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(54) **AIR CONDITIONER DEVICE**

(57) An air-conditioning apparatus includes a refrigerant circuit, a heat medium circuit, and a relay unit that exchanges heat between the refrigerant and the heat medium. The relay unit includes a heat exchange unit that exchanges heat between the refrigerant and the heat medium, and a plurality of heat medium flow switching units that supply the heat medium subjected to heat exchange in the heat exchange unit to plurality of indoor units through branched lines, and the heat exchange unit and the heat medium flow switching units are located in different casings.

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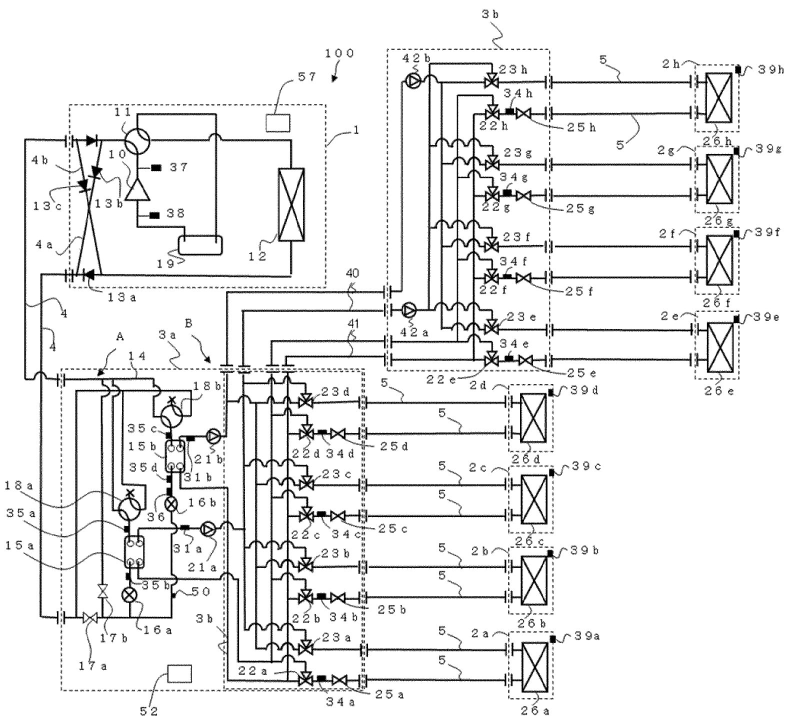

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Description

Technical Field

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

Background Art

[0002] Some of conventional air-conditioning apparatuses include, as in the case of a multi-air-conditioning apparatus for building, a heat source unit (outdoor unit) located outside of a building and indoor units located inside of the building. A refrigerant circulating in a refrigerant circuit of such an air-conditioning apparatus transmits or receives heat to or from air supplied to a heat exchanger of the indoor unit, thereby heating or cooling the air. Then the heated or cooled air is blown into a space to be air-conditioned, to heat or cool the space. Normally the building includes a plurality of indoor spaces, and hence a plurality of indoor units are provided. In addition, when the building is large the refrigerant pipe connecting between the outdoor unit and the indoor units may even reach 100 meters. When the pipe connecting between the outdoor unit and the indoor units is long, the amount of the refrigerant to be loaded in the refrigerant circuit increases as much.

[0003] The indoor units of the multi-air-conditioning apparatus for building are normally installed and utilized in indoor spaces where people are present (e.g., offices, living rooms, and stores). In case that for some reason the refrigerant leaks out of the indoor unit installed in the indoor space, serious concerns may arise from the viewpoint of impact to human body and safety, because some refrigerants are flammable and/or poisonous. Even when the refrigerant is harmless to human body, the leakage of the refrigerant leads to a decrease in oxygen concentration in the indoor space, which may exert a negative influence to human body. Accordingly, an air-conditioning apparatus has been proposed that includes a refrigerant circuit provided on the side of an outdoor unit in which a refrigerant is employed, a heat medium circuit provided on the side of indoor units in which a safe heat medium such as water or brine, and a relay unit that exchanges heat between the refrigerant circuit and the heat medium circuit (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-227242 (Abstract, Fig. 1)

Summary of Invention

Technical Problem

[0005] To perform the heat exchange between the refrigerant circuit and the heat medium circuit in the air-conditioning apparatus according to Patent Literature 1, a large number of components are necessary, and besides an increased number of valves have to be provided to distribute hot water or cool water generated in the heat medium circuit. On the other hand, when the air-conditioning apparatus is installed in a building or the like the size and weight of the casing of the relay unit have to be within a certain limit. Therefore, in the case where the components for conversion from the refrigeration cycle to the heat medium circuit are enclosed in a single casing, the number of branch lines for the indoor units is inevitably limited.

[0006] Accordingly, the present invention provides an air-conditioning apparatus that facilitates an increase in the number of indoor units that can be connected to a relay unit.

Solution to Problem

[0007] In an aspect, the present invention provides an air-conditioning apparatus that includes an outdoor unit including a compressor that compresses a refrigerant and a heat source-side heat exchanger that exchanges heat between air and the refrigerant, a plurality of indoor units each including an indoor heat exchanger that exchanges heat between air and a heat medium, a relay unit connected to the outdoor unit via a refrigerant pipe and connected to each of the indoor units via a heat medium pipe, the relay unit being configured to exchange heat between the refrigerant and the heat medium, and a first refrigerant flow switching device that switches a flow path of the refrigerant flowing into the relay unit between a heating flow path used in a heating operation and a cooling flow path used in a cooling operation. The relay unit includes a heat exchange unit that exchanges heat between the refrigerant and the heat medium, and a plurality of heat medium flow switching units that supply the heat medium subjected to heat exchange in the heat exchange unit to each of the plurality of indoor units through branched lines, the heat exchange unit and the heat medium flow switching units being located in different casings. The heat exchange unit includes a plurality of relay heat exchangers that exchange heat between the refrigerant and the heat medium, and a second refrigerant flow switching device that switches the flow path of the heat medium flowing into the relay heat exchanger according to the switching status between the cooling operation and the heating operation. The heat medium flow switching unit includes a plurality of heat medium flow switching devices corresponding to the respective indoor units and configured to switch a combination of the connection between the indoor units and the relay heat exchangers, and a plurality of heat medium flow control devices connected to the respective heat medium flow switching devices and configured to control a flow rate of the heat medium flowing into the plurality of indoor units.

Advantageous Effects of Invention

[0008] With the air-conditioning apparatus according to the present invention, the number of heat medium flow control devices that can be connected to the relay unit can be increased, by separately locating the relay heat exchanger that exchanges heat between the refrigerant and the heat medium from a part of the heat medium circuit including the heat medium flow switching devices and the heat medium flow control devices that control the flow rate of the heat medium flowing into the indoor units. Consequently, the number of indoor units that can be connected to the relay unit can be increased.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a schematic drawing showing an air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is an exemplary refrigerant circuit diagram of the air-conditioning apparatus shown in Fig. 1.

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

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

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

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

[Fig. 7] Fig. 7 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 2 of the present invention.

[Fig. 8] Fig. 8 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 3 of the present invention.

[Fig. 9] Fig. 9 is a refrigerant circuit diagram of an air-conditioning apparatus according to another Embodiment of the present invention. Description of Embodiments

Embodiment 1

[0010] Fig. 1 is a schematic drawing showing an air-conditioning apparatus 100 according to Embodiment 1 of the present invention, and the air-conditioning apparatus 100 will be described hereunder with reference to Fig. 1. The air-conditioning apparatus 100 is intended to cool or heat a plurality of rooms in a building or the like. The air-conditioning apparatus 100 includes an outdoor unit 1 serving as a heat source unit, a plurality of indoor units 2a to 2h, and a relay unit 3 intermediating between the outdoor unit 1 and the indoor units 2a to 2h. The air-conditioning apparatus 100 adopts indirect utilization of a refrigerant (indirect method), so as to transmit cooling energy or heating energy retained by the refrigerant to a heat medium which is different from the refrigerant, thereby cooling or heating a space to be air-conditioned with the cooling energy or heating energy retained by the heat medium.

[0011] The outdoor unit 1 is installed in an outdoor space 6 outside (e.g., roof) of an architectural structure, for example a building 9, and serves to supply cooling energy or heating energy to the indoor units 2 through the relay unit 3. The indoor units 2a to 2h are each located at a position that allows cooling air or heating air to be supplied into an indoor space 7 inside the building 9, for example a living room, and supplies the cooling air or heating air into the indoor space 7. In each of the indoor units 2a to 2h, either a cooling mode or a heating mode can be freely selected.

[0012] The relay unit 3 serves to exchange heat between the refrigerant and the heat medium, and is accommodated in an independent casing apart from the outdoor unit 1 and the indoor units 2, at a different position from the outdoor space 6 and the indoor spaces 7. The relay unit 3 includes a heat exchange unit 3a and a heat medium flow switching unit 3b, which are connected to each other via pipes 40. The outdoor unit 1 and the heat exchange unit 3a are connected to each other via a refrigerant pipe 4 through which the refrigerant is made to circulate. In addition, the heat exchange unit 3a and the heat medium flow switching unit 3b are connected to each of the indoor units 2 via heat medium pipes 5 through which the heat medium is made to circulate. Cooling energy or heating energy generated in the outdoor unit 1 is transmitted to the indoor units 2 through the relay unit 3. Thus, the outdoor unit 1 is connected to the relay unit 3 via the refrigerant pipe 4, and the indoor units 2 are connected to the relay unit 3 via the heat medium pipes 5. Such a configuration facilitates the installation work of the air-conditioning apparatus 100.

[0013] Although Fig. 1 illustrates the case where the outdoor unit 1 is installed in the outdoor space 6, the outdoor unit 1 may be installed in a different location. For example, the outdoor unit 1 may be located in an enclosed space such as a machine room with a ventilation port, or inside of the building 9 provided that waste heat can be discharged out of the building 9 through an exhaust duct. In addition, in the case where the outdoor unit 1 is of a water-cooled type the outdoor unit 1 may be located inside of the building 9.

[0014] Further, although Fig. 1 illustrates the case where the relay unit 3 is located inside of the building 9 but in a space 8 behind a ceiling (e.g., a ceiling plenum of the building 9) which is different from the indoor space 7, the relay unit 3 may be located, for example, in a common-use space where an elevator is installed. Still further, although Fig. 1 illustrates the case where the indoor units 2 are of a ceiling cassette type, the indoor units 2 may be recessed in the ceiling or suspended from the ceiling, or installed in any desired manner provided that the heating air or cooling air can be blown into the indoor space 7 directly or through a duct or the like.

[0015] In the configuration shown in Fig. 1, the heat conversion unit 3a and the heat medium flow switching unit 3b may be located in the vicinity of the outdoor unit 1. It is preferable, however, that the relay unit 3 is located within a short distance from the indoor units 2 from the viewpoint of economical use of energy. In addition, although a single piece of heat medium flow switching unit 3b is connected in Fig. 1, the number of heat medium flow switching units 3b may be determined, for example, according to the number of indoor units 2.

[0016] Fig. 2 is an exemplary refrigerant circuit diagram of the air-conditioning apparatus 100 shown in Fig. 1. As shown in Fig. 2, the air-conditioning apparatus 100 includes the outdoor unit 1 serving as the heat source unit, the plurality of indoor units 2a to 2h, and the relay unit 3.

[Outdoor Unit 1]

[0017] The outdoor unit 1 includes a compressor 10, a first refrigerant flow switching device 11, a heat source-side heat exchanger 12, and an accumulator 19, each of which is connected to the refrigerant pipe 4. The compressor 10 sucks the refrigerant, and compresses the refrigerant so as to give a high temperature and a high pressure to the refrigerant. The compressor 10 may be of a reciprocating, rotary, scroll, or screw type, and may be constituted of an inverter compressor with a variable capacity. Here, a second pressure sensor 37 and a third pressure sensor 38, which are pressure detection devices, are respectively provided upstream and downstream of the compressor 10 along the refrigerant flow path, so that the flow rate of the refrigerant outputted from the compressor 10 can be calculated on the basis of the values detected by the pressure sensors 37, 38.

[0018] The first refrigerant flow switching device 11 is constituted of, for example, a four-way valve, and serves to switch the refrigerant flow path according to the required operation mode. More specifically, the first refrigerant flow switching device 11 switches the flow path betrween a heating flow path for the heating operation (heating-only operation mode and heating-main operation mode) and a cooling flow path for the cooling operation (cooling-only operation mode and cooling-main operation mode).

[0019] The heat source-side heat exchanger 12 exchanges heat between air and the refrigerant, so as to serve as an evaporator in the heating operation and as a radiator (gas cooler) in the cooling operation. The heat source-side heat exchanger 12 may be a gasheat exchanger that exchanges heat with air supplied by a non-illustrated fan, or a liquid heat exchanger that employs water or brine as the heat source.

[0020] The accumulator 19 is provided on the suction side of the compressor 10, and serves to accumulate a surplus refrigerant produced from difference between the heating operation and the cooling operation, as well as a surplus refrigerant produced from a transition of the operation status, such as a change in the number of indoor units in operation.

