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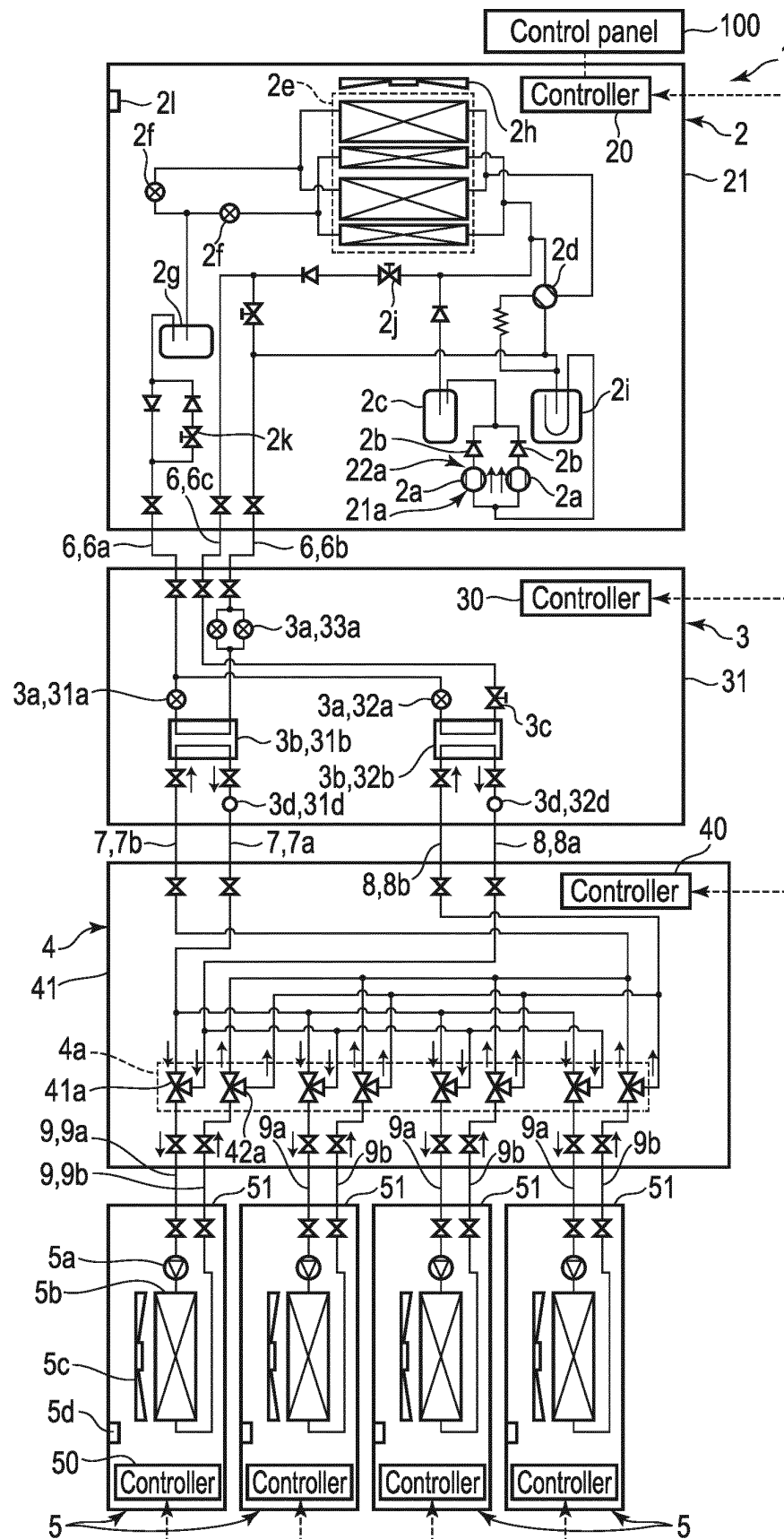
(54) **AIR CONDITIONER**

(57) An air conditioner according to one embodiment carries out a heating operation and a cooling operation, carries out a cooling/heating mixed operation in which a higher priority is given to cooling by causing a portion of exhaust gas to flow into one of a plurality of intermediate heat exchangers and condensing the same, condensing the remaining exhaust gas in an outdoor-side heat exchanger, causing the obtained condensate to flow through a liquid tube and mixing the same with the refrigerant condensed by the intermediate heat exchanger, and causing the mixed condensate to flow through a sec-

ond expansion valve into the other intermediate heat exchanger and evaporating the same, and carries out a cooling/heating mixed operation in which a higher priority is given to heating by causing exhaust gas to flow into one of the plurality of intermediate heat exchangers and condensing the same, causing a portion of the exhaust gas to flow through a liquid tube into the outdoor-side heat exchanger and evaporating the same, and causing the remaining condensate to flow through the second expansion valve into the other intermediate heat exchanger and evaporating the same.

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FIG. 2



Description

Technical Field

- 5 **[0001]** Embodiments described herein relate generally to an air conditioner configured to carry out cooling/heating by circulating a heat medium such as water or the like.

Background Art

- 10 **[0002]** In recent years, use of part of hydrofluorocarbon (HFC) refrigerants having high global warming potential (GWP) is regarded as a problem, and use of them is now regulated in stages by laws such as Regulation (EU) No. 517/2014 of Europe first of all and so on. Accordingly, development of an air conditioner using a cooling medium low in GWP is now advanced, and R410A which has been the mainstream in the air conditioners for household and professional use is now replaced with R32.
- 15 **[0003]** On the other hand, R32 is a mildly flammable (A2L) cooling medium and, when R32 is used in, for example, a variable refrigerant flow (VRF) air conditioner in which the refrigerant filling amount is large, it is necessary to take the safety in case of leakage of R32 into the room into consideration. Accordingly, in the VRF air conditioner, R410A has continuously been used, however, a system of circulating water as a heat medium to thereby carry out cooling/heating of indoor units separately from each other on an individual basis is proposed by the research and development of recent
- 20 years. As an example, in an air conditioner of such a system, a relay unit is interposed between the outdoor unit and indoor unit, the outdoor unit and relay unit are connected to each other by refrigerant piping, and the relay unit and indoor unit are connected to each other by water piping. In the relay unit, heat exchange is carried out between the refrigerant and heat medium. Accordingly, the refrigerant piping extends only from the outdoor unit to the relay unit, and between the relay unit and indoor unit, the water piping is arranged. Thereby, safety as to refrigerant leakage inside the room is
- 25 guaranteed and use of a mildly flammable refrigerant such as R32 is enabled.

