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

(11) EP 2 963 353 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
06.01.2016 Bulletin 2016/01

(21) Application number: **13876711.6**

(22) Date of filing: **01.03.2013**

(51) Int Cl.:
F24F 5/00 *(2006.01)* ***F24F 3/08*** *(2006.01)*
F24F 11/02 *(2006.01)* ***F25B 1/00*** *(2006.01)*
F25B 29/00 *(2006.01)*

(86) International application number:
PCT/JP2013/055640

(87) International publication number:
WO 2014/132433 (04.09.2014 Gazette 2014/36)

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

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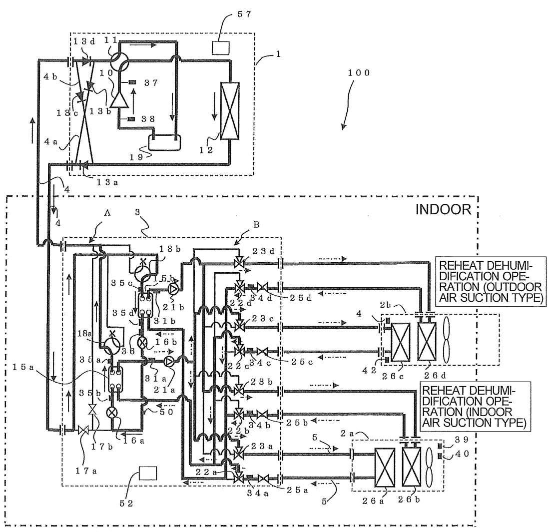
(54) AIR CONDITIONING DEVICE

(57) An air-conditioning apparatus includes indoor units 2a and 2b each housing two or more use side heat exchangers 26, and performs a reheat dehumidification operation mode in such a manner that low-temperature low-pressure heat source-side refrigerant flows in part of a plurality of intermediate heat exchangers 15a and 15b so as to cool a heat medium, the cooled heat medium is supplied to part of the use side heat exchangers 26 housed in the indoor unit 2a and 2b, and high-temperature high-pressure heat source-side refrigerant flows in another part of the intermediate heat exchangers 15a and 15b so as to heat a heat medium, and the heated heat medium is supplied to another part of the use side heat exchangers 26 housed in the indoor units 2a and 2b.

FIG. 7



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Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus to be applied to, for example, a multi-air-conditioning apparatus for buildings.

Background Art

[0002] In a typical air-conditioning apparatus, one heat source unit and one indoor unit are connected to each other by a refrigerant pipe, and two heat exchangers are connected to an indoor unit through flow rate control valves so that a mixture of air cooled and dehumidified by one of the heat exchangers and air heated by the other heat exchanger is blown, that is, a reheat dehumidification operation is performed (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2002-89988 (Abstract, Fig. 1)

Summary of Invention

Technical Problem

[0004] In the technique of Patent Literature 1, the refrigerant temperature significantly differs between an operation period and a stop period in the indoor unit, and the temperature and humidity of the indoor air greatly varies in the reheat dehumidification operation disadvantageously.

[0005] In the reheat dehumidification operation, it is desirable to set the temperature of the indoor air or the temperature and humidity of air blown from the indoor unit at a desired target value(s).

[0006] The present invention provides an air-conditioning apparatus capable of suppressing variations in the temperature and humidity of an indoor air in a reheat dehumidification operation.

[0007] The present invention also provides an air-conditioning apparatus capable of controlling the temperature of indoor air or the temperature and humidity of air blown from an indoor unit in the reheat dehumidification operation. Solution to Problem

[0008] An air-conditioning apparatus according to the present invention includes: a refrigerant circuit in which a compressor, a heat source side heat exchanger, a plurality of expansion devices, refrigerant channels of a plurality of intermediate heat exchangers, and a plurality of refrigerant channel switching devices for switching circulation channels are connected by refrigerant pipes so that heat source-side refrigerant circulates therein; a heat medium circuit in which a pump, a plurality of use side heat exchangers, a heat medium channel switching device, and heat medium channels of the intermediate heat exchangers are connected by heat medium pipes so that a heat medium circulates therein; and an indoor unit housing two or more of the plurality of use side heat exchangers, wherein a reheat dehumidification operation mode is performed in such a manner that low-temperature low-pressure heat source-side refrigerant flows in part of the plurality of intermediate heat exchangers so as to cool the heat medium, and the cooled heat medium is supplied to part of the use side heat exchangers housed in the indoor unit, and high-temperature high-pressure heat source-side refrigerant flows in another part of the plurality of intermediate heat exchangers so as to heat the heat medium, and the heated heat medium is supplied to another part of the use side heat exchangers housed in the indoor unit. Advantageous Effects of Invention

[0009] According to the present invention, variations in the temperature and humidity of indoor air can be suppressed in a reheat dehumidification operation. Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 schematically illustrates an installation example of an air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 2] Fig. 2 illustrates an example refrigerant circuit configuration of the air-conditioning apparatus of Embodiment of the present invention.

[Fig. 3] Fig. 3 is a refrigerant circuit diagram showing flow of refrigerant in a cooling-only operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 4] Fig. 4 is a refrigerant circuit diagram showing flow of refrigerant in a heating-only operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 5] Fig. 5 is a refrigerant circuit diagram showing flow of refrigerant in a cooling main operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 6] Fig. 6 is a refrigerant circuit diagram showing flow of refrigerant in a heating main operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 7] Fig. 7 is a refrigerant circuit diagram showing flow of refrigerant in a dehumidification reheat (cooling main) operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 8] Fig. 8 is a refrigerant circuit diagram showing flow of refrigerant in a dehumidification reheat (heating main) operation mode of the air-conditioning apparatus illustrated in Fig. 2.

[Fig. 9] Fig. 9 shows psychrometric charts for describing circulation amount control of a heat medium in a reheat dehumidification operation mode according to Embodiment of the present invention.

[Fig. 10] Fig. 10 shows psychrometric charts for describing circulation amount control of a heat medium in a reheat dehumidification operation mode according to Embodiment of the present invention.

[Fig. 11] Fig. 11 is a flowchart showing switching operation to the heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 12] Fig. 12 is a flowchart showing heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention.

[Fig. 13] Fig. 13 is a flowchart showing a variation of heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention.

Description of Embodiments

Embodiment

[0011] Fig. 1 schematically illustrates an installation example of an air-conditioning apparatus 100 according to Embodiment of the present invention. Referring to Fig. 1, an installation example of the air-conditioning apparatus 100 will be described. The air-conditioning apparatus 100 includes a refrigeration cycle in which refrigerant circulates, and also includes indoor units 2a and 2b each of which can freely select a cooling mode, a heating mode, or a dehumidification reheat mode, as an operation mode. The indoor unit 2b may be of a type that processes intake outdoor air. The air-conditioning apparatus 100 of this Embodiment includes a refrigerant circuit A (see Fig. 2) using, as refrigerant, single refrigerant such as R-22, R-32, or R-134a, a near-azeotropic refrigerant mixture such as R-410A or R-404A, a zeotropic refrigerant mixture such as R-407C, refrigerant that includes a double bond in its chemical formula and is regarded as a refrigerant having a relatively low global warming potential, such as $CF_3CF = CH_2$, and a mixture thereof, or natural refrigerant such as CO_2 or propane, and a heat medium circuit B using water, for example, as a heat medium.

[0012] The air-conditioning apparatus 100 of this Embodiment employs a technique (an indirect technique) that indirectly uses refrigerant (heat source-side refrigerant). Specifically, cooling energy or heating energy stored in heat source-side refrigerant is transferred to a refrigerant (hereinafter referred to as a heat medium) different from the heat source-side refrigerant so that an air-conditioned space is cooled or heated with cooling energy or heating energy stored in the heat medium. After dehumidification by the cooling function, heating is performed, thereby performing dehumidification reheat.

[0013] As illustrated in Fig. 1, the air-conditioning apparatus 100 of this Embodiment includes one outdoor unit 1 as a heat source unit, a plurality of indoor units 2, and a heat medium relay unit 3 interposed between the outdoor unit 1 and the indoor units 2. The heat medium relay unit 3 exchanges heat between the heat source-side refrigerant and the heat medium. The outdoor unit 1 is connected to the heat medium relay unit 3 by refrigerant pipes 4 for allowing the heat source-side refrigerant to circulate. The heat medium relay unit 3 is connected to the indoor units 2 by pipes (heat medium pipes) 5 for allowing the heat medium to circulate. Cooling energy or heating energy generated by the outdoor unit 1 is sent to the indoor units 2 through the heat medium relay unit 3.

[0014] The outdoor unit 1 is generally disposed in an outdoor space 6 that is a space (e.g., a rooftop) outside a structure 9 such as a building, and supplies cooling energy or heating energy to the indoor units 2 through the heat medium relay unit 3.

[0015] The indoor units 2 are disposed at locations such that the indoor units 2 can supply cooling air or heating air to an interior space 7 that is a space (e.g., a room) inside the structure 9, and supply cooling air or heating air to the interior space 7 to be an air-conditioned space.

[0016] The heat medium relay unit 3 is placed in a housing different from the outdoor unit 1 and the indoor units 2, and is disposed at a location different from the outdoor space 6 and the interior space 7. The heat medium relay unit 3 is connected to the outdoor unit 1 through the refrigerant pipes 4 and to the indoor units 2 through the pipes 5 so as to transmit cooling energy or heating energy from the outdoor unit 1 to the indoor units 2.

[0017] As illustrated in Fig. 1, in the air-conditioning apparatus 100 of this Embodiment, the outdoor unit 1 and the heat medium relay unit 3 are connected to each other through two refrigerant pipes 4, and the heat medium relay unit 3 is connected to each of the indoor units 2a and 2b through four pipes 5. In this manner, in the air-conditioning apparatus 100 of Embodiment 1, the units (i.e., the outdoor unit 1, the indoor units 2, and the heat medium relay unit 3) are connected to one another through the refrigerant pipes 4 and 5, thereby simplifying the construction.

[0018] In the example illustrated in Fig. 1, the heat medium relay unit 3 is installed in a space (e.g., a space such as a space above a ceiling in the structure 9, hereinafter simply hereinafter referred to as a space 8) that is inside the structure 9 but is different from the interior space 7. The heat medium relay unit 3 may be installed in, for example, a common space including an elevator or other equipment. In the example illustrated in Fig. 1, the indoor units 2 are of a ceiling concealed type, but the present invention is not limited to this type. The air-conditioning apparatus 100 may be of any type such as a ceiling cassette type, a ceiling suspension type as long as the air-conditioning apparatus 100 can blow heating air or cooling air to the interior space 7 directly or through a duct, for example. Further, the ai-conditioning apparatus 100 may take in outdoor air.

[0019] The heat medium relay unit 3 may be disposed near the outdoor unit 1. However, it should be noted that if the distance from the heat medium relay unit 3 to the indoor units 2 is excessively long, power to convey the heat medium is significantly large, and thus, the energy saving effect decreases.

[0020] Fig. 2 illustrates an example refrigerant circuit configuration of the air-conditioning apparatus 100 of Embodiment of the present invention.

[0021] As illustrated in Fig. 2, the outdoor unit 1 and the heat medium relay unit 3 are connected to each other by the refrigerant pipes 4 through an intermediate heat exchanger 15a and an intermediate heat exchanger 15b included in the heat medium relay unit 3. The heat medium relay unit 3 is connected to the indoor units 2 by the pipes 5. The refrigerant pipes 4 will be described in detail later.

[Outdoor Unit 1]

[0022] The outdoor unit 1 includes a compressor 10 that compresses refrigerant, a first refrigerant channel switching device 11 of, for example, a four-way valve, a heat source side heat exchanger 12 operating as an evaporator or a condenser, and an accumulator 19 that stores surplus refrigerant. These components are connected to the refrigerant pipes 4.

[0023] The outdoor unit 1 includes a first connection pipe 4a, a second connection pipe 4b, a check valve 13a, a check valve 13b, a check valve 13c, and a check valve 13d. The first connection pipe 4a, the second connection pipe 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d enable flow of heat source-side refrigerant into the heat medium relay unit 3 to be in one direction, irrespective of an operation required by the indoor units 2.

[0024] The compressor 10 sucks heat source-side refrigerant, compresses the heat source-side refrigerant into a high-temperature, high-pressure state, and may be, for example, an inverter compressor whose capacity can be controlled.

[0025] The first refrigerant channel switching device 11 switches the heat source-side refrigerant between a flow in a heating operation mode (a heating-only operation mode and a heating main operation mode) and a flow in a cooling operation mode (a cooling-only operation mode and a cooling main operation mode).

[0026] The heat source side heat exchanger 12 operates as an evaporator in the heating operation, operates as a condenser in the cooling operation, and exchanges heat between air supplied from an air-sending device such as a fan (not shown) and the heat source-side refrigerant.

[0027] The accumulator 19 is disposed at a suction side of the compressor 10. A second pressure sensor 37 and a third pressure sensor 38 that are pressure detectors are provided at the upstream and downstream sides of the compressor 10 so as to calculate the flow rate of refrigerant from the compressor 10 based on the rotation speed of the compressor 10 and values detected by the second pressure sensor 37 and the third pressure sensor 38.

[Indoor Unit 2]

[0028] Each of the indoor units 2 includes two use side heat exchangers 26. In the example illustrated in Fig. 2, two indoor units 2 are connected to the heat medium relay unit 3. The two indoor units 2 include an indoor unit 2a and an indoor unit 2b that are disposed in this order from the bottom in the drawing sheet. The number of the connected indoor units 2 is not limited to two. The indoor unit 2a is of an indoor air suction type that sucks indoor air, performs air-conditioning on the air, and blows out the air-conditioned air into the room. The indoor unit 2a includes a use side heat exchanger 26a and a use side heat exchanger 26b. The indoor unit 2b is of an outdoor air suction type that takes outdoor air, performs air-conditioning on the air, and blows out the air-conditioned air into the room. The indoor unit 2b includes a use side heat exchanger 26c and a use side heat exchanger 26d. The use side heat exchanger 26a and the use side heat exchanger 26c perform cooling or dehumidification. The use side heat exchanger 26b and the use side heat exchanger 26d perform heating or a reheat heating operation.

[0029] The use side heat exchangers 26 are connected to a heat medium flow control device 25 and a second heat medium channel switching device 23 of the heat medium relay unit 3 through the pipes 5. The use side heat exchangers 26 exchange heat between air supplied from an air-sending device such as a fan and a heat medium, and generates heating air or cooling air to be supplied to the interior space 7, while controlling humidity.

[0030] The indoor unit 2a of the indoor air suction type includes a sucked air temperature sensor 39 for detecting the temperature of indoor air sucked into the indoor unit 2a and a sucked air humidity sensor 40 for detecting the humidity of indoor air. The indoor unit 2b of the outdoor air suction type includes a blown air temperature sensor 41 for detecting the temperature of air blowing from the indoor unit 2b and a blown air humidity sensor 42 for detecting the humidity of air blowing from the indoor unit 2b.

[Heat Medium Relay Unit 3]

[0031] The heat medium relay unit 3 includes two intermediate heat exchangers 15a and 15b for exchanging heat between refrigerant and the heat medium, two expansion devices 16a and 16b for reducing the pressure of the refrigerant, two opening/closing devices 17a and 17b for opening and closing channels in the refrigerant pipes 4, two second refrigerant channel switching devices 18a and 18b for switching refrigerant channels, two pumps 21 a and 12b for circulating the heat medium, four first heat medium channel switching devices 22a to 22d connected to one side of the pipes 5, four second heat medium channel switching devices 23a to 23d connected to the other side of the pipes 5, and four heat medium flow control devices 25a to 25d connected to the side of the pipes 5 to which the first heat medium channel switching devices 22 are connected.

[0032] The two intermediate heat exchangers 15a and 15b (also collectively referred to as the intermediate heat exchangers 15) serve as condensers (radiators) or evaporators, exchange heat between the heat source-side refrigerant and the heat medium, and transfer cooling energy or heating energy generated in the outdoor unit 1 and stored in the heat source-side refrigerant to the heat medium. The intermediate heat exchanger 15a is disposed between the expansion device 16a and the second refrigerant channel switching device 18a in the refrigerant circuit A, and is used for cooling the heat medium in a cooling and heating mixed operation mode. The intermediate heat exchanger 15b is disposed between the expansion device 16b and the second refrigerant channel switching device 18b in the refrigerant circuit A, and is used for heating the heat medium in a cooling and heating mixed operation mode.

[0033] The two expansion devices 16a and 16b (also collectively referred to as the expansion devices 16) function as pressure reducing valves or expansion valves, and reduce the pressure of the heat source-side refrigerant so as to expand the heat source-side refrigerant. The expansion device 16a is disposed upstream of the intermediate heat exchanger 15a with regard to the flow of the heat source-side refrigerant in the cooling-only operation mode. The expansion device 16b is disposed upstream of the intermediate heat exchanger 15b with regard to the flow of the heat source-side refrigerant in the cooling-only operation mode. The two expansion devices 16 are preferably components having variable opening degrees, such as electronic expansion valves.

[0034] The opening/closing devices 17a and 17b are two-way valves, for example, and are used to open and close the refrigerant pipes 4.

[0035] The two second refrigerant channel switching devices 18a and 18b (also collectively referred to as the second refrigerant channel switching devices 18) are four-way valves, for example, and switch the flow of the heat source-side refrigerant in accordance with the operation mode. The second refrigerant channel switching device 18a is disposed downstream of the intermediate heat exchanger 15a with regard to the flow of the heat source-side refrigerant in the cooling-only operation mode. The second refrigerant channel switching device 18b is disposed downstream of the intermediate heat exchanger 15b with regard to the flow of the heat source-side refrigerant in the cooling-only operation mode.

[0036] The two pumps 21 a and 21 b (also collectively referred to as the pumps 21) cause a heat medium in the pipes 5 to circulate. The pump 21 a is disposed to the pipe 5 between the intermediate heat exchanger 15a and the second heat medium channel switching device 23. The pump 21 b is disposed to the pipe 5 between the intermediate heat exchanger 15b and the second heat medium channel switching device 23. The two pumps 21 can be pumps whose capacities can be controlled, for example. The pump 21 a may be disposed to the pipe 5 between the intermediate heat exchanger 15a and the first heat medium channel switching device 22. The pump 21 b may be disposed to the pipe 5 between the intermediate heat exchanger 15b and the first heat medium channel switching device 22.