[0021] The outdoor unit 1 further 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 check valve 13a is provided in the refrigerant pipe connecting between the heat source-side heat exchanger 12 and a pipe through which the refrigerant flows out of the outdoor unit 1, and allows the refrigerant to flow only toward the relay unit 3 from the heat source-side heat exchanger 12. The check valve 13b is provided in the first connection pipe 4a, and allows the refrigerant discharged from the compressor 10 to flow only toward the relay unit 3, in the heating operation. The check valve 13c is provided in the second connection pipe 4b, and allows the refrigerant returning from the relay unit 3 in the heating operation to flow only toward the heat source-side heat exchanger 12. The check valve 13d is provided in the refrigerant pipe connecting between the first refrigerant flow switching device 11 and a pipe through which the refrigerant flows into the outdoor unit 1, and allows the refrigerant to flow only toward the first refrigerant flow switching device 11 from the latter pipe. The mentioned configuration allows the refrigerant flowing into the heat exchange unit 3a to flow only in the predetermined direction, irrespective of the operation mode required by the indoor units 2.

[Indoor Units 2]

[0022] The air-conditioning apparatus 100 shown in Fig. 1 includes eight indoor units 2a to 2h, respectively including use side heat exchangers 26a to 26h. The use side heat exchangers 26a to 26h each serve as a radiator (gas cooler) in the heating operation, and serve as a heat remover in the cooling operation. The use side heat exchangers 26a to 26h are each connected to the heat conversion unit 3a and the heat medium flow switching unit 3b via the pipe 5, so as to receive the heat medium from the heat conversion unit 3a and the heat medium flow switching unit 3b. The use side heat exchangers 26a to 26h exchange heat between indoor air supplied from a non-illustrated fan and the heat medium so as to give cooling energy or heating energy to the air, thereby generating the heating air or cooling air to be supplied into the space to be air-conditioned. Here, the use side heat exchangers 26a to 26h may be coil-shaped heat exchangers with a wide fin pitch installed in a ceiling to utilize natural convection, generally known as a chilled beam, instead of receiving air from the fan. In addition, incoming air temperature sensors 39a to 39h are respectively attached to the indoor units 2a to 2h, to detect the temperature of the air sucked from the room. The incoming air temperatures detected by the incoming air temperature sensors 39a to 39h are transmitted to a relay unit control device 52, which controls the relay unit 3 on the basis of the incoming air temperature.

[Relay Unit 3]

[0023] The relay unit 3, which serves to exchange heat between the refrigerant circulating on the side of the outdoor unit 1 and the heat medium circulating on the side of the indoor units 2a to 2h, includes the heat exchange unit 3a and the heat medium flow switching unit 3b. In the air-conditioning apparatus 100 shown in Fig. 2, one heat medium flow switching unit 3b is incorporated in the heat exchange unit 3a, and another heat medium flow switching unit 3b is provided in a separate casing from the casing including the heat exchange unit 3a. The outdoor unit 1 is connected to the heat exchange unit 3a via the refrigerant pipe 4, and the indoor units 2a to 2h are each connected to the heat medium flow switching unit 3b via the heat medium pipe 5. The heat exchange unit 3a and the heat medium flow switching unit 3b are located in the separate casings (see Fig. 1), and connected to each other via the pipe 40. Thus, the heat medium circulates between the heat exchange unit 3a and the heat medium flow switching unit 3b through the pipe 40.

[Heat Conversion Unit 3a]

[0024] The heat conversion unit 3a includes relay heat exchangers 15a, 15b, expansion devices 16a, 16b, opening/closing devices 17a, 17b, second refrigerant flow switching devices 18a, 18b, and pumps 21 a, 21 b that drives the heat medium to circulate.

[0025] The two relay heat exchangers 15a, 15b each serve as a condenser (radiator) or an evaporator, and exchange heat between the refrigerant and the heat medium so as to transmit the cooling energy or heating energy, generated in the outdoor unit 1 and retained by the refrigerant, to the heat medium. The relay heat exchanger 15a is provided between the expansion device 16a and the second refrigerant flow switching device 18a in a refrigerant circuit A, and serves to cool the heat medium in a cooling and heating mixed operation mode. The relay heat exchanger 15b is provided between the expansion device 16b and the second refrigerant flow switching device 18b in the refrigerant circuit A, and serves to heat the heat medium in the cooling and heating mixed operation mode.

[0026] The expansion devices 16a, 16b are constituted of a device the opening degree of which is variable, for example an electronic expansion valve, and serve to depressurize and expand the refrigerant with the function of a pressure reducing valve or the expansion valve. The expansion device 16a has an end connected to the relay heat exchanger 15a, and the other end connected to the liquid refrigerant supply valve 17a. The expansion device 16b has an end connected to the relay heat exchanger 15b, and the other end connected to the liquid refrigerant supply valve 17a. Accordingly, the expansion device 16a is located upstream of the relay heat exchanger 15a, along the refrigerant flow in the cooling-only operation mode. The expansion device 16b is located upstream of the relay heat exchanger 15b along the refrigerant flow in the cooling-only operation mode.

[0027] The liquid refrigerant supply valve 17a and the gas refrigerant supply valve 17b are each constituted of a two-way valve or the like, and serve to open and close the refrigerant pipe in the refrigerant circuit A. The liquid refrigerant supply valve 17a has an end connected to the pipe through which the refrigerant flows into the relay unit 3, and the other end connected to the expansion devices 16a, 16b. The gas refrigerant supply valve 17b has an end connected to the pipe through which the refrigerant flows into the relay unit 3, and the other end connected to the second refrigerant flow switching devices 18a, 18b. The liquid refrigerant supply valve 17a and the gas refrigerant supply valve 17b may be selected according to the flow rate of the refrigerant flowing through the valve and the purpose of use, or may be constituted of a four-way valve in the case where the valves are controlled to open and close at different timings.

[0028] The second refrigerant flow switching devices 18a, 18b are each constituted of a four-way valve or the like, and switch the flow path of the heat medium flowing into the relay heat exchanger, according to the switching status between the cooling operation and the heating operation. More specifically, when the relay heat exchanger 15a serves as the radiator (refrigerant transmits heat to heat medium), the second refrigerant flow switching device 18a sets the heating flow path so as to cause the high-temperature/high-pressure refrigerant received through the gas refrigerant supply valve 17b to flow into the refrigerant flow path of the relay heat exchanger 15a. When the relay heat exchanger 15a serves as the evaporator (refrigerant removes heat from heat medium), the second refrigerant flow switching device 18a sets the cooling flow path so as to cause the refrigerant flowing out of the refrigerant flow path of the heat exchanger 15a to flow toward a pipe 14. When the relay heat exchanger 15b serves as the radiator (refrigerant transmits heat to water), the second refrigerant flow switching device 18b sets the heating flow path so as to cause the high-temperature/high-pressure refrigerant received through the liquid refrigerant supply valve 17b to flow into the refrigerant flow path of the relay heat exchanger 15b. When the relay heat exchanger 15b serves as the evaporator (refrigerant removes heat from water), the second refrigerant flow switching device 18b sets the cooling flow path so as to cause the refrigerant flowing out of the refrigerant flow path of the heat exchanger 15b to flow toward the pipe 14.

[0029] The pumps 21 a, 21 b are configured to variably control the capacity thereof, and deliver the heat medium from the heat exchange unit 3a to the heat medium flow switching unit 3b, so as to cause the heat medium to circulate in the pipe 5. More specifically, the pump 21 a is provided between the relay heat exchanger 15a and the heat medium flow switching unit 3b incorporated in the heat exchange unit 3a. The pump 21 b is provided between the relay heat exchanger 15b and the heat medium flow switching unit 3b incorporated in the heat exchange unit 3a. Further, the pumps 21 a, 21 b are connected via the pipe 40 to the heat medium flow switching unit 3b in the separate casing from the casing including the heat exchange unit 3a. Here, although the pumps 21 a, 21 b are connected to the outlet side toward the heat medium flow switching unit 3b (on the side of heat medium flow switching devices 23a to 23h) in Fig. 2, the pumps 21 a, 21 b may be connected to the inlet side from the heat medium flow switching unit 3b (on the side of first heat medium flow switching devices 22a to 22d).

[0030] The heat conversion unit 3a also includes first temperature sensors 31 a, 31 b, second temperature sensors 35a to 35d, a fourth temperature sensor 50, a first pressure sensor 36, and a relay unit control device 52. Information detected by these sensors (e.g., temperature information and pressure information) is transmitted to a controller that controls the overall operation of the air-conditioning apparatus 100, to be utilized for controlling the driving frequency of the compressor 10, the rotation speed of non-illustrated fans provided in the vicinity of the heat source-side heat exchanger 12 and the use side heat exchanger 26, the switching of the first refrigerant flow switching device 11, the driving frequency of the pumps 21 and pumps 42, the switching of the second refrigerant flow switching device 18, the switching of the heat medium flow path, and so forth.

[0031] The first temperature sensors 31 a, 31 b serve to detect the temperature of the heat medium flowing out of the relay heat exchangers 15, in other words the temperature of the heat medium at the outlet of the relay heat exchangers 15a, 15b, and may preferably be constituted of a thermistor. The first temperature sensor 31 a is provided in the pipe 5 at the inlet of the pump 21 a, and the first temperature sensor 31 b is provided in the pipe 5 at the inlet of the pump 21 b.

[0032] The second temperature sensors 35a to 35d serve to detect the temperature of the refrigerant flowing into or out of the relay heat exchangers 15, and may preferably be constituted of a thermistor. The second temperature sensors 35a to 35d are respectively provided at the inlet side and the outlet side on the refrigerant side of the relay heat exchangers 15a, 15b. More specifically, the second temperature sensor 35a is provided between the relay heat exchanger 15a and the second refrigerant flow switching device 18a, and the second temperature sensor 35b is provided between the relay heat exchanger 15a and the expansion device 16a. The second temperature sensor 35c is provided between the relay heat exchanger 15b and the second refrigerant flow switching device 18b, and the second temperature sensor 35d is provided between the relay heat exchanger 15b and the expansion device 16b. The fourth temperature sensor 50 serves to provide the temperature information used for calculating an evaporation temperature and a condensation temperature, and is provided between the expansion device 16a and the expansion device 16b.

[0033] The relay unit control device 52 is constituted of a microcomputer or the like, and calculates the evaporation temperature, the condensation temperature, a saturation temperature, a superheating degree, and a subcooling degree on the basis of the temperature information, pressure information and so forth detected by the sensors cited above. The controller 57 controls the opening degree of the expansion devices 16a, 16b, the rotation speed of the compressor 10, the rotation speed (also on/off) of the heat source-side heat exchanger 12 and the use side heat exchangers 26a to 26h on the basis of the calculation result, so as to optimize the performance of the air-conditioning apparatus 100. In addition, the controller 57 controls the driving frequency of the compressor 10, the rotation speed (also on/off) of the fans, the switching of the first refrigerant flow switching device 11, the driving of the pumps 21 a, 21 b, the opening degree of the expansion devices 16a, 16b, the opening/closing actions of the opening/closing devices 17a, 17b, the switching of the second refrigerant flow switching devices 18a, 18b, and so forth, on the basis of the detection information from the sensors and instructions from a remote controller. Thus, the controller 57 performs centralized control of the components for executing the operation modes to be subsequently described. Here, the outdoor unit 1 includes an outdoor unit control device 57, which controls the actuator of the outdoor unit 1 on the basis of information transmitted from the relay unit control device 52. Although the relay unit control device 52 is illustrated as a separate device from the outdoor unit control device 57 in Fig. 2, a single unified control device may be provided.

[0034] The relay unit control device 52 also calculates a liquid inlet enthalpy on the basis of the temperature information from the fourth temperature sensor 50. The relay unit control device 52 receives a temperature of a low-pressure two-phase refrigerant from the second temperature sensor 35d (or 35b), and calculates a saturated liquid enthalpy and a saturated gas enthalpy on the basis of the temperature information. In addition, the relay unit control device 52 may also calculate the evaporation temperature and the condensation temperature on the basis of the mentioned information.

[Heat Medium Flow Switching Unit 3b]

[0035] The heat medium flow switching unit 3b, to which the plurality of indoor units 2a to 2d (or indoor units 2e to 2h) are connected, serves to switch the flow path of the heat medium flowing toward the indoor units 2a to 2d according to the operation mode. As stated above, in the air-conditioning apparatus 100 shown in Fig. 1 and Fig. 2 one heat medium flow switching unit 3b is incorporated in the heat exchange unit 3a and another heat medium flow switching unit 3b is mounted in the separate casing from the casing including the heat exchange unit 3a. The heat medium flow switching unit 3b incorporated in the heat exchange unit 3a is connected to the indoor units 2a to 2d, and the heat medium flow switching unit 3b in the separate casing is connected to the indoor units 2e to 2h, in Fig. 1 and Fig. 2. The heat medium flow switching units 3b, 3b have the same configuration, and each of the constituents will be described hereunder, with respect to both of the heat medium flow switching units 3b, 3b, collectively.

[0036] The heat medium flow switching units 3b, 3b include the first heat medium flow switching devices 22a to 22h, the second heat medium flow switching devices 23a to 23h, and the heat medium flow control devices 25a to 25h, which are respectively connected to the indoor units 2a to 2h via the pipe 5. Here, the same number of indoor units 2 can be connected as the number of branch lines (eight in Embodiment 1) of the first heat medium flow switching devices 22a to 22h, the second heat medium flow switching devices 23a to 23h, and the heat medium flow control devices 25a to 25h.

