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(54) **AIR-CONDITIONING DEVICE**

(57) An object of the present invention is to provide an air conditioning apparatus allowing an indoor heat exchanger to function as a radiator for refrigerant to perform a heating operation and enabling detection of an accurate saturation temperature even if liquid pooling occurs in an operational state with circulation amounts in a low range. Even when the compressor (12) operates at a lower number of compressor rotations to output a minimum heating capacity to reduce a circulation amount of refrigerant, since liquid pooling does not occur above a height-wise center of the indoor heat exchanger (32) or the distributor body (81a), the air conditioning apparatus (10) enables the refrigerant temperature sensor (183) mounted at the above described region to detect an accurate saturation temperature. Consequently, the likelihood of hindrance of subcooling control is removed, so that the control of opening of an electric valve in the conventional manner needs not to be performed only for the removal of liquid pooling. Of course, no pressure sensor is needed.

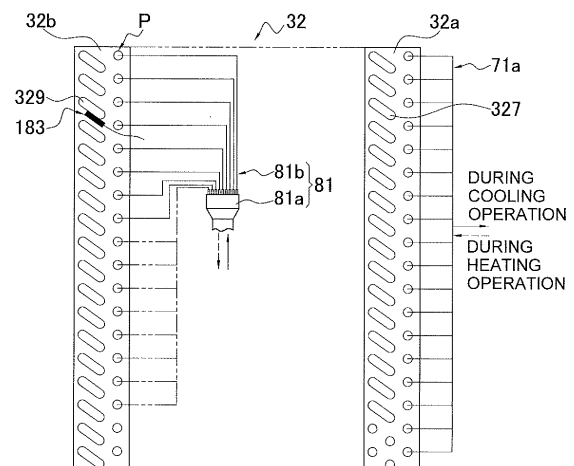


FIG. 6

Description

TECHNICAL FIELD

[0001] The present invention relates to an air conditioning apparatus and, in particular, to an air conditioning apparatus allowing an indoor heat exchanger to function as a radiator for refrigerant to perform a heating operation.

BACKGROUND ART

[0002] In recent years, there have been requests for improvement of operational efficiencies and indication of consumption efficiencies in actual environments of use, in particular at low load. To this end, it is necessary to allow an operational state with circulation amounts in a low range to appear for calculation of a minimum heating capacity. During the calculation, liquid pooling tends to occur since a circulation amount of refrigerant is less than that during an operation at an intermediate capacity.

[0003] As a countermeasure to prevent liquid pooling, for example, a patent literature (JP-A-H5-280808) discloses a heat pump system which adopts a method of opening an electric expansion valve to temporarily remove liquid pooling.

SUMMARY OF INVENTION

<Technical Problem>

[0004] In the meantime, in a conventional air conditioning apparatus, a mounting position of a thermistor to an indoor heat exchanger is in a lower portion of the heat exchanger, which is closer when a front panel of an indoor unit is opened, from the viewpoint of the lengths of harnesses of electrical components, maintenance, and the like.

[0005] However, in the case in which an operation is implemented at a lower number of compressor rotations to output a minimum heating capacity while the thermistor is mounted in the lower portion of the heat exchanger in the conventional manner, liquid pooling occurs at a portion corresponding to the mounting position of the thermistor. Thus, even if an electric expansion valve is opened to be controlled, the liquid pooling cannot be removed, which causes the failure of detection of an accurate saturation temperature under the influence of the liquid pooling. Thus, subcooling control is hindered and a high pressure is sensed to be lower than it is; these are not preferable from a safety standpoint.

[0006] Alternatively, as a countermeasure, it is possible to provide a pressure sensor to convert a value detected by the pressure sensor to a saturation temperature. However, it is not advisable to provide a pressure sensor since this would result in increases in product costs.

[0007] An object of the present invention is to provide

an air conditioning apparatus allowing an indoor heat exchanger to function as a radiator for refrigerant to perform a heating operation and enabling detection of an accurate saturation temperature even if liquid pooling occurs in an operational state with circulation amounts in a low range.

<Solution to Problem>

[0008] An air conditioning apparatus according to a first aspect of the present invention is an air conditioning apparatus allowing an indoor heat exchanger to function as a radiator for refrigerant to perform a heating operation, and comprises a distributor, a temperature sensor. The distributor includes a distributor body and a plurality of distribution pipes. The distributor body is positioned in the neighborhood of a refrigerant outlet of the indoor heat exchanger functioning as a radiator. The distribution pipes branch from the distributor body into each of a plurality of paths formed in the indoor heat exchanger. The temperature sensor is configured to detect a saturation temperature of refrigerant flowing through the indoor heat exchanger. The temperature sensor is mounted above a height-wise center of the indoor heat exchanger in use state or the distributor body.

[0009] When an operation is implemented at a lower number of compressor rotations to output a minimum heating capacity, liquid pooling tends not to occur in refrigerant paths higher than the distributor body while liquid pooling tends to occur in refrigerant paths lower than the distributor body. This would be caused by liquid in the refrigerant paths lower than the distributor body, which cannot be raised to the distributor body under the influence of gravity since a circulation amount of refrigerant is reduced.

[0010] However, even when an operation is implemented at a lower number of compressor rotations to output a minimum heating capacity to reduce a circulation amount of refrigerant, since liquid pooling does not occur above the height-wise center of the indoor heat exchanger or the distributor body, this air conditioning apparatus enables the temperature sensor mounted at the above described region to detect an accurate saturation temperature.

[0011] Consequently, the likelihood of hindrance of subcooling control is removed, so that the control of opening of an electric valve in the conventional manner needs not to be performed only for the removal of liquid pooling. Of course, no pressure sensor is needed.

[0012] An air conditioning apparatus according to a second aspect of the present invention is the air conditioning apparatus according to the first aspect, in which the temperature sensor is mounted to a path, out of the plurality of paths, in a range occupying 30% of all paths down from an uppermost row path. This air conditioning apparatus enables more secure detection of an accurate saturation temperature.

[0013] An air conditioning apparatus according to a third aspect of the present invention is the air conditioning

apparatus according to the second aspect, in which the temperature sensor is mounted to the uppermost row path out of the plurality of paths. This air conditioning apparatus enables more secure detection of an accurate saturation temperature.

[0014] An air conditioning apparatus according to a fourth aspect of the present invention is the air conditioning apparatus according to any one of the first to fourth aspects, in which the temperature sensor is mounted to a gas-side end of a particular path, out of the plurality of paths, to which the temperature sensor is mounted to a gas-side end of the particular path, with respect to a flow of refrigerant flowing through the particular path.

[0015] Since the temperature sensor is mounted not to a liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path, this air conditioning apparatus avoids a saturation temperature from failing to be detected when subcooling is produced in the entire system.

[0016] An air conditioning apparatus according to a fifth aspect of the present invention is the air conditioning apparatus according to any one of the first to fourth aspects, in which an operation is continuously performed for 30 seconds or more at a capacity lower than 45% of a rated capacity.

[0017] With a compressor having a range enough to allow a minimum heating operational state to appear simply in the course of events to implement an operation in accordance with a load, this air conditioning apparatus enables spontaneous appearance of a minimum heating operational state.

<Advantageous Effects of Invention>

[0018] Even when an operation is implemented at a lower number of compressor rotations to output a minimum heating capacity to reduce a circulation amount of refrigerant, since liquid pooling does not occur above the height-wise center of the indoor heat exchanger or the distributor body, the air conditioning apparatus according to the first aspect of the present invention enables the temperature sensor mounted at the above described region to detect an accurate saturation temperature. Consequently, the likelihood of hindrance of subcooling control is removed, so that the control of opening of an electric valve in the conventional manner needs not to be performed only for the removal of liquid pooling. Of course, no pressure sensor is needed.

[0019] Since the temperature sensor is mounted to a path, out of the plurality of paths, in a range occupying 30% of all paths down from an uppermost row path, the air conditioning apparatus according to the second aspect of the present invention enables more secure detection of an accurate saturation temperature.

[0020] Since the temperature sensor is mounted to the uppermost row path out of the plurality of paths, the air conditioning apparatus according to the third aspect of the present invention enables more secure detection of

an accurate saturation temperature.

[0021] Since the temperature sensor is mounted not to a liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path, the air conditioning apparatus according to the fourth aspect of the present invention avoids a saturation temperature from failing to be detected when subcooling is produced in the entire system.

[0022] With a compressor having a range enough to allow a minimum heating operational state to appear simply in the course of events to implement an operation in accordance with a load, the air conditioning apparatus according to the fifth aspect of the present invention enables spontaneous appearance of a minimum heating operational state.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is a diagram of a piping system showing a structure of a refrigerant circuit of an air conditioning apparatus according to an embodiment of the present invention.

FIG. 2 is a perspective external view of an indoor unit of the air conditioning apparatus.

FIG. 3 is a vertical cross sectional view of the indoor unit of the air conditioning apparatus.

FIG. 4 is a plan view of the inside of the indoor unit of the air conditioning apparatus as seen from the top surface thereof.

FIG. 5 is a front view of an indoor heat exchanger when a first side end portion is front.

FIG. 6 schematically shows a positional relationship of a distributor with respect to the height-wise direction of an indoor heat exchanger in use state.

FIG. 7 is a plan view of a heat transfer tube of the indoor heat exchanger.

FIG. 8 is a graph showing distributions of temperatures in the indoor heat exchanger during an operation at a heating minimum capacity.

FIG. 9 schematically shows, for an indoor heat exchanger used in a floor model indoor unit, a positional relationship of a distributor with respect to the height-wise direction of the indoor heat exchanger in use state.

FIG. 10 is a graph showing distributions of temperatures in the indoor heat exchanger during an operation at a heating minimum capacity.

FIG. 11 schematically shows, an indoor heat exchanger used in a two-way indoor unit, a positional relationship of a distributor with respect to the height-wise direction of an indoor heat exchanger in use state.