[0037] The four first heat medium channel switching devices 22a to 22d (also collectively referred to as the first heat medium channel switching devices 22) are three-way valves, for example, and switch channels of the heat medium. The number (four in this example) of the first heat medium channel switching devices 22 is twice the number of the indoor units 2a and 2b. One of the three ports of each of the first heat medium channel switching devices 22 is connected to the intermediate heat exchanger 15a, another port is connected to the intermediate heat exchanger 15b, and the other port is connected to the heat medium flow control device 25. The first heat medium channel switching devices 22 are disposed at the outlet side of the heat medium channel of the use side heat exchanger 26a. The first heat medium channel switching devices are designated as 22a, 22b, 22c, and 22d from the bottom of the drawing sheet, in correspondence with the use side heat exchanger 26a and the use side heat exchanger 26b of the indoor unit 2a and the use side heat exchanger 26c and the use side heat exchanger 26d of the indoor unit 2b, respectively. Although the first heat medium channel switching devices 22a, 22b, 22c, and 22d are disposed in the heat medium relay unit 3 in the illustration, but a larger number of first heat medium channel switching devices may be provided.

[0038] The four second heat medium channel switching devices 23a to 23d (also collectively referred to as the second heat medium channel switching devices 23) are three-way valves, for example, and switch channels of the heat medium. The number (four in this example) of the second heat medium channel switching devices 23 is selected in accordance with the number of the indoor units 2. One of the three ports of each of the second heat medium channel switching devices 23 is connected to the intermediate heat exchanger 15a, another port is connected to the intermediate heat exchanger 15b, and the other port is connected to the use side heat exchanger (or the heat recovery heat exchanger) 26. The second heat medium channel switching devices 23 are disposed at the inlet side of the heat medium channels of the use side heat exchangers (or the heat recovery heat exchangers) 26. The second heat medium channel switching devices are designated as 23a, 23b, 23c, and 23d from the bottom of the drawing sheet, in correspondence with the use side heat exchanger 26a and the use side heat exchanger 26b of the indoor unit 2a and the use side heat exchanger 26c and the use side heat exchanger 26d of the indoor unit 2b. The second heat medium channel switching devices 23a, 23b, 23c, and 23d are provided in the heat medium relay unit 3, and a larger number of second heat medium channel switching devices may be provided.

[0039] The four heat medium flow control devices 25a to 25d (also collectively referred to as the heat medium flow control devices 25) are two-way valves whose opening areas can be controlled, for example, to adjust the flow rate of the heat medium flowing in the pipes 5. The number (four in this example) of the heat medium flow control devices 25 is selected in accordance with the number of the indoor units 2. The heat medium flow control devices 25 are connected to the use side heat exchangers 26 at one side and to the first heat medium channel switching device 22 at the other side. The heat medium flow control devices 25 are disposed at the outlet sides of the heat medium channels of the use side heat exchangers (or the heat recovery heat exchangers) 26. The heat medium flow control devices are designated as 25a, 25b, 25c, and 25d from the bottom of the drawing sheet, in correspondence with the use side heat exchanger 26a and the use side heat exchanger 26b of the indoor unit 2a and the use side heat exchanger 26c and the use side heat exchanger 26d of the indoor unit 2b. The heat medium flow control devices 25a, 25b, 25c, and 25d are provided in the heat medium relay unit 3, and a larger number of heat medium flow control devices may be provided.

[0040] The heat medium flow control devices 25 may be disposed at the inlet sides of the heat medium channels of the use side heat exchangers 26.

[0041] The heat medium relay unit 3 includes various detection means (e.g., two first temperature sensors 31 a and 31 b, four second temperature sensors 34a to 34d, four third temperature sensors 35a to 35d, a fourth temperature sensor 50, and a first pressure sensor 36). Information (e.g., temperature information and pressure information) detected by these detection means is sent to a controller that integrally controls the air-conditioning apparatus 100, and is used for controlling the driving frequency of the compressor 10, the rotation speeds of air-sending devices disposed near the heat source side heat exchangers 12 and the use side heat exchangers (or the heat recovery heat exchangers) 26, switching of the first refrigerant channel switching device 11, the driving frequencies of the pumps 21, switching of the second refrigerant channel switching device 18, and switching of the channel of the heat medium, for example.

[0042] The controller (not shown) is, for example, a microcomputer, and calculates an evaporating temperature, a condensing temperature, a saturation temperature, the degree of superheat, and the degree of subcooling, based on computation results of an arithmetic unit 52. Based on results of these calculations, the controller controls the opening degree of the expansion device 16, the rotation speed of the compressor 10, and the speed (including ON/OFF) of fans of the heat source side heat exchanger 12 and the use side heat exchangers 26 to maximize performance of the air-conditioning apparatus 100. In addition, based on detection information obtained by the detection means and an instruction from a remote controller, the controller controls the driving frequency of the compressor 10, the rotation speed (including ON/OFF) of the air-sending device, switching of the first refrigerant channel switching device 11, driving of the pumps 21, the opening degree of the expansion devices 16, opening/closing of the opening/closing devices 17, switching of the second refrigerant channel switching devices 18, switching of the first heat medium channel switching devices 22, switching of the second heat medium channel switching devices 23, and the opening degree of the heat medium flow control devices 25, for example. That is, the controller integrally controls the devices to perform operation modes described later. The outdoor unit 1 also includes a controller that controls an actuator of the outdoor unit 1 based on information transmitted from the controller of the heat medium relay unit 3. The controller of the heat medium relay unit 3 is different from the arithmetic unit 57 in this example, but may be identical to the arithmetic unit 57.

[0043] The two first temperature sensors 31 a and 31 b (also collectively referred to as the first temperature sensors 31) detect the temperature of the heat medium that has flowed from the intermediate heat exchangers 15, that is, the heat medium at the outlet of the intermediate heat exchangers 15, and are preferably thermistors, for example. The first temperature sensor 31 a is disposed to the pipe 5 at the inlet of the pump 21 a. The first temperature sensor 31 b is disposed to the pipe 5 at the inlet of the pump 21 b.

[0044] The four second temperature sensors 34a to 34d (also collectively referred to as the second temperature sensors 34) are disposed between the first heat medium channel switching devices 22 and the heat medium flow control devices 25, detect the temperature of the heat medium that has flowed from the use side heat exchangers 26, and are preferably thermistors, for example. The number (four in this example) of the second temperature sensors 34 is selected in accordance with the number of the indoor units 2. The second temperature sensors are designated as 34a, 34b, 34c, and 34d from the bottom of the drawing sheet, in correspondence with the use side heat exchanger 26a and the use side heat exchanger 26b of the indoor unit 2a and the use side heat exchanger 26c and the use side heat exchanger 26d of the indoor unit 2b.

[0045] The four third temperature sensors 35a to 35d (also collectively referred to as the third temperature sensors 35) are disposed at the inlet or outlet sides of the heat source-side refrigerant of the intermediate heat exchangers 15, detect the temperatures of heat source-side refrigerant flowing into the intermediate heat exchangers 15 or heat source-side refrigerant that has flowed from the intermediate heat exchangers 15, and are preferably thermistors, for example. The third temperature sensor 35a is disposed between the intermediate heat exchanger 15a and the second refrigerant channel switching device 18a. The third temperature sensor 35b is disposed between the intermediate heat exchanger 15a and the expansion device 16a. The third temperature sensor 35c is disposed between the intermediate heat exchanger 15b and the second refrigerant channel switching device 18b. The third temperature sensor 35d is disposed between the intermediate heat exchanger 15b and the expansion device 16b.

[0046] The fourth temperature sensor 50 is configured to obtain temperature information for use in calculating an evaporating temperature and a dewpoint temperature, and is disposed between the expansion device 16a and the expansion device 16b.

[0047] The pipes 5 that allow the heat medium to circulate are composed of pipes connected to the intermediate heat exchanger 15a and pipes connected to the intermediate heat exchanger 15b. The pipes 5 are branched into parts (four parts in this example) twice as many as the number of the indoor units 2 connected to the heat medium relay unit 3. The pipes 5 are connected to the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23. It is determined whether the heat medium from the intermediate heat exchanger 15a is caused to flow into the use side heat exchangers 26 or the heat medium from the intermediate heat exchanger 15b is caused to flow into the use side heat exchangers 26, by controlling the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23.

[Operation Mode]

[0048] In the air-conditioning apparatus 100, the refrigerant circuit A is constituted by connecting, through the refrigerant pipes 4, the compressor 10, the first refrigerant channel switching device 11, the heat source side heat exchanger 12, the opening/closing devices 17, the second refrigerant channel switching devices 18, the refrigerant channel of the intermediate heat exchanger 15a, the expansion devices 16, and the accumulator 19. In addition, the heat medium circuit B is constituted by connecting, through the pipes 5, the heat medium channel of the intermediate heat exchanger 15a, the pumps 21, the first heat medium channel switching devices 22, the heat medium flow control devices 25, the use side heat exchangers 26, and the second heat medium channel switching devices 23. That is, the intermediate heat exchangers 15 are individually connected to the use side heat exchangers 26 in parallel, and thereby, the heat medium circuit B has a plurality of systems. In this Embodiment, the use side heat exchangers 26 are divided into the use side heat exchangers 26a and 26c dedicated to cooling or dehumidification and the use side heat exchangers 26b and 26d for heating or reheat heating, depending on their purposes.

[0049] Thus, in the air-conditioning apparatus 100, the outdoor unit 1 and the heat medium relay unit 3 are connected to each other through the intermediate heat exchanger 15a and the intermediate heat exchanger 15b provided in the heat medium relay unit 3, and the heat medium relay unit 3 and the indoor units 2 are connected to each other through the intermediate heat exchanger 15a and the intermediate heat exchanger 15b. That is, in the air-conditioning apparatus 100, the intermediate heat exchanger 15a and the intermediate heat exchanger 15b exchange heat between the heat source-side refrigerant circulating in the refrigerant circuit A and the heat medium circulating in the heat medium circuit B.

[0050] Operation modes of the air-conditioning apparatus 100 will now be described. The air-conditioning apparatus 100 is configured such that the indoor units 2 can perform a cooling operation, a heating operation, or a dehumidification reheat operation, based on instructions from the indoor units 2. That is, in the air-conditioning apparatus 100, all the indoor units 2 are allowed to perform the same operation and also to perform different operations and to additionally perform a dehumidification reheat operation.

[0051] Operation modes of the air-conditioning apparatus 100 include: a cooling-only operation mode in which all the driven indoor units 2 perform a cooling operation; a heating-only operation mode in which all the driven indoor units 2 perform a heating operation; a cooling main operation mode as a cooling and heating mixed operation mode in which a cooling load is larger than a heating load; and a heating main operation mode as a cooling and heating mixed operation mode in which the heating load is larger than the cooling load. The air-conditioning apparatus 100 can also perform a dehumidification reheat operation (cooling main) in the same operating state as that in the cooling main operation mode and a dehumidification reheat operation (heating main) in the same operating state as that in the heating main operation mode. The operation modes will now be described in relation to the flow of the heat source-side refrigerant and the flow of the heat medium.

[Cooling-only Operation Mode]

[0052] Fig. 3 is a refrigerant circuit diagram showing flow of refrigerant in the cooling-only operation mode of the air-conditioning apparatus 100 illustrated in Fig. 2. Referring to Fig. 3, the cooling-only operation mode in a case where the indoor unit 2a and the indoor unit 2b generate cooling loads will be described as an example. In Fig. 3, pipes in which refrigerant (heat source-side refrigerant and a heat medium) flows are indicated by bold lines. In addition, in Fig. 3, the flow direction of the heat source-side refrigerant is indicated by solid arrows, and the flow direction of the heat medium is indicated by dashed arrows.

[0053] In the case of the cooling-only operation mode shown in Fig. 3, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven, the heat medium flow control devices 25a and 25c are opened, and the heat medium flow control devices 25b and 25d are closed so that the heat medium circulates between each of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b and the use side heat exchangers 26a and 26c.

[0054] First, flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0055] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12 through the first refrigerant channel switching device 11. The refrigerant then becomes high-temperature liquid refrigerant while transferring heat to the outdoor air via the heat source side heat exchanger 12. The high-pressure refrigerant from the heat source side heat exchanger 12 flows out of the outdoor unit 1 through the check valve 13a and enters the heat medium relay unit 3 through the refrigerant pipes 4. The high-pressure refrigerant that has entered the heat medium relay unit 3 branches after passing through the opening/closing device 17a, is expanded in the expansion device 16a and the expansion device 16b, and becomes low-temperature low-pressure two-phase refrigerant. The opening/closing device 17b is closed.

[0056] The two-phase refrigerant flows into each of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b, each serving as an evaporator, and receives heat from the heat medium circulating in the heat medium circuit B, and thereby, becomes low-temperature low-pressure gas refrigerant while cooling the heat medium. The gas refrigerant that has flowed out of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b flows out of the heat medium relay unit 3 through the second refrigerant channel switching device 18a and the second refrigerant channel switching device 18b, and flows into the outdoor unit 1 again through the refrigerant pipes 4. The refrigerant that has flowed into the outdoor unit 1 passes through the check valve 13d and is sucked into the compressor 10 again through the first refrigerant channel switching device 11 and the accumulator 19.

[0057] At this time, the second refrigerant channel switching device 18a and the second refrigerant channel switching device 18b communicate with low-pressure pipes. The opening degree of the expansion device 16a is controlled such that superheat (the degree of superheating) obtained as a difference between the temperature detected by the third temperature sensor 35a and the temperature detected by the third temperature sensor 35b is constant. Similarly, the opening degree of the expansion device 16b is controlled such that superheat obtained as a difference between the temperature detected by the third temperature sensor 35c and the temperature detected by the third temperature sensor 35d is constant.

[0058] A flow of the heat medium in the heat medium circuit B will now be described.

[0059] In the cooling-only operation mode, cooling energy of the heat source-side refrigerant is transferred to the heat medium in both of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b, and the cooled heat medium is caused to move in the pipes 5 by the pump 21 a and the pump 21 b. The heat medium that has been pressurized by the pump 21 a and the pump 21 b and flowed out enters the use side heat exchanger 26a and the use side heat exchanger 26c through the second heat medium channel switching device 23a and the second heat medium channel switching device 23c. The heat medium receives heat from the indoor air in the use side heat exchanger 26a and the use side heat exchanger 26c, thereby cooling the interior space 7.

[0060] Thereafter, the heat medium flows out of the use side heat exchanger 26a and the use side heat exchanger 26c, and enters the heat medium flow control device 25a and the heat medium flow control device 25c. At this time, action of the heat medium flow control device 25a and the heat medium flow control device 25c controls the flow rate of the heat medium to a flow rate necessary for generating an air-conditioning load required in the room, and the resulting heat medium flows into the use side heat exchanger 26a and the use side heat exchanger 26c. The heat medium that has flowed out of the heat medium flow control device 25a and the heat medium flow control device 25c flows into the intermediate heat exchanger 15a and the intermediate heat exchanger 15b through the first heat medium channel switching device 22a and the first heat medium channel switching device 22c, and is sucked into the pump 21 a and the pump 21 b again.

[0061] In the pipes 5 of the use side heat exchangers 26a and 26c, the heat medium flows in the direction from the second heat medium channel switching devices 23 to the first heat medium channel switching devices 22 by way of the heat medium flow control devices 25. The air-conditioning load required in the interior space 7 can be obtained by controlling the temperature detected by the first temperature sensor 31 a or the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34a or 34c as a target value. As the outlet temperature of the intermediate heat exchangers 15, any one of the temperature of the first temperature sensor 31 a or the temperature of the first temperature sensor 31 b may be used, or an average temperature of these temperatures may be used. At this time, the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23 have intermediate opening degrees so as to obtain channels allowing the heat medium to flow toward both the intermediate heat exchanger 15a and the intermediate heat exchanger 15b.

[0062] In performing an operation in the cooling-only operation mode, the heat medium does not need to flow into the use side heat exchangers 26 (including a thermo-off) without thermal loads, and thus, the channel is closed by the heat medium flow control devices 25 so that the heat medium does not flow into the use side heat exchangers 26. In Fig. 3, since the use side heat exchangers 26a and 26c have thermal loads, the heat medium flows therein. On the other hand, since the use side heat exchangers 26b and 26d dedicated to heating or reheat heating do not operate, the corresponding heat medium flow control devices 25b and 25d are fully closed. In a case where the use side heat exchangers 26b and 26d are used for cooling, the heat medium flow control devices 25 are opened so that the heat medium circulates therein.

[0063] The refrigerant in the fourth temperature sensor 50 is liquid refrigerant, and based on temperature information of this refrigerant, the arithmetic unit 52 calculates a liquid inlet enthalpy. The third temperature sensor 35d detects the temperature of the low-pressure two-phase state, and based on this temperature information, the arithmetic unit 52 calculates a saturated liquid enthalpy and a saturated gas enthalpy. Based on the information, an evaporating temperature and a dewpoint temperature are obtained with a method described later.

[Heating-only Operation Mode]

[0064] Fig. 4 is a refrigerant circuit diagram showing flow of refrigerant in the heating-only operation mode of the air-conditioning apparatus 100 illustrated in Fig. 2. Referring to Fig. 4, the heating-only operation mode in a case where the indoor unit 2a and the indoor unit 2b generate heating loads will be described as an example. In Fig. 4, pipes in which refrigerant flows are indicated by bold lines. In addition, in Fig. 4, the flow direction of the heat source-side refrigerant is indicated by solid arrows, and the flow direction of the heat medium is indicated by dashed arrows.

[0065] In the case of the heating-only operation mode shown in Fig. 4, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 flows into the heat medium relay unit 3 without passing through the heat source side heat exchanger 12. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven, the heat medium flow control devices 25b and 25d are opened, and the heat medium flow control devices 25a and 25c are closed so that the heat medium circulates between each of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b and the use side heat exchangers 26b and 26d.

[0066] First, a flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0067] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 flows out of the outdoor unit 1 through the first refrigerant channel switching device 11 and the check valve 13b. The high-temperature high-pressure gas refrigerant that has flowed out of the outdoor unit 1 enters the heat medium relay unit 3 through the refrigerant pipes 4. The high-temperature high-pressure gas refrigerant that has entered the heat medium relay unit 3 branches, and flows into the intermediate heat exchanger 15a and the intermediate heat exchanger 15b through the second refrigerant channel switching device 18a and the second refrigerant channel switching device 18b, respectively.

[0068] The high-temperature high-pressure gas refrigerant that has flowed into the intermediate heat exchanger 15a and the intermediate heat exchanger 15b becomes high-temperature liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit B. The liquid refrigerant that has flowed out of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b is expanded in the expansion device 16a and the expansion device 16b, and becomes low-temperature low-pressure two-phase refrigerant. This two-phase refrigerant flows out of the heat medium relay unit 3 through the opening/closing device 17b, and enters the outdoor unit 1 again through the refrigerant pipes 4. The opening/closing device 17a is closed.

[0069] The refrigerant that has entered the outdoor unit 1 passes through the check valve 13c and flows into the heat source side heat exchanger 12 serving as an evaporator. The refrigerant that has entered the heat source side heat exchanger 12 then absorbs heat from the outdoor air in the heat source side heat exchanger 12, and becomes low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant that has flowed out of the heat source side heat exchanger 12 is sucked into the compressor 10 again through the first refrigerant channel switching device 11 and the accumulator 19.