Citation List

Patent Literature

- 30 **[0004]** Patent Literature 1: JP 5236009 B

Summary of Invention

35 Technical Problem

- [0005]** In the relay unit of such an air conditioner, the flow path is appropriately switched by a flow path change-over valve in such a manner that cool water is circulated through an indoor unit of which a cooling operation is required, and warm water is circulated through an indoor unit of which a heating operation is required. When an air conditioner is
- 40 operated (cooling/heating-mixed operation) in a mode in which cooling and heating are mixed with each other, the outdoor unit is operated in the following aspect according to the percentage of the setting demand for the operation mode of the indoor unit. For example, when the percentage of the cooling demand for the indoor unit is greater than or equal to the majority, the outdoor unit carries out a cooling-prioritized cooling/heating-mixed operation. Conversely, when the percentage of the heating demand for the indoor unit is greater than or equal to the majority, the outdoor unit carries
- 45 out a heating-prioritized cooling/heating-mixed operation. As described above, when the operation mode of the outdoor unit is switched, there is a possibility of the capability in an operation mode for which much demand is expected such as cooling in the summer season, and heating in the winter season being lowered depending on the variation in the percentage of the setting demand of the indoor unit. Further, there is also a possibility of hunting of the cycle state occurring concomitantly with switching of the operation mode of the outdoor unit.
- 50 **[0006]** The present invention has been contrived in consideration of the above, and a first object thereof is to provide a water circulation air conditioner capable of suppressing occurrence of capability degradation as to an operation mode for which much demand is expected and hunting of the cycle state.
- [0007]** Further, in such an air conditioner, the rotational speed of the compressor provided in the outdoor unit is controlled on the basis of the heat medium temperature on the heat medium downstream side of the intermediate heat
- 55 exchanger. At this time, the target heat medium temperature of the intermediate heat exchanger is uniformly determined so that the cooling capability or heating capability of the indoor unit can acquire the predetermined capability. Accordingly, for example, when the target cooling capability on the indoor unit side is the minimum capability of the air conditioner, the rotational speed of the outdoor unit compressor becomes excessive relatively to the necessary cooling capability

on the indoor unit side, and energy more than necessary is used.

[0008] The present invention has been contrived in consideration of the above, and a second object thereof is to provide a water circulation air conditioner capable of realizing energy saving.

[0009] Further, in such an air conditioner, for example, when a cooling/heating-mixed operation is carried out in a winter season in an environment in which the temperature falls below 0°C, there is apprehension that the evaporation temperature of the evaporator at the time of a refrigerating cycle may lower to become the temperature equal to the outdoor exchanger. This is because when a heating-prioritized cooling/heating-mixed operation is executed in a winter season, the outdoor heat exchanger is used as an evaporator, and hence the refrigerant flowing through the cooling intermediate heat exchanger is pulled toward the outdoor heat exchanger side and the pressure thereof lowers. At this time, when the refrigerant is water, it is possible that a situation in which freezing occurs to the cooling intermediate heat exchanger may happen, and hence it is necessary to prevent the freezing from occurring.

[0010] Further, in such an air conditioner, water circulates separately through each individual indoor unit. Accordingly, there is a need to take the piping resistance due to the length of the flow path of water into consideration so that differences in the water flow rate may not occur between the indoor units. As a countermeasure therefor, for example, arranging a flow control valve for each indoor unit in the relay unit can be mentioned, however, in this case, the housing size, cost or the like of the relay unit is liable to increase. Particularly, when the waste heat produced from the outdoor unit is used as heat recovery, there is a need to accommodate, in the relay unit, a water heat exchanger, flow path change-over valve, circulating pump and, furthermore even, flow regulating valve each having capability to be compatible with VRF. As a result, the housing size of the relay unit becomes further larger, and it is possible that problems such as an increase in the manpower to carry out the installation operation, and securement of the installation space may occur.

[0011] Furthermore, although in the air conditioner described already, it is made possible to carry out a cooling-dedicated operation or heating-dedicated operation by using two heat exchangers, for example, when the relay unit is provided in a small and confined space such as a ceiling cavity, the size of the relay unit in the height direction is limited and, a need to configure the cooling-dedicated heat exchanger and heating-dedicated heat exchanger by using a plurality of small-sized heat exchangers arises. In this case, while there is a problem of the cost increase of the single body of the intermediate heat exchanger, the manufacturing cost also increases due to an increase in the number of brazed parts and increase in the parts count.

[0012] The present invention has been contrived in consideration of the above, and a third object thereof is to provide a water circulation air conditioner capable of preventing freezing of a cooling intermediate heat exchanger from occurring.

[0013] Further, a fourth object of the present invention is to provide a water circulation air conditioner capable of suppressing an increase in the manufacturing cost.

Solution to Problem

[0014] According to an embodiment, an air conditioner includes an outdoor unit, heat exchange unit, indoor units, valve unit, and control unit. The outdoor unit includes a compressor configured to circulate a refrigerant, outdoor side heat exchanger, and first expansion valve. The heat exchange unit includes a plurality of intermediate heat exchangers configured to carry out heat exchange between the refrigerant and heat medium, and second expansion valves corresponding to the plurality of intermediate heat exchangers. Each of the indoor units includes an indoor side heat exchanger configured to carry out heat exchange between the heat medium and room air. The valve unit includes flow path change-over valves each of which is configured to make one of the heat medium cooled by the intermediate heat exchanger and heat medium heated by the intermediate heat exchanger flow into the indoor side heat exchanger. The control unit includes controllers each of which is configured to control each of the units. The outdoor unit, heat exchange unit, indoor units, and valve unit are individually cased separately from each other. Further, the outdoor unit and heat exchange unit are connected to each other by a liquid pipe configured to send a condensate liquid condensed by the outdoor side heat exchanger to the heat exchange unit or send a condensate liquid condensed by the intermediate heat exchanger to the outdoor unit, suction gas pipe configured to send the refrigerant evaporated by the intermediate heat exchanger to the outdoor unit, and discharged gas pipe configured to send a discharged gas compressed by the compressor to the heat exchange unit.

