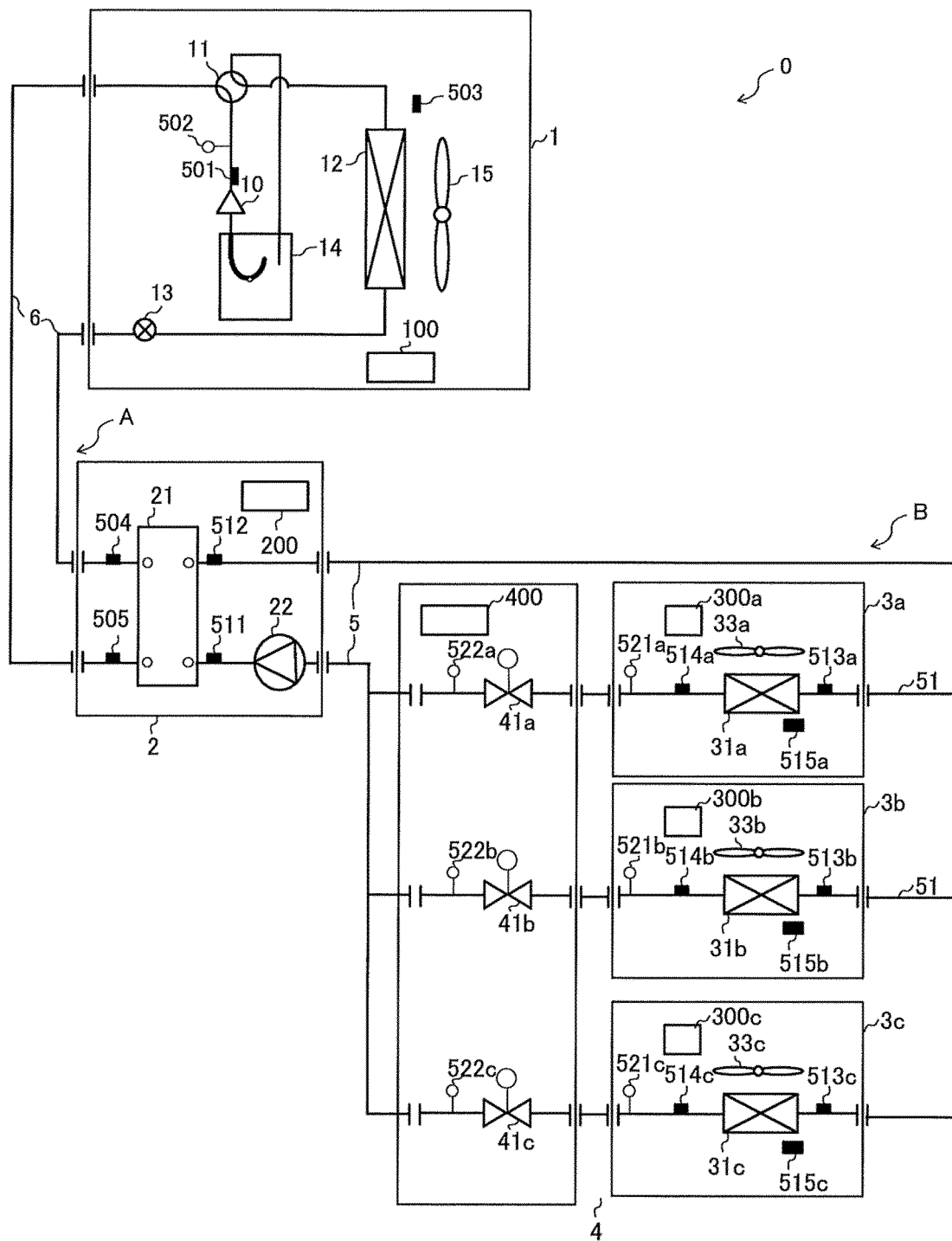


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/014597

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F24F11/86 (2018.01) i, F24F11/83 (2018.01) i, F25B1/00 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F24F11/86, F24F11/83, F25B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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.
X Y A	WO 2014/045358 A1 (MITSUBISHI ELECTRIC CORPORATION) 27 March 2014, paragraphs [0010]-[0045], [0101], fig. 1, 2, 9 & EP 2899477 A1, paragraphs [0010]-[0045], [0100], fig. 1, 2, 9	1, 4 5-8 2-3
Y A	WO 2016/170575 A1 (MITSUBISHI ELECTRIC CORPORATION) 27 October 2016, paragraphs [0010]-[0022], fig. 1 & CN 107532830 A	5, 7-8 2-3



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search
19.06.2018Date of mailing of the international search report
26.06.2018Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/014597

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2013/038577 A1 (MITSUBISHI ELECTRIC CORPORATION) 21 March 2013, paragraphs [0010]-[0012], fig. 1 & US 2014/0196483 A1, paragraphs [0023]-[0027], fig. 1 & EP 2759787 A1 & CN 103797317 A	6-8 2-3
Y A	WO 2015/087421 A1 (MITSUBISHI ELECTRIC CORPORATION) 18 June 2015, paragraph [0095], fig. 8 (Family: none)	7 2-3

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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