DESCRIPTION OF EMBODIMENTS

[0024] Hereinafter, exemplary embodiments of the

present invention will be described with reference to the drawings. The embodiments below are specific examples of the present invention and are not intended to limit the technical scope of the present invention.

(1) Air Conditioning System 10

[0025] FIG. 1 is a diagram of a piping system showing a structure of a refrigerant circuit C of an air conditioning apparatus 10 according to one embodiment of the present invention. In FIG. 1, the air conditioning apparatus 10 cools and heats indoor air. As shown in FIG. 1, the air conditioning apparatus 10 includes an outdoor unit 11 installed outdoors and an indoor unit 20 installed indoors. The outdoor unit 11 and the indoor unit 20 are connected to each other through two communication pipes 2, 3, which thus forms the refrigerant circuit C in this air conditioning apparatus 10. In the refrigerant circuit C, refrigerant injected therein circulates to perform a vapor compression refrigeration cycle.

(1-1) Outdoor Unit 11

[0026] The outdoor unit 11 is provided with a compressor 12, an outdoor heat exchanger 13, an outdoor expansion valve 14, and a four-way switching valve 15.

(1-1-1) Compressor 12

[0027] The compressor 12 compresses low pressure refrigerant, and discharges the high pressure refrigerant thus compressed. In the compressor 12, a compression mechanism such as a scroll or rotary compression mechanism is driven by a compressor motor 12a. The compressor motor 12a is configured to have an operation frequency which can be varied by an inverter.

(1-1-2) Outdoor Heat Exchanger 13

[0028] The outdoor heat exchanger 13 is a fin and tube heat exchanger. An outdoor fan 16 is installed in the neighborhood of the outdoor heat exchanger 13. In the outdoor heat exchanger 13, air carried by the outdoor fan 16 exchanges heat with the refrigerant.

(1-1-3) Outdoor Expansion Valve 14

[0029] The outdoor expansion valve 14 is an electronic expansion valve having a variable degree of opening. The outdoor expansion valve 14 is disposed on the downstream side of the outdoor heat exchanger 13 in a flow direction of the refrigerant in the refrigerant circuit C during a cooling operation.

[0030] During a cooling operation, the degree of opening of the outdoor expansion valve 14 is in a fully opened state. On the other hand, during a heating operation, the degree of opening of the outdoor expansion valve 14 is adjusted to reduce a pressure of the refrigerant flowing

into the outdoor heat exchanger 13 to a pressure enabling the refrigerant to evaporate in the outdoor heat exchanger 13 (i.e., an evaporation pressure).

5 (1-1-4) Four-Way Switching Valve 15

[0031] The four-way switching valve 15 includes first to fourth ports. In the four-way switching valve 15, the first port is connected to a discharge side of the compressor 12, the second port is connected to a suction side of the compressor 12, the third port is connected to a gas-side end portion of the outdoor heat exchanger, and the fourth port is connected to a gas-side shut-off valve 5.

[0032] The four-way switching valve 15 is switchable between a first state (a state indicated by the solid curves in FIG. 1) and a second state (a state indicated by the broken curves in FIG. 1). In the four-way switching valve 15 in the first state, the first port communicates with the third port, and the second port communicates with the fourth port. In the four-way switching valve 15 in the second state, the first port communicates with the fourth port, and the second port communicates with the third port.

(1-1-5) Outdoor Fan 16

[0033] The outdoor fan 16 is configured with a propeller fan driven by an outdoor fan motor 16a. The outdoor fan motor 16a is configured to have the number of rotations which can be varied by an inverter.

(1-1-6) Liquid Communication Pipe 2 and Gas Communication Pipe 3

[0034] The two communication pipes are configured with a liquid communication pipe 2 and a gas communication pipe 3. One end of the liquid communication pipe 2 is connected to a liquid-side shut-off valve 4, and the other end thereof is connected to a liquid-side end portion of an indoor heat exchanger 32. One end of the gas communication pipe 3 is connected to the gas-side shut-off valve 5, and the other end thereof is connected to a gas-side end portion of the indoor heat exchanger 32.

(1-2) Indoor Unit 20

[0035] The indoor unit 20 is provided with the indoor heat exchanger 32, an indoor expansion valve 39, an indoor fan 27, and a refrigerant temperature sensor 183.

50 (1-2-1) Indoor Heat Exchanger 32

[0036] The indoor heat exchanger 32 is a fin and tube heat exchanger. The indoor heat exchanger 32 is installed in the neighborhood of the indoor fan 27.

(1-2-2) Indoor Expansion Valve 39

[0037] In the refrigerant circuit C, the indoor expansion

valve 39 is connected to the liquid-side end portion side of the indoor heat exchanger 32. The indoor expansion valve 39 is configured with an electronic expansion valve having a variable degree of opening.

(1-2-3) Indoor Fan 27

[0038] The indoor fan 27 is a centrifugal blower driven by an indoor fan motor 27a. The indoor fan motor 27a is configured to have the number of rotations which can be varied by an inverter.

(1-2-4) Refrigerant Temperature Sensor 183

[0039] The refrigerant temperature sensor 183 is mounted to a predetermined position of the indoor heat exchanger 32, and detects a temperature of the refrigerant in a gas-liquid two-phase state flowing through the indoor heat exchanger 32. The air conditioning apparatus 10 have its cooling capacity and heating capacity adjusted on the basis of a temperature detected by this refrigerant temperature sensor 183.

(1-3) Controller 800

[0040] A controller 800 is configured with an outdoor-side controller 801 and an indoor-side controller 803. The outdoor-side controller 801 is disposed in the outdoor unit 11, and controls operations of respective components. The indoor-side controller 803 is disposed in the indoor unit 20, calculates a saturation temperature from a value detected by the refrigerant temperature sensor 183, and controls the number of rotations of the indoor fan 27.

[0041] The outdoor-side controller 801 and the indoor-side controller 803 each have a microcomputer, a memory, and the like, and can send control signals and the like to each other and receive them from each other.

(2) Detailed Structure of Indoor Unit 20

[0042] FIG. 2 is a perspective external view of the indoor unit 20 of the air conditioning apparatus 10. FIG. 3 is a vertical cross sectional view of the indoor unit 20 of the air conditioning apparatus 10. FIG. 4 is a plan view of the inside of the indoor unit 20 of the air conditioning apparatus 10 as seen from the top surface thereof.

[0043] In FIGS. 2, 3 and 4, the indoor unit 20 of the present embodiment is configured with a ceiling mounted unit. The indoor unit 20 includes an indoor unit body 21 and an ornamental panel 40 mounted to the lower portion of the indoor unit body 21.

(2-1) Indoor Unit Body 21

[0044] As shown in FIGS. 2 and 3, the indoor unit body 21 includes a box-shaped casing 22 having a substantially rectangular parallelepiped shape. A liquid-side con-

necting pipe 6 and a gas-side connecting pipe 7, which are connected to the indoor heat exchanger 32, run through a side panel 24 of the casing 22 (see FIG. 4). The liquid-side connecting pipe 6 is connected to the liquid communication pipe 2, and the gas-side connecting pipe 7 is connected to the gas communication pipe 3.

[0045] The casing 22 houses the indoor fan 27, a bell mouth 31, the indoor heat exchanger 32, and a drain pan 36.

[0046] As shown in FIGS. 3 and 4, the indoor fan 27 is centrally disposed inside the casing 22. The indoor fan 27 includes the indoor fan motor 27a and an impeller 30. The indoor fan motor 27a is supported on the top panel of the casing 22. The impeller 30 is configured with a plurality of turbo blades 30a arranged in a rotation direction of the drive shaft 27b.

[0047] The bell mouth 31 is disposed below the indoor fan 27. The bell mouth 31 has a circular opening at each of its upper and lower ends, and is formed in a tubular shape such that the region of the opening increases toward the ornamental panel 40. The inner space of the bell mouth 31 communicates with an impeller housing space of the indoor fan 27.

[0048] As shown in FIG. 4, in the indoor heat exchanger 32, bent heat transfer tubes are arranged in such a way as to surround the indoor fan 27. The indoor heat exchanger 32 is installed on the upper surface of the drain pan 36 in such a way as to upwardly stand up. Air blowing laterally from the indoor fan 27 passes through the indoor heat exchanger 32. The indoor heat exchanger 32 constitutes an evaporator cooling the air during a cooling operation, and also constitutes a condenser (a radiator) heating the air during a heating operation.

(2-2) Ornamental Panel 40

[0049] The ornamental panel 40 is mounted to the lower surface of the casing 22. The ornamental panel 40 includes a panel body 41 and a suction grill 60.

[0050] The panel body 41 has a rectangular frame shape in a plan view. The panel body 41 has one panel-side suction flow channel 42 and four panel-side blowout flow channels 43.

[0051] As shown in FIG. 3, the panel-side suction flow channel 42 is formed in a central portion of the panel body 41. A suction port 42a facing the room space is formed at the lower end of the panel-side suction flow channel 42. A dust collection filter 45 for catching dirt and dust in the air sucked through the suction port 42a is provided in the panel-side suction flow channel 42.

[0052] The respective panel-side blowout flow channels 43 are formed outside the panel-side suction flow channel 42 in such a way as to surround the panel-side suction flow channel 42. Each of the panel-side blowout flow channels 43 extends along an associated one of four sides of the panel-side suction flow channel 42. An outlet port 43a facing the room space is formed at the lower end of each of the panel-side blowout flow channels

43.

[0053] The suction grill 60 is mounted to the lower end of the panel-side suction flow channel 42 (i.e., the suction port 42a).

(3) Operations

[0054] Next, operations of the air conditioning apparatus 10 according to the present embodiment will be described. The air conditioning apparatus 10 selectively performs a cooling operation and a heating operation.