[0070] At this time, the second refrigerant channel switching device 18a and the second refrigerant channel switching device 18b communicate with high-pressure pipes. The opening degree of the expansion device 16a is controlled such that subcool (the degree of subcooling) obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35b is constant. Similarly, the opening degree of the expansion device 16b is controlled such that subcool obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35d is constant. In a case where the temperature at an intermediate location of the intermediate heat exchangers 15 can be measured, the temperature at this intermediate location may be used instead of the value obtained by the first pressure sensor 36. In this case, the system can be configured at low cost.

[0071] A flow of the heat medium in the heat medium circuit B will now be described.

[0072] In the heating-only operation mode, heating energy of the heat source-side refrigerant is transferred to the heat medium in both of the intermediate heat exchanger 15a and the intermediate heat exchanger 15b, and the heated heat medium is caused to move in the pipes 5 by the pump 21 a and the pump 21 b. The heat medium that has been pressurized by the pump 21 a and the pump 21 b and flowed out enters the use side heat exchanger 26b and the use side heat exchanger 26d through the second heat medium channel switching device 23b and the second heat medium channel switching device 23d. The heat medium transfers heat to the indoor air in the use side heat exchanger 26b and the use side heat exchanger 26d, thereby heating the interior space 7.

[0073] Thereafter, the heat medium flows out of the use side heat exchanger 26b and the use side heat exchanger 26d, and flows into the heat medium flow control device 25b and the heat medium flow control device 25d. At this time, action of the heat medium flow control device 25b and the heat medium flow control device 25d controls the flow rate of the heat medium at a flow rate necessary for generating an air-conditioning load required in the room, and the resulting heat medium flows into the use side heat exchanger 26b and the use side heat exchanger 26d. The heat medium that has flowed out of the heat medium flow control device 25b and the heat medium flow control device 25d flows into the intermediate heat exchanger 15a and the intermediate heat exchanger 15b through the first heat medium channel switching device 22b and the first heat medium channel switching device 22d, and is sucked into the pump 21 a and the pump 21 b again.

[0074] In pipes 5 of the use side heat exchangers 26, the heat medium flows in the direction from the second heat medium channel switching device 23 to the first heat medium channel switching device 22 by way of the heat medium flow control device 25. The air-conditioning load required in the interior space 7 can be obtained by controlling the temperature detected by the first temperature sensor 31 a or the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34b or 34d as a target value. As the outlet temperature of the intermediate heat exchangers 15, any one of the temperature of the first temperature sensor 31 a or the temperature of the first temperature sensor 31 b may be used, or an average temperature of these temperatures may be used.

[0075] At this time, the first heat medium channel switching device 22 and the second heat medium channel switching device 23 have intermediate opening degrees so as to obtain channels allowing the heat medium to flow toward both the intermediate heat exchanger 15a and the intermediate heat exchanger 15b. Although the use side heat exchanger 26 should be originally controlled based on the temperature difference between the inlet and outlet thereof, the heat medium temperature at the inlet of the use side heat exchangers 26 is substantially the same as the temperature detected by the first temperature sensor 31 b, and thus, the use of the first temperature sensor 31 b can reduce the number of temperature sensors. As a result, the system can be configured at low cost.

[0076] In performing an operation in the heating-only operation mode, the heat medium does not need to flow into the use side heat exchangers 26 (including a thermo-off) without thermal loads, and thus, channels are closed by the heat medium flow control devices 25 so that the heat medium does not flow into the use side heat exchangers 26. In Fig. 4, since the use side heat exchangers 26b and 26d have thermal loads, the heat medium flows therein. On the other hand, since the use side heat exchangers 26a and 26c dedicated to cooling or dehumidification do not operate, the corresponding heat medium flow control devices 25a and 25c are fully closed. In a case where the use side heat exchangers 26a and 26c dedicated to cooling or dehumidification are to be used for heating, the heat medium flow control devices 25 are opened so that the heat medium circulates therein.

[Cooling Main Operation Mode]

[0077] Fig. 5 is a refrigerant circuit diagram showing flow of refrigerant in the cooling main operation mode of the air-conditioning apparatus 100 illustrated in Fig. 2. Referring to Fig. 5, the cooling main operation mode in a case where the indoor unit 2b generates a heating load and the indoor unit 2a generates a cooling load will be described as an example. In Fig. 5, pipes indicated by bold lines are pipes in which refrigerant (heat source-side refrigerant and a heat medium) circulates. In addition, in Fig. 5, the direction of flow of the heat source-side refrigerant is indicated by solid arrows, and the direction of flow of the heat medium is indicated by dashed arrows.

[0078] In the case of the cooling main operation mode shown in Fig. 5, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven and the heat medium flow control devices 25a and 25d are opened so that the heat medium circulates between the intermediate heat exchanger 15a and the use side heat exchanger 26a and between the intermediate heat exchanger 15b and the use side heat exchanger 26d.

[0079] First, a flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0080] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12 through the first refrigerant channel switching device 11. The refrigerant then becomes liquid refrigerant while transferring heat to the outdoor air in the heat source side heat exchanger

12. The refrigerant from the heat source side heat exchanger 12 flows out of the outdoor unit 1 and enters the heat medium relay unit 3 through the check valve 13a and the refrigerant pipes 4. The refrigerant that has entered the heat medium relay unit 3 passes through the second refrigerant channel switching device 18b and flows into the intermediate heat exchanger 15b serving as a condenser.

[0081] The refrigerant that has flowed into the intermediate heat exchanger 15b becomes refrigerant having a reduced temperature while transferring heat to the heat medium circulating in the heat medium circuit B. The refrigerant that has flowed out of the intermediate heat exchanger 15b is expanded in the expansion device 16b and becomes low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the intermediate heat exchanger 15a serving as an evaporator through the expansion device 16a. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 15a receives heat from the heat medium circulating in the heat medium circuit B, and becomes low-pressure gas refrigerant while cooling the heat medium. The gas refrigerant flows out of the intermediate heat exchanger 15a, flows out of the heat medium relay unit 3 through the second refrigerant channel switching device 18a, and enters the outdoor unit 1 again through the refrigerant pipes 4. The refrigerant that has entered the outdoor unit 1 is sucked into the compressor 10 again through the check valve 13d, the first refrigerant channel switching device 11, and the accumulator 19.

[0082] At this time, the second refrigerant channel switching device 18a communicates with a low-pressure pipe, whereas the second refrigerant channel switching device 18b communicates with a high-pressure side pipe. The opening degree of the expansion device 16b is controlled such that superheat obtained as a difference between the temperature detected by the third temperature sensor 35a and the temperature detected by the third temperature sensor 35b is constant. The expansion device 16a is fully open, and the opening/closing devices 17a and 17b are closed. The opening degree of the expansion device 16b may be controlled such that subcool obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35d is constant. The expansion device 16b may be fully open so that the expansion device 16a controls the superheat or the subcool.

[0083] A flow of the heat medium in the heat medium circuit B will now be described.

[0084] In the cooling main operation mode, heating energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15b, and the heated heat medium is caused to move in the pipes 5 by the pump 21 b. In addition, in the cooling main operation mode, cooling energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15a, and the cooled heat medium is caused to move in the pipes 5 by the pump 21 a.

[0085] In the use side heat exchanger 26d, the heat medium transfers heat to the indoor air, thereby heating the interior space 7. In the use side heat exchanger 26a, the heat medium absorbs heat from the indoor air, thereby cooling the interior space 7. At this time, action of the heat medium flow control devices 25a and 25d controls the flow rate of the heat medium to a flow rate necessary for generating an air-conditioning load required in the room, and the resulting heat medium flows into the use side heat exchangers 26a and 26d. The heat medium that has passed through the use side heat exchanger 26d and has its temperature slightly reduced, flows into the intermediate heat exchanger 15b through the heat medium flow control device 25d and the first heat medium channel switching device 22d, and is sucked into the pump 21 b again. The heat medium that has passed through the use side heat exchanger 26a and has its temperature slightly increased, flows into the intermediate heat exchanger 15a through the heat medium flow control device 25a and the first heat medium channel switching device 22a, and is sucked into the pump 21 a again.

[0086] Meantime, the hot heat medium and the cold heat medium are not mixed together because of the action of the first heat medium channel switching device 22 and the second heat medium channel switching device 23, and are individually introduced into the use side heat exchangers 26a and 26d having heating loads and cooling loads. In the pipes 5 of the use side heat exchangers 26a and 26d, the heat medium flows in the direction from the second heat medium channel switching devices 23 to the first heat medium channel switching devices 22 by way of the heat medium flow control devices 25 in both the heating side and the cooling side. The air-conditioning load required in the interior space 7 can be supplied by controlling the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34 in the heating side and the difference between the temperature detected by the second temperature sensor 34 and the temperature detected by the first temperature sensor 31 a in the cooling side, as target values.

[0087] In performing an operation in the cooling main operation mode, the heat medium does not need to flow into the use side heat exchangers 26 (including a thermo-off) without thermal loads, and thus, the channels are closed by the heat medium flow control devices 25 so that the heat medium does not flow into the use side heat exchangers 26. In Fig. 5, the heat medium flow control devices 25 corresponding to the use side heat exchangers 26b and 26c with no thermal loads are closed.

[Heating Main Operation Mode]

[0088] Fig. 6 is a refrigerant circuit diagram showing flow of refrigerant in the heating main operation mode of the air-conditioning apparatus 100 illustrated in Fig. 2.

Referring to Fig. 6, the heating main operation mode in a case where the indoor unit 2b generates a heating load and the indoor unit 2a generates a cooling load will be described as an example. In Fig. 6, pipes indicated by bold lines are pipes in which refrigerant (heat source-side refrigerant and a heat medium) circulates. In addition, in Fig. 6, the direction of flow of the heat source-side refrigerant is indicated by solid arrows, and the direction of flow of the heat medium is indicated by dashed arrows.

[0089] In the case of the heating main operation mode illustrated in Fig. 6, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 does not pass through the heat source side heat exchanger 12 and flows into the heat medium relay unit 3. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven and the heat medium flow control devices 25a and 25d are opened so that the heat medium circulates between the intermediate heat exchanger 15a and the use side heat exchanger 26a and between the intermediate heat exchanger 15b and the use side heat exchanger 26d.

[0090] First, a flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0091] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant from the compressor 10 flows out of the outdoor unit 1 through the first refrigerant channel switching device 11 and the check valve 13b. The high-temperature high-pressure gas refrigerant that has flowed out of the outdoor unit 1 enters the heat medium relay unit 3 through the refrigerant pipes 4. The high-temperature high-pressure gas refrigerant that has entered the heat medium relay unit 3 passes through the second refrigerant channel switching device 18b and flows into the intermediate heat exchanger 15b serving as a condenser.

[0092] The gas refrigerant that has flowed into the intermediate heat exchanger 15b becomes liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit B. The refrigerant that has flowed out of the intermediate heat exchanger 15b is expanded in the expansion device 16b and becomes low-pressure two-phase refrigerant. This low-pressure two-phase refrigerant passes through the expansion device 16a and flows into the intermediate heat exchanger 15a serving as an evaporator. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 15a evaporates by absorbing heat from the heat medium circulating in the heat medium circuit B, thereby cooling the heat medium. This low-pressure two-phase refrigerant flows out of the intermediate heat exchanger 15a, flows out of the heat medium relay unit 3 through the second refrigerant channel switching device 18a, and flows into the outdoor unit 1 again.

[0093] The refrigerant that has flowed into the outdoor unit 1 passes through the check valve 13c and enters the heat source side heat exchanger 12 serving as an evaporator. The refrigerant that has flowed into the heat source side heat exchanger 12 then absorbs heat from the outdoor air in the heat source side heat exchanger 12, and becomes low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant that has flowed out of the heat source side heat exchanger 12 is sucked into the compressor 10 again through the first refrigerant channel switching device 11 and the accumulator 19.

[0094] At this time, the second refrigerant channel switching device 18a communicates with a low-pressure side pipe, whereas the second refrigerant channel switching device 18b communicates with a high-pressure side pipe. The opening degree of the expansion device 16b is controlled such that subcool obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35b is constant. The expansion device 16a is fully open, and the opening/closing devices 17a and 17b are closed. The subcool may be controlled by the expansion device 16a with the expansion device 16b being fully open.

[0095] A flow of the heat medium in the heat medium circuit B will now be described.

[0096] In the heating main operation mode, heating energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15b, and the heated heat medium is caused to move in the pipes 5 by the pump 21 b. In the heating main operation mode, cooling energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15a, and the cooled heat medium is caused to move in the pipes 5 by the pump 21a. The heat medium that has been pressurized by the pump 21 a and the pump 21 b and flowed out enters the use side heat exchangers 26a and 26d through the second heat medium channel switching device 23a and the second heat medium channel switching device 23d.

[0097] In the use side heat exchanger 26a, the heat medium absorbs heat from the indoor air, thereby cooling the interior space 7. In the use side heat exchanger 26d, the heat medium transfers heat to the indoor air, thereby heating the interior space 7. At this time, action of the heat medium flow control device 25a and the heat medium flow control device 25d controls the flow rate of the heat medium to a flow rate necessary for generating an air-conditioning load required in the room, and the resulting heat medium flows into the use side heat exchangers 26a and 26d. The heat medium that has passed through the use side heat exchanger 26a and has its temperature slightly increased, flows into the intermediate heat exchanger 15a through the heat medium flow control device 25a and the first heat medium channel switching device 22a, and is sucked into the pump 21 a again. The heat medium that has passed through the use side heat exchanger 26d and has its temperature slightly reduced, flows into the intermediate heat exchanger 15b through the heat medium flow control device 25d and the first heat medium channel switching device 22d, and is sucked into the pump 21 b again.

[0098] Meantime, the hot heat medium and the cold heat medium are not mixed together because of the action of the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23, and individually flow into the use side heat exchanger 26a having a heating load and the use side heat exchanger 26d having a cooling load. In the pipes 5 of the use side heat exchangers 26a and 26d, the heat medium flows in the direction from the second heat medium channel switching devices 23 to the first heat medium channel switching devices 22 by way of the heat medium flow control devices 25 in both the heating side and the cooling side. The air-conditioning load required in the interior space 7 can be supplied by controlling the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34 in the heating side and the difference between the temperature detected by the second temperature sensor 34 and the temperature detected by the first temperature sensor 31 a in the cooling side, as target values.

[0099] In performing an operation in the heating main operation mode, the heat medium does not need to flow into the use side heat exchangers 26 (including a thermo-off) without thermal loads, and thus, the channels are closed by the heat medium flow control devices 25 so that the heat medium does not flows into the use side heat exchangers 26. In Fig. 6, for the use side heat exchangers 26b and 26c having no thermal loads, all the corresponding heat medium flow control devices 25 are closed.

[Reheat Dehumidification Operation (Cooling Main) Mode]

[0100] Fig. 7 is a refrigerant circuit diagram showing flow of refrigerant in the reheat dehumidification operation (cooling main) mode of the air-conditioning apparatus 100 illustrated in Fig. 2. Referring to Fig. 7, the reheat dehumidification operation (cooling main) mode in a case where the indoor unit 2a adjusts an indoor humidity and an indoor temperature and the indoor unit 2b adjusts an outlet humidity and an outlet temperature will be described as an example. In Fig. 7, pipes indicated by bold lines are pipes in which refrigerant (heat source-side refrigerant and a heat medium) circulates. In addition, in Fig. 7, the flow direction of the heat source-side refrigerant is indicated by solid arrows, and the flow direction of the heat medium is indicated by dashed arrows.

[0101] In the case of the reheat dehumidification operation (cooling main) mode illustrated in Fig. 7, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven, and the heat medium flow control devices 25a to 25d are opened.

[0102] The first heat medium channel switching devices 22a and 22c and the second heat medium channel switching devices 23a and 23c are switched to channels to the intermediate heat exchanger 15a so that the heat medium circulates between the intermediate heat exchanger 15a and the use side heat exchangers 26a and 26c. The first heat medium channel switching devices 22b and 22d and the second heat medium channel switching devices 23b and 23d are switched to channels to the intermediate heat exchanger 15b so that the heat medium circulates between the intermediate heat exchanger 15b and the use side heat exchangers 26b and 26d.

[0103] First, a flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0104] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12 through the first refrigerant channel switching device 11. Then, the refrigerant becomes liquid refrigerant while transferring heat to the outdoor air in the heat source side heat exchanger 12. The refrigerant that has flowed out of the heat source side heat exchanger 12 flows out of the outdoor unit 1 and enters the heat medium relay unit 3 through the check valve 13a and the refrigerant pipes 4. The refrigerant that has entered the heat medium relay unit 3 passes through the second refrigerant channel switching device 18b and flows into the intermediate heat exchanger 15b serving as a condenser.

[0105] The refrigerant that has flowed into the intermediate heat exchanger 15b becomes refrigerant with a reduced temperature while transferring heat to the heat medium circulating in the heat medium circuit B. The refrigerant that has flowed out of the intermediate heat exchanger 15b is expanded in the expansion device 16b, and becomes low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant passes through the expansion device 16a and flows into the intermediate heat exchanger 15a serving as an evaporator. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 15a receives heat from the heat medium circulating in the heat medium circuit B, and thereby, becomes low-pressure gas refrigerant while cooling the heat medium. This gas refrigerant flows out of the intermediate heat exchanger 15a and then out of the heat medium relay unit 3 through the second refrigerant channel switching device 18a, and enters the outdoor unit 1 again through the refrigerant pipes 4. The refrigerant that has entered the outdoor unit 1 is sucked into the compressor 10 again through the check valve 13d, the first refrigerant channel switching device 11, and the accumulator 19.

[0106] At this time, the second refrigerant channel switching device 18a communicates with a low-pressure pipe, whereas the second refrigerant channel switching device 18b communicates with a high-pressure side pipe. The expansion device 16a is fully open, and the opening/closing devices 17a and 17b are closed.

[0107] The opening degree of the expansion device 16b is controlled based on a target condensing temperature and a target evaporating temperature described later. Alternatively, the opening degree of the expansion device 16b may be controlled such that a superheat (SH) obtained as a difference between the temperature detected by the third temperature sensor 35a and the temperature detected by the third temperature sensor 35b is equal to a target value described later. The opening degree of the expansion device 16b is controlled such that a subcool (SC) obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35d is equal to a target value. This control will be described in detail later. The superheat or subcool may be controlled by the expansion device 16a with the expansion device 16b being fully open.

[0108] A flow of the heat medium in the heat medium circuit B will now be described.