[0037] The first heat medium flow switching devices 22a to 22h are each constituted of a three-way valve or the like, and serve to switch the flow path of the heat medium flowing toward the indoor units 2a to 2h. The first heat medium flow switching devices 22a to 22h are each provided on the outlet side of the heat medium flow path of the use side heat exchangers 26a to 26h, such that one of the three ways is connected to the inlet side of the relay heat exchanger 15a, and another of the three ways is connected to the inlet side of the relay heat exchanger 15b.

[0038] The second heat medium flow switching devices 23a to 23h are each constituted of a three-way valve or the like, and serve to switch the flow path of the heat medium flowing toward the indoor units 2a to 2h. One of the three ways of each of the second heat medium flow switching devices 23a to 23h is connected to the discharge side of the relay heat exchanger 15a, another of the three ways is connected to the discharge side of the relay heat exchanger 15b, and the remaining one of the three ways is connected to the inlet side of the heat medium flow path of the corresponding one of the use side heat exchangers 26a to 26h.

[0039] The heat medium flow control devices 25a to 25h are each constituted of a two-way valve or the like with variable aperture area, and serve to adjust the flow rate of the heat medium flowing in the pipe 5. The heat medium flow control devices 25a to 25h each have an end connected to the outlet side of the heat medium flow path of the use side heat exchangers 26 to 26h, and the other end connected to the first heat medium flow switching devices 22a to 22h. Here, although the heat medium flow control devices 25a to 25h are provided on the outlet side of the heat medium flow path of the use side heat exchangers 26a to 26h in Fig. 2, the heat medium flow control devices 25a to 25h may be provided on the inlet side (on the side of the second heat medium flow switching devices 23a to 23h).

[0040] As described above, the pipe 5 through which the heat medium circulates is branched according to the number of branch lines of the heat medium flow switching unit 3b (i.e., the number of indoor units 2) connected to the relay unit 3. Accordingly, the connection between the indoor units 2a to 2h and the relay heat exchanger 15a or the relay heat exchanger 15b via the pipe 5 can be switched by controlling the first heat medium flow switching devices 22a to 22h and the second heat medium flow switching devices 23a to 23h. With such a configuration, the relay unit control device 52 can control the heat medium flow so as to allow the heat medium from the relay heat exchanger 15a to flow into the use side heat exchanger 26 or allow the heat medium from the relay heat exchanger 15b to flow into the use side heat exchanger 26, by individually controlling the first heat medium flow switching devices 22a to 22h and the second heat medium flow switching devices 23a to 23h.

[0041] Further, two pumps 42a, 42b that drive the heat medium to circulate are provided on the side of the heat medium flow switching unit 3b in the separate casing from the casing inclulding the heat exchange unit 3a. The respective suction ports of the pumps 42a, 42b are connected to the heat conversion unit 3a via the pipe 40. In addition, a pipe connected to the four first heat medium flow switching devices 22, different from the pipe on the side of the indoor units, are connected to the heat conversion unit 3a via the pipe 41.

[0042] Although Fig. 1 illustrates the case where the heat medium flow switching unit 3b has four branch lines and hence four indoor units 2a to 2d (or 2e to 2h) at maximum can be connected, the number of branch lines may be just two or more, or more than four.

[0043] The heat medium flow switching unit 3b further includes third temperature sensors 34a to 34h. The third temperature sensors 34a to 34h are respectively provided between the first heat medium flow switching devices 22a to 22h and the heat medium flow control devices 25a to 25h. The third temperature sensors 34a to 34h each serve to detect the temperature of the heat medium flowing out of the use side heat exchanger 26, and are constituted of a thermistor. The temperatures detected by the third temperature sensors 34a to 34h are transmitted to the relay unit control device 52.

[Refrigerant Circuit]

[0044] The air-conditioning apparatus 100 includes the refrigerant circuit A and a heat medium circuit B, and the relay heat exchangers 15a, 15b exchange heat between the refrigerant circulating in the refrigerant circuit A and the water circulating in the heat medium circuit B. The refrigerant circuit A includes the compressor 10, the first refrigerant flow switching device 11, the heat source-side heat exchanger 12, the opening/closing devices 17a, 17b, the second refrigerant flow switching devices 18a, 18b, the refrigerant flow path of the relay heat exchangers 15a, 15b, the expansion devices 16a, 16b, and the accumulator 19, which are connected via the refrigerant pipe 4. The heat medium circuit B includes the heat medium flow path of the relay heat exchangers 15a, 15b, the pumps 21 a, 21 b, the pumps 42a, 42b, the first heat medium flow switching devices 22a to 22h, the heat medium flow control devices 25a to 25h, the use side heat exchangers 26a to 26h, and the second heat medium flow switching devices 23a to 23h, which are connected via the pipe 5.

[0045] The refrigerant circulating in the refrigerant circuit A is not specifically limited and may be, for example, a single mixed refrigerant such as R-22 or R-135a, a pseudo-azeotropic refrigerant mixture such as R-410A or R-404A, a non-azeotropic refrigerant mixture such as R-407C, a refrigerant containing a double bond in the formula and having a relatively low global warming potential such as $CF_3CF=CH_2$, or a mixture thereof, or a natural refrigerant such as CO_2 or propane. The heat medium circulating in the heat medium circuit B may be, for example, water or brine (antifreeze solution). The type of the antifreeze agent of the antifreeze solution is not specifically limited, but preferably ethyleneglycol, propyleneglycol, or the like may be adopted according to the purpose of use. Since the cited heat media have high level of safety, there is little likelihood that harm or trouble is incurred even though the heat medium leaks into the air-conditioned space through the indoor units 2a to 2h.

[Description of Operation Modes]

[0046] The operation modes performed by the air-conditioning apparatus 100 will be described hereunder. The air-conditioning apparatus 100 is configured to receive an instruction from each of the indoor units 2 and to cause the corresponding indoor unit 2 to perform the cooling operation or heating operation. Further, the air-conditioning apparatus 100 is configured to cause all of the indoor units 2 to perform the same operation, or allow each of the indoor units 2 to perform a different operation.

[0047] The operation modes that the air-conditioning apparatus 100 is configured to perform include a cooling-only operation mode in which all of the indoor units 2 in operation perform the cooling operation, a heating-only operation mode in which all of the indoor units 2 in operation perform the heating operation, a cooling-main operation mode in which the load of cooling is greater, and a heating-main operation mode in which the load of heating is greater. Each of these operation modes will be described hereunder, along with the flow of the refrigerant and the heat medium.

[Cooling-Only Operation Mode]

[0048] Fig. 3 is a refrigerant circuit diagram showing the flow of the heat medium in the cooling-only operation mode of the air-conditioning apparatus 100 shown in Fig. 2. Referring to Fig. 3, the cooling-only operation mode will be described on the assumption that a cooling load has arisen in the indoor units corresponding to the use side heat exchangers 26a to 26c and 26e to 26g. In Fig. 3, the pipes illustrated in bold lines represent the pipes in which the refrigerant (refrigerant and heat medium) flows, and the flow of the refrigerant is indicated by solid arrows and the flow of the heat medium is indicated by broken-line arrows.

[0049] In the cooling-only operation mode shown in Fig. 3, the first refrigerant flow switching device 11 is switched so as to cause the refrigerant discharged from the compressor 10 to flow into the heat source-side heat exchanger 12, in the outdoor unit 1. In the heat conversion unit 3a, the pump 21 a and the pump 21 b are driven so as to open the heat medium flow control devices 25a to 25c and fully close the heat medium flow control device 25d, so that the heat medium circulates between each of the relay heat exchanger 15a and the relay heat exchanger 15b and the use side heat exchangers 26a to 26c. In addition, a part of the heat medium discharged from the pump 21 a and the pump 21 b is caused to circulate between each of the relay heat exchanger 15a and the relay heat exchanger 15b and the use side heat exchangers 26e to 26g, by causing the heat medium flow switching unit 3b to drive the pump 42a and the pump 42b so as to open the heat medium flow control devices 25e to 25g and fully close the heat medium flow control device 25h.

[0050] The flow of the refrigerant in the refrigerant circuit A will first be described. The refrigerant in a low-temperature/low-pressure state is compressed by the compressor 10 and discharged therefrom in the form of high-temperature/high-pressure gas refrigerant. 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 flow switching device 11, and transmits heat to outdoor air in the heat source-side heat exchanger 12 thereby turning into high-pressure liquid refrigerant. The high-pressure refrigerant which has flowed out of the heat source-side heat exchanger 12 flows out of the outdoor unit 1 through the check valve 13a, and flows into the relay unit 3 through the refrigerant pipe 4. The high-pressure refrigerant which has entered the relay unit 3 flows through the high-pressure refrigerant opening/closing device 17a and is then branched and expanded in the expansion device 16a and the expansion device 16b so as to turn into low-temperature/low-pressure two-phase refrigerant. Here, the opening/closing device 17b is closed.

[0051] The two-phase refrigerant flows into each of the relay heat exchanger 15a and the relay heat exchanger 15b acting as an evaporator, and cools the heat medium circulating in the heat medium circuit B by removing heat from the heat medium, thereby turning into low-temperature/low-pressure gas refrigerant. The gas refrigerant which has flowed out of the relay heat exchanger 15a and the relay heat exchanger 15b flows out of the relay unit 3 through the second refrigerant flow switching device 18a and the second refrigerant flow switching device 18b, and again flows into the outdoor unit 1 through the refrigerant pipe 4. The refrigerant which has entered the outdoor unit 1 passes through the check valve 13d, and is again sucked into the compressor 10 through the first refrigerant flow switching device 11 and the accumulator 19.

[0052] In the mentioned process, the second refrigerant flow switching device 18a and the second refrigerant flow switching device 18b communicate with the low-pressure pipe. In addition, the opening degree of the expansion device 16a is controlled by the relay unit control device 52 so as to keep a degree of superheating at a constant level, the degree of superheating representing a difference between the temperature detected by the second temperature sensor 35a and the temperature detected by the second temperature sensor 35b. Likewise, the opening degree of the expansion device 16b is controlled by the relay unit control device 52 so as to keep a degree of superheating at a constant level, the degree of superheating representing a difference between the temperature detected by the second temperature sensor 35c and the temperature detected by the second temperature sensor 35d.

[0053] The flow of the heat medium in the heat medium circuit B will now be described. In the cooling-only operation mode, the cooling energy of the refrigerant is transmitted to the heat medium in both of the relay heat exchanger 15a and the relay heat exchanger 15b, and the cooled heat medium is driven by the pumps 21 a, 21 b to flow through the pipe 5. A part of the heat medium pressurized in the pump 21 a and the pump 21 b and discharged therefrom flows into each of the use side heat exchangers 26a to 26c through the second heat medium flow switching devices 23a to 23c, respectively. Then the heat medium removes heat from indoor air in the use side heat exchangers 26a to 26c, thereby cooling the indoor space 7.

[0054] Thereafter, the heat medium flows out of the use side heat exchangers 26a to 26c and flows into the heat medium flow control devices 25a to 25c. At this point, the heat medium flows into the use-side heat exchangers 26a to 26c at a flow rate controlled by the heat medium flow control devices 25a to 25c so as to satisfy the air-conditioning load required in the indoor space. The heat medium which has flowed out of the heat medium flow control devices 25a to 25c passes through the first heat medium flow switching devices 22a to 22c, respectively, and flows into the relay heat exchanger 15a and the relay heat exchanger 15b, and is again sucked into the pump 21 a and the pump 21 b.

[0055] Apart from the above, the heat medium pressurized in the pump 21 a and the pump 21 b and discharged therefrom is transmitted through the pipe 40 to the heat medium flow switching unit 3b in the separate casing from the casing including the heat exchange unit 3a. In the heat medium flow switching unit 3b, the heat medium is further pressurized in the heat medium pumps 42a, 42b and flows into each of the use side heat exchangers 26e to 26g through the second heat medium flow switching devices 23e to 23g, respectively. Then the heat medium removes heat from indoor air in the use side heat exchangers 26e to 26g, thereby cooling the indoor space 7.

[0056] Thereafter, the heat medium flows out of the use side heat exchangers 26e to 26g and flows into the heat medium flow control devices 25e to 25g, respectively. At this point, the heat medium flows into the use-side heat exchangers 26e to 26g at a flow rate controlled by the heat medium flow control devices 25e to 25g so as to satisfy the air-conditioning load required in the indoor space. The heat medium which has flowed out of the heat medium flow control devices 25e to 25g passes through each of the first heat medium flow switching devices 22e to 22g and flows into the relay heat exchanger 15a and the relay heat exchanger 15b through the pipe 41, and is again sucked into the pump 21 a and the pump 21 b.

[0057] The air-conditioning load required in the indoor space 7 can be secured by controlling so as to maintain a target value representing a difference between the temperature detected by the first temperature sensor 31 a or the first temperature sensor 31 b and the temperature detected by each of the third temperature sensors 34a to 34c and 34e to 34g. The temperature detected by whichever of the first temperature sensors 31 a, 31 b may be adopted as the outlet temperature of the relay heat exchangers 15a, 15b, or the average of the temperatures respectively detected by the first temperature sensors 31 a, 31 b may be adopted as the outlet temperature. At this point, the opening degree of the first heat medium flow switching devices 22a to 22c and 22e to 22g, and the second heat medium flow switching devices 23a to 23c and 23e to 23g is set to an intermediate level to secure the flow path leading to both of the relay heat exchanger 15a and the relay heat exchanger 15b.