[0015] The control unit carries out one of a heating operation, cooling operation, cooling-prioritized cooling/heating-mixed operation, and heating-prioritized cooling/heating-mixed operation. In the heating operation, the control unit makes the discharged gas flow into the intermediate heat exchanger. In the cooling operation, the control unit condenses the discharged gas in the outdoor side heat exchanger and makes the condensed condensate liquid flow into the intermediate heat exchanger through the second expansion valve. In the cooling-prioritized cooling/heating-mixed operation, the control unit makes part of the discharged gas flow into one of the plurality of intermediate heat exchangers to thereby condense the part of the discharged gas, condenses the remainder of the discharged gas in the outdoor side heat exchanger, mixes the condensed condensate liquid with the refrigerant condensed in the intermediate heat exchanger through the liquid pipe, and makes the mixed condensate liquid flow into the other of the intermediate heat exchanger

through the second expansion valve to thereby evaporate the mixed condensate liquid. In the heating-prioritized cooling/heating-mixed operation, the control unit makes the discharged gas flow into one of the plurality of intermediate heat exchangers to thereby condense the discharged gas, makes part of the discharged gas flow into the outdoor side heat exchanger through the liquid pipe to thereby evaporate the part of the discharged gas, and makes the remainder of the condensate liquid flow into the other of the intermediate heat exchangers through the second expansion valve to thereby evaporate the remainder of the condensate liquid.

Brief Description of Drawings

[0016]

FIG. 1 is a view schematically showing the configuration of an air conditioner according to a first embodiment.
FIG. 2 is a view schematically showing the piping system of the air conditioner according to the first embodiment.
FIG. 3 is a view schematically showing an example of installation of the units of the air conditioner according to the first embodiment.

FIG. 4A is a view schematically showing the piping system of the heat source side refrigerating cycle at the time of a cooling/heating-mixed operation of the air conditioner according to the first embodiment.

FIG. 4B is a Mollier diagram of the heat source side refrigerating cycle at the time of a cooling/heating-mixed operation of the air conditioner according to the first embodiment.

FIG. 5 is a view showing relationships between the refrigerant density (kg/m^3), percentage (%), refrigerant flow velocity (m/s), (refrigerant flow velocity)², percentage (%), and pressure percentage and discharged gas pipe, liquid pipe, and suction gas pipe according to the first embodiment.

FIG. 6A is a view schematically showing the piping system of an air conditioner according to a first modified example.

FIG. 6B is a view schematically showing the piping system of an air conditioner according to a second modified example.

FIG. 7 is a control flow showing operation mode selection processing of an outdoor unit in the air conditioner according to the first embodiment.

FIG. 8 is a control flowchart showing summer season operation mode selection processing of the outdoor unit in the air conditioner according to the first embodiment.

FIG. 9 is a control flowchart showing winter season operation mode selection processing of the outdoor unit in the air conditioner according to the first embodiment.

FIG. 10 is a control flowchart showing intermediate stage operation mode selection processing of the outdoor unit in the air conditioner according to the first embodiment.

FIG. 11 is a view showing examples of a temporal change in each of the percentages of the demand for cooling and demand for heating on the indoor unit in the air conditioner according to the first embodiment.

FIG. 12A is a view showing examples of a change in the operation mode of the outdoor unit corresponding to the outdoor air temperature in the intermediate stage in the case where the percentages of the demand for cooling and demand for heating change as shown in FIG. 11 in the air conditioner according to the first embodiment.

FIG. 12B is a view showing examples of a change in the operation mode of the outdoor unit corresponding to the outdoor air temperature in the summer season in the case where the percentages of the demand for cooling and demand for heating change as shown in FIG. 11 in the air conditioner according to the first embodiment.

FIG. 12C is a view showing examples of a change in the operation mode of the outdoor unit corresponding to the outdoor air temperature in the winter season in the case where the percentages of the demand for cooling and demand for heating change as shown in FIG. 11 in the air conditioner according to the first embodiment.

FIG. 13 is a view showing a relationship between the operation mode and target temperature of the heat medium at the time of each of the cooling operation and heating operation according to a second embodiment.

FIG. 14 is a control flowchart showing an example of changeover processing of the operation mode according to the second embodiment.

FIG. 15 is a view schematically showing the configuration of an air conditioner according to a third modified example.

FIG. 16 is a view showing an example of installation of cooling intermediate heat exchangers according to a third embodiment.

FIG. 17 is a view showing an example of installation of a heating intermediate heat exchanger according to the third embodiment.

[0017] Mode for Carrying Out the Invention Embodiments of the present invention will be described below with reference to the accompanying drawings.

(First Embodiment)

[0018] FIG. 1 is a view schematically showing the configuration of an air conditioner according to this embodiment. FIG. 2 is a view schematically showing the piping system of the air conditioner according to this embodiment. FIG. 3 is a view schematically showing an example of installation of the units of the air conditioner according to this embodiment.

[0019] As shown in FIG. 1, FIG. 2, and FIG. 3, the air conditioner 1 includes an outdoor unit 2, heat exchange unit 3, valve unit 4, and indoor units 5. These units are individually cased separately from each other, and are connected to each other by predetermined piping members 6 to 9. Of these units, for example, the outdoor unit 2 is installed on the rooftop RF of the building B, heat exchange unit 3, valve unit 4, and indoor units 5 are respectively installed in the ceiling spaces CS and the like of the floors 1F and 2F of the building B. The ceiling space CS is a space or the like defined by the beam in the ceiling cavity of the building B and ceiling board in between them. It should be noted that FIG. 1, FIG. 2, and FIG. 3 schematically show the air conditioner 1, and the number of units, and number of piping members can appropriately be increased or decreased from the aspect shown.

[0020] These units 2, 3, 4, and 5 respectively includes controllers 20, 30, 40, and 50 each configured to control an operation of each constituent member to be described later. These controllers 20, 30, 40, and 50 constitute a control unit of the air conditioner 1, and each of the controllers 20 to 50 includes a CPU, memory, storage (nonvolatile memory), input/output circuit, timer, and the like and executes predetermined arithmetic processing. For example, each of the controllers 20, 30, 40, and 50 reads various data items by means of the input/output circuit, carries out arithmetic processing by means of the CPU by using a program read from the storage into the memory, and carries out operation control of the constituent members of each of the units. At this time, the controllers 20, 30, 40, and 50 carry out transmission/reception of a control signal to/from the unit constituent members and to/from the controllers by wire or by wireless.