[0109] In the reheat dehumidification operation (cooling main) mode, heating energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15b, and the heated heat medium is caused to move in the pipes 5 by the pump 21 b. In the reheat dehumidification operation (cooling main) mode, cooling energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15a, and the cooled heat medium is caused to move in the pipes 5 by the pump 21 a.

[0110] In the use side heat exchanger 26a, the heat medium receives heat from the indoor air, thereby reducing the humidity and temperature in the room. In the use side heat exchanger 26b, the heat medium transfers heat to the indoor air, thereby adjusting the room temperature of the interior space 7 reduced by the use side heat exchanger 26a. As a result, the temperature and humidity of the indoor air are adjusted.

[0111] In the use side heat exchanger 26c, the heat medium receives heat from the outdoor air, thereby reducing the humidity and temperature of the intake air. In the use side heat exchanger 26d, the heat medium transfers heat to the indoor air, thereby adjusting the intake outdoor air reduced in the use side heat exchanger 26c so as to adjust the outlet temperature. As a result, the temperature and humidity of air blown from the indoor unit 2b are adjusted.

[0112] At this time, action of the heat medium flow control devices 25a to 25d controls the flow rate of the heat medium to a flow rate necessary for generating an air-conditioning load or dehumidifying capacity required in the room, and the resulting heat medium flows into the use side heat exchangers 26a to 26d. This control will be described in detail later.

[0113] The heat medium that has passed through the use side heat exchangers 26b and 26d and has its temperature slightly reduced, flows into the intermediate heat exchanger 15b through the heat medium flow control devices 25b and 25d and the first heat medium channel switching devices 22b and 22d, and is sucked into the pump 21 b again. The heat medium that has passed through the use side heat exchangers 26a and 26c and has its temperature slightly increased, flows into the intermediate heat exchanger 15a through the heat medium flow control devices 25a and 25c and the first heat medium channel switching devices 22a and 22c, and is sucked into the pump 21 a again.

[0114] Meantime, the hot heat medium and the cold heat medium are not mixed together because of the action of the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23, and are individually introduced into the use side heat exchangers 26a to 26d having heating loads (reheat loads) and cooling loads (dehumidification loads). In the pipes 5 of the use side heat exchangers 26a to 26d, the heat medium flows in the direction from the second heat medium channel switching devices 23 to the first heat medium channel switching devices 22 by way of the heat medium flow control devices 25 in both the heating side (reheat side) and the cooling side (dehumidification side).

[0115] The air-conditioning load (the dehumidification load and the reheat load) required in the interior space 7 can be supplied by controlling the heat medium flow control devices 25 such that the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34 is equal to a target temperature difference ΔTm in the heating side. In the cooling side, the air-conditioning load can be supplied by controlling the heat medium flow control devices 25 such that the difference between the temperature detected by the second temperature sensor 34 and the temperature detected by the first temperature sensor 31 a is equal to a target temperature difference ΔTm. These controls will be described in detail later.

[0116] In Fig. 7, since there are no use side heat exchangers 26 without thermal loads, all the corresponding heat medium flow control devices 25 are open. However, the present invention is not limited to this example. In performing an operation in the reheat dehumidification operation (cooling main) mode, the heat medium does not need to flow into the indoor units 2 (including a thermo-off) with no thermal loads. Thus, the channels are closed by the heat medium flow control devices 25 so that the heat medium does not flow into the use side heat exchangers 26.

[Reheat Dehumidification Operation (Heating Main) Mode]

[0117] Fig. 8 is a refrigerant circuit diagram showing flow of refrigerant in the reheat dehumidification operation (heating main) of the air-conditioning apparatus 100 illustrated in Fig. 2. Referring to Fig. 8, the reheat dehumidification operation (heating main) mode in a case where the indoor unit 2a adjusts an indoor humidity and an indoor temperature and the indoor unit 2b adjusts an outlet humidity and an outlet temperature. In Fig. 8, pipes indicated by bold lines are pipes in which refrigerant (heat source-side refrigerant and a heat medium) circulates. In addition, in Fig. 8, the flow direction of the heat source-side refrigerant is indicated by solid arrows, and the flow direction of the heat medium is indicated by dashed arrows.

[0118] In the case of the reheat dehumidification operation (heating main) mode illustrated in Fig. 8, in the outdoor unit 1, the first refrigerant channel switching device 11 is switched such that the heat source-side refrigerant discharged from the compressor 10 flows into the heat source side heat exchanger 12. In the heat medium relay unit 3, the pump 21 a and the pump 21 b are driven, and the heat medium flow control devices 25a to 25d are opened.

[0119] The first heat medium channel switching devices 22a and 22c and the second heat medium channel switching devices 23a and 23c are switched to channels to the intermediate heat exchanger 15a so that the heat medium circulates between the intermediate heat exchanger 15a and the use side heat exchangers 26a and 26c. The first heat medium channel switching devices 22b and 22d and the second heat medium channel switching devices 23b and 23d are switched to channels to the intermediate heat exchanger 15b so that the heat medium circulates between the intermediate heat exchanger 15b and the use side heat exchangers 26b and 26d.

[0120] First, a flow of the heat source-side refrigerant in the refrigerant circuit A will be described.

[0121] Low-temperature low-pressure refrigerant is compressed by the compressor 10, becomes high-temperature high-pressure gas refrigerant, and is discharged. The high-temperature high-pressure gas refrigerant discharged from the compressor 10 flows out of the outdoor unit 1 through the first refrigerant channel switching device 11 and the check valve 13b. The high-temperature high-pressure gas refrigerant that has flowed out of the outdoor unit 1 flows into the heat medium relay unit 3 through the refrigerant pipes 4. The high-temperature high-pressure gas refrigerant that has flowed into the heat medium relay unit 3 passes through the second refrigerant channel switching device 18b and flows into the intermediate heat exchanger 15b serving as a condenser.

[0122] The gas refrigerant that has flowed into the intermediate heat exchanger 15b becomes liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit B. The refrigerant that has flowed out of the intermediate heat exchanger 15b is expanded in the expansion device 16b and becomes low-pressure two-phase refrigerant. This low-pressure two-phase refrigerant passes through the expansion device 16a and flows into the intermediate heat exchanger 15a serving as an evaporator. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 15a absorbs heat from the heat medium circulating in the heat medium circuit B to evaporate, thereby cooling the heat medium. This low-pressure two-phase refrigerant flows out of the intermediate heat exchanger 15a then out of the heat medium relay unit 3 through the second refrigerant channel switching device 18a, and enters the outdoor unit 1 again.

[0123] The refrigerant that has flowed into the outdoor unit 1 passes through the check valve 13c and flows into the heat source side heat exchanger 12 serving as an evaporator. The refrigerant that has flowed into the heat source side heat exchanger 12 then absorbs heat from the outdoor air in the heat source side heat exchanger 12, and becomes low-temperature low-pressure gas refrigerant. The low-temperature low-pressure gas refrigerant that has flowed out of the heat source side heat exchanger 12 is sucked into the compressor 10 again through the first refrigerant channel switching device 11 and the accumulator 19.

[0124] At this time, the second refrigerant channel switching device 18a communicates with a low-pressure side pipe, whereas the second refrigerant channel switching device 18b communicates with a high-pressure side pipe. The expansion device 16a is fully open, and the opening/closing devices 17a and 17b are closed.

[0125] The opening degree of the expansion device 16b is controlled based on a target condensing temperature and a target evaporating temperature described later. Alternatively, the opening degree of the expansion device 16b may be controlled such that a superheat (SH) obtained as a difference between the temperature detected by the third temperature sensor 35a and the temperature detected by the third temperature sensor 35b is equal to a target value described later. The opening degree of the expansion device 16b is controlled such that a subcool (SC) obtained as a difference between a value converted into a saturation temperature from the pressure detected by the first pressure sensor 36 and the temperature detected by the third temperature sensor 35d is equal to a target value. This control will be described in detail later. The superheat or subcool may be controlled by the expansion device 16a with the expansion device 16b being fully open.

[0126] A flow of the heat medium in the heat medium circuit B will now be described.

[0127] In the reheat dehumidification operation (heating main) mode, heating energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15b, and the heated heat medium is caused to move in the pipes 5 by the pump 21 b. In the reheat dehumidification operation (cooling main) mode, cooling energy of the heat source-side refrigerant is transferred to the heat medium in the intermediate heat exchanger 15a, and the cooled heat medium is caused to move in the pipes 5 by the pump 21 a.

[0128] In the use side heat exchanger 26a, the heat medium absorbs heat from the indoor air, thereby reducing the humidity and temperature in the room. In the use side heat exchanger 26b, the heat medium transfers heat to the indoor air, thereby adjusting the room temperature of the interior space 7 reduced in the use side heat exchanger 26a. As a result, the temperature and humidity of the indoor air are adjusted.

[0129] In the use side heat exchanger 26c, the heat medium receives heat from the intake outdoor air, thereby reducing the humidity and temperature of the intake air. In the use side heat exchanger 26d, the heat medium transfers heat to the indoor air, thereby adjusting the intake outdoor air reduced in the use side heat exchanger 26c so as to adjust the outlet temperature. As a result, the temperature and humidity of air blown from the indoor unit 2b are adjusted.

[0130] At this time, action of the heat medium flow control devices 25a to 25d controls the flow rate of the heat medium to a flow rate necessary for generating an air-conditioning load or dehumidifying capacity required in the room, and the resulting heat medium flows into the use side heat exchangers 26a to 26d. This control will be described in detail later.

[0131] The heat medium that has passed through the use side heat exchangers 26b and 26d and has its temperature slightly reduced, flows into the intermediate heat exchanger 15b through the heat medium flow control devices 25b and 25d and the first heat medium channel switching devices 22b and 22d, and is sucked into the pump 21 b again. The heat medium that has passed through the use side heat exchangers 26a and 26c and has its temperature slightly increased, flows into the intermediate heat exchanger 15a through the heat medium flow control devices 25a and 25c and the first heat medium channel switching devices 22a and 22c, and is sucked into the pump 21 a again.

[0132] Meantime, the hot heat medium and the cold heat medium are not mixed together because of the action of the first heat medium channel switching devices 22 and the second heat medium channel switching devices 23, and are individually introduced into the use side heat exchangers 26a to 26d having heating loads (reheat loads) and cooling loads (dehumidification loads). In the pipes 5 of the use side heat exchangers 26a to 26d, the heat medium flows in the direction from the second heat medium channel switching devices 23 to the first heat medium channel switching devices 22 by way of the heat medium flow control devices 25 in both the heating side (reheat side) and the cooling side (dehumidification side).

[0133] The air-conditioning load (the dehumidification load and the reheat load) required in the interior space 7 can be supplied by controlling the heat medium flow control devices 25 such that the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34 is equal to a target temperature difference ΔTm in the heating side. In the cooling side, the air-conditioning load can be supplied by controlling the heat medium flow control devices 25 such that the difference between the temperature detected by the second temperature sensor 34 and the temperature detected by the first temperature sensor 31 a is equal to a target temperature difference ΔTm. This control will be described in detail later.

[0134] In Fig. 8, since there are no use side heat exchangers 26 without thermal loads, all the corresponding heat medium flow control devices 25 are open. However, the present invention is not limited to this example. In performing an operation in the reheat dehumidification operation (heating main) mode, the heat medium does not need to flow into the indoor units 2 (including a thermo-off) with no thermal loads. Thus, the channels are closed by the heat medium flow control devices 25 so that the heat medium does not flow into the use side heat exchangers 26.

[0135] As described above, the reheat dehumidification operation is performed such that the heat source-side refrigerant in the refrigerant circuit A serving as a primary loop exchanges heat with the heat medium in the heat medium circuit B serving as a secondary loop, and the air cooled and dehumidified by the use side heat exchangers 26 in which the cooled heat medium flows and air heated by the use side heat exchangers 26 in which the heated heat medium flows are mixed and blown.

[0136] Thus, temperature variations of the heat medium are reduced, thereby suppressing variations in the temperature and humidity of the indoor air. As a result, the temperature and humidity in the room are stabilized, thereby enhancing comfort in the room.

[Control of Circulation Amount of Heat Medium]

[0137] A flow rate control of the heat medium in the reheat dehumidification operation (heating main) mode and the reheat dehumidification operation (cooling main) mode (which can be collectively referred as a reheat dehumidification operation mode) will now be described.

[Control of Indoor Unit 2a of Indoor Air Suction Type]

[0138] First, control of the indoor unit 2a of an indoor air suction type will be described with reference to Fig. 9.

[0139] Fig. 9 shows psychrometric charts for describing circulation amount control of the heat medium in the reheat dehumidification operation mode according to Embodiment of the present invention. Fig. 9(a) is a psychrometric chart showing a target temperature difference ΔTm of the use side heat exchanger 26a (hereinafter also referred to as a main-side heat exchanger). Fig. 9(b) is a psychrometric chart showing a target temperature difference ΔTm of the use side heat exchanger 26b (hereinafter also referred to as a reheat-side heat exchanger).

[Main-side Heat Exchanger]

[0140] As shown in Fig. 9(a), the psychrometric chart showing a correlation between the temperature and humidity of air is divided into a plurality of regions in accordance with the difference between the temperature of air sucked into the indoor unit 2a and a target temperature Xm and the difference between the humidity of the air and a target humidity Ym. A target temperature difference ΔTm (heat exchange capacity) is previously determined for each of the regions. Specifically, suppose the value detected by the sucked air temperature sensor 39 is X and the value detected by the sucked air humidity sensor 40 is Y, the temperature range is divided into three regions of $X - Xm \geq 1$ degree C, $1 > X - Xm \geq -1$ degree C, and $X - Xm < -1$ degree C. The humidity range is divided into three regions of $Y - Ym \geq 5\%$, $5\% > Y - Ym \geq -5\%$, and $Y - Ym < -5\%$. The chart is divided into nine regions corresponding to combinations of temperature ranges and humidity ranges. In this example, the humidity is detected as a relative humidity.

[0141] One of target temperature differences ΔTm (heat exchange capacities) (1) to (4) is previously determined for each of the nine regions. In this example, (1) is a target temperature difference ΔTm = 2, (2) is a target temperature difference ΔTm = 3, (3) is a target temperature difference ΔTm = 5, and (4) is a target temperature difference ΔTm = 7. In this manner, the target temperature difference ΔTm (heat exchange capacity) of the main-side heat exchanger increases as the temperature of sucked air increases and the humidity of the air increases. In the example shown in Fig. 9(a), the psychrometric chart is divided into nine regions. However, the present invention is not limited to this example, and the psychrometric chart may be divided into any number of regions.

[0142] The controller controls the opening degree (opening area) of the heat medium flow control device 25a such that the difference between the temperature detected by the first temperature sensor 31 a and the temperature detected by the second temperature sensor 34a is equal to the target temperature difference ΔTm. That is, in a case where the difference between the temperature of the heat medium before flowing into the main-side heat exchanger and the temperature of the heat medium after having flowed out of the main-side heat exchanger is larger than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25a is increased to increase the heat exchange capacity. On the other hand, in a case where the difference between the temperature of the heat medium before flowing into the main-side heat exchanger and the temperature of the heat medium after having flowed out of the main-side heat exchanger is smaller than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25a is reduced to reduce the heat exchange capacity.

[0143] In a case where the temperature of air sucked into the indoor unit 2a is smaller than the target temperature Xm by a predetermined value or more, circulation of the heat medium may be stopped to prevent an excessive decrease in the temperature. Specifically, in the case of detecting $X - Xm < -5$, the controller causes the heat medium flow control device 25a to be fully closed.

[Reheat-side Heat Exchanger]

[0144] As shown in Fig. 9(b), the psychrometric chart is divided into a plurality of regions in accordance with the difference between the temperature of air sucked into the indoor unit 2a and a target temperature Xm. A target temperature difference ΔTm (heat exchange capacity) is previously determined for each of the regions. Specifically, suppose the value detected by the sucked air temperature sensor 39 is X, the temperature range is divided into three regions of $0.5 > X - Xm \geq -1$, $-1 > X - Xm \geq -2$, and $X - Xm < -2$.

[0145] One of target temperature differences ΔTm (heat exchange capacities) (1) to (3) is previously determined for each of the three regions. In this example, (1) is a target temperature difference ΔTm = 2, (2) is a target temperature difference ΔTm = 4, and (3) is a target temperature difference ΔTm = 6. In this manner, the target temperature difference ΔTm (heat exchange capacity) of the reheat-side heat exchanger increases as the temperature of sucked air decreases. In the example shown in Fig. 9(b), the psychrometric chart is divided into three regions. However, the present invention is not limited to this example, and the psychrometric chart may be divided into any number of regions.

[0146] The controller controls the opening degree (opening area) of the heat medium flow control device 25b such that the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34b is equal to the target temperature difference ΔTm. That is, in a case where the difference between the temperature of the heat medium before flowing into the reheat-side heat exchanger and the temperature of the heat medium after having flowed out of the reheat-side heat exchanger is larger than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25b is increased to increase the heat exchange capacity. On the other hand, in a case where the difference between the temperature of the heat medium before flowing into the reheat-side heat exchanger and the temperature of the heat medium after having flowed out of the reheat-side heat exchanger is smaller than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25b is reduced to reduce the heat exchange capacity.

[0147] In a case where the temperature of air sucked into the indoor unit 2a is larger than the target temperature Xm by a predetermined value or more, circulation of the heat medium is stopped to prevent an excessive increase in the temperature. For example, in the case of detecting X - Xm ≥ 0.5, the controller causes the heat medium flow control device 25b to be fully closed.

[0148] In the foregoing manner, in the reheat dehumidification operation mode, the temperature and humidity of indoor air sucked into the indoor unit 2a of the indoor air suction type can be controlled.

[Control of Indoor Unit 2b of Outdoor Air Suction Type]

[0149] Next, control of the indoor unit 2b of an outdoor air suction type will be described with reference to Fig. 10.

[0150] Fig. 10 shows psychrometric charts for describing circulation amount control of the heat medium in the reheat dehumidification operation mode according to Embodiment of the present invention. Fig. 10(a) is a psychrometric chart showing a target temperature difference ΔTm of the use side heat exchanger 26c (hereinafter also referred to as a main-side heat exchanger). Fig. 10(b) is a psychrometric chart for showing a target temperature difference ΔTm of the use side heat exchanger 26b (hereinafter also referred to as a reheat-side heat exchanger).

[Main-side Heat Exchanger]

[0151] As shown in Fig. 10(a), the psychrometric chart showing a correlation between the temperature and humidity of air is divided into a plurality of regions in accordance with the difference between the temperature of air blown from the indoor unit 2b and a target temperature Xm and the difference between the humidity of the air and a target humidity Ym. A target temperature difference ΔTm (heat exchange capacity) is previously determined for each of the regions. Specifically, suppose the value detected by the blown air temperature sensor 41 is X and the value detected by the blown air humidity sensor 42 is Y, the temperature range is divided into three regions of X - Xm ≥ 1 degree C, 1 > X - Xm ≥ -1 degree C, and X - Xm < -1 degree C. The humidity range is divided into three regions of Y - Ym ≥ 5%, 5% > Y - Ym ≥ -5%, and Y - Ym < -5%. The chart is divided into nine regions corresponding to combinations of temperature ranges and humidity ranges. In this example, the humidity is detected as a relative humidity.