(3-1) Cooling Operation

[0055] During a cooling operation, the four-way switching valve 15 is switched to the state indicated by the solid curves in FIG. 1 to make the compressor 12, the indoor fan 27, and the outdoor fan 16 operate. Thus, the refrigerant circuit C performs a refrigeration cycle in which the outdoor heat exchanger 13 functions as a condenser and the indoor heat exchanger 32 functions as an evaporator.

[0056] Specifically, high pressure refrigerant compressed by the compressor 12 flows through the outdoor heat exchanger 13 and exchanges heat with outdoor air. In the outdoor heat exchanger 13, the high pressure refrigerant dissipates heat to the outdoor air and consequently condenses. The refrigerant thus condensed in the outdoor heat exchanger 13 is passed to the indoor unit 20. In the indoor unit 20, the refrigerant has its pressure reduced by the indoor expansion valve 39, and subsequently flows through the indoor heat exchanger 32.

[0057] In the indoor unit 20, indoor air upwardly flows through the suction port 42a, the panel-side suction flow channel 42, and the inner space of the bell mouth 31 in this order, and then is sucked into the impeller housing space of the indoor fan 27. The air in the impeller housing space is carried by the impeller 30 and is radially outwardly blown out. This air passes through the indoor heat exchanger 32 and exchanges heat with the refrigerant. In the indoor heat exchanger 32, the refrigerant absorbs heat from the indoor air and evaporates, thereby cooling the air.

[0058] The air cooled by the indoor heat exchanger 32 divides and flows into the respective body-side blowout flow channels 37, then downwardly flows through the panel-side blowout flow channels 43, and is subsequently supplied through the outlet ports 43a into the room space. The refrigerant evaporated in the indoor heat exchanger 32 is sucked into the compressor 12, and is compressed there again.

(3-2) Heating Operation

[0059] During a heating operation, the four-way switching valve 15 is switched to the state indicated by the broken curves in FIG. 1 to make the compressor 12, the indoor fan 27, and the outdoor fan 16 operate. Thus, the refrigerant circuit C performs a refrigeration cycle in

which the indoor heat exchanger 32 functions as a condenser and the outdoor heat exchanger 13 functions as an evaporator. Specifically, high pressure refrigerant compressed by the compressor 12 flows through the indoor heat exchanger 32 of the indoor unit 20. In the indoor unit 20, indoor air upwardly flows through the suction port 42a, the panel-side suction flow channel 42, and the inner space of the bell mouth 31 in this order, and then is sucked into the impeller housing space of the indoor fan 27. The air in the impeller housing space is carried by the impeller 30 and is radially outwardly blown out. This air passes through the indoor heat exchanger 32 and exchanges heat with the refrigerant. In the indoor heat exchanger 32, the refrigerant dissipates heat to indoor air and condenses, thereby heating the air.

[0060] The air heated by the indoor heat exchanger 32 divides and flows into the respective body-side blowout flow channels 37, then downwardly flows through the panel-side blowout flow channels 43, and is subsequently supplied through the outlet ports 43a into the room space. The refrigerant condensed in the indoor heat exchanger 32 has its pressure reduced by the outdoor expansion valve 14, and subsequently flows through the outdoor heat exchanger 13. In the outdoor heat exchanger 13, the refrigerant absorbs heat from outdoor air, and evaporates. The refrigerant evaporated in the outdoor heat exchanger 13 is sucked into the compressor 12, and is compressed there again.

(4) Gas-Side Pipe 70, Liquid-Side Pipe 80, and Their Surrounding Structures

[0061] Next, a gas-side pipe 70 and a liquid-side pipe 80 housed in the indoor unit 20, and their surrounding structures will be described.

[0062] As shown in FIG. 4, the indoor heat exchanger 32 has a first side end portion 32a and a second side end portion 32b. The first side end portion 32a is formed on one of the side ends of the indoor heat exchanger 32 in the longitudinal direction of the heat transfer tubes thereof. The second side end portion 32b is formed on the other side end of the indoor heat exchanger 32 in the longitudinal direction of the heat transfer tubes thereof. The gas-side pipe 70 and the liquid-side pipe 80 are installed in a pipe housing space S between the first and second side end portions 32a, 32b of the indoor heat exchanger 32.

(4-1) Gas-Side Pipe 70

[0063] FIG. 5 is a front view of the indoor heat exchanger 32 when the first side end portion 32a is front. In FIGS. 4 and 5, the gas-side pipe 70 is disposed and extends between the gas-side end portion of the indoor heat exchanger 32 at the first side end portion 32a and the gas-side connecting pipe 7 described above. The gas-side pipe 70 includes a header 71, which is connected to the indoor heat exchanger 32, and a gas relay pipe 72 con-

nected to the header 71 and the gas-side connecting pipe 7 therebetween.

[0064] The header 71 is disposed in the neighborhood of the first side end portion 32a of the indoor heat exchanger 32. The header 71 includes a header body 71a and a plurality of branch pipes 71b branching from the header body 71a.

(4-1-1) Header Body 71a

[0065] The header body 71a extends along the first side end portion 32a of the indoor heat exchanger 32 in the up-and-down direction. In other words, the header body 71a is parallel to the first side end portion 32a with a predetermined distance from the first side end portion 32a of the indoor heat exchanger 32.

[0066] During a cooling operation, the header body 71a allows refrigerant flowing out of the respective branch pipes 71b to join together. On the other hand, during a heating operation, the header body 71a allows refrigerant flowing out of the gas relay pipe 72 to divide and flow into the respective branch pipes 71b.

(4-1-2) Branch Pipes 71b

[0067] The branch pipes 71b are arranged between the header body 71a and the first side end portion 32a of the indoor heat exchanger 32. The branch pipes 71b are arranged along the side surface of the header body 71a (i.e., arranged in the up-and-down direction) to be parallel to each other. One end of each of the branch pipes 71b is connected to an associated one of the heat transfer tubes (i.e., refrigerant paths P) at the first side end portion 32a of the indoor heat exchanger 32. The other end of each of the branch pipes 71b is connected to the header body 71a, and communicates with the inside of the header body 71a.

(4-2) Liquid-Side Pipe 80

[0068] The liquid-side pipe 80 is disposed and extends between the liquid-side end portion of the indoor heat exchanger 32 at the second side end portion 32b and the liquid-side connecting pipe 6 described above. The liquid-side pipe 80 includes a distributor 81 and a liquid relay pipe 82 connected to the distributor 81 and the liquid-side connecting pipe 6 therebetween. The distributor 81 is positioned in the neighborhood of the second side end portion 32b of the indoor heat exchanger 32. The distributor 81 includes a distributor body 81a and a plurality of distribution pipes 81b branching from the distributor body 81a.

(4-2-1) Distributor Body 81a

[0069] The distributor body 81a is disposed in the pipe housing space S between the first side end portion 32a and the second side end portion 32b of the indoor heat

exchanger 32. The distributor body 81a is formed in a tubular shape with a bottom and a vertically extending axis. The distribution pipes 81b are connected to an upper end surface of the distributor body 81a.

[0070] FIG. 6 schematically shows a positional relationship of the distributor 81 with respect to the height-wise direction of the indoor heat exchanger 32 in use state. In FIG. 6, the top of the distributor body 81a (i.e., a connection to the distribution pipes 81b) is located above the center of the height of the indoor heat exchanger 32 with respect to the height-wise direction of the indoor heat exchanger 32 in a front view of FIG. 6. The distributor body 81a faces the second side end portion 32b of the indoor heat exchanger 32 with the connection to the distribution pipes 81b facing vertically upwardly.

[0071] As shown in FIGS. 1 and 6, during a cooling operation, the distributor body 81a allows refrigerant flowing out of the liquid relay pipe 82 to divide and flow into the respective distribution pipes 81b. On the other hand, during a heating operation, the distributor body 81a allows refrigerant flowing out of the respective distribution pipes 81b to join together.

(4-2-2) Distribution pipes 81b

[0072] The distribution pipes 81b are arranged between the distributor body 81a and the second side end portion 32b of the indoor heat exchanger 32. Each of the distribution pipes 81b is configured with a capillary tube, of which the flow channel is smaller in diameter than that of the distributor body 81a.

[0073] As shown in FIG. 6, the connection of the distributor body 81a to the distribution pipes 81b is located above the center of the height of the indoor heat exchanger 32; in the present embodiment taken as an example, this connection is located slightly higher than the height position of a seventh row heat transfer tube down from the top of the indoor heat exchanger 32.

[0074] Moreover, the connection of the distributor body 81a to the distribution pipes 81b faces vertically upwardly. For these reasons, distribution pipes 81b connected to respective uppermost through sixth row heat transfer tubes of the indoor heat exchanger 32 are located higher than the connection of the distributor body 81a to the distribution pipes 81b.

[0075] On the other hand, distribution pipes 81b connected to respective seventh through sixteenth row heat transfer tubes of the indoor heat exchanger 32 are located lower than the connection of the distributor body 81a to the distribution pipes 81b.

[0076] Thus, during cooling, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through sixth row heat transfer tubes of the indoor heat exchanger 32 flows against gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective seventh through sixteenth row heat transfer tubes of the indoor heat exchanger 32 flows according to the pull of gravity.

[0077] On the other hand, during heating, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through sixth row heat transfer tubes of the indoor heat exchanger 32 flows according to the pull of gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective seventh through sixteenth row heat transfer tubes of the indoor heat exchanger 32 flows against gravity.

(4-2-3) Liquid Relay Pipe 82

[0078] The liquid relay pipe 82 connects the distributor body 81a to the liquid-side connecting pipe 6 via a bent relay portion 83 bent in substantially U-shape, vertically downwardly extending from the distributor body 81a, and upwardly extending to the liquid-side connecting pipe 6.