[0021] In this embodiment, a control panel 100 is connected to the outdoor unit 2. The control panel 100 includes a plurality of switches, buttons, dials, and the like and is contrived in such a manner that it is possible for the manager to set and adjust the operation of the air conditioner by operating these switches, buttons, dials, and the like. In this embodiment, the operation mode of the air conditioner 1 is configured in such a manner that the operation mode can be changed by the manager by operating the control panel 100.

[0022] Further, the controller 30 of the heat exchange unit 3 stores therein setting of the target temperature of the heat medium for each of the operation modes at the time of the cooling operation and at the time of the heating operation, and acquires the temperature of the heat medium by means of a temperature sensor 3d to be described later. The controller 20 of the outdoor unit 2 controls the rotational speed of a compressor 2a on the basis of the temperature acquired by the temperature sensor 3d and set target temperature. Setting of the target temperature, and control concerned (changeover processing of the operation mode) will be described later with reference to FIG. 4 and FIG. 5, respectively. The air conditioner 1 has, as the operation modes thereof at the time of the cooling operation and at the time of the heating operation, two modes, i.e., a first mode (also called a normal operation mode) and second mode (hereinafter referred to also as an energy-saving operation mode) in which an operation is carried out with a higher degree of power saving than the first mode.

[0023] The outdoor unit 2 and heat exchange unit 3 constitute a heat source side refrigerating cycle in which the refrigerant is circulated through the air conditioner 1. Further, the heat exchange unit 3, valve unit 4, and indoor units 5 constitute a heat medium circulating cycle in the air conditioner 1.

[0024] The outdoor unit 2 and heat exchange unit 3 are connected to each other by piping (hereinafter referred to as refrigerant piping) 6. The refrigerant piping 6 includes a liquid pipe 6a, suction gas pipe 6b, and discharged gas pipe 6c.

[0025] The outdoor unit 2 includes, as major constituents, a compressor 2a, check valve 2b, oil separator 2c, four-way valve 2d, outdoor side heat exchanger 2e, expansion valve 2f, liquid tank 2g, outdoor unit fan 2h, accumulator 2i, on-off valves 2j and 2k, and outdoor air temperature sensor 21. The constituents other than the outdoor unit fan 2h and outdoor air sensor 21 are connected to each other by piping inside the housing 21, and are respectively arranged in the refrigerant flow path formed between the outdoor unit 2 and heat exchange unit 3 through which the refrigerant circulates. The outdoor unit fan 2h is arranged on the wall part of the housing 21 adjacent to the outdoor side heat exchanger 2e. The housing 21 defines the contour (outer hull) of the outdoor unit 2.

[0026] The heat exchange unit 3 is configured to individually accommodate in the housing 31 thereof, as major constituents, expansion valves 3a, 31a, 32a, and 33a, intermediate heat exchangers 3b, 31b, and 32b, on-off valve 3c, and temperature sensors 3d, 31d, and 32d. The housing 31 defines the contour (outer hull) of the heat exchange unit 3. The expansion valves 31a and 32a correspond to second expansion valves relative to the expansion valves 2f (first expansion valves) included in the outdoor unit 2, and expansion valve 33a corresponds to a third expansion valve relative to the expansion valve 2f. The intermediate heat exchanger 3b carries out heat exchange between the refrigerant and heat medium. In this embodiment, the heat exchange unit 3 includes a plurality of intermediate heat exchangers 3b, and at least one of the intermediate heat exchangers 3b cools the heat medium by the refrigerant, and intermediate heat exchanger other than the above intermediate heat exchanger heats the heat medium by the refrigerant. The refrigerant is, for example, R32 lower in GWP as compared with R410A and R407C. Although the heat medium is water as an

example, heat medium may also be antifreeze. The temperature sensor 3d is provided on the downstream side of the intermediate heat exchanger 3b, and detects the temperature of the heat medium flowing out of the intermediate heat exchanger 3b. The temperature detected in this manner is transmitted to the controller 20.

[0027] The heat exchange unit 3 includes the cooling intermediate heat exchanger 31b and heating intermediate heat exchanger 32b, whereby the air conditioner 1 is enabled to carry out one of the cooling operation and heating operation or is enabled to simultaneously carry out both the operations.

[0028] The heat source side refrigerating cycle constituted of the outdoor unit 2 and heat exchange unit 3 will be described below individually as to the operation aspect at the time of the cooling operation of the air conditioner 1, at the time of heating operation, and at the time of cooling/heating-mixed operation. At the time of each of the above operations to be described hereinafter, in the outdoor unit 2 and heat exchange unit 3, the controllers 20 and 30 appropriately carry out transmission/reception of a control signal to/from the controllers 40 and 50 of the valve unit 4 and indoor units 5 to thereby operate the constituent members of the units 2 and 3.

[0029] At the time of the cooling operation, each of the outdoor unit 2 and heat exchange unit 3 operates in the following manner. At this time, in the outdoor unit 2, the compressor 2a sucks the gaseous refrigerant from a suction port 21a, compresses the sucked gaseous refrigerant, and discharges the compressed gaseous refrigerant from a discharge outlet 22a. The compressor 2a is a device configured to compress the refrigerant to thereby bring the refrigerant into a high-temperature/high-pressure state, and is, for example, an inverter compressor or the like capable of carrying out capacity control. The discharged gaseous refrigerant (discharged gas) passes through the check valve 2b, is then separated from a lubricating oil component contained therein by the oil separator 2c and, then flows into the outdoor side heat exchanger 2e. At this time, part of the gaseous refrigerant is branched therefrom by the four-way valve 2d and flows into the outdoor side heat exchanger 2e. The gaseous refrigerant flowing into the heat exchanger 2e radiates heat to the outdoor air to thereby be condensed and liquefied. The outdoor side heat exchanger 2e carries out heat exchange between the refrigerant and outdoor air, and functions as a condenser at the time of the cooling operation. The liquefied refrigerant (condensate liquid) is decompressed by the expansion valve 2f to thereby be accumulated in the liquid tank 2g and is then supplied to the heat exchange unit 3 through the liquid pipe 6a. The outdoor unit fan 2h sucks the outdoor air into the inside of the housing 21 to thereby make the sucked air flow into the outdoor side heat exchanger 2e, and thereafter discharges the air to the outside of the housing 21.