[0152] One of target temperature differences ΔTm (heat exchange capacities) (1) to (4) is previously determined for each of the nine regions. In this example, (1) is a target temperature difference ΔTm = 2, (2) is a target temperature difference ΔTm = 3, (3) is a target temperature difference ΔTm = 5, and (4) is a target temperature difference ΔTm = 7. In this manner, the target temperature difference ΔTm (heat exchange capacity) of the main-side heat exchanger increases as the temperature of blown air increases and the humidity increases. In the example shown in Fig. 10(a), the psychrometric chart is divided into nine regions. However, the present invention is not limited to this example, and the psychrometric chart may be divided into any number of regions.

[0153] The controller controls the opening degree (opening area) of the heat medium flow control device 25c such that the difference between the temperature detected by the first temperature sensor 31 a and the temperature detected by the second temperature sensor 34c is equal to the target temperature difference ΔTm. That is, in a case where the difference between the temperature of the heat medium before flowing into the main-side heat exchanger and the temperature of the heat medium after having flowed out of the main-side heat exchanger is larger than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25c is increased to increase the heat exchange capacity. On the other hand, in a case where the difference between the temperature of the heat medium before flowing into the main-side heat exchanger and the temperature of the heat medium after having flowed out of the main-side heat exchanger is smaller than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25c is reduced to reduce the heat exchange capacity.

[0154] In a case where the temperature of air blown from the indoor unit 2a is smaller than the target temperature Xm by a predetermined value or more, circulation of the heat medium may be stopped to prevent an excessive decrease in the temperature. Specifically, in the case of detecting X - Xm < -5, the controller causes the heat medium flow control device 25c to be fully closed.

[Reheat-side Heat Exchanger]

[0155] As shown in Fig. 10(b), the psychrometric chart is divided into a plurality of regions in accordance with the difference between the temperature of air blown from the indoor unit 2b and a target temperature Xm. A target temperature difference ΔTm (heat exchange capacity) is previously determined for each of the regions. Specifically, suppose the value detected by the blown air temperature sensor 41 is X, the temperature range is divided into three regions of 0.5 > X - Xm ≥ -1, -1 > X - Xm ≥ -2, and X - Xm < -2.

[0156] One of the target temperature differences ΔTm (heat exchange capacities) (1) to (3) is previously determined for each of the three regions. In this example, (1) is a target temperature difference ΔTm = 2, (2) is a target temperature difference ΔTm = 4, and (3) is a target temperature difference ΔTm = 6. In this manner, the target temperature difference ΔTm (heat exchange capacity) of the reheat-side heat exchanger increases as the temperature of sucked air decreases. In the example shown in Fig. 10(b), the psychrometric chart is divided into three regions. However, the present invention is not limited to this example, and the psychrometric chart may be divided into any number of regions.

[0157] The controller controls the opening degree (opening area) of the heat medium flow control device 25d such that the difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the second temperature sensor 34d is equal to the target temperature difference ΔTm. That is, in a case where the difference between the temperature of the heat medium before flowing into the reheat-side heat exchanger and the temperature of the heat medium after having flowed out of the reheat-side heat exchanger is larger than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25d is increased to increase the heat exchange capacity. On the other hand, in a case where the difference between the temperature of the heat medium before flowing into the reheat-side heat exchanger and the temperature of the heat medium after having flowed out of the reheat-side heat exchanger is smaller than the target temperature difference ΔTm, the opening degree of the heat medium flow control device 25d is reduced to reduce the heat exchange capacity.

[0158] In a case where the temperature of air blown from the indoor unit 2b is larger than the target temperature Xm by a predetermined value or more, circulation of the heat medium is stopped to prevent an excessive increase in the temperature. For example, in the case of detecting X - Xm ≥ 0.5, the controller causes the heat medium flow control device 25d to be fully closed.

[0159] In the foregoing manner, in the reheat dehumidification operation mode, the temperature and humidity of indoor air blown from the indoor unit 2b of the outdoor air suction type can be controlled.

[Temperature Control of Heat Medium]

[0160] Temperature control of the heat medium in the reheat dehumidification operation mode will now be described.

[0161] Fig. 11 is a flowchart showing switching operation to the heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention. The switching will be described with reference to Steps shown in Fig. 11.

[0162] When operation of the air-conditioning apparatus 100 starts (Step 1), the controller starts switching operation to the heat medium temperature control, and determines whether there is an indoor unit 2 executing the reheat dehumidification operation mode (Step 2). If there is an indoor unit 2 executing the reheat dehumidification operation mode, the controller determines whether the indoor unit 2 executing the reheat dehumidification operation mode is the indoor unit 2b of the outdoor air suction type or not (Step 3).

[0163] If the indoor unit 2 executing the reheat dehumidification operation mode is the indoor unit 2b of the outdoor air suction type, the controller obtains a dewpoint temperature Zm based on the target temperature Xm and the target humidity Ym. Then, a target value (a cooling target heat medium temperature) of the temperature of the heat medium flowing in the main-side heat exchanger of the indoor unit 2b is set at the dewpoint temperature Zm. A target value (a heating target heat medium temperature) of the temperature of the heat medium flowing in the reheat-side heat exchanger of the indoor unit 2b is set at a predetermined value (e.g., 50 degrees C). Then, heat medium temperature control described later is performed (Step 4).

[0164] If the indoor unit 2 executing the reheat dehumidification operation mode is the indoor unit 2a of the indoor air suction type, the controller sets a target value (a cooling target heat medium temperature) of the temperature of the heat medium flowing in the main-side heat exchanger of the indoor unit 2a at a predetermined value (e.g., 5 degrees C). A target value (a heating target heat medium temperature) of the temperature of the heat medium flowing in the reheat-side heat exchanger of the indoor unit 2a is set at a predetermined value (e.g., 50 degrees C). Then, heat medium temperature control described later is performed (Step 5).

[0165] If there is no indoor units 2 executing the reheat dehumidification operation mode, the controller does not perform heat medium temperature control described later, and performs control in the heating-only operation mode, the cooling-only operation mode, the cooling main operation mode, and the heating main operation mode described above (Step 6).

[0166] The controller determines whether operation of the air-conditioning apparatus 100 stops or not (Step 7). If the operation does not stop, the process returns to Step 2, or otherwise, this control is finished (Step 8).

[0167] Fig. 12 is a flowchart showing heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention. The control will be described with reference to Steps shown in Fig. 12.

[0168] When heat medium temperature control starts (Step 11), the controller sets a target value (a target condensing temperature) of the temperature of the heat source-side refrigerant in the intermediate heat exchanger 15b serving as a condenser, based on a heating target refrigerant temperature. The controller also sets a target value (a target evaporating temperature) of the temperature of heat source-side refrigerant in the intermediate heat exchanger 15a serving as an evaporator, based on a cooling target refrigerant temperature. The controller also sets a target value (a target SH) of superheat and a target value (a target SC) of supercool in the refrigerant circuit A. Specifically, the target condensing temperature is a temperature obtained by adding a predetermined value to the heating target refrigerant temperature (e.g., target condensing temperature = heating target refrigerant temperature + 5 degrees C). The target evaporating temperature is a temperature obtained by subtracting a predetermined value from the cooling target refrigerant temperature, and set at a temperature above the lower limit temperature (e.g., a temperature above -2 degrees C) (e.g., target evaporating temperature = cooling target water temperature - 5 degrees C > -2 degrees C). The target SH and the target SC are set at predetermined values (e.g., target SH = 2, target SC = 10) (Step 2).

[0169] The controller determines whether a predetermined time (e.g., 20 minutes) has elapsed from the start of the heat medium temperature control (Step 13). If the predetermined time has not elapsed, the process returns to Step 12, or otherwise, returns to Step 14.

[0170] The controller determines whether the difference between the cooling target refrigerant temperature and each of the temperatures (the values detected by the second temperature sensors 34a and 34c) of the heat medium flowing in the main-side heat exchanger is larger than a predetermined temperature (e.g., 3 degrees C) or not (Step 14).

[0171] If the determination at Step 14 is satisfied, the controller sets the target evaporating temperature at a temperature that is obtained by subtracting a second predetermined value (e.g., 7 degrees C) from the cooling target refrigerant temperature and is a temperature above the lower limit temperature (e.g., -2 degrees C) (e.g., target evaporating temperature = cooling target water temperature - 7 degrees C > -2 degrees C) (Step 15).

[0172] If the determination at Step 14 is not satisfied, the controller sets the target evaporating temperature at a temperature that is obtained by subtracting a third predetermined value (e.g., 5 degrees C) from the cooling target refrigerant temperature and is a temperature above the lower limit temperature (e.g., -2 degrees C) (e.g., target evaporating temperature = cooling target water temperature - 5 degrees C > -2 degrees C) (Step 16). The third predetermined value is smaller than the second predetermined value. The controller controls the compressor 10 and the expansion device 16a, for example, in the refrigerant circuit A, based on the target evaporating temperature and the target condensing temperature.

[0173] The controller determines whether the heat medium temperature control is finished or not (Step 17). If the heat medium temperature control is not finished, the process returns to Step 14, or otherwise, the control is finished (Step 18).

[0174] In the foregoing manner, the temperature of the heat medium in the heat medium circuit B serving as a secondary loop varies depending on a temperature variation of the heat source-side refrigerant in the refrigerant circuit A serving as a primary loop. Thus, the temperature variation of the heat medium is reduced, thereby suppressing variations in the temperature and humidity of the indoor air. As a result, the temperature and humidity in the room are stabilized, thereby enhancing comfort in the room.

[0175] Since the target evaporating temperature and the target condensing temperature in the refrigerant circuit A are set based on the cooling target heat medium temperature and the heating target heat medium temperature of the heat medium in the heat medium circuit B, the temperature following by the heat source-side refrigerant in the refrigerant circuit A serving as a primary loop is consequently delayed. Accordingly, the temperature and humidity in the room are stabilized, thereby enhancing comfort in the room.

[0176] In the foregoing description, circulation amount control of the heat medium and the temperature control of the heat medium are performed. However, the present invention is not limited to this example. Only one of the circulation amount control of the heat medium or the temperature control of the heat medium may be performed. At least one of the indoor unit 2a or the indoor unit 2b only needs to perform one of the circulation amount control or the temperature control of the heat medium.

[Variation]

[0177] Fig. 13 is a flowchart showing a variation of the heat medium temperature control of the air-conditioning apparatus according to Embodiment of the present invention. Different aspects from Steps in Fig. 12 will be mainly described with reference to Steps shown in Fig. 13.

[0178] Steps 21 to 24 are the same as Steps 11 to 14 in Fig. 12.

[0179] If the determination at Step 24 is satisfied, the controller sets the target SH at a second predetermined value (e.g., 2) (Step 25).

[0180] If the determination at Step 24 is not satisfied, the controller sets the target SH at a third predetermined value (e.g., 5) (Step 25). The third predetermined value is smaller than the second predetermined value. Based on the target SH and the target SC, the controller controls the compressor 10 and the expansion device 16a, for example, in the refrigerant circuit A.

[0181] Steps 27 and 28 are the same as Steps 17 and 18 in Fig. 12.

[0182] As described above, the temperature of the heat source-side refrigerant in the refrigerant circuit A may be controlled based on the target SH and the target SC. In this case, similar advantages can be obtained.

[0183] In this Embodiment, the indoor units 2 are only of a type that performs a reheat dehumidification operation. Alternatively, an indoor unit that performs only normal cooling or heating may be added.

Reference Signs List

[0184] 1 outdoor unit, 2a indoor unit, 2b indoor unit, 3 heat medium relay unit, 4 refrigerant pipe, 4a first connection pipe, 4b second connection pipe, 5 pipe, 6 outdoor space, 7 interior space, 8 space, 9 structure, 10 compressor, 11 first refrigerant channel switching device, 12 heat source side heat exchanger, 13a to 13d check valve, 15a, 15b intermediate heat exchanger, 16a, 16b expansion device, 17a, 17b opening/closing device, 18a, 18b second refrigerant channel switching device, 19 accumulator, 21 a, 21 b pump, 22a to 22d first heat medium channel switching device, 23a to 23d second heat medium channel switching device, 25a to 25d heat medium flow control device, 26a to 26d use side heat exchanger, 31 a, 31 b first temperature sensor, 34a to 34d second temperature sensor, 35a to 35d third temperature sensor, 36 first pressure sensor, 37 second pressure sensor, 38 third pressure sensor, 39 sucked air temperature sensor, 40 sucked air humidity sensor, 41 blown air temperature sensor, 42 blown air humidity sensor, 50 fourth temperature sensor, 52 arithmetic unit, 57 arithmetic unit, 100 air-conditioning apparatus, A refrigerant circuit, B heat medium circuit.

Claims

1. An air-conditioning apparatus comprising:

a refrigerant circuit in which a compressor, a heat source side heat exchanger, a plurality of expansion devices, refrigerant channels of a plurality of intermediate heat exchangers, and a plurality of refrigerant channel switching devices to switch circulation channels are connected by refrigerant pipes so that heat source-side refrigerant circulates therein;
a heat medium circuit in which a pump, a plurality of use side heat exchangers, a heat medium channel switching device, and heat medium channels of the intermediate heat exchangers are connected by heat medium pipes so that a heat medium circulates therein; and
an indoor unit housing two or more of the plurality of use side heat exchangers, wherein
a reheat dehumidification operation mode is operated in such a manner that
the low-temperature low-pressure heat source-side refrigerant flows in part of the plurality of intermediate heat exchangers so as to cool the heat medium, and the cooled heat medium is supplied to part of the use side heat exchangers housed in the indoor unit, and
the high-temperature high-pressure heat source-side refrigerant flows in an other part of the plurality of intermediate heat exchangers so as to heat the heat medium, and the heated heat medium is supplied to an other part of the use side heat exchangers housed in the indoor unit.

2. The air-conditioning apparatus of claims 1, wherein
heat exchange capacity of the use side heat exchangers to which the cooled heat medium is supplied is determined based on a temperature difference between a temperature of air sucked into the indoor unit and a target temperature and a humidity difference between a humidity of air sucked into the indoor unit and a target humidity,
heat exchange capacity of the use side heat exchangers to which the heated heat medium is determined based on a temperature difference between a temperature of air sucked into the indoor unit and a target temperature, and
at least one of a circulation amount of the heat medium circulating the use side heat exchangers and a temperature of the heat medium is controlled based on the heat exchange capacity.

3. The air-conditioning apparatus of claim 1, wherein
heat exchange capacity of the use side heat exchangers to which the cooled heat medium is supplied is determined based on a temperature difference between a temperature of air blown from the indoor unit and a target temperature and a humidity difference between a humidity of air blown from the indoor unit and a target humidity,
heat exchange capacity of the use side heat exchangers to which the heated heat medium is supplied is determined based on a temperature difference between a temperature of air blown from the indoor unit and a target temperature, and
at least one of a circulation amount of the heat medium circulating in the use side heat exchangers and a temperature of the heat medium is controlled based on the heat exchange capacity.

4. The air-conditioning apparatus of claim 2 or 3, wherein
the heat exchange capacity of the use side heat exchangers to which the cooled heat medium is supplied is determined to increase as the temperature of the air increases and the humidity of the air increases, and
the heat exchange capacity of the use side heat exchangers to which the heated heat medium is supplied is determined to increase as the temperature of the air decreases.

5. The air-conditioning apparatus of any one of claims 2 to 4, wherein
a psychrometric chart showing a correlation between a temperature and a humidity of air is divided into a plurality of regions in accordance with a difference between the target temperature and the target humidity, and a heat exchange capacity is previously determined for each of the plurality of regions, and
the heat exchange capacity of one of the regions corresponding to the temperature and the humidity of air is determined in the use side heat exchangers to which the heated heat medium is supplied.

6. The air-conditioning apparatus of any one of claims 2 to 5, wherein
a dewpoint temperature is obtained based on the target temperature and the target humidity, and
a target value of a temperature of the cooled heat medium is set at the dewpoint temperature.

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

2 to 6, wherein
a temperature of the cooled heat medium is adjusted by controlling an evaporating temperature of heat source-side refrigerant circulating in the refrigerant circuit.

8. The air-conditioning apparatus of any one of claims 2 to 7, wherein
a temperature of the heated heat medium is adjusted by controlling a condensing temperature of heat source-side refrigerant circulating in the refrigerant circuit.