(5) Mounting Position of Refrigerant Temperature Sensor 183

[0079] Next, the refrigerant temperature sensor 183 for sensing a temperature of the refrigerant flowing through the indoor heat exchanger 32 is mounted to the indoor heat exchanger 32.

[0080] Since heat transfer fins are present between the first side end portion 32a and the second side end portion 32b of the indoor heat exchanger 32, the refrigerant temperature sensor 183 is mounted to one of a plurality of U-portions laterally projecting from the first side end portion 32a or the second side end portion 32b of the indoor heat exchanger 32.

(5-1) Detail of Mounting Position

[0081] FIG. 7 is a plan view of a heat transfer tube of the indoor heat exchanger 32. In FIGS. 6 and 7, the indoor heat exchanger 32 has eighteen heat transfer tubes (hereinafter, referred to as refrigerant paths P) making one and a half round trip between the first side end portion 32a and the second side end portion 32b.

[0082] Each of the refrigerant paths P is configured with a plurality of straight pipes 323, a plurality of bends 325, a first U-portion 327, and a second U-portion 329.

[0083] In the present embodiment, the height-wise direction of the indoor heat exchanger 32 in use state is oriented in the up-and-down direction. The refrigerant paths P as shown in FIG. 7 are arranged in the up-and-down direction of the indoor heat exchanger 32.

[0084] To form the first U-portion 327 of the indoor heat exchanger 32, two straight pipes are joined to each other with a U-shaped pipe. On the other hand, to form the second U-portion 329, a straight pipe is subjected to bending in a U-shape.

[0085] Since the refrigerant path P as shown in FIG. 7 makes one and a half round trip between the first side end portion 32a and the second side end portion 32b as described above, the first U-portion 327 is located on the

first side end portion 32a side, and the second U-portion 329 is located on the second side end portion 32b side.

[0086] For a configuration of the refrigerant path P as described above, it is desirable that a mounting position of the refrigerant temperature sensor 183 to a refrigerant path P is located above the height-wise center of the indoor heat exchanger 32 in use state or the distributor body 81a.

[0087] For example, in the air conditioning apparatus 10, when the compressor 12 operates at a lower number of compressor rotations to output a minimum heating capacity less than 45% of a heating rated capacity thereof, liquid pooling tends not to occur in the refrigerant paths P higher than the distributor body 81a while liquid pooling tends to occur in the refrigerant paths P lower than the distributor body 81a.

[0088] This would be caused by liquid in the refrigerant paths P lower than the distributor body 81a, which cannot be raised to the distributor body 81a under the influence of gravity since a circulation amount of refrigerant is reduced.

[0089] However, even when the compressor 12 operates at a lower number of compressor rotations to output the minimum heating capacity to reduce a circulation amount of refrigerant, liquid pooling does not occur above the height-wise center of the indoor heat exchanger 32 or the distributor body 81a. Thus, the refrigerant temperature sensor 183 mounted at the above described region can detect an accurate saturation temperature.

[0090] For a more specific mounting position, the refrigerant temperature sensor 183 is mounted to a refrigerant path P, out of the plurality of refrigerant paths P, in a range occupying 30% of all paths down from the uppermost row refrigerant path P of the indoor heat exchanger 32.

[0091] For example, it is preferable to mount it to one of the uppermost through sixth row refrigerant paths P in an indoor heat exchanger 32 having eighteen paths in total such as that of the present embodiment. In the present embodiment, as shown in FIG. 6, the refrigerant temperature sensor 183 is mounted to a third row second U-portion 329.

[0092] The refrigerant temperature sensor 183 is mounted to the second U-portion 329 of the indoor heat exchanger 32 because the fins between the first side end portion 32a and the second side end portion 32b makes it difficult to allocate an efficient mounting space. Thus, it is inevitable to mount it to either the first U-portion 327 or the second U-portion 329.

[0093] However, when subcooling is produced in the entire system, in order to avoid a saturation temperature from failing to be detected, it is preferable to mount it not to the first U-portion 327 as a liquid side but to the second U-portion 329 as a gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P.

[0094] It should be noted that the refrigerant temperature sensor 183 may be mounted to the uppermost row refrigerant path P of the indoor heat exchanger 32.

(5-2) Effect of Mounting Position of Refrigerant Temperature Sensor 183

[0095] FIG. 8 is a graph showing distributions of temperatures in the indoor heat exchanger 32 during an operation at a heating minimum capacity. FIG. 8 shows a value detected by the refrigerant temperature sensor 183 in ordinate and the position of the refrigerant paths in abscissa. The number of positions of the refrigerant paths P of the indoor heat exchanger 32 starts at 1 from the uppermost row refrigerant path P, and the number of positions sequentially increases for lower refrigerant paths P.

[0096] As shown in FIG. 8, in the case in which the refrigerant temperature sensor 183 is positioned at the liquid side of a refrigerant path P, as the number of positions of the refrigerant paths increases, the values are more different from the saturation temperature except the uppermost row refrigerant path P (plot ▲).

[0097] In contrast to this, in the case in which the refrigerant temperature sensor 183 is positioned at an intermediate position of a refrigerant path P, the values at the uppermost through eighth row refrigerant paths P are closer to the saturation temperature, and the values at the refrigerant paths P lower than these refrigerant paths are more different from the saturation temperature (plot ●).

[0098] On the other hand, in the case in which the refrigerant temperature sensor 183 is positioned at the gas side of a refrigerant path P, the values at the uppermost through thirteenth row refrigerant paths P are closer to the saturation temperature, and the values at the refrigerant paths P lower than these refrigerant paths are more different from the saturation temperature (plot ■).

[0099] The results as described above has proven "it is desirable that a mounting position of the refrigerant temperature sensor 183 to a refrigerant path P is located above the height-wise center of the indoor heat exchanger 32 in use state or the distributor body 81a" and "it is preferable to mount it not to the liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P".

(6) Features

[0100]

(6-1) Even when the compressor 12 operates at a lower number of compressor rotations to output the minimum heating capacity to reduce a circulation amount of refrigerant, since liquid pooling does not occur above the height-wise center of the indoor heat exchanger 32 or the distributor body 81a, the air conditioning apparatus 10 enables the refrigerant temperature sensor 183 mounted at the above described region to detect an accurate saturation temperature. Consequently, the likelihood of hindrance of subcooling control is removed, so that the control of

opening of an electric valve in the conventional manner needs not to be performed only for the removal of liquid pooling. Of course, no pressure sensor is needed.

(6-2) Since the refrigerant temperature sensor 183 is mounted to a refrigerant path P, out of the plurality of refrigerant paths P, in an area occupying 30% of all paths down from the uppermost row refrigerant path P, the air conditioning apparatus 10 enables more secure detection of an accurate saturation temperature.

(6-3) In the case in which the refrigerant temperature sensor 183 is mounted to the uppermost row refrigerant path P out of the plurality of refrigerant paths P, the air conditioning apparatus 10 enables more secure detection of an accurate saturation temperature.

(6-4) Since the refrigerant temperature sensor 183 is mounted not to the first side end portion 32a side of the indoor heat exchanger 32 as the liquid side but to the second side end portion 32b side of the indoor heat exchanger 32 as the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P, the air conditioning apparatus 10 avoids a saturation temperature from failing to be detected when subcooling is produced in the entire system.

(6-5) With the compressor 12 having a range enough to allow "a minimum heating operational state in which the compressor 12 continuously operates for 30 seconds or more at a lower number of compressor rotations to output a minimum heating capacity less than 45% of a heating rated capacity thereof" to appear, even if the compressor 12 operates at a lower number of compressor rotations in the course of events to output a minimum heating capacity to reduce a circulation amount of refrigerant, since liquid pooling does not occur above the height-wise center of the indoor heat exchanger 32 or the distributor body 81a, the refrigerant temperature sensor 183 mounted at the above described region can detect an accurate saturation temperature, the air conditioning apparatus 10 enables the refrigerant temperature sensor 183 to detect an accurate saturation temperature.

(7) Other Embodiments

[0101] In the above embodiment, for the mounting position of the refrigerant temperature sensor 183, the indoor heat exchanger used in the ceiling mounted indoor unit 20 has been described as an example. The idea of the mounting position of the refrigerant temperature sensor 183 can be applied to indoor heat exchangers used in indoor units other than the indoor unit previously described. For example, floor model indoor units, two-way indoor units, ceiling suspended indoor units, ducted indoor units, ceiling mounted one-way indoor units will be

given. Here, as typical examples, a floor model indoor unit and a two-way indoor unit will be described.

(7-1) Indoor Heat Exchanger 132 Used in Floor Model Indoor Unit

[0102] FIG. 9 schematically shows, for an indoor heat exchanger 132 used in a floor model indoor unit, a positional relationship of the distributor 81 with respect to the height-wise direction of the indoor heat exchanger 132 in use state.

[0103] As shown in FIG. 9, the indoor heat exchanger 132 in use state assumes an inclined orientation, and in this indoor heat exchanger, ten refrigerant paths P are disposed from top to bottom. Intervals between the refrigerant paths P are not equal to each other.

[0104] The connection of the distributor body 81a to the distribution pipes 81b is located slightly lower than the height position of a sixth row refrigerant path P down from the top of the indoor heat exchanger 132, and corresponds to the height-wise center of the indoor heat exchanger 132.

[0105] Moreover, the connection of the distributor body 81a to the distribution pipes 81b faces vertically upwardly. For these reasons, distribution pipes 81b connected to respective uppermost through sixth row refrigerant paths P of the indoor heat exchanger 132 are located higher than the connection of the distributor body 81a to the distribution pipes 81b.

[0106] On the other hand, distribution pipes 81b connected to respective seventh through tenth row refrigerant paths P of the indoor heat exchanger 132 are located lower than the connection of the distributor body 81a to the distribution pipes 81b.