[0030] In the heat exchange unit 3, the supplied liquid refrigerant (condensate liquid) is expanded by the cooling expansion valve 31a and then flows into the cooling intermediate heat exchanger 31b. The liquid refrigerant flowing into the heat exchanger 31b absorbs heat from the heat medium in the cooling intermediate heat exchanger 31b to thereby be evaporated and gasified. The gasified refrigerant (evaporation gas) is returned to the outdoor unit 2 through the pressure control expansion valve 33a and suction gas pipe 6b. The evaporation gas is defined as a refrigerant that has undergone the evaporation process after passing through the cooling intermediate heat exchanger 31b.

[0031] In the evaporation gas, for example, a refrigerant not completely evaporated and containing a liquid refrigerant at a dryness fraction of 1.0 or less is also included. The pressure control expansion valve 33a controls the evaporation temperature of the cooling intermediate heat exchanger 31b to thereby avoid freezing of the water serving as the heat medium.

[0032] The evaporation gas returned to the outdoor unit 2 is separated into the gaseous refrigerant and liquid refrigerant in the accumulator 2i. The separated gaseous refrigerant is sucked into the compressor 2a from the suction port 21a and is compressed again. On the other hand, the separated liquid refrigerant is accumulated in the accumulator 2i.

[0033] Conversely, at the time of the heating operation, each of the outdoor unit 2 and heat exchange unit 3 operates in the following manner. At this time, in the outdoor unit 2, the gaseous refrigerant discharged from the compressor 2a, as in the case of the time of the cooling operation, passes through the check valve 2b, and is then separated from a lubricating oil component contained therein by the oil separator 2c. At this time, the on-off valve 2j is opened, and gaseous refrigerant (discharged gas) is supplied to the heat exchange unit 3 through the discharged gas pipe 6c.

[0034] In the heat exchange unit 3, the on-off valve 3c is opened, and the supplied gaseous refrigerant radiates heat to the heat medium in the heating intermediate heat exchanger 32b to thereby be condensed and liquefied. The liquefied refrigerant (condensate liquid) is expanded in the heating expansion valve 32a and is then returned to the outdoor unit 2 through the liquid pipe 6a.

[0035] At that time, the on-off valve 2k is opened, and liquid refrigerant (condensate liquid) returned to the outdoor unit 2 is expanded by the expansion valve 2f after passing through the liquid tank 2g, and flows into the outdoor side heat exchanger 2e. The liquid refrigerant flowing into the heat exchanger 2e absorbs heat from the outside air in the outdoor side heat exchanger 2e to thereby be evaporated and gasified. At the time of the heating operation, the outdoor side heat exchanger 2e functions as an evaporator. At that time, the outdoor unit fan 2h sucks the outdoor air into the inside of the housing 21 to thereby make the sucked air flow into the outdoor side heat exchanger 2e, and thereafter discharges the air to the outside of the housing 21. The gasified refrigerant (evaporation gas) is sucked into the compressor 2a from the suction port 21a through the four-way valve 2d and accumulator 2i and is compressed again.

[0036] Further, at the time of the cooling/heating-mixed operation, each of the outdoor unit 2 and heat exchange unit

3 operates in the following manner. At this time, in the outdoor unit 2, the gaseous refrigerant (discharged gas) discharged from the compressor 2a is, as in the case of the time of the heating operation, supplied to the heat exchange unit 3 through the discharged gas pipe 6c. In the heat exchange unit 3, as in the case of the time of the heating operation, the supplied gaseous refrigerant radiates heat to the heat medium in the heating intermediate heat exchanger 32b to thereby be condensed and liquefied. The liquefied refrigerant (condensate liquid) is expanded in each of the heating expansion valve 32a and cooling expansion valve 31a and flows into the cooling intermediate heat exchanger 31b. The liquid refrigerant (condensate liquid) flowing into the heat exchanger 31b absorbs heat from the heat medium in the cooling intermediate heat exchanger 31b to thereby be evaporated and gasified.

[0037] At this time, when cooling has priority over heating, the flow path is switched in such a manner that the liquid refrigerant (condensate liquid) is supplied from the outdoor unit 2 to the heat exchange unit 3. On the other hand, when heating has priority over cooling, the flow path is switched in such a manner that the liquid refrigerant (condensate liquid) is supplied from the heat exchange unit 3 to the outdoor unit 2. For example, the on-off valves 2j, 2k, and 3c are opened or closed, and flow path is changed by the four-way valve 2d, whereby the supply direction of the liquid refrigerant passing through the liquid pipe 6a is switched. When the on-off valves 2j, 2k, and 3c are closed, the liquid refrigerant is supplied from the outdoor unit 2 to the heat exchange unit 3 through the four-way valve 2d. When the on-off valves 2j, 2k, and 3c are opened, the liquid refrigerant is supplied from the heat exchange unit 3 to the outdoor unit 2 through the four-way valve 2d.

[0038] The heat exchange unit 3, valve unit 4, and indoor units 5 constitute the heat medium circulating cycle in the air conditioner 1.

[0039] The valve unit 4 is interposed between the heat exchange unit 3 and each of the indoor units 5. The valve unit 4 is connected to the heat exchange unit 3 by each of the heat medium piping 7 and heat medium piping 8.

[0040] The heat medium piping 7 constitutes a flow path of the heat medium (hereinafter referred to as the cooled heat medium) cooled by the cooling intermediate heat exchanger 31b. The heat medium piping 7 includes a cooling heat medium supply pipe 7a and cooling heat medium reflux pipe 7b. The cooling heat medium supply pipe 7a is a flow path configured to supply the cooled heat medium from the heat exchange unit 3 to the valve unit 4. The cooling heat medium reflux pipe 7b is a flow path configured to reflux the cooled heat medium from the valve unit 4 to the heat exchange unit 3.