FIG. 1

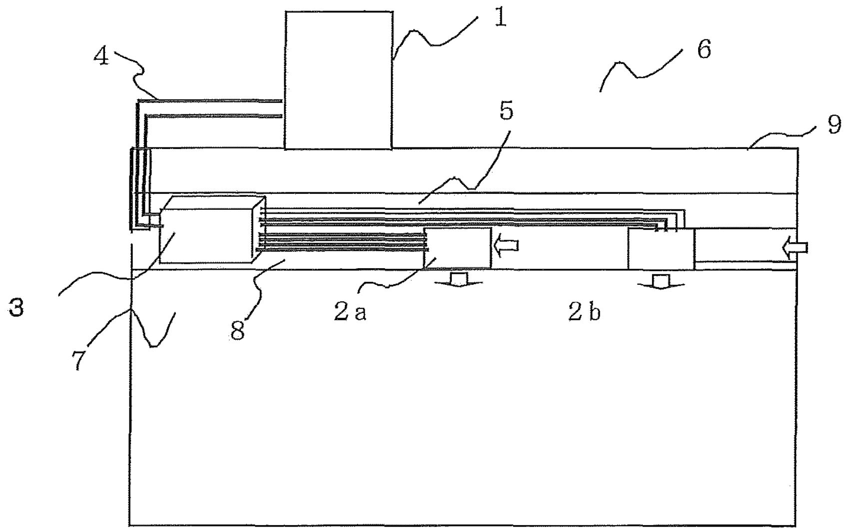
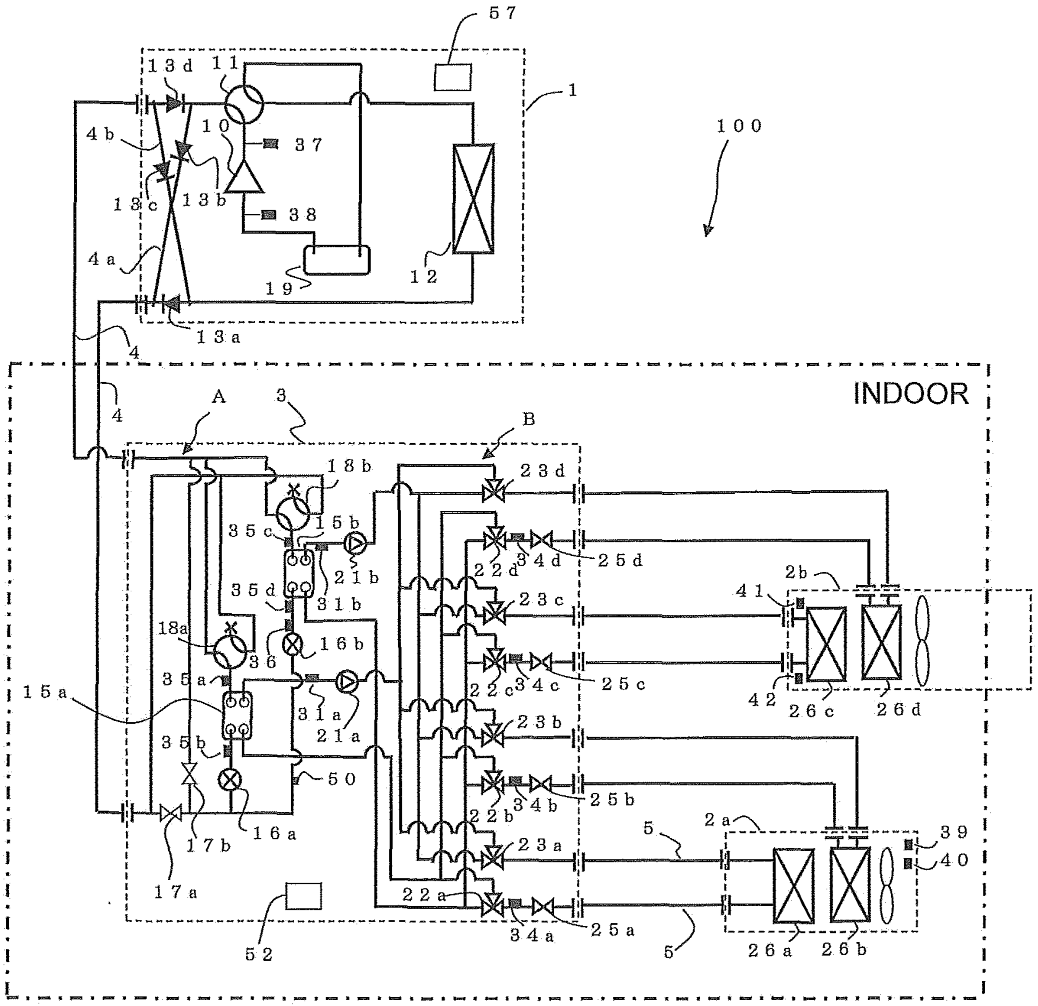

1
6
4
5
9
3
8
2a
2b
7

FIG. 2


57
13d
11
1
10
100
4b
37
13c
13b
38
4a
19
12
13a
4
INDOOR
4
A
3
B
18b
23d
35c
15b
21b
25d
22d
34d
35d
31b
2b
41
23c
18a
16b
36
22c
34c
25c
35a
15a
31a
42
26c
26d
21a
23b
35b
50
34b
25b
22b
5
2a
39
17b
16a
23a
40
17a
22a
52
34a
25a
5
26a
26b

F I G. 3

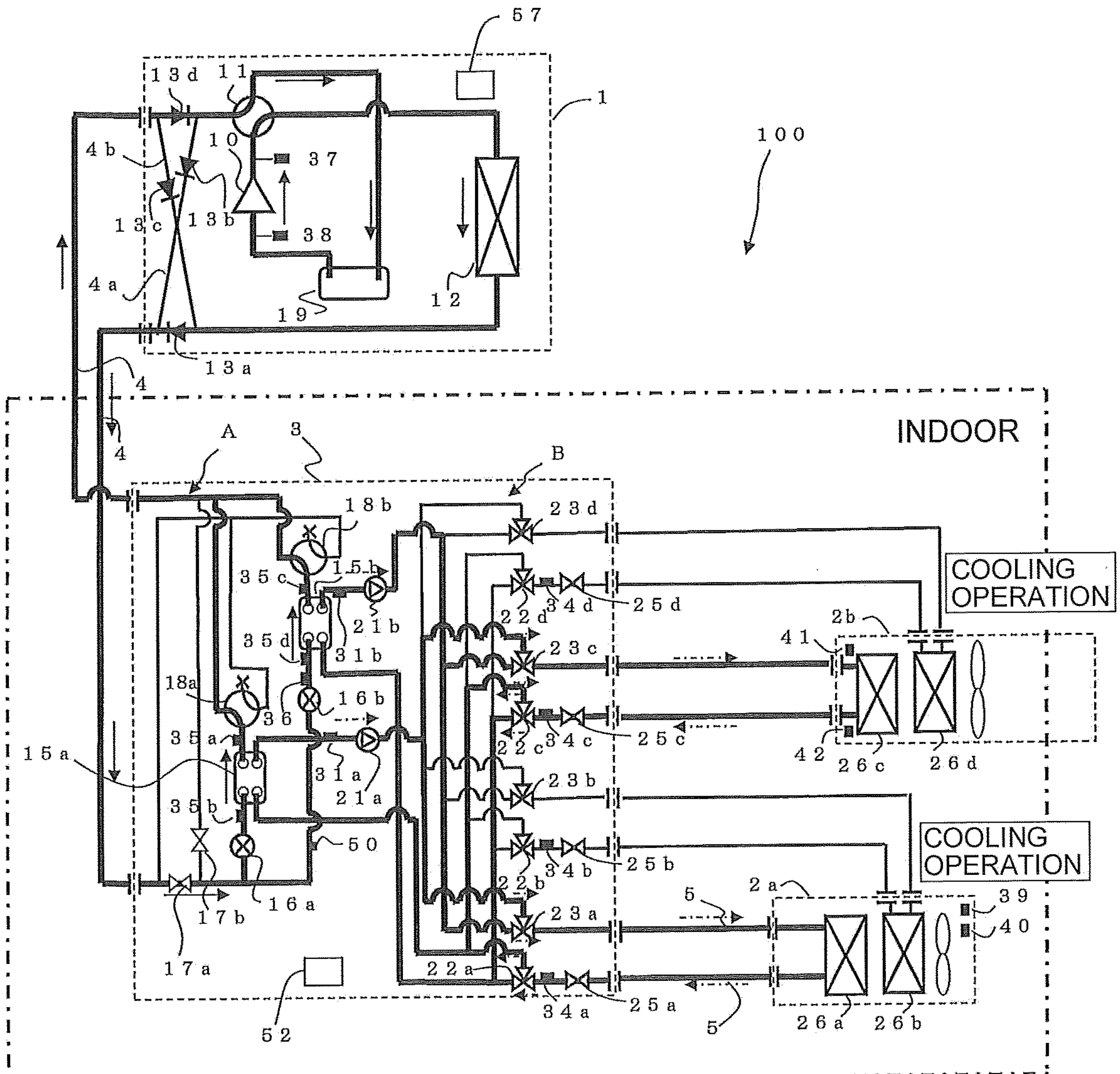

57
1
100
13d
11
10
37
4b
13c
13b
38
4a
19
12
13a
4
INDOOR
A
3
B
18b
23d
35c
15b
25d
34d
22d
21b
COOLING OPERATION
35d
31b
2b
23c
41
18a
16b
36
15a
35a
31a
34c
25c
22c
21a
42
26c
26d
23b
35b
50
COOLING OPERATION
25b
34b
22b
17b
16a
5
2a
39
40
23a
17a
52
22a
34a
25a
26a
26b

FIG. 4

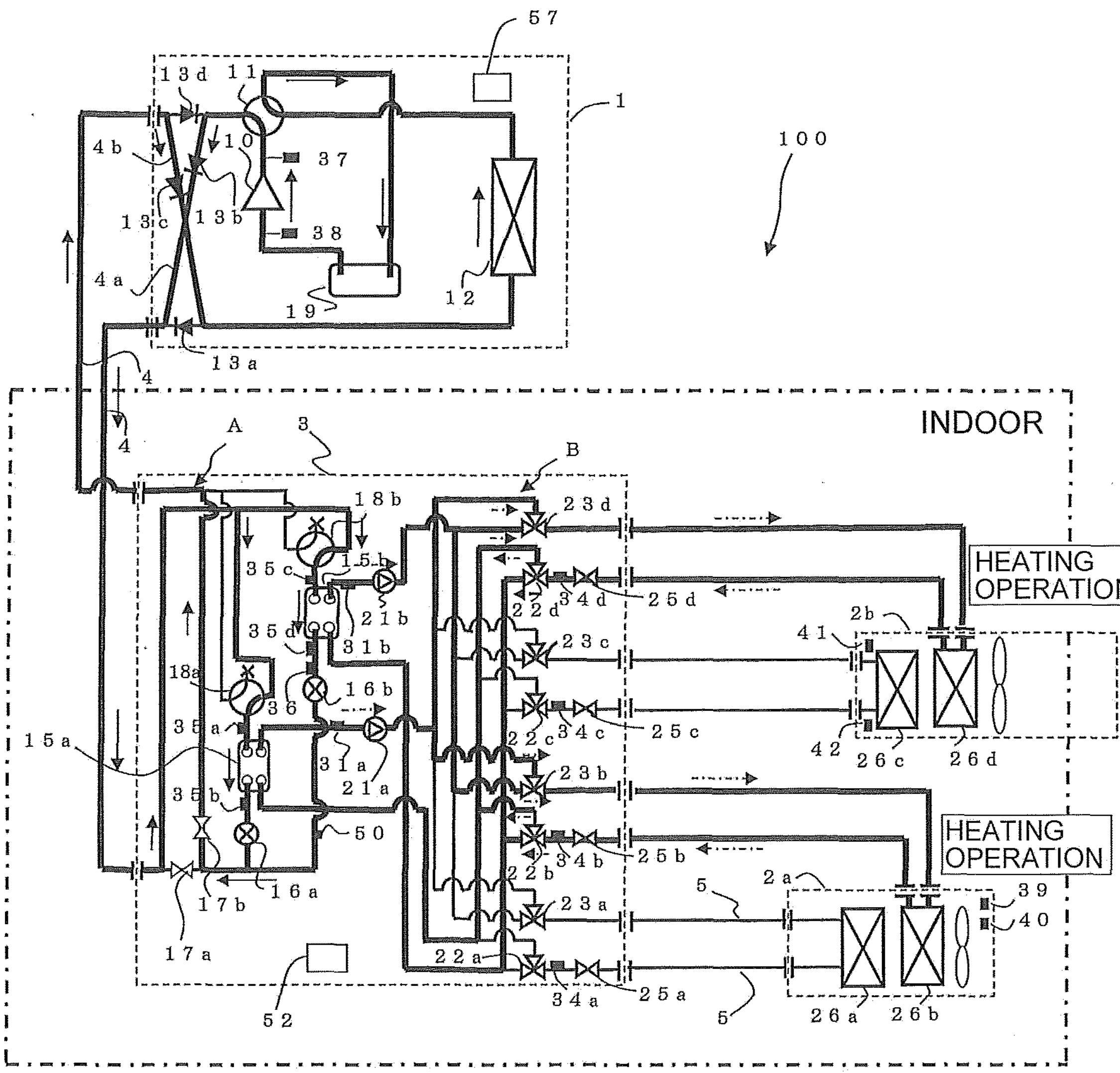

57
1
100
13d
11
4b
10
37
13c
13b
38
4a
19
12
13a
4
INDOOR
A
3
B
18b
23d
35c
15b
21b
HEATING OPERATION
22d
34d
25d
2b
35d
31b
23c
41
18a
16b
36
35a
22c
34c
25c
15a
31a
21a
42
26c
26d
23b
35b
50
HEATING OPERATION
22b
34b
25b
2a
5
39
40
17b
16a
23a
17a
22a
52
34a
25a
5
26a
26b

FIG. 5

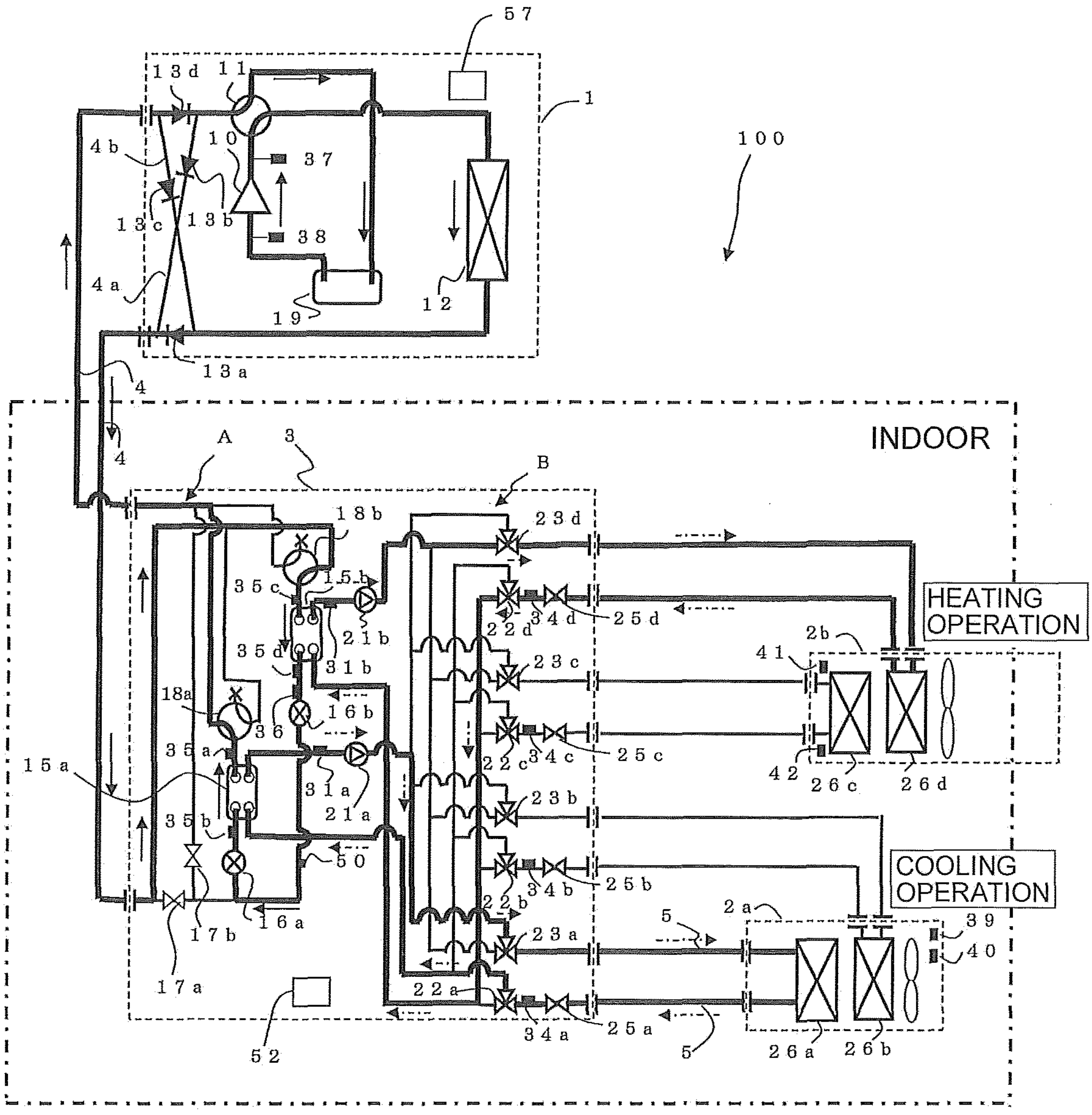
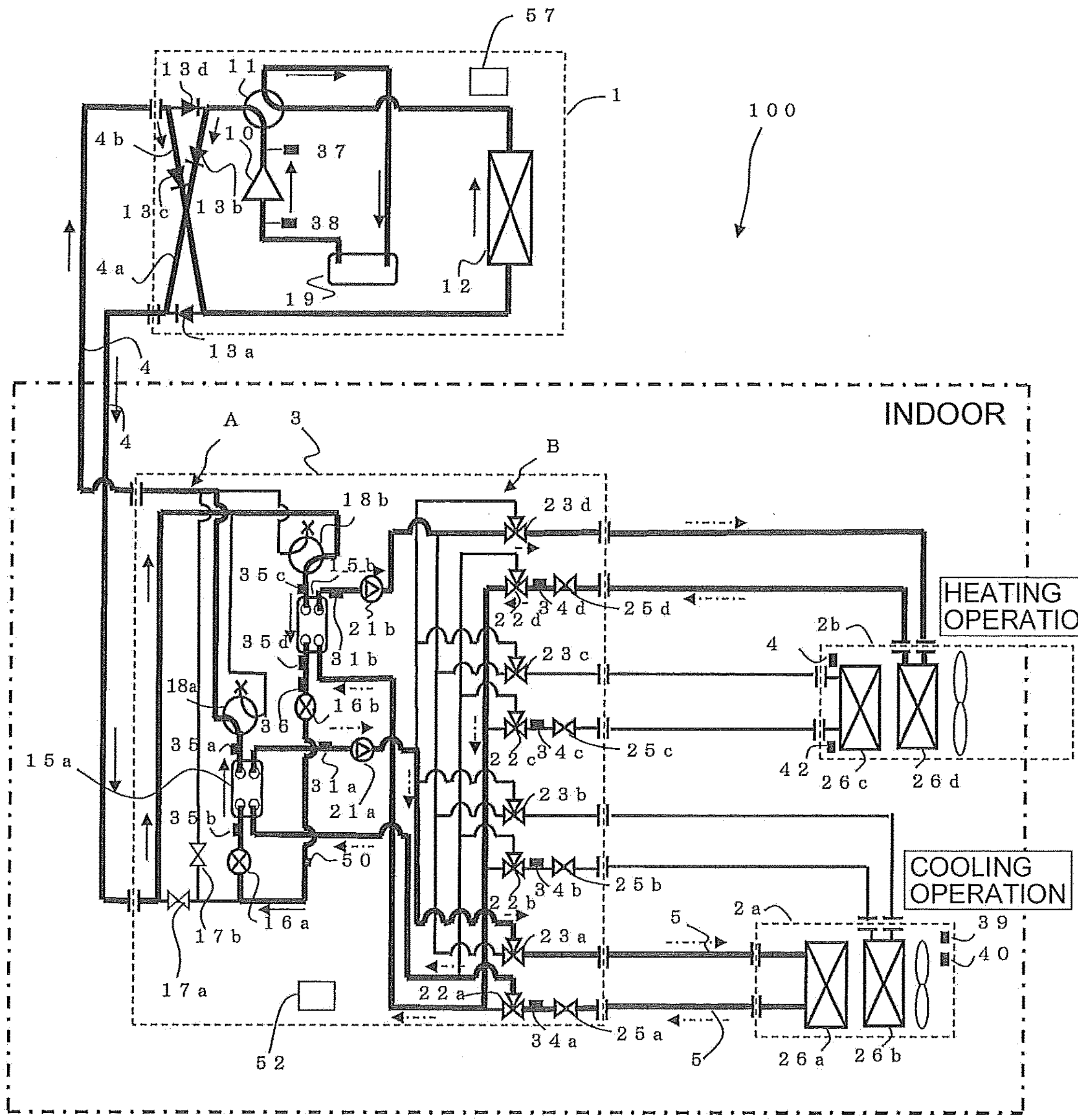
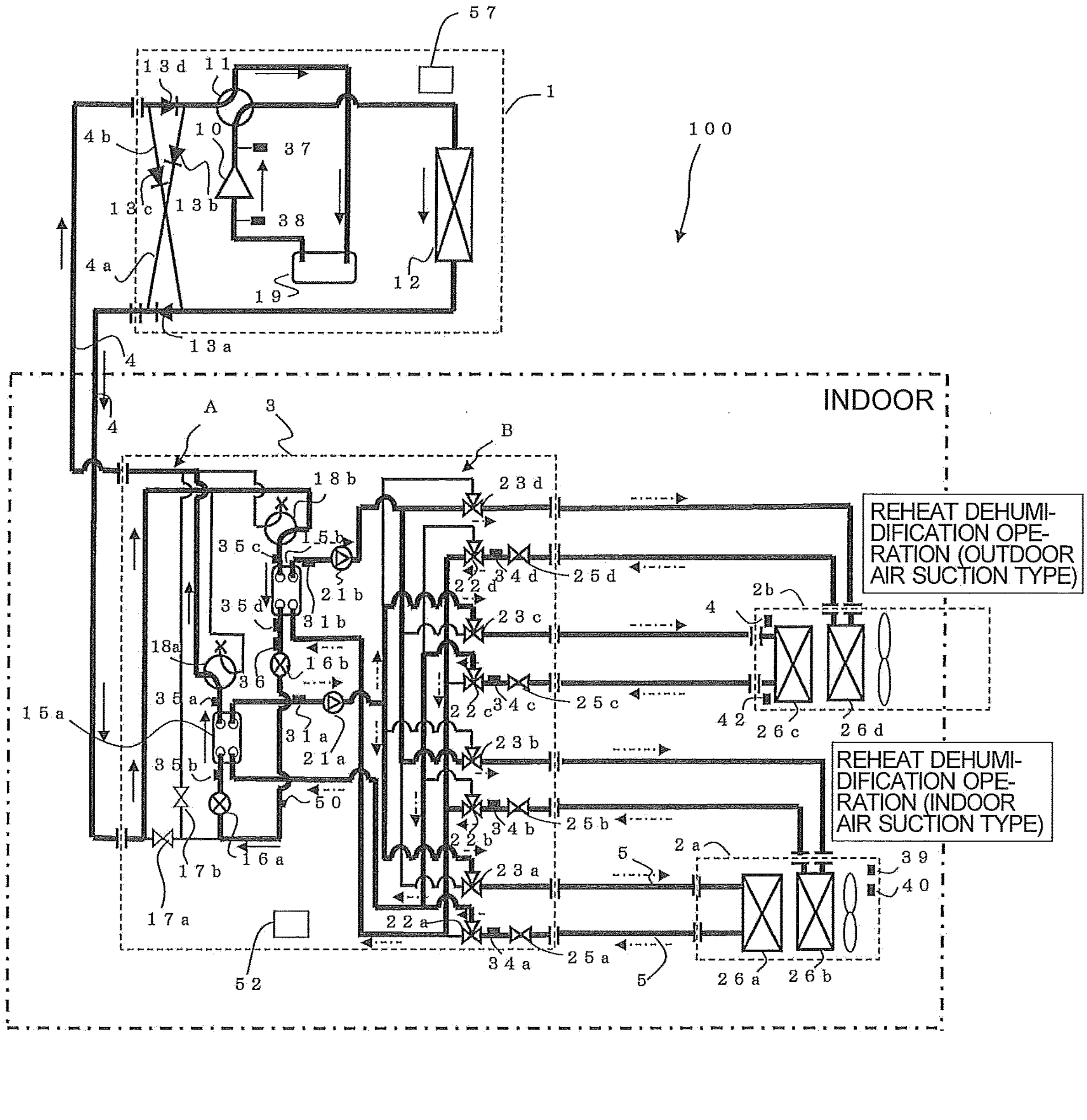