[0107] Thus, during cooling, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through sixth row refrigerant paths P of the indoor heat exchanger 132 flows against gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective seventh through tenth row heat transfer tubes of the indoor heat exchanger 132 flows according to the pull of gravity.

[0108] On the other hand, during heating, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through sixth row refrigerant paths P of the indoor heat exchanger 132 flows according to the pull of gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective seventh through tenth row refrigerant paths P of the indoor heat exchanger 132 flows against gravity.

[0109] In order to detect an accurate saturation temperature even if liquid pooling occurs in an operational state with circulation amounts in a low range, as shown in FIG. 9, it is desirable that a mounting position of the refrigerant temperature sensor 183 to a refrigerant path P is located above the height-wise center of the indoor heat exchanger 132 in use state or the distributor body 81a in the same manner as the indoor heat exchanger

of the embodiment previously described. Moreover, it is preferable to mount it not to the liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P.

[0110] FIG. 10 is a graph showing distributions of temperatures in the indoor heat exchanger 132 during an operation at a heating minimum capacity. FIG. 10 shows a value detected by the refrigerant temperature sensor 183 in ordinate and the position of the refrigerant paths P in abscissa. The number of positions of the refrigerant paths P of the indoor heat exchanger 32 starts at 1 from the uppermost row refrigerant path P, and the number of positions sequentially increases for lower refrigerant paths P.

[0111] As shown in FIG. 10, in the case in which the refrigerant temperature sensor 183 is positioned at the liquid side of a refrigerant path P, as the number of positions of the refrigerant paths increases, the values are more different from the saturation temperature except the uppermost through fifth row refrigerant paths P (plot ▲).

[0112] In contrast to this, in the case in which the refrigerant temperature sensor 183 is positioned at an intermediate position of a refrigerant path P, the values at the uppermost through seventh row refrigerant paths P are closer to the saturation temperature, and the values at the refrigerant paths P lower than these refrigerant paths are more different from the saturation temperature (plot ●).

[0113] On the other hand, in the case in which the refrigerant temperature sensor 183 is positioned at the gas side of a refrigerant path P, the values at the uppermost through eighth row refrigerant paths P are closer to the saturation temperature, and only the values at ninth and lowermost, tenth row refrigerant paths P are more different from the saturation temperature (plot ■).

[0114] The results as described above has proven "it is desirable that a mounting position of the refrigerant temperature sensor 183 to a refrigerant path P is located above the height-wise center of the indoor heat exchanger 132 in use state or the distributor body 81a" and "it is preferable to mount it not to the liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P".

(7-2) Indoor Heat Exchanger 232 Used in Two-Way Indoor Unit

[0115] FIG. 11 schematically shows, for an indoor heat exchanger 232 used in a two-way indoor unit, a positional relationship of the distributor 81 with respect to the height-wise direction of the indoor heat exchanger 232 in use state.

[0116] As shown in FIG. 11, the indoor heat exchanger 232 includes two heat exchangers facing each other, and in each of these heat exchangers, seven refrigerant paths P are disposed from top to bottom.

[0117] The connection of the distributor body 81a to

the distribution pipes 81b is located slightly higher than the height position of a fourth row refrigerant path P down from the top of the indoor heat exchanger 232, and almost corresponds to the height-wise center of the indoor heat exchanger 232.

[0118] Moreover, the connection of the distributor body 81a to the distribution pipes 81b faces vertically upwardly. For these reasons, distribution pipes 81b connected to respective uppermost through third row refrigerant paths P of the indoor heat exchanger 232 are located higher than the connection of the distributor body 81a to the distribution pipes 81b.

[0119] On the other hand, distribution pipes 81b connected to respective fourth through seventh row refrigerant paths P of the indoor heat exchanger 232 are located lower than the connection of the distributor body 81a to the distribution pipes 81b.

[0120] Thus, during cooling, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through third row refrigerant paths P of the indoor heat exchanger 232 flows against gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective fourth through seventh row refrigerant paths P of the indoor heat exchanger 232 flows according to the pull of gravity.

[0121] On the other hand, during heating, liquid refrigerant flowing through the distribution pipes 81b connected to the respective uppermost through third row refrigerant paths P of the indoor heat exchanger 232 flows according to the pull of gravity, and liquid refrigerant flowing through the distribution pipes 81b connected to the respective fourth through seventh row refrigerant paths P of the indoor heat exchanger 232 flows against gravity.

[0122] In order to detect an accurate saturation temperature even if liquid pooling occurs in an operational state with circulation amounts in a low range, as shown in FIG. 11, it is desirable that a mounting position of the refrigerant temperature sensor 183 to a refrigerant path P is located above the height-wise center of the indoor heat exchanger 232 in use state or the distributor body 81a in the same manner as the indoor heat exchanger of the embodiment previously described. Moreover, it is preferable to mount it not to the liquid side but to the gas-side end with respect to the flow of the refrigerant flowing through the refrigerant path P.

INDUSTRIAL APPLICABILITY

[0123] The present invention is useful for an air conditioning apparatus being able to spontaneously implement a minimum heating operational state.

REFERENCE SIGNS LIST

[0124]

10 Air Conditioning Apparatus
32 Indoor Heat Exchanger

81 Distributor
81a Distributor Body
81b Distribution pipe
183 Temperature Sensor

5

CITATION LIST

PATENT LITERATURE

10 [0125] Patent Literature 1: JP-A-H5-280808

Claims

15 1. An air conditioning apparatus configured to allow an indoor heat exchanger (32) to function as a radiator for refrigerant and perform a heating operation, comprising:

20 a distributor (81) including:

25 a distributor body (81a) positioned in the neighborhood of a refrigerant outlet of the indoor heat exchanger (32) functioning as a radiator; and
a plurality of distribution pipes (81b) branching from the distributor body (81a) into each of a plurality of paths formed in the indoor heat exchanger (32); and

30 a temperature sensor (183) configured to detect a saturation temperature of refrigerant flowing through the indoor heat exchanger (32), wherein the temperature sensor (183) is mounted above a height-wise center of the indoor heat exchanger (32) in use state or the distributor body (81a).

35 2. The air conditioning apparatus according to claim 1, wherein the temperature sensor (183) is mounted to a path, out of the plurality of paths, in a range occupying 30% of all paths down from an uppermost row path.

40 3. The air conditioning apparatus according to claim 2, wherein the temperature sensor (183) is mounted to the uppermost row path out of the plurality of paths.

45 4. The air conditioning apparatus according to any one of claims 1 to 3, wherein on a particular path, out of the plurality of paths, to which the temperature sensor (183) is mounted, the temperature sensor (183) is mounted to a gas-side end of the particular path, with respect to a flow of refrigerant flowing through the particular path.

50 5. The air conditioning apparatus according to any one of claims 1 to 4, wherein an operation is continuously

performed for 30 seconds or more at a capacity lower than 45% of a rated capacity.

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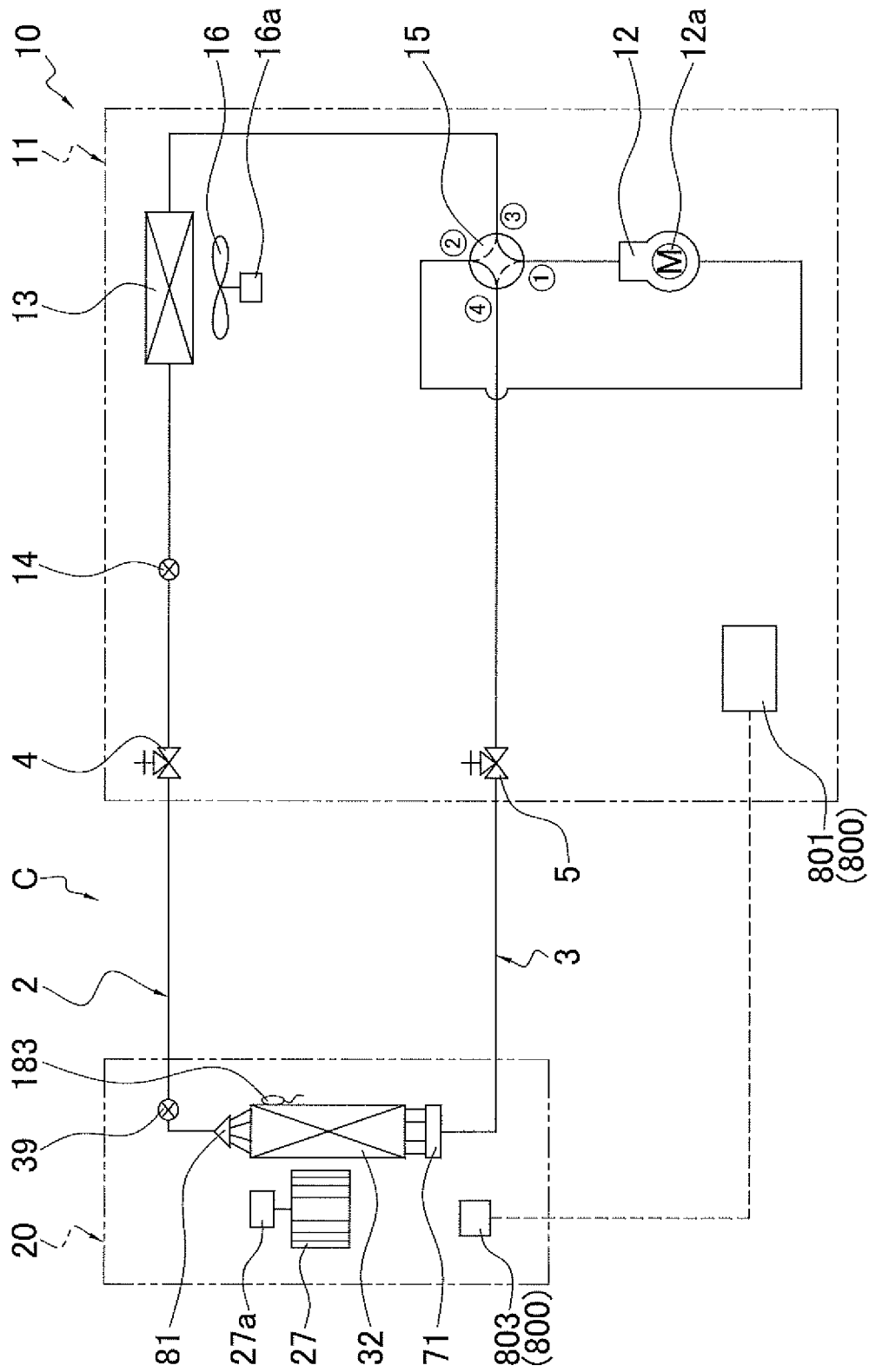