[0041] The heat medium piping 8 constitutes a flow path of the heat medium (hereinafter referred to as the heated heat medium) heated by the heating intermediate heat exchanger 32b. The heat medium piping 8 includes a heating heat medium supply pipe 8a and heating heat medium reflux pipe 8b. The heating heat medium supply pipe 8a is a flow path configured to supply the heated heat medium from the heat exchange unit 3 to the valve unit 4. The heating heat medium reflux pipe 8b is a flow path configured to reflux the heated heat medium from the valve unit 4 to the heat exchange unit 3.

[0042] Further, the valve unit 4 is connected to the indoor units by distribution pipes 9. The distribution pipes 9 include water advancing pipes 9a configured to supply the heat medium to the indoor unit 5 and water returning pipes 9b configured to return the heat medium to the valve unit 4. The water advancing pipe 9a constitutes a flow path configured to supply the cooled heat medium supplied from the cooling heat medium supply pipe 7a and heated heat medium supplied from the heating heat medium supply pipe 8a to the indoor unit 5. The water returning pipe 9b constitutes a flow path configured to return the cooled heat medium and heated heat medium to the valve unit 4.

[0043] Thereby, the cooled heat medium and heated heat medium respectively circulate between the heat exchange unit 3 and each indoor unit 5 through the valve unit 4. In the configuration example shown in FIG. 2, each of the cooling heat medium supply pipe 7a and heating heat medium supply pipe 8a is divided into four water advancing pipes 9a, and the cooled heat medium and heated heat medium are respectively distributed to the four indoor units 5. The distributed cooled heat medium and heated heat medium are respectively returned to the valve unit 4 from the four water returning pipes 9b, and circulate between the valve unit 4 and heat exchange unit 3 through the cooling heat medium reflux pipe 7b or heating heat medium reflux pipe 8b.

[0044] Accordingly, the heat medium piping 7 or 8 and distribution pipe 9 are different from each other in the piping diameter. In this embodiment, as an example, the piping diameter of the cooling heat medium supply pipe 7a and cooling heat medium reflux pipe 7b is greater than the piping diameter of the water advancing pipe 9a. Further, the piping diameter of the heating heat medium supply pipe 8a and heating heat medium reflux pipe 8b is greater than the piping diameter of the water returning pipe 9b. Thereby, it is possible to smoothly and stably circulate the heat medium between the heat medium piping 7 or 8 and distribution pipe 9.

[0045] Further, it is advisable to make the piping diameter of the heat medium piping 7 and 8 differ according to the total connecting capacity of the indoor units 5. The indoor units 5 differ in the design flow rate according to each individual capacity (capability), and hence each of the rated flow rates is obtained according to each individual capacity. Assuming that indoor units of the capacity ranging from 0.5 HP to 5 HP are lined up, the indoor units differ from each other in the rated flow rate, and it is conceivable as to the capacity of the circulating pump 5a that about three capacity ranks may be required for the lineup. Although in this embodiment, the case where the heat medium circulating cycle is a sealed

circuit is assumed, by taking an admixture of a foreign substance or entry of air due to water leakage into consideration, the piping flow velocity is made to have an appropriate value. Accordingly, the piping diameter of the heat medium piping 7, 8 is made to differ according to the total connecting capacity of the indoor units 5.

[0046] The valve unit 4 is configured to accommodate a flow path change-over valve 4a in the housing 41 thereof as a major constituent. The flow path change-over valve 4a is a valve configured to make one of the cooled heat medium and heated heat medium flow into the indoor side heat exchangers 5b of the indoor units 5, and includes water advancing valves 41a and water returning valves 42a. Each of the water advancing valve 41a and water returning valve 42a is a three-way valve to be opened/closed by the controller 40, and details thereof will be described later. The housing 41 defines the contour (outer hull) of the valve unit 4.

[0047] The indoor unit 5 includes, as major constituents, a circulating pump 5a, indoor side heat exchanger 5b, indoor unit fan 5c, and information acquisition device 5d. The circulating pump 5a and indoor side heat exchanger 5b are connected to each other by piping inside the housing 51, and are respectively arranged in the heat medium flow path of the heat medium circulating between the indoor unit 5 and heat exchange unit 3 through the valve unit 4. The indoor unit fan 5c and information acquisition device 5d are arranged on the wall part of the housing 51 in such a manner as to be adjacent to each other. The housing 51 defines the contour (outer hull) of the indoor unit 5. The circulating pump 5a circulates the heat medium through the heat medium flow path.

[0048] The information acquisition device 5d is an interface device configured to carry out an exchange of information between the indoor unit 5 and user, and is, for example, an operating panel, switch, button, display for displaying information, and the like. The information acquisition device 5d acquires information (data) such as a start of an operation of the indoor unit 5, mode selection between the cooling operation and heating operation, setting of the indoor temperature, and the like, and imparts the acquired information to the controller 50.

[0049] The heat medium circulating cycle constituted of the heat exchange unit 3, valve unit 4, and indoor unit 5 will be described below.

[0050] In the heat medium circulating cycle, the heat medium (cooled heat medium) cooled by radiating heat to the refrigerant in the cooling intermediate heat exchanger 31b of the heat exchange unit 3 is supplied to the valve unit 4 from the cooling heat medium supply pipe 7a. Further, the heat medium (heated heat medium) heated by absorbing heat from the refrigerant in the heating intermediate heat exchanger 32b is supplied to the valve unit 4 from the heating heat medium supply pipe 8a. The supplied cooled heat medium and heated heat medium are supplied to the indoor unit 5 from the water advancing pipe 9a through the water advancing valve 41a. The water advancing valve 41a supplies one of the cooled heat medium and heated heat medium to the indoor unit 5. More specifically, with respect to the indoor unit 5 carrying out the cooling operation, the water advancing valve 41a switches the flow path of the valve unit 4 in such a manner as to connect the flow path to the cooling heat medium supply pipe 7a and supplies the cooled heat medium to the indoor unit 5. On the other hand, with respect to the indoor unit 5 carrying out the heating operation, the water advancing valve 41a switches the flow path of the valve unit 4 in such a manner as to connect the flow path to the heating heat medium supply pipe 8a and supplies the heated heat medium to the indoor unit 5. The cooling operation and heating operation in the indoor unit 5 are switched between each other by the controller 50 according to, for example, selection or the like of the operation mode carried out by the user and acquired by the information acquisition device 5d.