57
1
100
13d
11
10
37
4b
13b
13c
38
4a
19
12
13a
4
INDOOR
A
3
B
18b
23d
35c
15b
22d
34d
25d
21b
HEATING
OPERATION
2b
35d
31b
23c
41
18a
16b
36
25c
34c
35a
22c
15a
31a
42
26c
26d
21a
23b
35b
50
34b
25b
COOLING
OPERATION
22b
2a
5
39
17b
16a
23a
40
17a
22a
34a
25a
52
5
26a
26b

FIG. 6



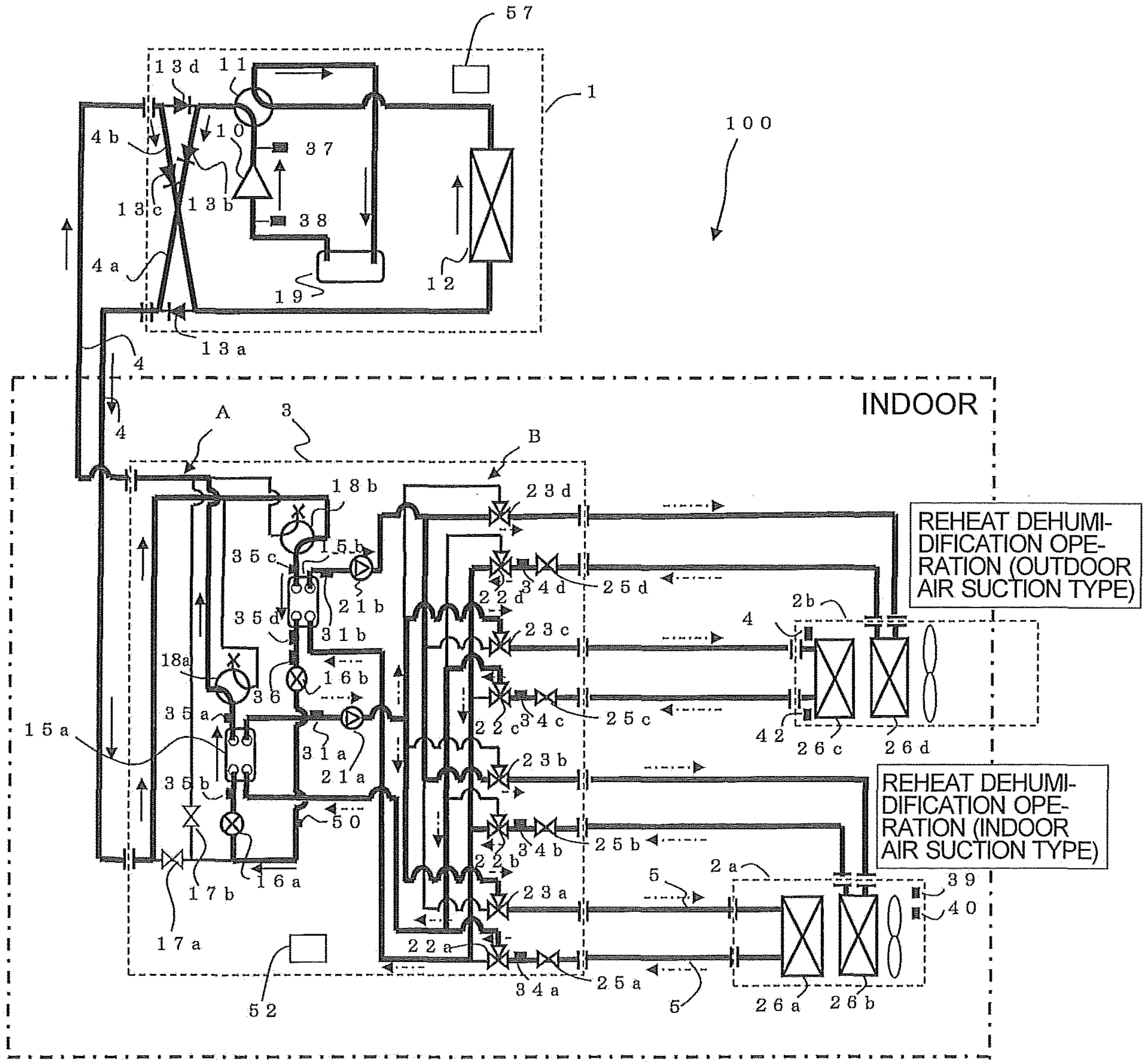
57
1
100
13d
11
10
4b
37
13c
13b
38
4a
19
12
13a
4
4
INDOOR
A
3
B
18b
23d
35c
15b
21b
34d
25d
HEATING OPERATION
22d
35d
31b
2b
23c
4
18a
16b
36
25c
35a
22c
34c
42
26c
26d
15a
31a
23b
35b
21a
50
25b
COOLING OPERATION
22b
34b
16a
2a
39
5
17b
23a
40
17a
22a
52
25a
34a
5
26a
26b

FIG. 7



57
1
100
13d
11
10
37
38
4b
13c
13b
4a
19
12
13a
4
INDOOR
A
3
B
18b
23d
35c
15b
21b
31b
22d
34d
25d
REHEAT DEHUMIDIFICATION OPERATION (OUTDOOR AIR SUCTION TYPE)
2b
35d
16b
36
18a
23c
22c
34c
25c
42
26c
26d
15a
35a
31a
21a
23b
REHEAT DEHUMIDIFICATION OPERATION (INDOOR AIR SUCTION TYPE)
35b
50
22b
34b
25b
2a
39
40
17b
16a
23a
17a
22a
34a
25a
26a
26b
52

F I G. 8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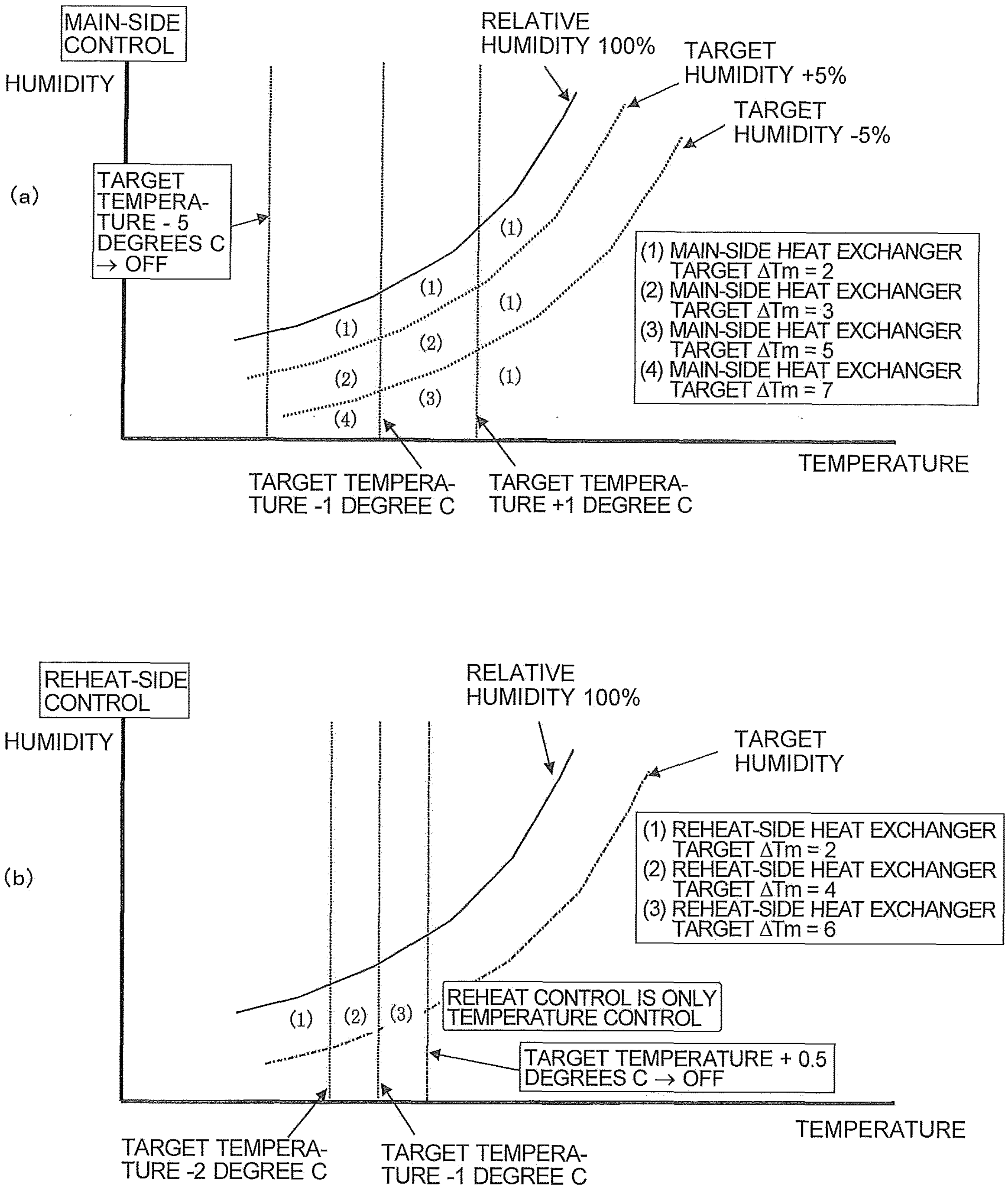
1
100
13d
11
4b
10
37
13c
13b
38
4a
19
12
13a
4
INDOOR
A
3
B
18b
23d
35c
15b
REHEAT DEHUMIDIFICATION OPERATION (OUTDOOR AIR SUCTION TYPE)
34d
25d
21b
22d
35d
31b
2b
23c
18a
16b
36
22c
34c
25c
35a
15a
31a
23b
42
26c
26d
21a
35b
REHEAT DEHUMIDIFICATION OPERATION (INDOOR AIR SUCTION TYPE)
50
34b
25b
22b
2a
5
39
17b
16a
23a
40
17a
22a
34a
25a
52
26a
26b

F I G. 9


MAIN-SIDE CONTROL
HUMIDITY
(a)
TARGET TEMPERA-TURE - 5 DEGREES C → OFF
RELATIVE HUMIDITY 100%
TARGET HUMIDITY +5%
TARGET HUMIDITY -5%
(1)
(2)
(3)
(4)
(1) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 2
(2) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 3
(3) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 5
(4) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 7
TARGET TEMPERA-TURE -1 DEGREE C
TARGET TEMPERA-TURE +1 DEGREE C
TEMPERATURE
REHEAT-SIDE CONTROL
HUMIDITY
(b)
RELATIVE HUMIDITY 100%
TARGET HUMIDITY
(1) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 2
(2) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 4
(3) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 6
REHEAT CONTROL IS ONLY TEMPERATURE CONTROL
TARGET TEMPERATURE + 0.5 DEGREES C → OFF
TARGET TEMPERA-TURE -2 DEGREE C
TARGET TEMPERA-TURE -1 DEGREE C
TEMPERATURE

F I G. 1 0

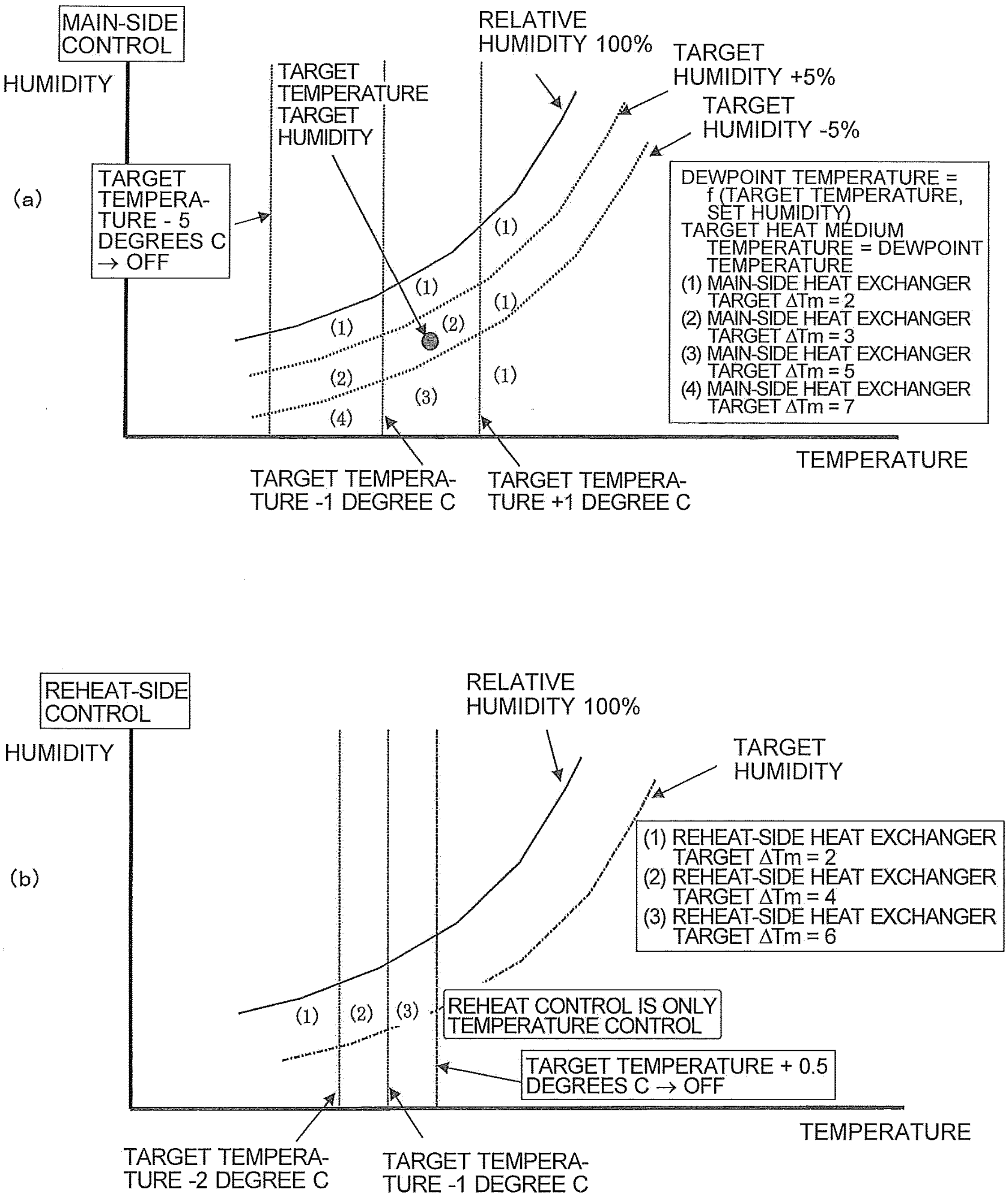

(a)
MAIN-SIDE CONTROL
HUMIDITY
TARGET TEMPERATURE TARGET HUMIDITY
RELATIVE HUMIDITY 100%
TARGET HUMIDITY +5%
TARGET HUMIDITY -5%
TARGET TEMPERA-TURE - 5 DEGREES C → OFF
DEWPOINT TEMPERATURE = f (TARGET TEMPERATURE, SET HUMIDITY)
TARGET HEAT MEDIUM TEMPERATURE = DEWPOINT TEMPERATURE
(1) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 2
(2) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 3
(3) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 5
(4) MAIN-SIDE HEAT EXCHANGER TARGET ΔTm = 7
(1)
(1)
(1)
(1)
(2)
(2)
(3)
(4)
(1)
TEMPERATURE
TARGET TEMPERA-TURE -1 DEGREE C
TARGET TEMPERA-TURE +1 DEGREE C
(b)
REHEAT-SIDE CONTROL
HUMIDITY
RELATIVE HUMIDITY 100%
TARGET HUMIDITY
(1) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 2
(2) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 4
(3) REHEAT-SIDE HEAT EXCHANGER TARGET ΔTm = 6
(1)
(2)
(3)
REHEAT CONTROL IS ONLY TEMPERATURE CONTROL
TARGET TEMPERATURE + 0.5 DEGREES C → OFF
TEMPERATURE
TARGET TEMPERA-TURE -2 DEGREE C
TARGET TEMPERA-TURE -1 DEGREE C