FIG. 1

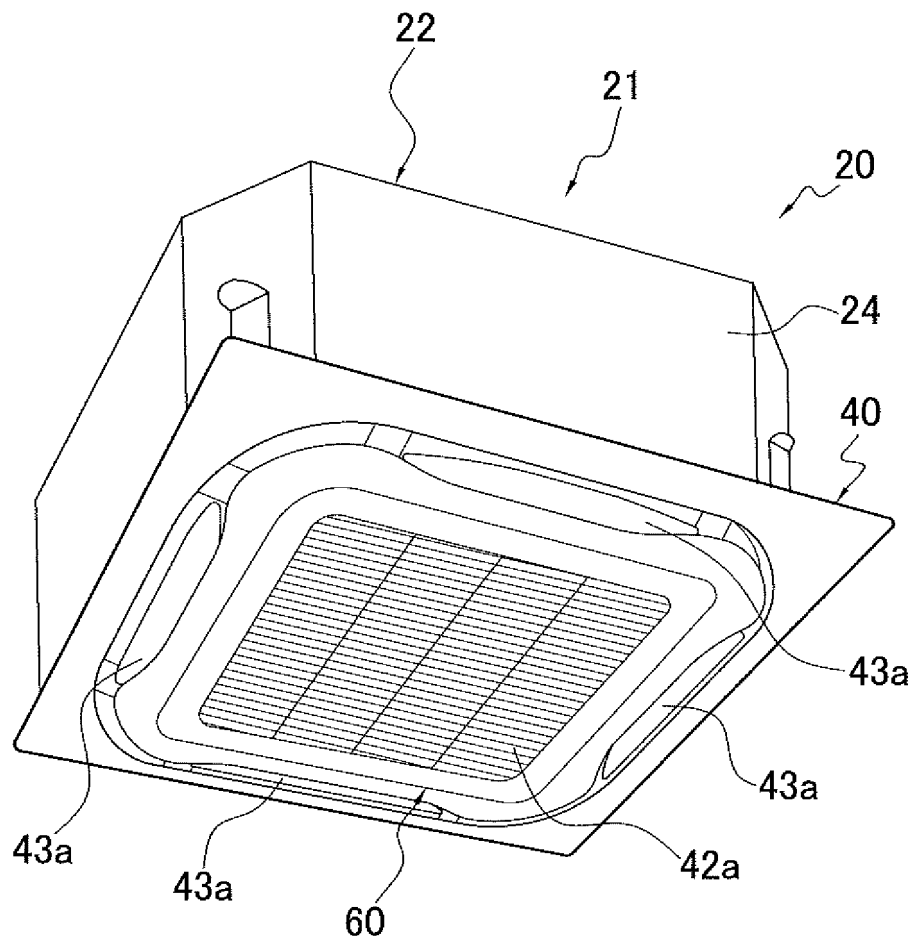


FIG. 2

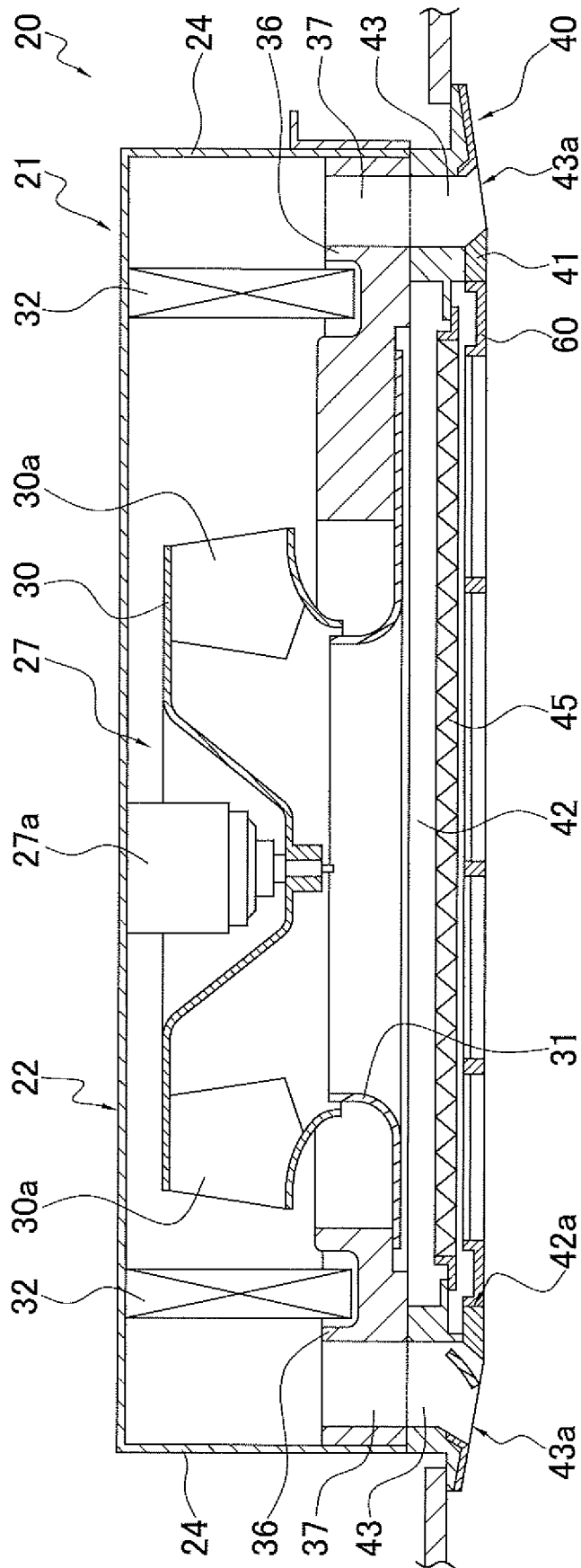


FIG. 3

FIG. 4

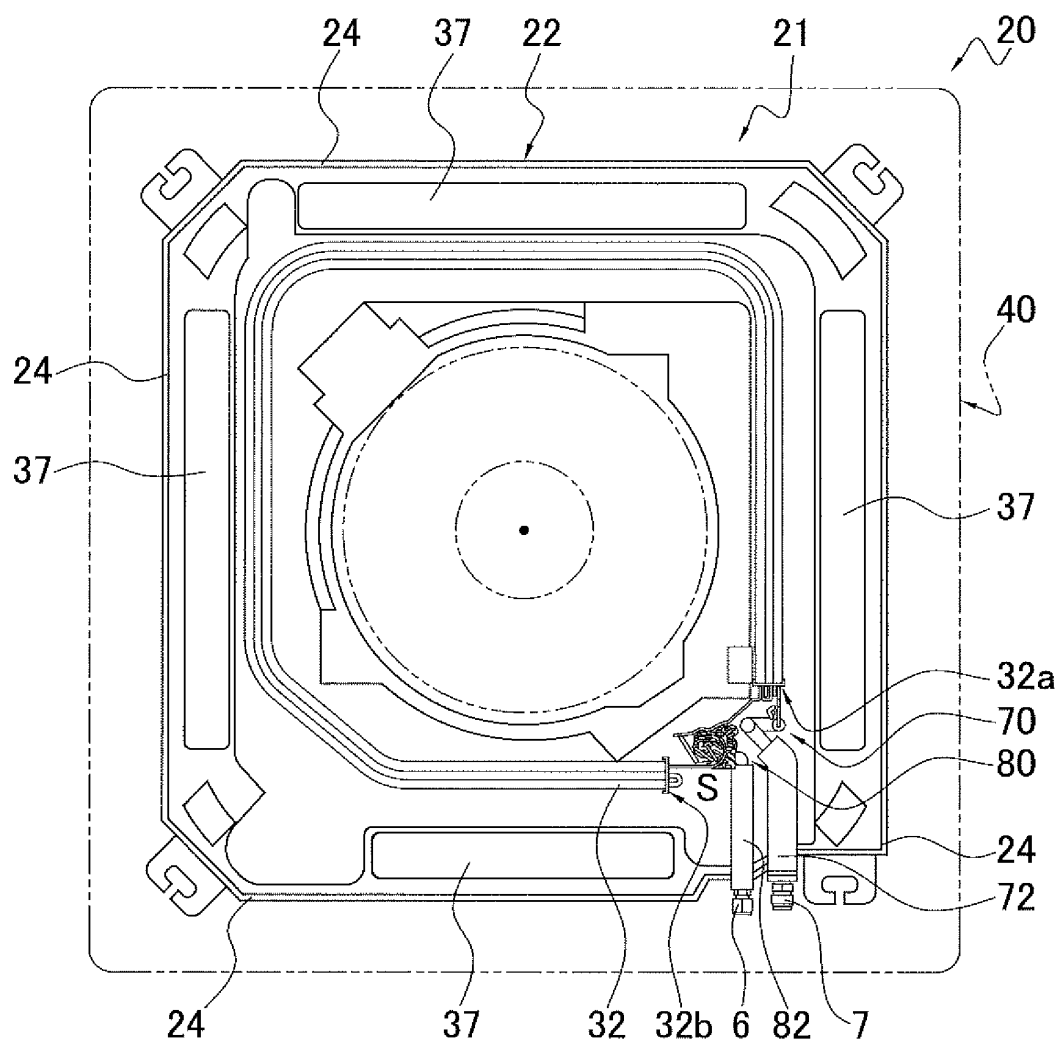
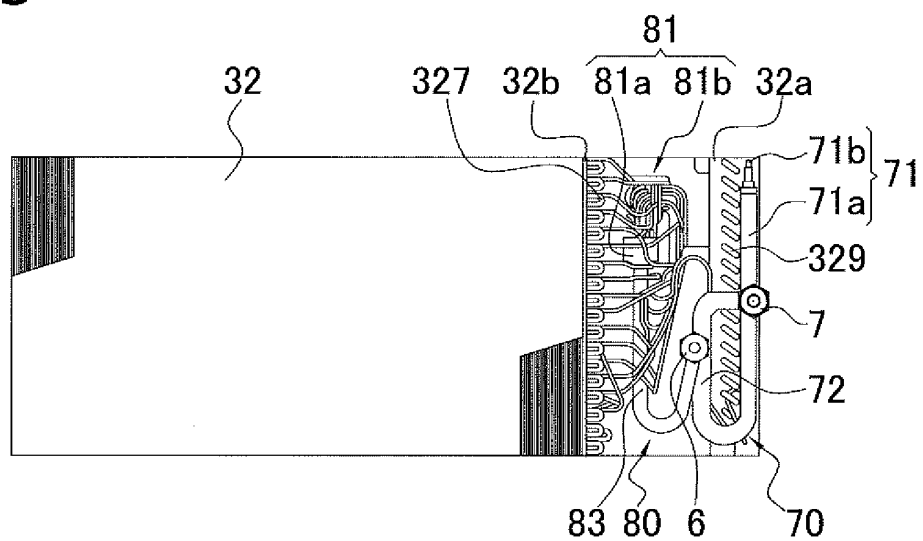