[0051] Further, the heat medium returned from the indoor unit 5 is returned to the valve unit 4 from the water returning pipe 9b through the water returning valve 42a. The water returning valve 42a operates in concert with the water advancing valve 41a on the same flow path to return the heat medium supplied to the indoor unit 5 to the valve unit 4. More specifically, the water returning valve 42a switches the flow path of the valve unit 4 in such a manner as to guide the heat medium returned from the indoor unit 5 carrying out the cooling operation to the cooling heat medium reflux pipe 7b. The heat medium guided to the cooling heat medium reflux pipe 7b radiates heat to the refrigerant in the cooling intermediate heat exchanger 31b to thereby be cooled again. On the other hand, the water returning valve 42a switches the flow path of the valve unit 4 in such a manner as to guide the heat medium returned from the indoor unit 5 carrying out the heating operation to the heating heat medium reflux pipe 8b. The heat medium guided to the heating heat medium reflux pipe 8b absorbs heat from the refrigerant in the heating intermediate heat exchanger 32b to thereby be heated again.

[0052] In the indoor unit 5, the circulating pump 5a operates according to whether the indoor unit 5 is in operation or is at a stop, and sucks the cooled heat medium or heated heat medium and discharges the sucked heat medium into the indoor side heat exchanger 5b. The circulating pump 5a is a inverter pump capable of increasing/decreasing the rotational speed thereof and increases/decreases the rotational speed on the basis of, for example, the outlet temperature (outlet water temperature of indoor side heat exchanger 5b) of the heat medium. The indoor side heat exchanger 5b carries out a heat exchange between the room air and heat medium to thereby carry out temperature adjustment of the room air. The indoor unit fan 5c sucks the room air into the inside of the housing 51 to thereby make the sucked room air flow into the indoor side heat exchanger 5b, and thereafter blows the temperature-regulated air toward the air-conditioning object space from the housing 51. The indoor unit fan 5c starts to rotate approximately simultaneously with the operation start request for cooling or heating, and stops approximately simultaneously with the operation stop request. Regarding the order of stopping the circulating pump 5a and indoor unit fan 5c, either one of them may be earlier. As

an example, from the viewpoint of sensing of the indoor temperature, it is desirable that first the circulating pump 5a be stopped at the time of thermo-off and rotation of the indoor unit fan 5c be continued.

[0053] In this embodiment, the air conditioner 1, more specifically, the outdoor unit 2 is operated in one of the operation modes of the cooling operation, heating operation, cooling-prioritized cooling/heating-mixed operation, and heating-prioritized cooling/heating-mixed operation. These operation modes may be selected by the controller 20 on the basis of, for example, the outdoor air temperature detected by the outdoor air temperature sensor 21 or may be selected on the basis of an instruction from the control panel 100 of the outdoor unit 2.

[0054] The cooling operation mode is an operation mode in which the discharged gas from the compressor 2a is condensed by the outdoor side heat exchanger 2e, and the condensate liquid flows into the cooling intermediate heat exchanger 31b through the cooling expansion valve 31a.

[0055] The heating operation mode is an operation mode in which the discharged gas from the compressor 2a flows into the heating intermediate heat exchanger 32b.

[0056] The cooling-prioritized cooling/heating-mixed operation mode is, although the cooling operation and heating operation are executed therein in a coexisting manner, an operation mode in which the cooling operation is appropriately executed by priority. In the cooling-prioritized cooling/heating-mixed operation, part of the discharged gas from the compressor 2a flows into the heating intermediate heat exchanger 32b to be condensed therein, and the remainder of the discharged gas is condensed in the outdoor side heat exchanger 2e. The condensate liquids of both the heat exchangers 32b and 2e are mixed with each other, and the mixed condensate liquid flows into the cooling intermediate heat exchanger 31b through the cooling expansion valve 31a to be evaporated therein.

[0057] The heating-prioritized cooling/heating-mixed operation mode is, although the cooling operation and heating operation are executed therein in a coexistent manner, an operation mode in which the heating operation is appropriately executed by priority. In the heating-prioritized cooling/heating-mixed operation, the discharged gas from the compressor 2a flows into the heating intermediate heat exchanger 32b to be condensed therein. Part of the condensate liquid flows into the outdoor side heat exchanger 2e through the liquid pipe 6a to be evaporated therein. The remainder of the condensate liquid flows into the cooling intermediate heat exchanger 31b through the heating expansion valve 32a and cooling expansion valve 31a to be evaporated therein.

[0058] In FIG. 4A and FIG. 4B, the heat source side refrigerating cycle at the time of each of these cooling/heating-mixed operations is shown. FIG. 4A is a view schematically showing the piping system of the heat source side refrigerating cycle, and FIG. 4B is a Mollier diagram of the heat source side refrigerating cycle. In FIG. 4B, the part from P1 to P2 indicates the state change of the refrigerant in the compressor 2a, part from P2 to P3 indicates state change thereof in the outdoor side heat exchanger 2e (condenser), part from P3a to P4 indicates state change thereof in the cooling expansion valve 31a, part from P4 to P5 indicates state change thereof in the cooling intermediate heat exchanger 31b, and part from P5 to P1 indicates state change thereof in the pressure control expansion valve 33a. Further, in FIG. 4B, the part from P3b to P6 indicates the state change of the refrigerant in the heating expansion valve 32a and expansion valve 2f, and part from P6 to P7 (P1) indicates state change thereof in the outdoor side heat exchanger 2e (evaporator). The part from P1 to P7 indicated by outlined dots in FIG. 4B corresponds to the points of the piping system shown in FIG. 4A. The curved line L41 shown in FIG. 4B is a saturated liquid line and curved line L42 is a saturated vapor line.

[0059] The piping diameter of the piping 6 of the air conditioner 1 described above will be described below.

[0060] First, in general, the pressure loss dP of the refrigerant can be obtained from the following formula (1) and formula (2).

$$dP = \rho \times g \times dH \quad \dots (1)$$

$$dH = \left(\lambda \frac{l}{d} + \sum_n \zeta_n \right) \frac{v^2}{2g} \quad \dots (2)$$

[0061] Here, dP is pressure loss, dH is total loss head, g is gravitational acceleration, ρ is fluid density, λ is pipe friction coefficient, l is pipe length, d is pipe inner diameter, and v is average intra-pipe fluid velocity.

$$\sum_n \zeta_n$$

is a coefficient for losses other than friction.