[0058] When the cooling-only operation mode is performed, the heat medium is supplied to the use side heat exchangers 26a to 26c and 26e to 26g because the thermal load is required in these heat exchangers, however since thermal load is not required in the use side heat exchanger 26d and the use side heat exchanger 26h and hence there is no need to supply the heat medium thereto, the heat medium flow control device 25d and the heat medium flow control device 25h are fully closed. When a thermal load arises in the use side heat exchanger 26d or the use side heat exchanger 26h, the heat medium flow control device 25d or the heat medium flow control device 25h is opened so as to cause the heat medium to circulate.

[Heating Only Operation Mode]

[0059] Fig. 4 is a refrigerant circuit diagram showing the flow of the heat medium in the heating-only operation mode of the air-conditioning apparatus 100 shown in Fig. 2. Referring to Fig. 4, the heating-only operation mode will be described on the assumption that a heating load has arisen only in the use side heat exchangers 26a to 26c and 26e to 26g. In Fig. 4, the pipes illustrated in bold lines represent the pipes in which the refrigerant (refrigerant and heat medium) flows, and the flow of the refrigerant is indicated by solid arrows and the flow of the heat medium is indicated by broken-line arrows.

[0060] In the heating-only operation mode shown in Fig. 4, the first refrigerant flow switching device 11 is switched so as to cause the refrigerant discharged from the compressor 10 to flow into the heat conversion unit 3a without passing through the heat source-side heat exchanger 12, in the outdoor unit 1. In the heat conversion unit 3a, the pump 21 a and the pump 21 b are driven so as to open the heat medium flow control devices 25a to 25c and fully close the heat medium flow control device 25d, so that the heat medium circulates between each of the relay heat exchanger 15a and the relay heat exchanger 15b and the use side heat exchangers 26a to 26c. In addition, a part of the heat medium discharged from the pump 21 a and the pump 21 b is caused to circulate between each of the relay heat exchanger 15a and the relay heat exchanger 15b and the use side heat exchangers 26e to 26g, by causing the heat medium flow switching unit 3b to drive the pump 42a and the pump 42b so as to open the heat medium flow control devices 25e to 25g and fully close the heat medium flow control device 25h.

[0061] The flow of the refrigerant in the refrigerant circuit A will first be described. The refrigerant in a low-temperature/low-pressure state is compressed by the compressor 10 and discharged therefrom in the form of high-temperature/high-pressure gas refrigerant. The high-temperature/high-pressure gas refrigerant discharged from the compressor 10 passes through the first refrigerant flow switching device 11 and the check valve 13b, and flows out of the outdoor unit 1. The high-temperature/high-pressure gas refrigerant which has flowed out of the outdoor unit 1 flows into the relay unit 3 through the refrigerant pipe 4. The high-temperature/high-pressure gas refrigerant which has entered the relay unit 3 is branched and passes through the second refrigerant flow switching device 18a and the second refrigerant flow switching device 18b, and flows into each of the relay heat exchanger 15a and the relay heat exchanger 15b.

[0062] The high-temperature/high-pressure gas refrigerant which has entered the relay heat exchanger 15a and the relay heat exchanger 15b transmits heat to the heat medium circulating in the heat medium circuit B, thereby turning into high-pressure liquid refrigerant. The liquid refrigerant which has flowed out of the relay heat exchanger 15a and the relay heat exchanger 15b is expanded in the expansion device 16a and the expansion device 16b thereby turning into low-temperature/low-pressure two-phase refrigerant. The two-phase refrigerant flows out of the relay unit 3 through the opening/closing device 17b, and again flows into the outdoor unit 1 through the refrigerant pipe 4. Here the, opening/closing device 17a is closed.

[0063] The refrigerant which has entered the outdoor unit 1 flows into the heat source-side heat exchanger 12 acting as an evaporator, through the check valve 13c. The refrigerant which has entered the heat source-side heat exchanger 12 removes heat from outdoor air in the heat source-side heat exchanger 12 thereby turning into low-temperature/low-pressure gas refrigerant. The low-temperature/low-pressure gas refrigerant which has flowed out of the heat source-side heat exchanger 12 is again sucked into the compressor 10, through the first refrigerant flow switching device 11 and the accumulator 19.

[0064] In the mentioned process, the second refrigerant flow switching device 18a and the second refrigerant flow switching device 18b communicate with the high-pressure pipe. In addition, the opening degree of the expansion device 16a is controlled so as to keep a degree of subcooling at a constant level, the degree of subcooling representing a difference between a saturation temperature converted from the pressure detected by the pressure sensor 36 and the temperature detected by the second temperature sensor 35b. Likewise, the opening degree of the expansion device 16b is controlled so as to keep a degree of subcooling at a constant level, the degree of subcooling representing a difference between a saturation temperature converted from the pressure detected by the pressure sensor 36 and the temperature detected by the second temperature sensor 35d. Here, in the case where the temperature at an intermediate position of the relay heat exchangers 15 can be measured, the temperature at the intermediate position may be used instead of the pressure sensor 36, in which case the system can be formed at a lower cost.

[0065] The flow of the heat medium in the heat medium circuit B will now be described. In the heating-only operation mode, the heating energy of the refrigerant is transmitted to the heat medium in both of the relay heat exchanger 15a and the relay heat exchanger 15b, and the heated heat medium is driven by the pumps 21 a, 21 b to flow through the pipe 5. A part of the heat medium pressurized in the pumps 21 a, 21 b and discharged therefrom flows into the use side heat exchangers 26a to 26c through the second heat medium flow switching devices 23a to 23c, respectively. Then the heat medium transmits heat to indoor air in the use side heat exchangers 26a to 26c, thereby heating the indoor space 7.

[0066] Thereafter, the heat medium flows out of the use side heat exchangers 26a to 26c and flows into the heat medium flow control devices 25a to 25c, respectively. At this point, the heat medium flows into the use-side heat exchangers 26a to 26c at a flow rate controlled by the heat medium flow control devices 25a to 25c so as to satisfy the air-conditioning load required in the indoor space. The heat medium which has flowed out of the heat medium flow control devices 25a to 25c passes through the first heat medium flow switching devices 22a to 22c and flows into the relay heat exchanger 15a and the relay heat exchanger 15b, and is again sucked into the pump 21 a and the pump 21 b.

[0067] Another part of the heat medium pressurized in the pump 21 a and the pump 21 b and discharged therefrom passes through the pipe 40 and is then further pressurized in the pump 42a, 42b, and flows into the use side heat exchangers 26e to 26g through the second heat medium flow switching devices 23e to 23g, respectively. Then the heat medium transmits heat to the indoor air in the use side heat exchangers 26e to 26g, thereby heating the indoor space 7.

[0068] Thereafter, the heat medium flows out of the use side heat exchangers 26e to 26g and flows into the heat medium flow control devices 25e to 25g, respectively. At this point, the heat medium flows into the use-side heat exchangers 26e to 26g at a flow rate controlled by the heat medium flow control devices 25e to 25g so as to satisfy the air-conditioning load required in the indoor space. The heat medium which has flowed out of the heat medium flow control devices 25e to 25g passes through the first heat medium flow switching devices 22e to 22g and flows into the relay heat exchanger 15a and the relay heat exchanger 15b through the pipe 41, and is again sucked into the pump 21 a and the pump 21 b.

[0069] The air-conditioning load required in the indoor space 7 can be secured by controlling so as to maintain a target value representing a difference between the temperature detected by the first temperature sensor 31 a or the first temperature sensor 31 b and the temperature detected by each of the third temperature sensors 34a to 34c and 34e to 34g. The temperature detected by whichever of the first temperature sensors 31 a, 31 b may be adopted as the outlet temperature of the relay heat exchangers 15a, 15b, or the average of the temperatures respectively detected by the first temperature sensors 31 a, 31 b may be adopted as the outlet temperature.

[0070] In the mentioned process, the opening degree of the first heat medium flow switching devices 22a to 22c and 22e to 22g, and the second heat medium flow switching devices 23a to 23c and 23e to 23g is set to an intermediate level to secure the flow path leading to both of the relay heat exchanger 15a and the relay heat exchanger 15b. Although in principle the use side heat exchangers 26 have to be controlled on the basis of the difference in temperature between the inlet and the outlet, actually the heat medium temperature at the inlet of the use side heat exchangers 26 is nearly the same as the temperature detected by the first temperature sensor 31 b. Therefore, adopting the value of the first temperature sensor 31 b allows reduction of the number of temperature sensors, which leads to reduction in cost of the system.

[0071] When the heating-only operation mode is performed, the heat medium is supplied to the use side heat exchangers 26a to 26c and 26e to 26g because the thermal load is required in these heat exchangers, however since thermal load is not required in the use side heat exchanger 26d and the use side heat exchanger 26h and hence there is no need to supply the heat medium thereto, the heat medium flow control device 25d and the heat medium flow control device 25h are fully closed. When a thermal load arises in the use side heat exchanger 26d or the use side heat exchanger 26h, the heat medium flow control device 25d or the heat medium flow control device 25h is opened so as to cause the heat medium to circulate.

[Cooling Main Operation Mode]

[0072] Fig. 5 is a refrigerant circuit diagram showing the flow of the heat medium in the cooling-main operation mode of the air-conditioning apparatus 100 shown in Fig. 2. Referring to Fig. 5, the cooling-main operation mode will be described on the assumption that a heating load has arisen in the use side heat exchanger 26a and a cooling load has arisen in the use side heat exchangers 26d, 26e. In Fig. 5, the pipes illustrated in bold lines represent the pipes in which the refrigerant (refrigerant and heat medium) circulates, and the flow of the refrigerant is indicated by solid arrows and the flow of the heat medium is indicated by broken-line arrows.

[0073] In the cooling-main operation mode shown in Fig. 5, the first refrigerant flow switching device 11 is switched so as to cause the refrigerant discharged from the compressor 10 to flow into the heat source-side heat exchanger 12, in the outdoor unit 1. In the heat conversion unit 3a, the pump 21 a and the pump 21 b are driven so as to open the heat medium flow control device 25a and the heat medium flow control device 25d and fully close the heat medium flow control devices 25b, 25c, so that the heat medium circulates between the relay heat exchanger 15a and the use side heat exchanger 26a, as well as between the relay heat exchanger 15b and the use side heat exchanger 26b. In the heat medium flow switching unit 3b, only the pump 42a is driven so as to open the heat medium flow control device 25e and fully close the heat medium flow control devices 25f, 25g, and 25h, so that the heat medium circulates between the relay heat exchanger 15a and the use side heat exchanger 26e. Here, in the case where a heating load has arisen in any of the indoor units 2e to 2h connected to the heat medium flow switching unit 3b, the pump 42b is also activated.

[0074] The flow of the refrigerant in the refrigerant circuit A will first be described. The refrigerant in a low-temperature/low-pressure state is compressed by the compressor 10 and discharged therefrom in the form of high-temperature/high-pressure gas refrigerant. 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 flow switching device 11, and transmits heat to outdoor air in the heat source-side heat exchanger 12 thereby turning into liquid refrigerant. The refrigerant which has flowed out of the heat source-side heat exchanger 12 flows out of the outdoor unit 1, and flows into the relay unit 3 through the check valve 13a and the refrigerant pipe 4. The refrigerant which has entered the relay unit 3 flows into the relay heat exchanger 15b acting as a condenser through the second refrigerant flow switching device 18b.

[0075] The refrigerant which has entered the relay heat exchanger 15b transmits heat to the heat medium circulating in the heat medium circuit B, thereby further lowering the temperature thereof. The refrigerant which has flowed out of the relay heat exchanger 15b is expanded in the expansion device 16b so as to turn into low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the relay heat exchanger 15a acting as an evaporator through the expansion device 16a. The low-pressure two-phase refrigerant which has entered the relay heat exchanger 15a removes heat from the heat medium circulating in the heat medium circuit B, thereby turning into low-pressure gas refrigerant while cooling the heat medium. The gas refrigerant flows out of the relay heat exchanger 15a, flows out of the relay unit 3 through the second refrigerant flow switching device 18a, and again flows into the outdoor unit 1 through the refrigerant pipe 4. The refrigerant which has entered the outdoor unit 1 passes through the check valve 13d, the first refrigerant flow switching device 11, and the accumulator 19, and is again sucked into the compressor 10.

[0076] In the mentioned process, the second refrigerant flow switching device 18a communicates with the low-pressure pipe, and the second refrigerant flow switching device 18b communicates with the high-pressure side pipe. In addition, the opening degree of the expansion device 16b is controlled by the relay unit control device 52 so as to keep a degree of superheating at a constant level, the degree of superheating representing a difference between the temperature detected by the second temperature sensor 35c and the temperature detected by the second temperature sensor 35d. In addition, the expansion device 16a is fully opened and the opening/closing devices 17a, 17b are closed. Here, the opening degree of the expansion device 16b may be controlled by the relay unit control device 52 so as to keep a degree of subcooling at a constant level, the degree of subcooling representing a difference between a saturation temperature converted from the pressure detected by the pressure sensor 36 and the temperature detected by the second temperature sensor 35d. Alternatively, the expansion device 16b may be fully opened and the expansion device 16a may be employed to control the degree of superheating or subcooling.