FIG. 11

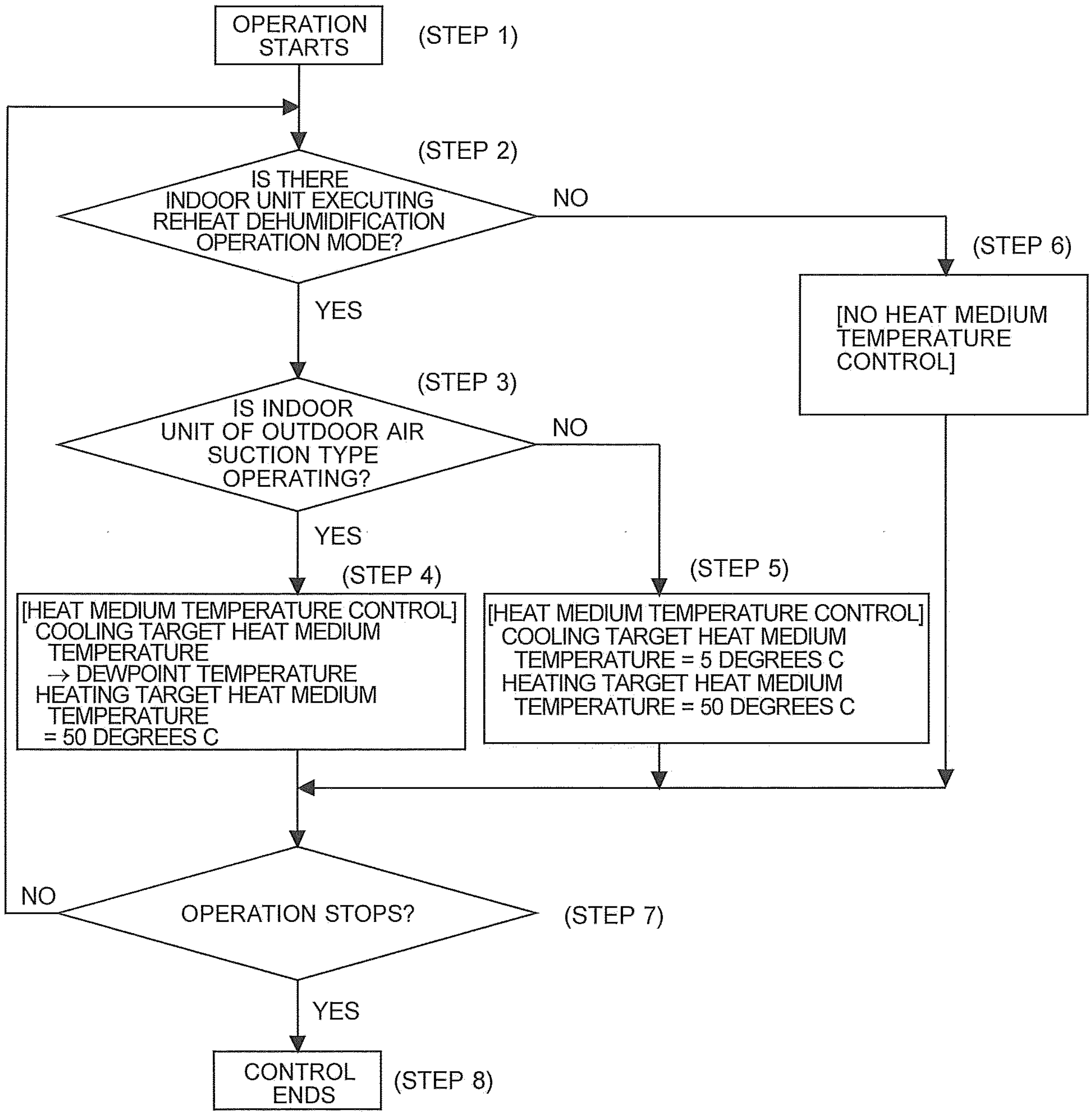

OPERATION STARTS
(STEP 1)
(STEP 2)
IS THERE INDOOR UNIT EXECUTING REHEAT DEHUMIDIFICATION OPERATION MODE?
NO
(STEP 6)
[NO HEAT MEDIUM TEMPERATURE CONTROL]
YES
(STEP 3)
IS INDOOR UNIT OF OUTDOOR AIR SUCTION TYPE OPERATING?
NO
YES
(STEP 4)
[HEAT MEDIUM TEMPERATURE CONTROL] COOLING TARGET HEAT MEDIUM TEMPERATURE → DEWPOINT TEMPERATURE HEATING TARGET HEAT MEDIUM TEMPERATURE = 50 DEGREES C
(STEP 5)
[HEAT MEDIUM TEMPERATURE CONTROL] COOLING TARGET HEAT MEDIUM TEMPERATURE = 5 DEGREES C HEATING TARGET HEAT MEDIUM TEMPERATURE = 50 DEGREES C
NO
OPERATION STOPS?
(STEP 7)
YES
CONTROL ENDS
(STEP 8)

FIG. 12

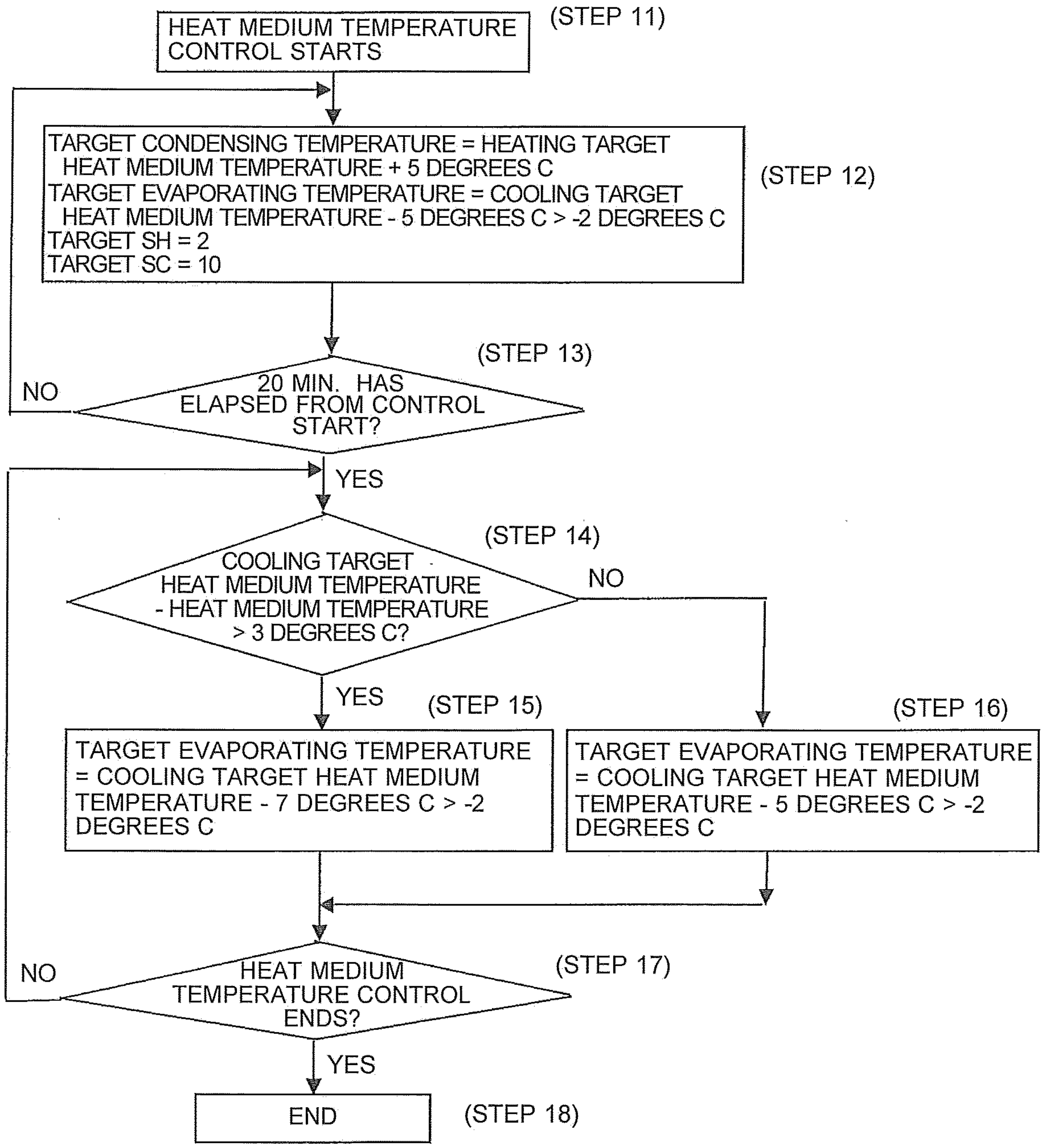
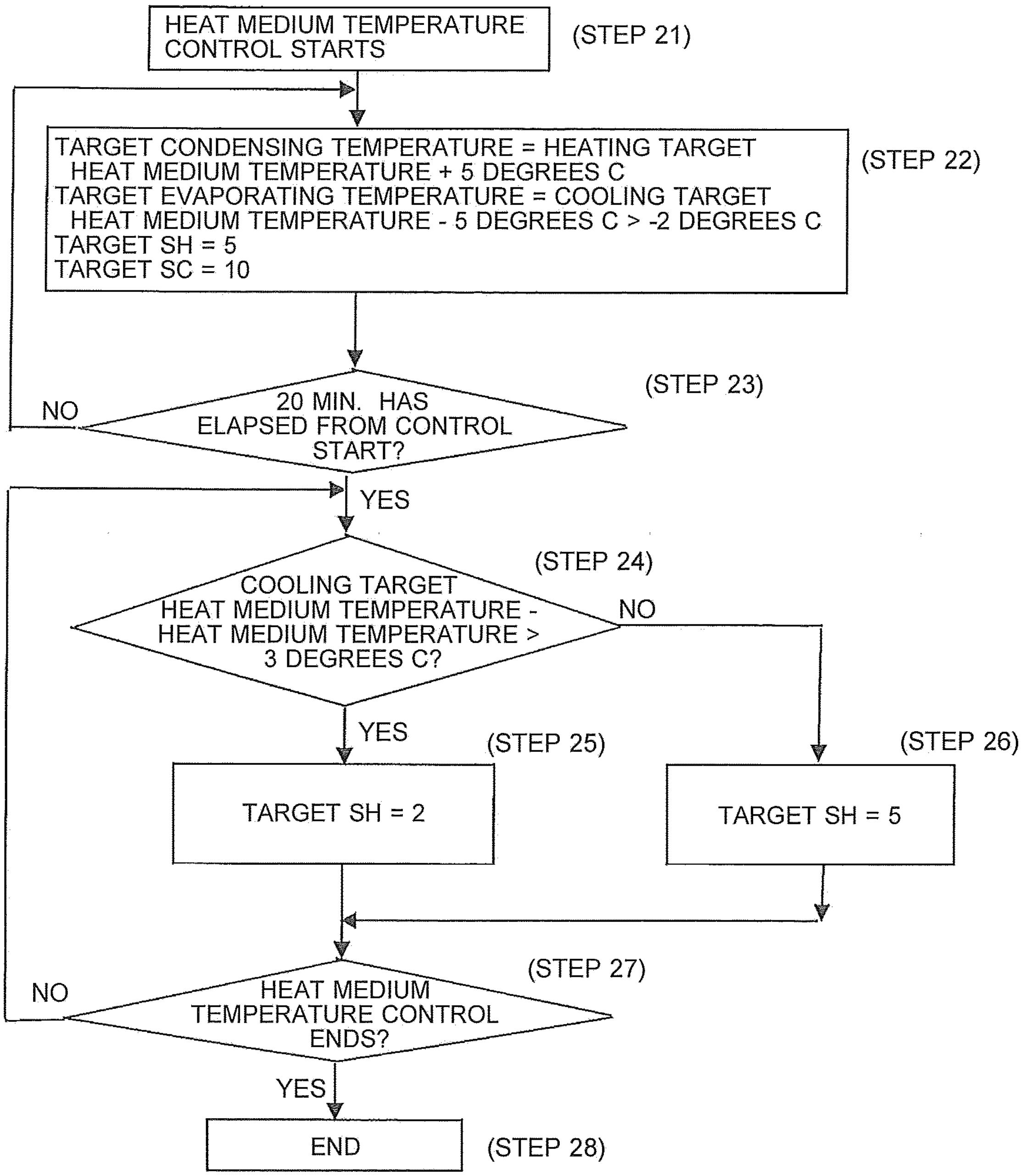

HEAT MEDIUM TEMPERATURE CONTROL STARTS
(STEP 11)
TARGET CONDENSING TEMPERATURE = HEATING TARGET HEAT MEDIUM TEMPERATURE + 5 DEGREES C
TARGET EVAPORATING TEMPERATURE = COOLING TARGET HEAT MEDIUM TEMPERATURE - 5 DEGREES C > -2 DEGREES C
TARGET SH = 2
TARGET SC = 10
(STEP 12)
20 MIN. HAS ELAPSED FROM CONTROL START?
(STEP 13)
NO
YES
COOLING TARGET HEAT MEDIUM TEMPERATURE - HEAT MEDIUM TEMPERATURE > 3 DEGREES C?
(STEP 14)
NO
YES
(STEP 15)
TARGET EVAPORATING TEMPERATURE = COOLING TARGET HEAT MEDIUM TEMPERATURE - 7 DEGREES C > -2 DEGREES C
(STEP 16)
TARGET EVAPORATING TEMPERATURE = COOLING TARGET HEAT MEDIUM TEMPERATURE - 5 DEGREES C > -2 DEGREES C
NO
HEAT MEDIUM TEMPERATURE CONTROL ENDS?
(STEP 17)
YES
END
(STEP 18)

FIG. 13


HEAT MEDIUM TEMPERATURE CONTROL STARTS
(STEP 21)
TARGET CONDENSING TEMPERATURE = HEATING TARGET HEAT MEDIUM TEMPERATURE + 5 DEGREES C
TARGET EVAPORATING TEMPERATURE = COOLING TARGET HEAT MEDIUM TEMPERATURE - 5 DEGREES C > -2 DEGREES C
TARGET SH = 5
TARGET SC = 10
(STEP 22)
20 MIN. HAS ELAPSED FROM CONTROL START?
(STEP 23)
NO
YES
COOLING TARGET HEAT MEDIUM TEMPERATURE - HEAT MEDIUM TEMPERATURE > 3 DEGREES C?
(STEP 24)
NO
YES
(STEP 25)
TARGET SH = 2
(STEP 26)
TARGET SH = 5
HEAT MEDIUM TEMPERATURE CONTROL ENDS?
(STEP 27)
NO
YES
END
(STEP 28)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/055640

A. CLASSIFICATION OF SUBJECT MATTER

F24F5/00(2006.01)i, *F24F3/08*(2006.01)i, *F24F11/02*(2006.01)i, *F25B1/00*(2006.01)i, *F25B29/00*(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)
F24F5/00, F24F3/08, F24F11/02, F25B1/00, F25B29/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2011-105150 A (Hitachi, Ltd.), 02 June 2011 (02.06.2011), paragraphs [0008] to [0017], [0032] to [0034]; fig. 3 & US 2011/0113800 A1 & EP 2327575 A1 & CN 102059932 A	1-5,7,8 6
Y	WO 2010/050000 A1 (Mitsubishi Electric Corp.), 06 May 2010 (06.05.2010), paragraphs [0057] to [0059], [0069]; fig. 7 & EP 2314945 A1 & CN 102112817 A	1-5,7,8
Y A	JP 2004-317091 A (Mitsubishi Electric Corp.), 11 November 2004 (11.11.2004), paragraphs [0014], [0057], [0058]; fig. 1, 6 (Family: none)	2-5,7,8 6

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 May, 2013 (02.05.13)	14 May, 2013 (14.05.13)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2013/055640

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-85294 A (Hitachi, Ltd.), 28 April 2011 (28.04.2011), paragraphs [0082] to [0092]; fig. 15 to 17 & WO 2011/045977 A1 & CN 102472530 A	1-8
A	JP 2003-139436 A (Mitsubishi Electric Corp.), 14 May 2003 (14.05.2003), paragraph [0027]; fig. 4 (Family: none)	2
A	JP 2007-198646 A (Mitsubishi Electric Corp.), 09 August 2007 (09.08.2007), paragraphs [0017] to [0019]; fig. 2 (Family: none)	2
A	JP 2012-17889 A (Daikin Industries, Ltd.), 26 January 2012 (26.01.2012), claim 1; paragraph [0049] (Family: none)	2
A	WO 2010/095238 A1 (Mitsubishi Electric Corp.), 26 August 2010 (26.08.2010), paragraph [0031]; fig. 4 & EP 2400234 A1 & CN 102317699 A	5

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Patent documents cited in the description

- JP 2002089988 A **[0003]**