FIG. 5



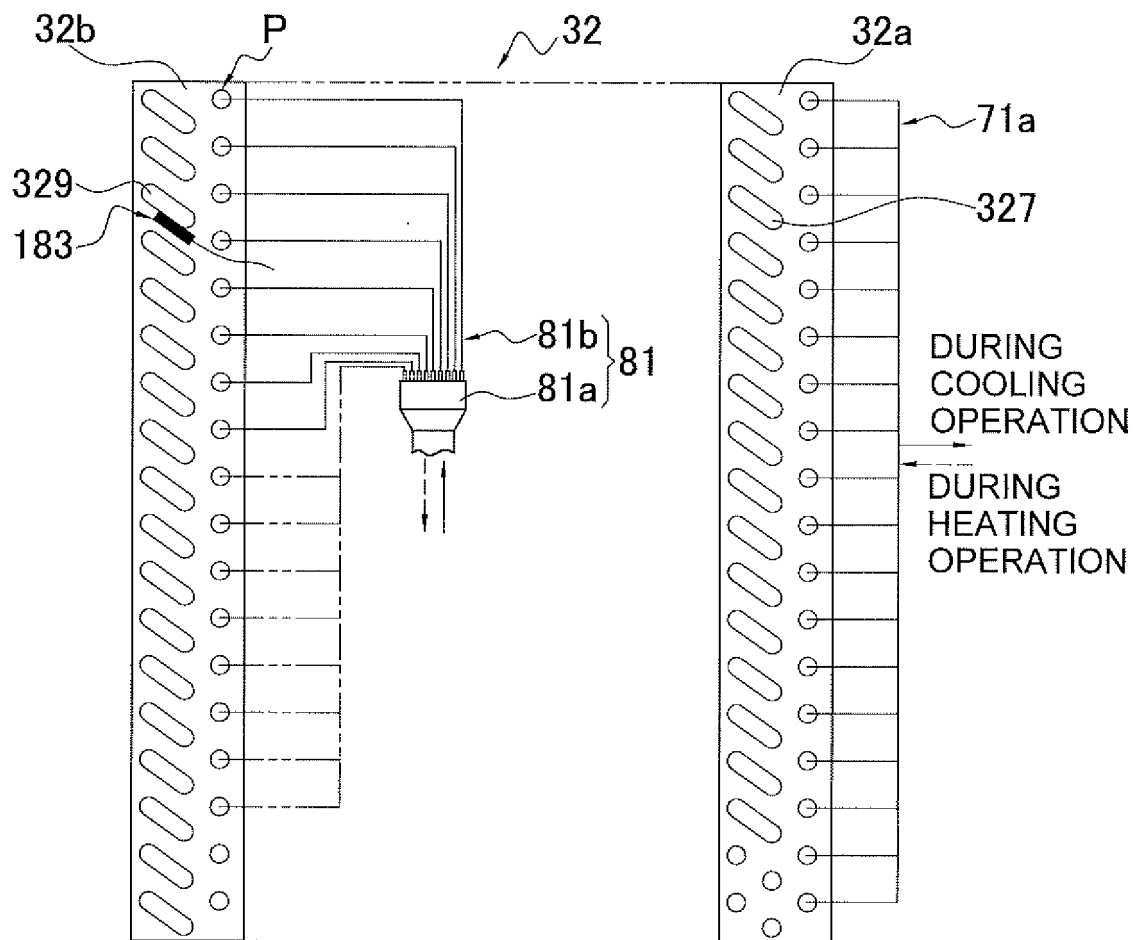


FIG. 6

FIG. 7

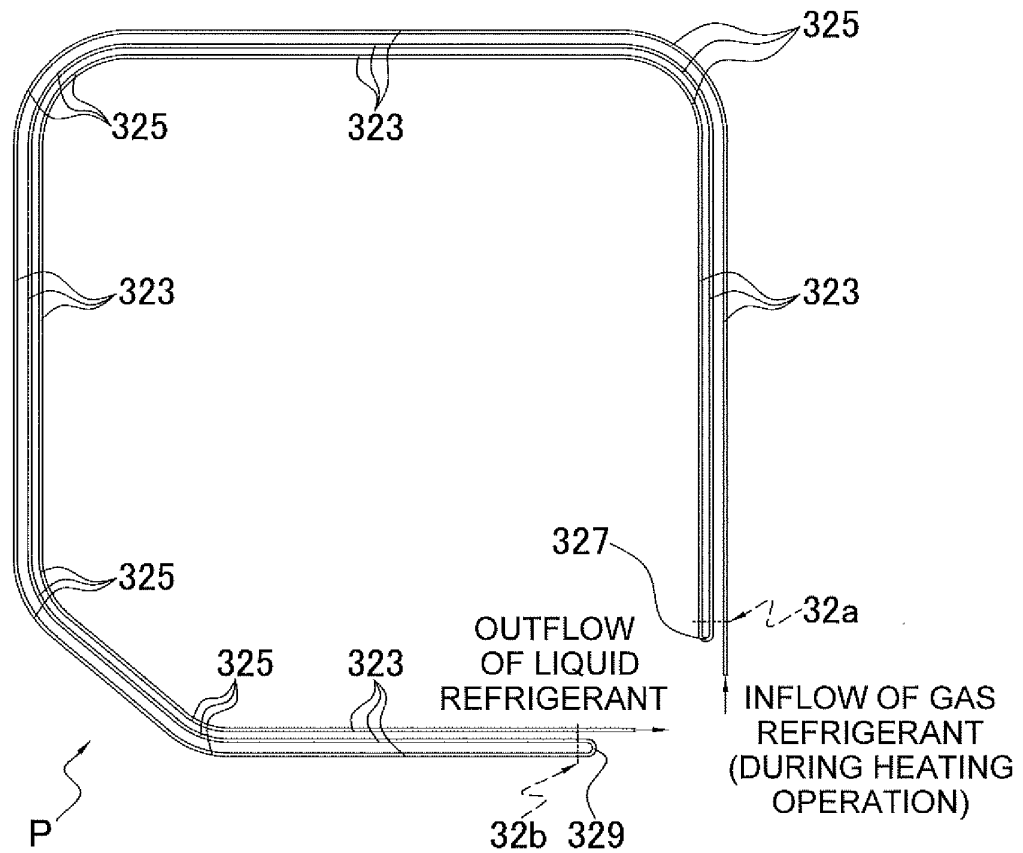


FIG. 8

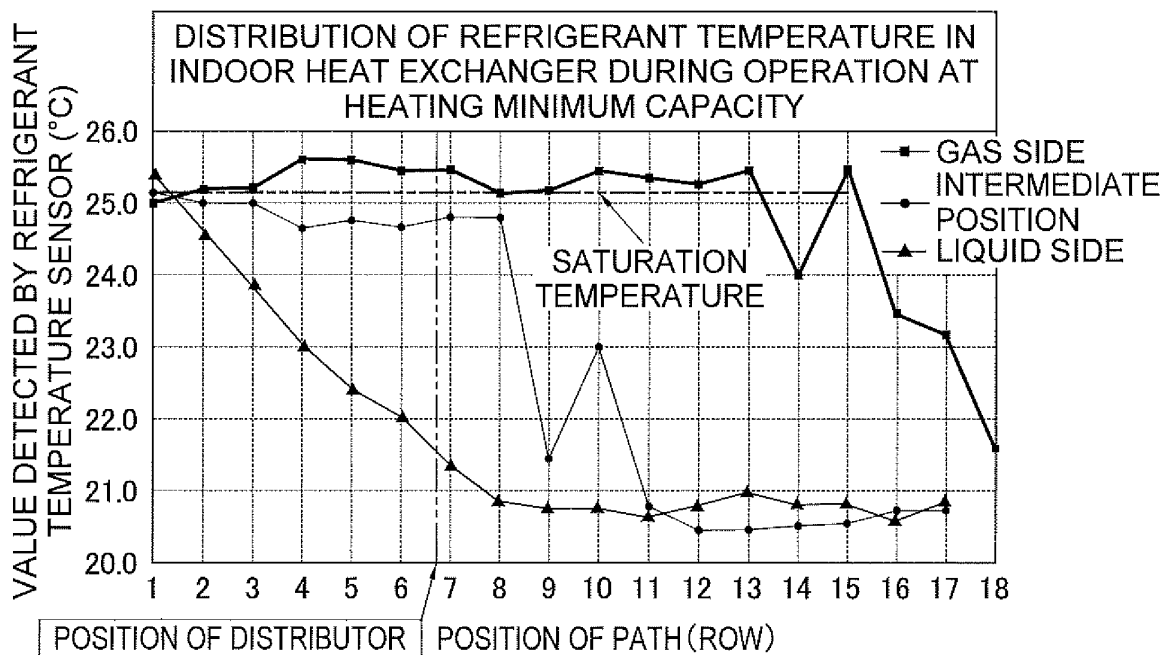


FIG. 9

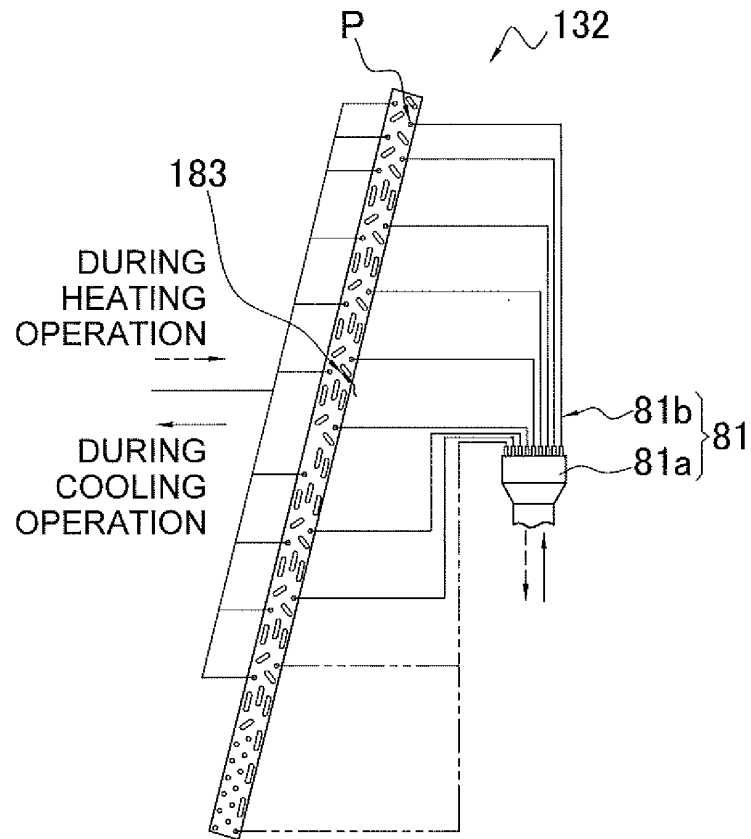
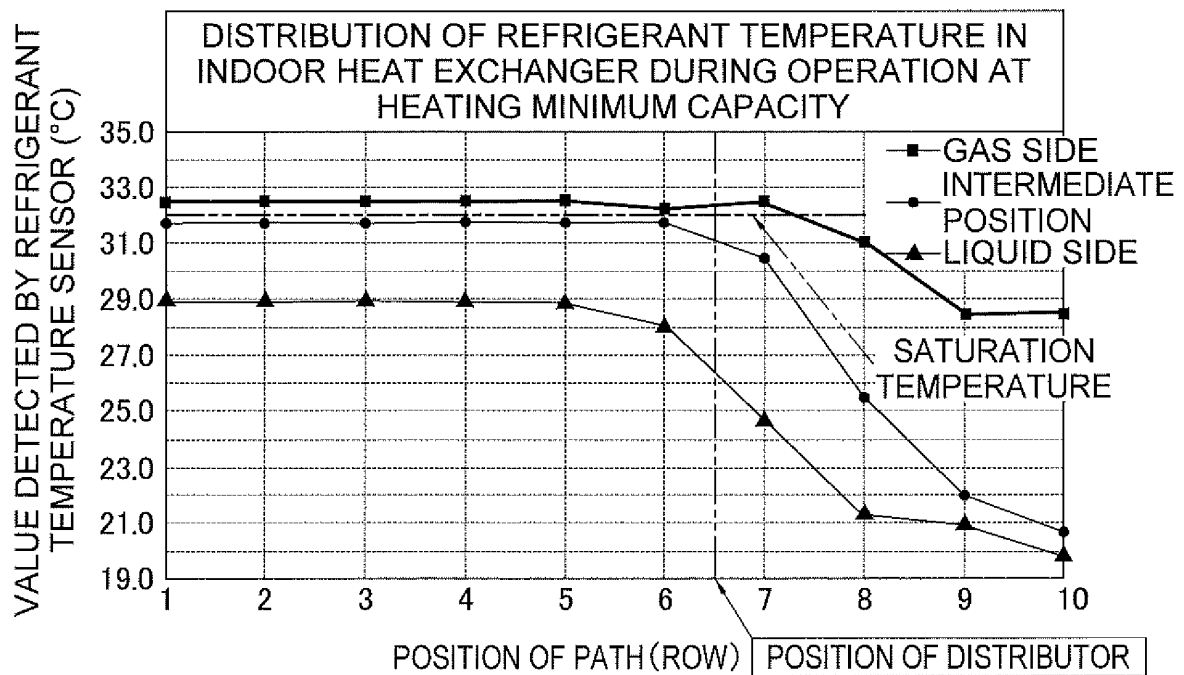


FIG. 10



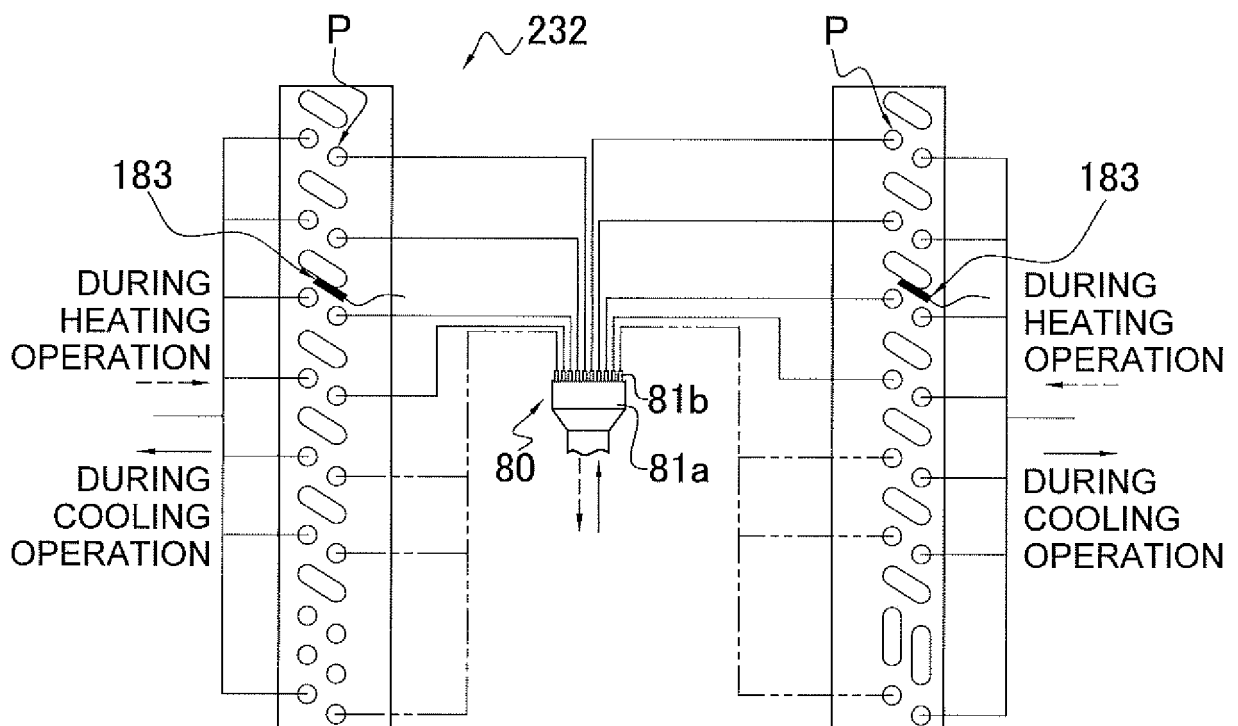


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/051743

A. CLASSIFICATION OF SUBJECT MATTER

F25B49/02(2006.01)i, F24F11/02(2006.01)i, F25B1/00(2006.01)i, F25B13/00(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, F25B13/00, F25B39/00-41/00, F25B49/02, F24F1/00, F24F11/02

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 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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	JP 7-127942 A (Sanyo Electric Co., Ltd.), 19 May 1995 (19.05.1995), paragraphs [0003] to [0017]; fig. 1 to 3 (Family: none)	1-5
Y	JP 2000-88362 A (Matsushita Refrigeration Co.), 31 March 2000 (31.03.2000), paragraph [0036]; fig. 1 (Family: none)	1-5
Y	JP 2013-137165 A (Daikin Industries, Ltd.), 11 July 2013 (11.07.2013), paragraphs [0002] to [0009], [0016], [0039], [0043], [0063] to [0064], [0074]; fig. 1, 4 (Family: none)	1-5

☐ 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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search
28 March 2016 (28.03.16)

Date of mailing of the international search report
12 April 2016 (12.04.16)

Name and mailing address of the ISA/
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H5280808 A [0003] [0125]