[0077] The flow of the heat medium in the heat medium circuit B will now be described. In the cooling-main operation mode, the heating energy of the refrigerant is transmitted to the heat medium in the relay heat exchanger 15b, and the heated heat medium is driven by the pump 21 b to flow through the pipe 5. In addition, the cooling energy of the refrigerant is transmitted to the heat medium in the relay heat exchanger 15a, and the cooled heat medium is driven by the pump 21a to flow through the pipe 5. A part of the heat medium pressurized in the pumps 21 a, 21 b and discharged therefrom flows into the use side heat exchangers 26a and 26d, through the second heat medium flow switching devices 23a and 23d, respectively.

[0078] In the use side heat exchanger 26a, the heat medium transmits heat to the indoor air thereby heating the indoor space 7. In the use side heat exchanger 26d, the heat medium removes heat from the indoor air, thereby cooling the indoor space 7. At this point, the heat medium flows into the use-side heat exchanger 26a and the use side heat exchanger 26d at a flow rate controlled by the heat medium flow control device 25a and the heat medium flow control device 25d respectively, so as to satisfy the air-conditioning load required in the indoor space. The heat medium with the temperature slightly lowered in the use side heat exchanger 26a flows into the relay heat exchanger 15b through the heat medium flow control device 25a and the first heat medium flow switching device 22a, and is again sucked into the pump 21 b. The heat medium with the temperature slightly increased in the use side heat exchanger 26d flows into the relay heat exchanger 15a through the heat medium flow control device 25d and the first heat medium flow switching device 22d, and is again sucked into the pump 21a. In addition, a part of the heat medium pressurized in the pump 21 a and discharged therefrom is further pressurized in the heat medium pump 42a and flows into the use side heat exchanger 26e through the second heat medium flow switching device 23e.

[0079] The heat medium removes heat from the indoor air in the use side heat exchanger 26e, thereby cooling the indoor space 7. At this point, the heat medium flows into the use-side heat exchanger 26e at a flow rate controlled by the heat medium flow control device 25e so as to satisfy the air-conditioning load required in the indoor space. The heat medium with the temperature slightly increased in the use side heat exchanger 26e flows into the relay heat exchanger 15a through the heat medium flow control device 25e and the first heat medium flow switching device 22e, and is again sucked into the pump 21 a.

[0080] In the mentioned process, the heated heat medium and the cooled heat medium are introduced into the use side heat exchangers 26a, 26d, and 26e where the heating load and the cooling load are required, without being mixed with each other, under the control of the first heat medium flow switching devices 22a, 22d, and 22e and the second heat medium flow switching devices 23a, 23d, and 23e, respectively. The air-conditioning load required in the indoor space 7 can be secured by causing the relay unit control device 52 to control so as to maintain a target value representing a difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the third temperature sensor 34a on the heating side, and between the temperature detected by the third temperature sensors 34d, 34e and the temperature detected by the first temperature sensor 31 a on the cooling side.

[0081] When the cooling-main operation mode is performed, the heat medium is supplied to the use side heat exchangers 26a, 26d, and 26e because the thermal load is required in these heat exchangers, however since thermal load is not required in the use side heat exchanger 26b and the use side heat exchangers 26c, 26f, 26g, and 26h and hence there is no need to supply the heat medium thereto, the corresponding heat medium flow control device 25b and the heat medium flow control devices 25c, 25f, 25g, and 25h are fully closed. When a thermal load arises in the use side heat exchanger 26b or any of the use side heat exchangers 26c, 26f, 26g, and 26h, the heat medium flow control device 25b or the corresponding one of the heat medium flow control devices 25c, 25f, 25g, and 25h is opened so as to cause the heat medium to circulate.

[Heating Main Operation Mode]

[0082] Fig. 6 is a refrigerant circuit diagram showing the flow of the heat medium in the cooling-main operation mode of the air-conditioning apparatus 100 shown in Fig. 2. Referring to Fig. 6, the heating-main operation mode will be described on the assumption that a heating load has arisen in the use side heat exchangers 26a, 26e and a cooling load has arisen in the use side heat exchanger 26d. In Fig. 6, the pipes illustrated in bold lines represent the pipes in which the refrigerant (refrigerant and heat medium) circulates, and the flow of the refrigerant is indicated by solid arrows and the flow of the heat medium is indicated by broken-line arrows.

[0083] In the heat medium flow switching unit 3b, only the pump 42b is driven so as to open the heat medium flow control device 25e and fully close the heat medium flow control devices 25f, 25g, and 25h, so that the heat medium circulates between the relay heat exchanger 15b and the use side heat exchanger 26e. Here, in the case where a cooling load has arisen in any of the indoor units connected to the heat medium flow switching unit 3b, the pump 42a is also activated.

[0084] In the heating-main operation mode shown in Fig. 6, the first refrigerant flow switching device 11 is switched so as to cause the refrigerant discharged from the compressor 10 to flow into the relay unit 3 without passing through the heat source-side heat exchanger 12, in the outdoor unit 1. In the heat conversion unit 3a, the pump 21 a and the pump 21 b are driven so as to open the heat medium flow control device 25a and the heat medium flow control device 25d and fully close the heat medium flow control device 25b and the heat medium flow control device 25c, so that the heat medium circulates between the relay heat exchanger 15a and the use side heat exchanger 26d, as well as between the relay heat exchanger 15b and the use side heat exchanger 26a.

[0085] First, the flow of the refrigerant in the refrigerant circuit A will be described. The refrigerant in a low-temperature/low-pressure state is compressed by the compressor 10 and discharged therefrom in the form of high-temperature/high-pressure gas refrigerant. The high-temperature/high-pressure gas refrigerant discharged from the compressor 10 flows out of the outdoor unit 1 through the first refrigerant flow switching device 11 and the check valve 13b. The high-temperature/high-pressure gas refrigerant which has flowed out of the outdoor unit 1 flows into the relay unit 3 through the refrigerant pipe 4. The high-temperature/high-pressure gas refrigerant which has entered the relay unit 3 flows into the relay heat exchanger 15b acting as a condenser through the second refrigerant flow switching device 18b.

[0086] The gas refrigerant which has entered the relay heat exchanger 15b transmits heat to the heat medium circulating in the heat medium circuit B, thereby turning into liquid refrigerant. The refrigerant which has flowed out of the relay heat exchanger 15b is expanded in the expansion device 16b thereby turning into low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant flows into the relay heat exchanger 15a acting as an evaporator through the expansion device 16a. The low-pressure two-phase refrigerant which has entered the relay heat exchanger 15a evaporates by removing heat from the heat medium circulating in the heat medium circuit B, thereby cooling the heat medium. The low-pressure two-phase refrigerant then flows out of the relay heat exchanger 15a, flows out of the relay unit 3 through the second refrigerant flow switching device 18a, and again flows into the outdoor unit 1.

[0087] The refrigerant which has entered the outdoor unit 1 flows into the heat source-side heat exchanger 12 acting as an evaporator, through the check valve 13c. The refrigerant which has entered the heat source-side heat exchanger 12 removes heat from outdoor air in the heat source-side heat exchanger 12 thereby turning into low-temperature/low-pressure gas refrigerant. The low-temperature/low-pressure gas refrigerant which has flowed out of the heat source-side heat exchanger 12 is again sucked into the compressor 10, through the first refrigerant flow switching device 11 and the accumulator 19.

[0088] In the mentioned process, the second refrigerant flow switching device 18a communicates with the low-pressure pipe, and the second refrigerant flow switching device 18b communicates with the high-pressure side pipe. In addition, the opening degree of the expansion device 16b is controlled by the relay unit control device 52 so as to keep a degree of subcooling at a constant level, the degree of subcooling representing a difference between a saturation temperature converted from the pressure detected by the pressure sensor 36 and the temperature detected by the second temperature sensor 35b. Here, the expansion device 16a is fully opened and the opening/closing devices 17a, 17b are closed. Alternatively, the expansion device 16b may be fully opened and the expansion device 16a may be employed to control the degree of subcooling.

[0089] The flow of the heat medium in the heat medium circuit B will now be described. In the heating-main operation mode, the heating energy of the refrigerant is transmitted to the heat medium in the relay heat exchanger 15b, and the heated heat medium is driven by the pump 21 b to flow through the pipe 5. In addition, the cooling energy of the refrigerant is transmitted to the heat medium in the relay heat exchanger 15a, and the cooled heat medium is driven by the pump 21a to flow through the pipe 5. A part of the heat medium pressurized in the pumps 21 a, 21 b and discharged therefrom flows into the use side heat exchanger 26a and the use side heat exchanger 26d, through the second heat medium flow switching device 23a and the second heat medium flow switching device 23d, respectively.

[0090] In the use side heat exchanger 26d, the heat medium removes heat from the indoor air, thereby cooling the indoor space 7. In the use side heat exchanger 26a, the heat medium transmits heat to the indoor air thereby heating the indoor space 7. At this point, the heat medium flows into the use-side heat exchanger 26a and the use side heat exchanger 26d at a flow rate controlled by the heat medium flow control device 25a and the heat medium flow control device 25d respectively, so as to satisfy the air-conditioning load required in the indoor space. The heat medium with the temperature slightly increased in the use side heat exchanger 26d flows into the relay heat exchanger 15a through the heat medium flow control device 25d and the first heat medium flow switching device 22d, and is again sucked into the pump 21 a. The heat medium with the temperature slightly lowered in the use side heat exchanger 26a flows into the relay heat exchanger 15b through the heat medium flow control device 25a and the first heat medium flow switching device 22a, and is again sucked into the pump 21b. In addition, a part of the heat medium pressurized in the pump 21 b and discharged therefrom is further pressurized in the heat medium pump 42b and flows into the use side heat exchanger 26e through the second heat medium flow switching device 23e.

[0091] The heat medium transmits heat to the indoor air in the use side heat exchanger 26e, thereby heating the indoor space 7. At this point, the heat medium flows into the use-side heat exchanger 26e at a flow rate controlled by the heat medium flow control device 25e so as to satisfy the air-conditioning load required in the indoor space. The heat medium with the temperature slightly lowered in the use side heat exchanger 26e flows into the relay heat exchanger 15b through the heat medium flow control device 25e and the first heat medium flow switching device 22e, and is again sucked into the pump 21 b.

[0092] In the mentioned process, the heated heat medium and the cooled heat medium are introduced into the use side heat exchangers 26 where the heating load and the cooling load are required, without being mixed with each other, under the control of the first heat medium flow switching devices 22 and the second heat medium flow switching devices 23. The air-conditioning load required in the indoor space 7 can be secured by causing the relay unit control device 52 to control so as to maintain a target value representing a difference between the temperature detected by the first temperature sensor 31 b and the temperature detected by the third temperature sensors 34a, 34e on the heating side, and between the temperature detected by the third temperature sensors 34d and the temperature detected by the first temperature sensor 31 a on the cooling side.

[0093] When the heating-main operation mode is performed, the heat medium is supplied to the use side heat exchangers 26a, 26d, and 26e because the thermal load is required in these heat exchangers, however since thermal load is not required in the use side heat exchanger 26b and the use side heat exchangers 26c, 26f, 26g, and 26h and hence there is no need to supply the heat medium thereto, the corresponding heat medium flow control device 25b and the heat medium flow control devices 25c, 25f, 25g, and 25h are fully closed. When a thermal load arises in the use side heat exchanger 26b or any of the use side heat exchangers 26c, 26f, 26g, and 26h, the heat medium flow control device 25b or the corresponding one of the heat medium flow control devices 25c, 25f, 25g, and 25h is opened so as to cause the heat medium to circulate.

[0094] Now, as stated earlier, the relay unit 3 includes the heat exchange unit 3a and the heat medium flow switching unit 3b located in different casings, and therefore the number of branch lines can be increased. In addition, locating the heat medium flow switching unit 3b in the separate casing allows the heat medium flow switching unit 3b to be located in the vicinity of the indoor units 2a to 2d (or 2e to 2h), thereby reducing the driving load of the pumps 21 a, 21 b, 42a, 42b, which would otherwise be greater because of the extended pipe length.

[0095] In particular, the number of indoor units to be connected to the relay unit 3 can be increased by increasing the number of heat medium flow switching units 3b, instead of increasing the number of relay units 3 as a whole, and therefore the cost can be reduced. To be more detailed, with the conventional system the number of heat exchange units 3a including the relay heat exchangers 15a, 15b has to be increased in order to increase the number of indoor units 2a to 2h that can be connected, however with the configuration shown in Fig. 1 the number of indoor units 2a to 2h that can be connected can be increased by increasing only the number of heat medium flow switching units 3b, without increasing the heat exchange unit 3a. Therefore, the number of branch lines for the indoor unit 2a to 2h can be efficiently increased without introducing additional structures. Further, the heat medium flow switching unit 3b requires a smaller footprint than the heat exchange unit 3a, and therefore the increase in footprint can be suppressed compared with the case of increasing the number of relay units 3.

[0096] The present invention is in no way limited to the foregoing Embodiment. For example, although the air-conditioning apparatus 100 is configured to perform the cooling and heating mixed operation in Embodiment, a different configuration may be adopted. The same advantageous effects can be obtained from a configuration in which, for example, one each of the relay heat exchangers 15a, 15b and the expansion devices 16a, 16b are provided and the plurality of use side heat exchangers 26a to 26h and the heat medium flow control devices 25a to 25h are connected in parallel to the relay heat exchanger and the expansion device, so that only either of the cooling operation and the heating operation is performed.

[0097] Whereas Fig. 2 to Fig. 6 illustrate the case where the plurality of indoor units are provided, it is a matter of course that such a configuration can be realized even when only one each of the use side heat exchanger 26 and the heat medium flow control device 25 are provided. Further, a plurality of relay heat exchangers and expansion devices may be provided that have the same functions as the relay heat exchanger 15 and the expansion device 16.

[0098] Generally the heat source-side heat exchanger 12 and the use side heat exchangers 26 each include a fan so as to expedite the condensation or evaporation by sending air, however a different configuration may be adopted. For example, a panel heater or the like that utilize radiation may be employed as the use side heat exchanger 26, and a water-cooled heat exchanger that utilize water or brine to transfer heat may be employed as the heat source-side heat exchanger 12. Thus, any type of device may be employed as the heat source-side heat exchanger 12 and the use side heat exchanger 26, provided that the device is capable of transmitting or removing heat.

[0099] Although the pumps 42a, 42b are connected to the heat medium flow switching unit 3b in Embodiment, these pumps may be excluded as shown in Fig. 7. Alternatively, the pumps 42a, 42b may be connected in parallel to the pumps 21 a, 21 b of the heat conversion unit 3a, as shown in Fig. 8. Here, the distance between the heat medium flow switching unit 3b and the first units, as well as the height thereof, can be increased by providing the pumps 42a, 42b to the heat medium flow switching unit 3b as shown in Fig. 2, or adding the pump 42a, 42b in parallel or in series to the pumps 21 a, 21 b of the heat exchange unit 3a.

[0100] Further, although Fig. 1 to Fig. 8 illustrate the case where one heat medium flow switching unit 3b is included in the heat exchange unit 3a, a different configuration may be adopted. For example, as shown in Fig. 9, the heat conversion unit 3a and the heat medium flow switching unit 3b may be located apart from each other.

Reference Signs List

[0101] 1: outdoor unit, 2: indoor unit, 2a to 2d: indoor unit, 3: relay unit, 3a: heat exchange unit, 3b: heat medium flow switching unit, 4: refrigerant pipe, 4a: first connection pipe, 4b: second connection pipe, 5: pipe, 6: outdoor space, 7: indoor space, 8: space, 9: building, 10: compressor, 11: first refrigerant flow switching device, 12: heat source-side heat exchanger, 13a to 13d: check valve, 15a, 15b: relay heat exchanger, 16a, 16b: expansion device, 17a, 17b: opening/closing device, 18: second refrigerant flow switching device, 18a, 18b: second refrigerant flow switching device, 19: accumulator, 21: pump, 21 a, 21b: pump, 22a to 22h: first heat medium flow switching device, 23a to 23h: second heat medium flow switching device, 25: heat medium flow control device, 25a to 25h: heat medium flow control device, 26a to 26h: use side heat exchanger, 31: first temperature sensor, 31 a, 31b: first temperature sensor, 35: second temperature sensor, 35a to 35d: second temperature sensor, 34: third temperature sensor, 34a to 34h: third temperature sensor, 36: first pressure sensor, 37: second pressure sensor, 38: third pressure sensor, 39a to 39h: incoming air temperature sensor, 40: pipe, 41: pipe, 42a, 42b: pump, 50: fourth temperature sensor, 52: relay unit control device, 57: outdoor unit control device, 100: air-conditioning apparatus, A: refrigerant circuit, B: heat medium circuit

Claims

1. An air-conditioning apparatus comprising:

an outdoor unit including a compressor that compresses a refrigerant and a heat source-side heat exchanger that exchanges heat between air and the refrigerant;
a plurality of indoor units each including an indoor heat exchanger that exchanges heat between air and a heat medium;
a relay unit connected to the outdoor unit via a refrigerant pipe and connected to each of the indoor units via a heat medium pipe, the relay unit being configured to exchange heat between the refrigerant and the heat medium; and
a first refrigerant flow switching device that switches a flow path of the refrigerant flowing into the relay unit between a heating flow path

used in a heating operation and a cooling flow path used in a cooling operation,
wherein the relay unit includes a heat exchange unit that exchanges heat between the refrigerant and the heat medium, and a plurality of heat medium flow switching units that supply the heat medium subjected to heat exchange in the heat exchange unit to the plurality of indoor units through branched lines, the heat exchange unit and the heat medium flow switching units being located in different casings,
the heat exchange unit includes:

a plurality of relay heat exchangers that exchange heat between the refrigerant and the heat medium; and
a second refrigerant flow switching device that switches the flow path of the heat medium flowing into the relay heat exchanger according to the switching status between the cooling operation and the heating operation, and
the heat medium flow switching unit includes:

a plurality of heat medium flow switching devices corresponding to the respective indoor units and configured to switch a combination of the connection between the indoor units and the relay heat exchangers; and
a plurality of heat medium flow control devices connected to the respective heat medium flow switching devices and configured to control a flow rate of the heat medium flowing into the plurality of indoor units.

2. The air-conditioning apparatus of claim 1,
wherein the heat medium flow switching unit includes a pump that delivers the heat medium discharged from the heat exchange unit to the indoor unit.

3. The air-conditioning apparatus of claim 1 or 2,
wherein the heat exchange unit incudes a pump that delivers the heat medium subjected to heat exchange in the relay heat exchanger to the heat medium flow switching unit.

4. The air-conditioning apparatus of claim 2 or 3,
wherein a plurality of the pumps are connected in series or in parallel.

5. The air-conditioning apparatus of any one of claims 1 to 4,
wherein the heat exchange unit includes thereinside one of the plurality of heat medium flow switching units.

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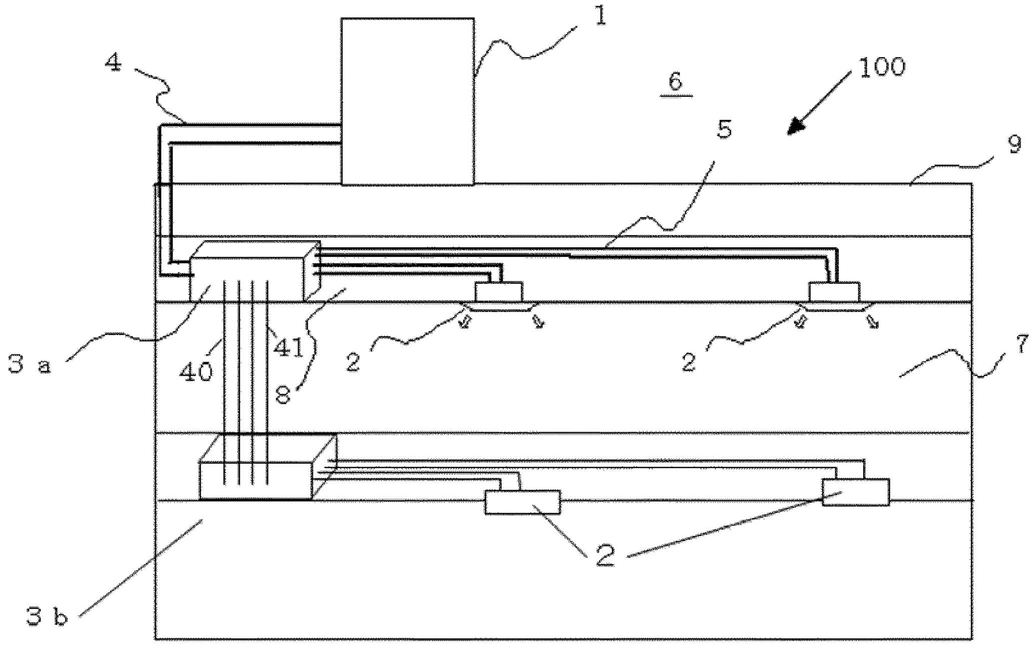
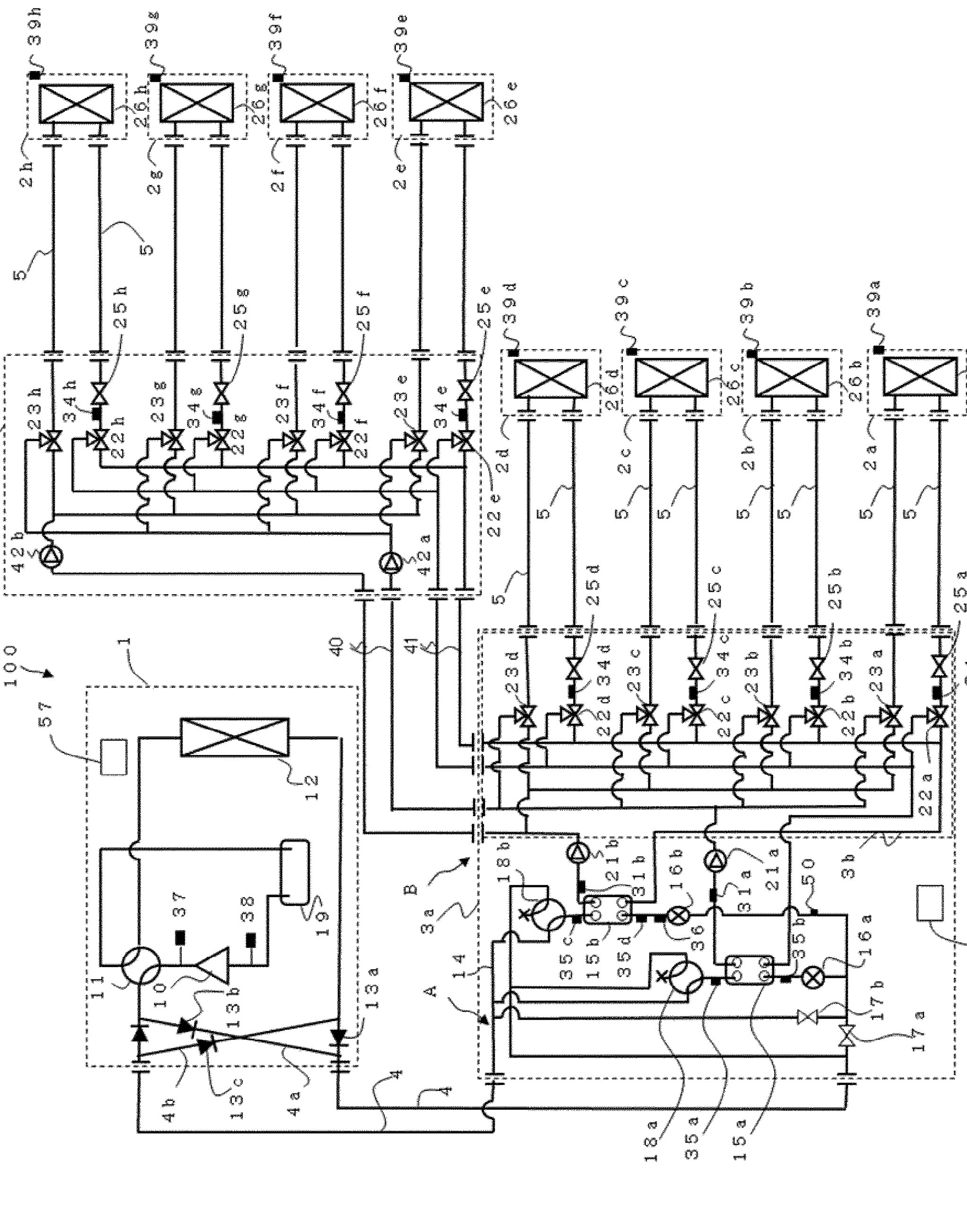


FIG. 2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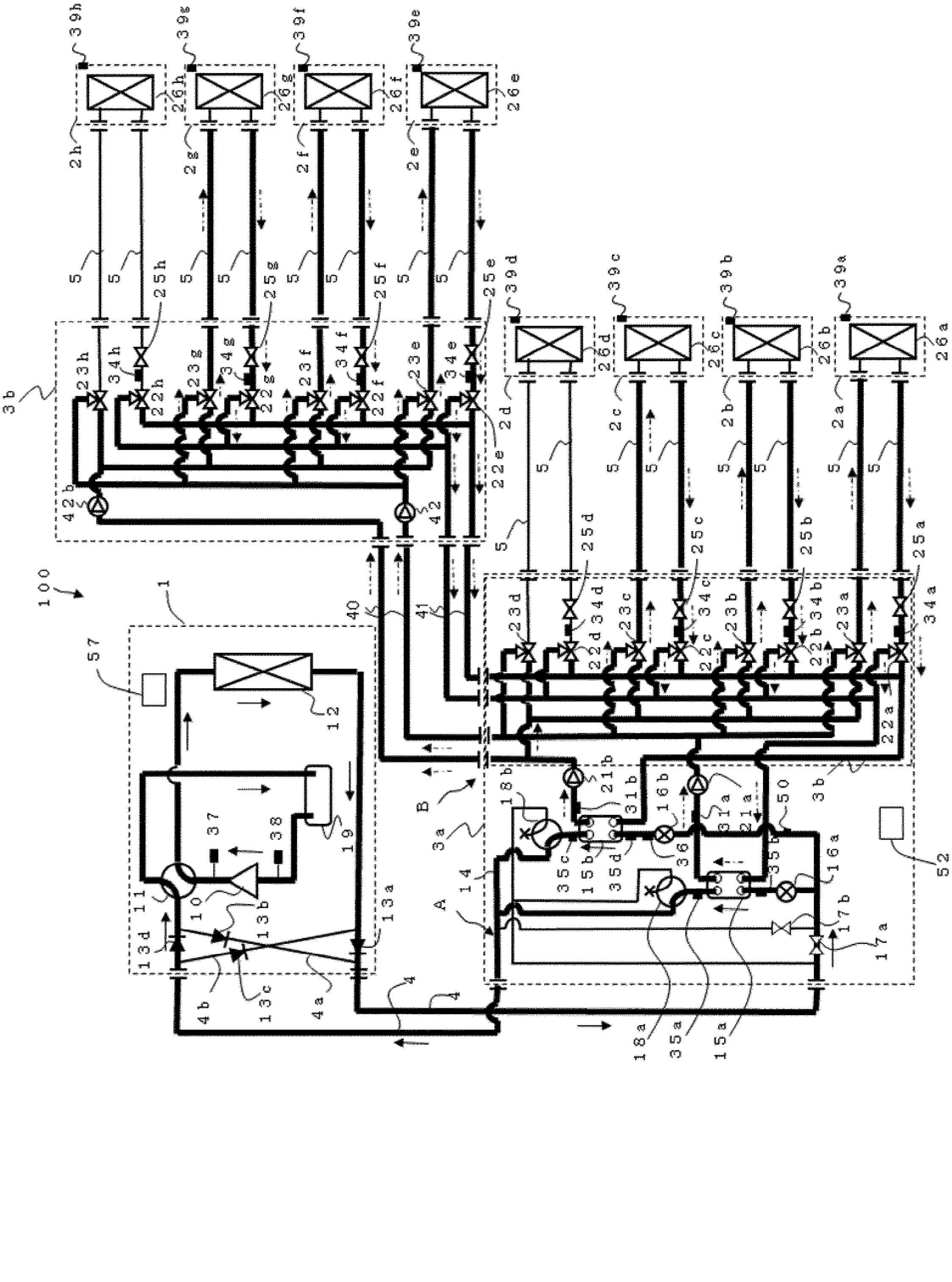

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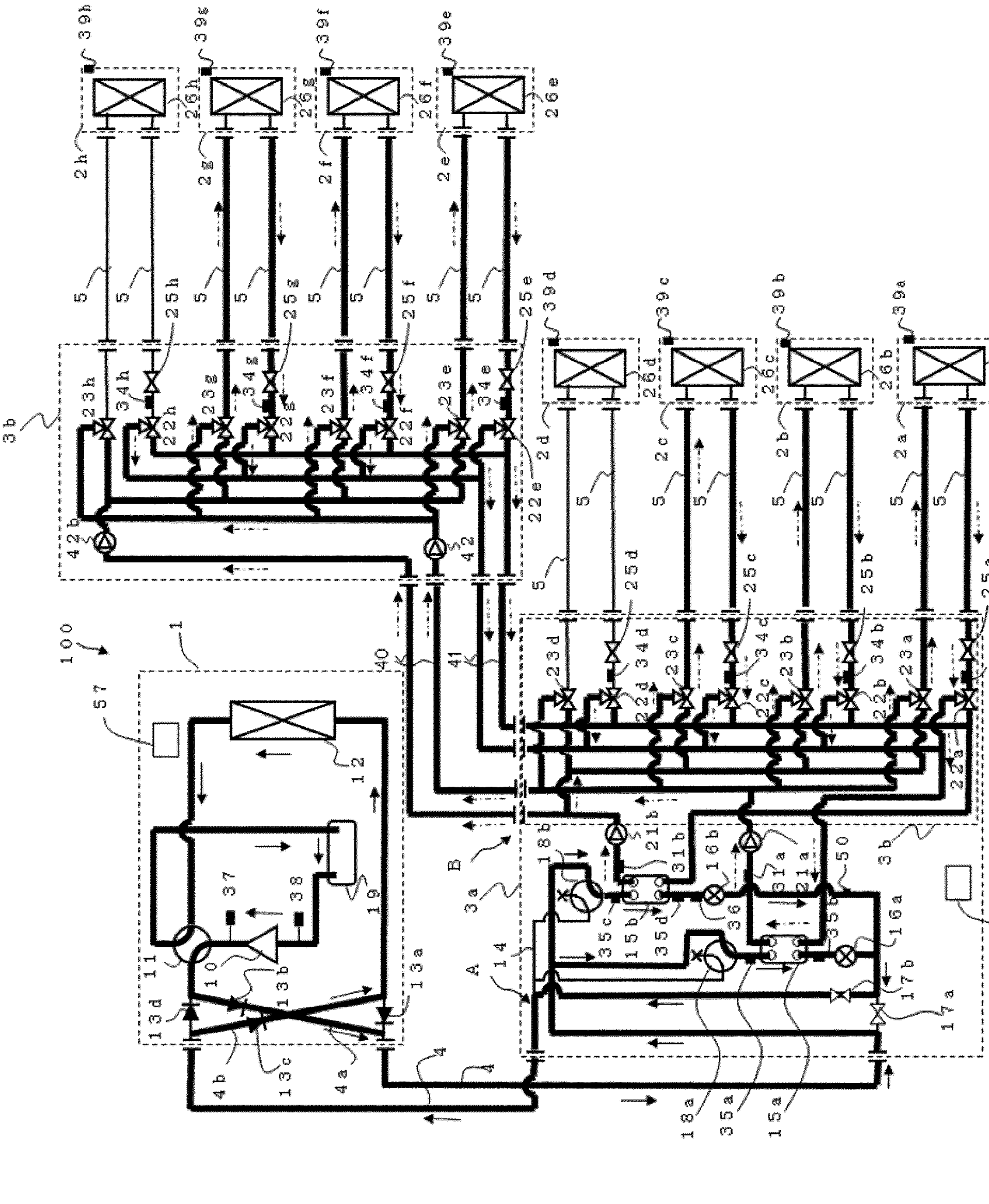
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FIG. 5

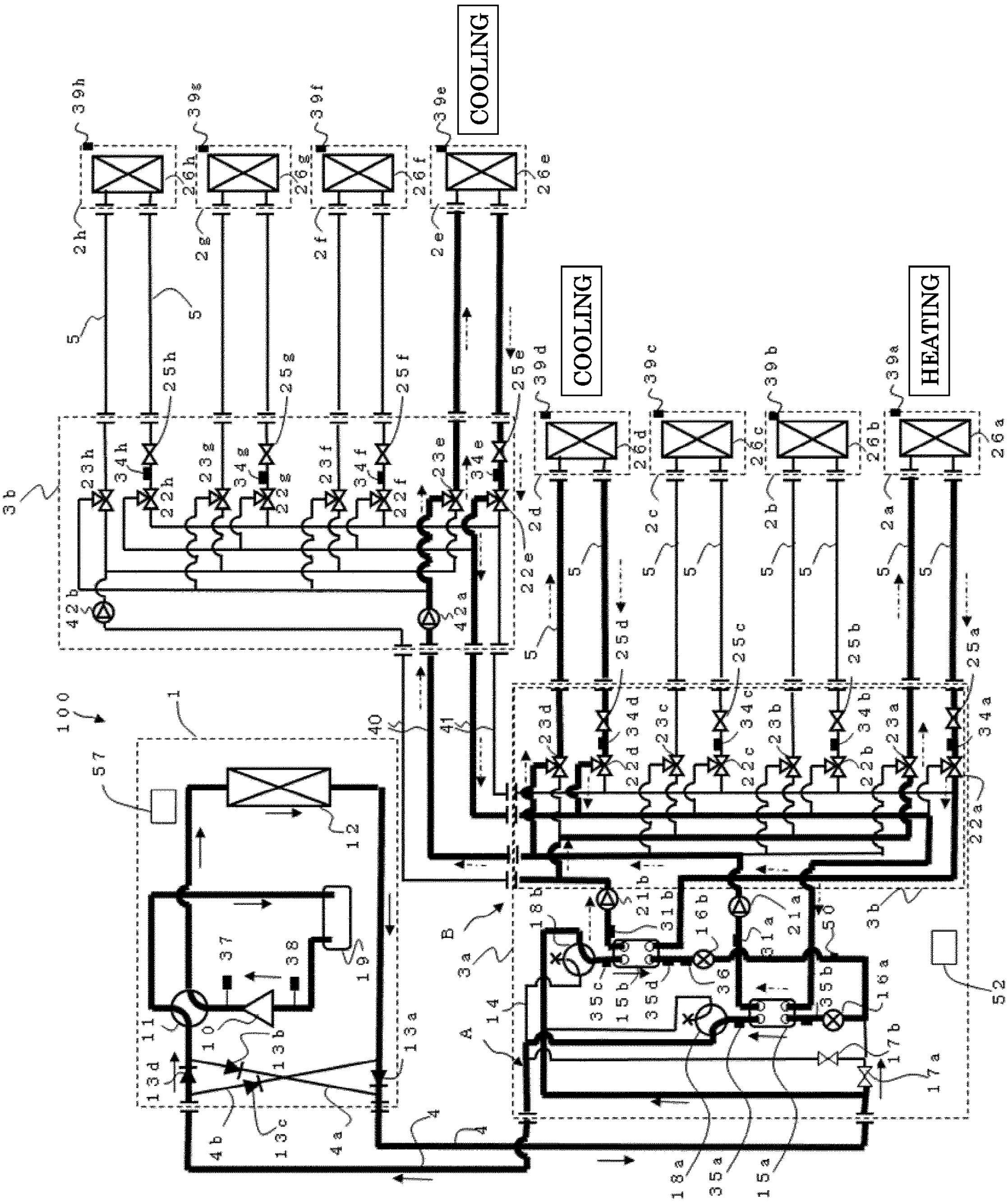
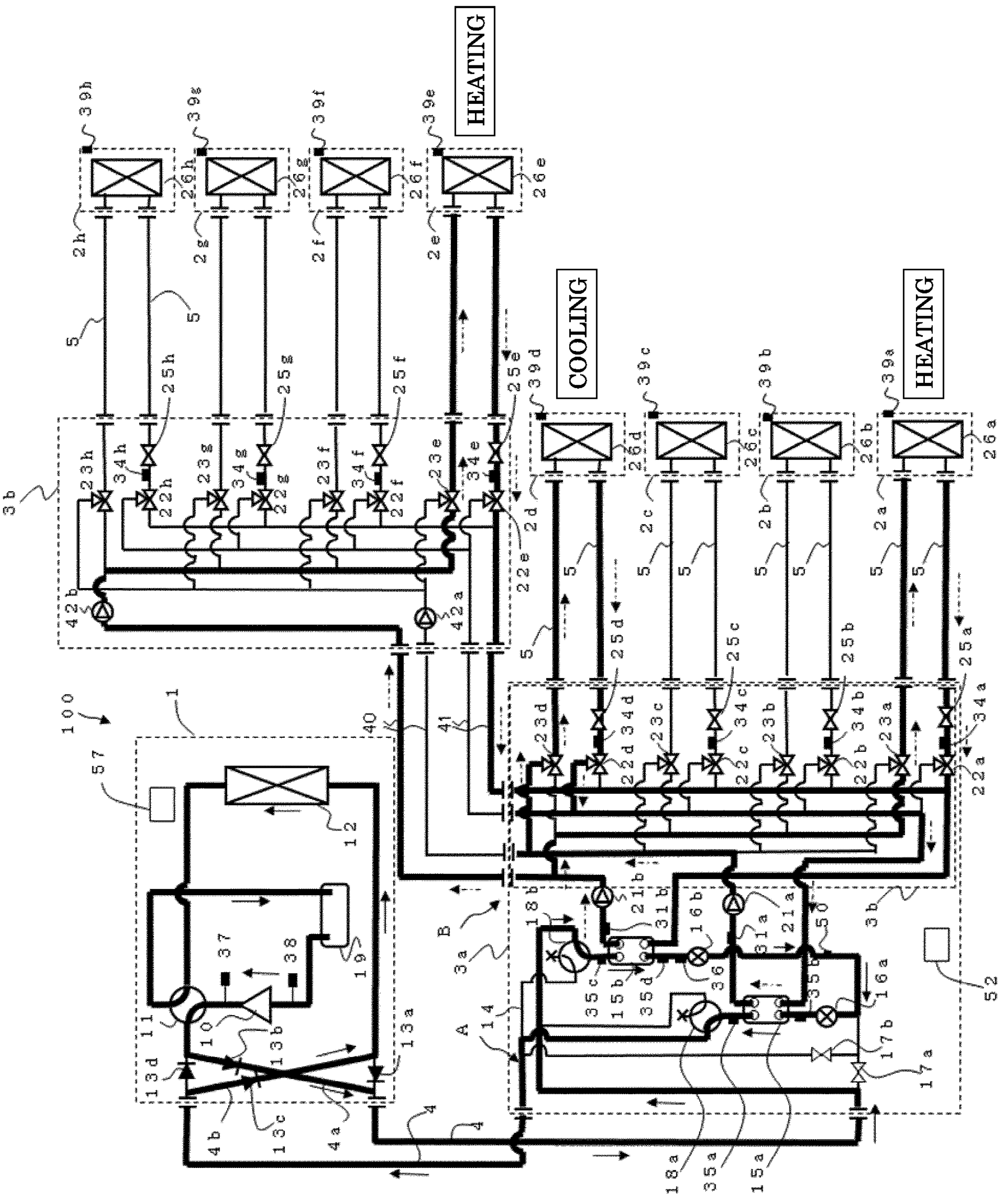


FIG. 6



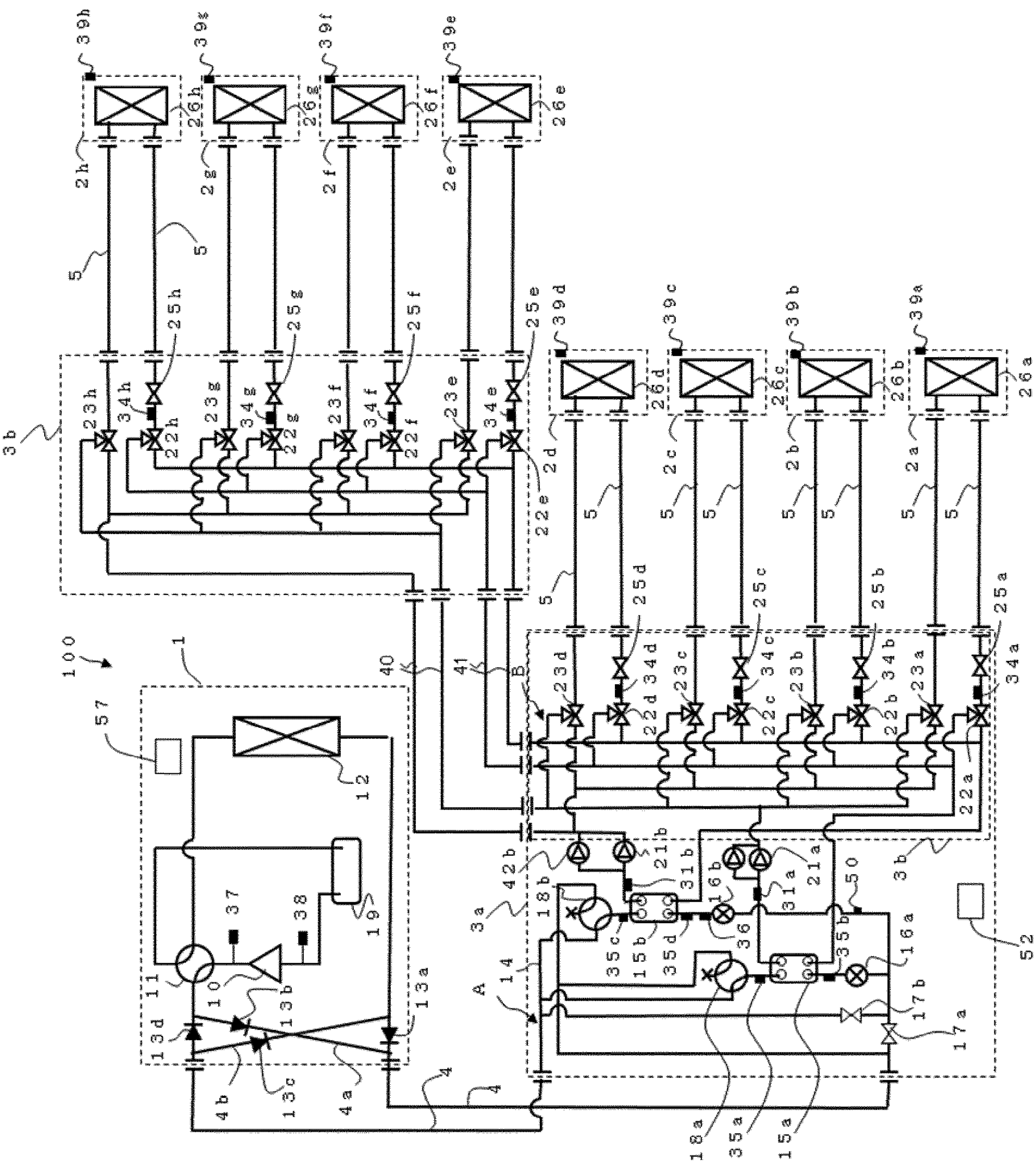
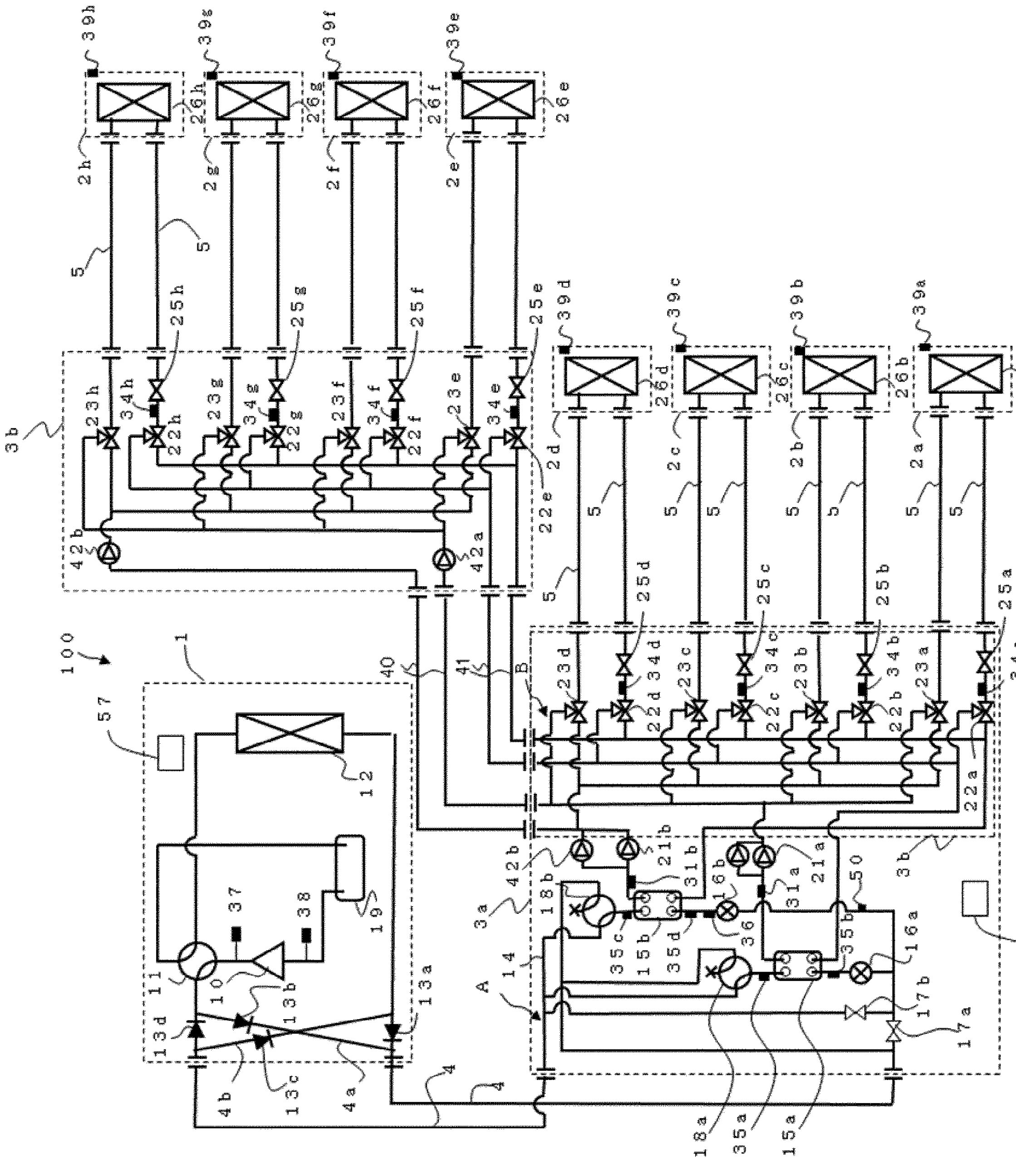


FIG. 7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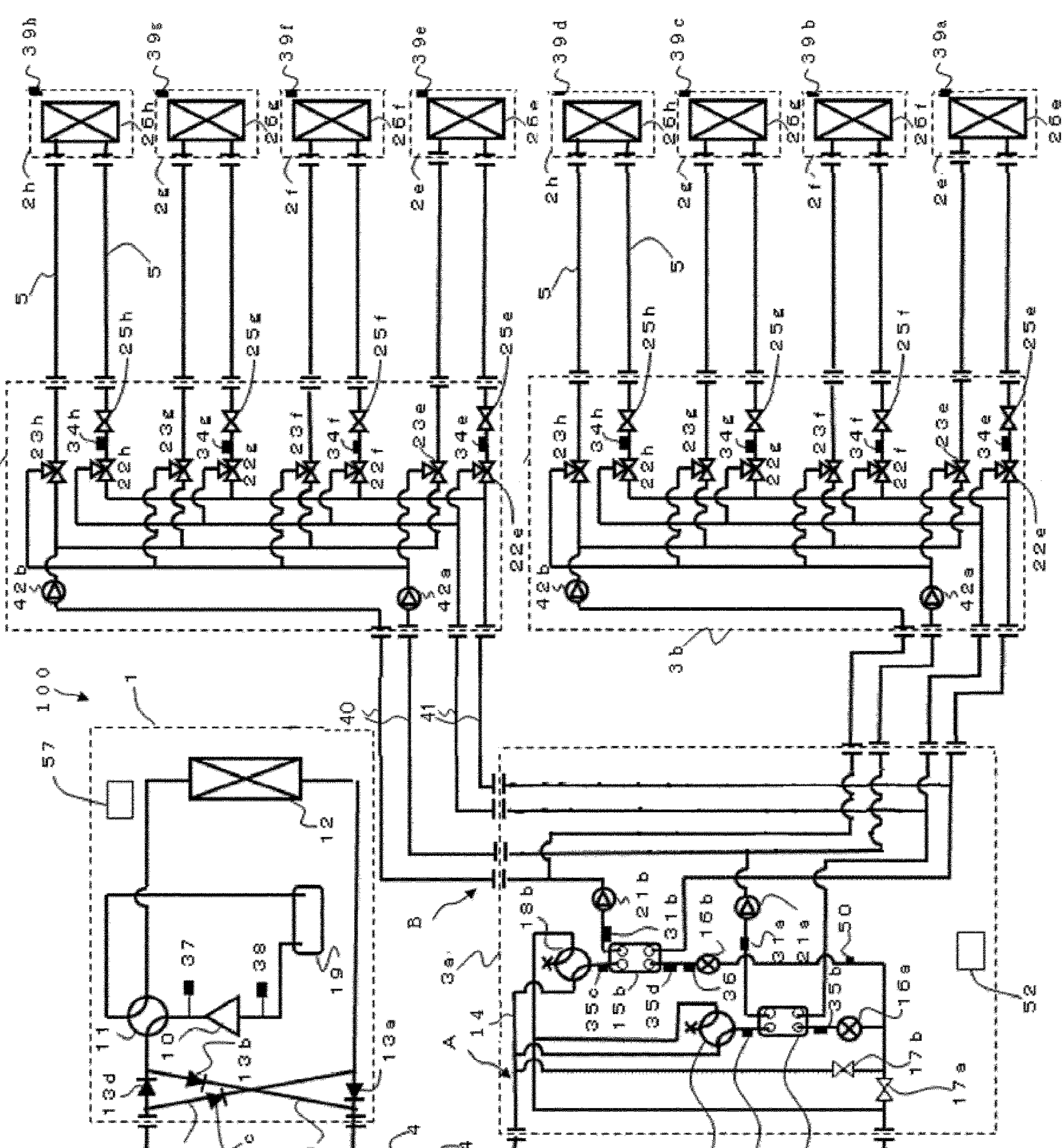
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/073975

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i, *F24F5/00*(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)
F25B1/00, F24F5/00, 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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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	WO 2011/114368 A1 (Mitsubishi Electric Corp.), 22 September 2011 (22.09.2011), paragraphs [0015] to [0036]; fig. 1 to 5 (Family: none)	1-5
Y	JP 2010-243129 A (Asahi Kasei Homes Corp.), 28 October 2010 (28.10.2010), paragraphs [0059] to [0068]; fig. 4 to 6 (Family: none)	1-5
Y	JP 2005-257269 A (Takasago Thermal Engineering Co., Ltd.), 22 September 2005 (22.09.2005), paragraphs [0060] to [0071]; fig. 3 (Family: none)	2-5

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

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Date of the actual completion of the international search	Date of mailing of the international search report
06 December, 2012 (06.12.12)	18 December, 2012 (18.12.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/073975

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5-248665 A (Hitachi, Ltd.), 24 September 1993 (24.09.1993), paragraph [0009]; fig. 1 (Family: none)	2-5
Y	WO 2009/133640 A1 (Mitsubishi Electric Corp.), 05 November 2009 (05.11.2009), paragraphs [0123] to [0130]; fig. 21 & US 2011/0088421 A1 & EP 2282144 A1 & CN 102016450 A	5
A	WO 2011/030418 A1 (Mitsubishi Electric Corp.), 17 March 2011 (17.03.2011), fig. 3 & EP 2476965 A1 & CN 102483249 A	1-5

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Patent documents cited in the description

- JP 2000227242 A **[0004]**