[0062] As can be seen from formula (1) and formula (2), when the piping diameter d is fixed, regarding the influence on the pressure loss dP , the influences of the pipe friction coefficient λ , fluid density ρ , and average intra-pipe fluid velocity v become stronger.

[0063] Here, in this embodiment, an example of the refrigerant density and refrigerant flow velocity in each of the discharged gas pipe 6c, liquid pipe 6a, and suction gas pipe 6b of the case where the piping diameter d is fixed is as shown in Table T1 of FIG. 5. It should be noted that the pressure loss percentage is the percentage of "refrigerant density $\times$ (refrigerant flow velocity)²".

[0064] In FIG. 5, relationships between the refrigerant density (kg/m³), percentage (%), refrigerant flow velocity (m/s), (refrigerant flow velocity)², percentage (%), and pressure percentage and discharged gas pipe, liquid pipe, and suction gas pipe are shown. As shown in FIG. 5, the refrigerant density is "94.2" in the discharged gas pipe, "980.4" in liquid pipe, and "34.6" in suction gas pipe, and percentage is "100" in the discharged gas pipe, "1041" in liquid pipe, and "37" in suction gas pipe. Further, the refrigerant flow velocity is "23.3" in the discharged gas pipe, "2.2" in liquid pipe, and "63.4" in suction gas pipe, pressure loss is "542.4" in the discharged gas pipe, "5.0" in liquid pipe, and "4025.7" in suction gas pipe, and pressure loss percentage is "100" in the discharged gas pipe, "10" in liquid pipe, and "272" in suction gas pipe.

[0065] Regarding the pressure loss percentage, the value of the liquid pipe is the smallest and value of the suction gas pipe is the largest. That is, in order to equalize the pressure loss coefficients, it is necessary to make the piping diameters d of the suction gas pipe 6b, discharged gas pipe 6c, and liquid pipe 6a satisfy the condition "suction gas pipe 6b > discharged gas pipe 6c > liquid pipe 6a". By configuring the piping diameters d of the air conditioner 1 in this manner, it is possible to make the air conditioner 1 a system of a high degree of efficiency.

[0066] In FIG. 4A, when the number of heating loads (loads to be heated) is large, it is necessary for the outdoor side heat exchanger 2e to operate as an evaporator. Accordingly, for example, when the outdoor air temperature becomes 0°C in the winter season, the outdoor side heat exchanger 2e absorbs heat from the outdoor air, and hence the evaporation temperature of the outdoor side heat exchanger 2e becomes a temperature in the neighborhood of -10°C.

[0067] Here, when it is assumed that the air conditioner 1 includes no expansion valve (intermediate pressure control expansion valve) 33a in FIG. 4A, the evaporation temperature of the cooling intermediate heat exchanger 31b becomes a temperature approximately equal to the outdoor side heat exchanger 2e. Accordingly, when water is used as the heat medium, the cooling intermediate heat exchanger 31b is frozen, and there is a possibility of the heat exchanger 31b being burst (actually, the evaporation temperature of the cooling intermediate heat exchanger becomes slightly higher by an amount corresponding to the piping pressure loss).

[0068] Accordingly, in an air conditioner 1a according to a first modified example shown in FIG. 6A, a temperature sensor 34 is provided in addition to the expansion valve 33a. The temperature sensor 34 detects the temperature of the refrigerant flowing into the intermediate heat exchanger 31b. Opening/closing control of the expansion valve 33a is executed by the controller 30 on the basis of the temperature detected by the temperature sensor 34. Thereby, the evaporation temperature of the cooling intermediate heat exchanger 31b is controlled on the basis of the detection temperature of the temperature sensor 34.

[0069] In general, it is desirable that, as the intermediate heat exchanger, a plate heat exchanger configured by laminating plates be used, however, in the plate heat exchanger used as an evaporator, there is sometimes a case where a pressure loss is caused by a flow-dividing mechanism provided at the refrigerant inlet port. Conversely, the air conditioner 1a of the first modified example can control the evaporation temperature of the cooling intermediate heat exchanger 31b on the basis of the detection temperature of the temperature sensor 34, and hence can suppress the risk of the burst of the cooling intermediate heat exchanger 31b caused by freezing.

[0070] Further, although in the first modified example (FIG. 6A), the descriptions have been given of the case where opening/closing of the expansion valve 33a is controlled on the basis of the temperature detected by the temperature sensor 34 provided at the entrance of the cooling intermediate heat exchanger 31b, opening/closing control of the expansion valve 33a is not limited to this. For example, as in the case of an air conditioner 1b according to a second modified example shown in FIG. 6B, opening/closing of the expansion valve 33a may be controlled by the controller 30 by providing a pressure sensor 35 at the exit of the cooling intermediate heat exchanger 31b in place of the temperature sensor 34 on the basis of the pressure detected by the pressure sensor 35. More specifically, the controller 30 may convert the pressure value detected by the pressure sensor 35 into the saturation temperature, and may control the opening/closing of the expansion valve 33a on the basis of the converted saturation temperature. By also the configuration described above, it is possible to suppress the risk of the burst of the cooling intermediate heat exchanger 31b caused by freezing as in the case where the temperature sensor 34 is provided.

[0071] It should be noted that the fundamental configuration of each of the air conditioner 1a shown in FIG. 6A and air conditioner 1b shown in FIG. 6B is equal to the configuration of the air conditioner 1 according to the first embodiment described above. Accordingly, configurations identical to the air conditioner 1 are denoted by reference symbols identical to the air conditioner 1 on the drawings and descriptions of the configurations are omitted.

[0072] Next, an example of selection control (operation mode selection processing) of the operation mode based on the outdoor air temperature will be described according to the control flow of the controller 20. In FIG. 7, a control flow

of the controller 20 in the operation mode selection processing (S0) of the indoor unit 2 is shown.

[0073] As shown in FIG. 7, in the operation mode selection processing (S0), in the air conditioner 1, the controllers 20, 30, 40, and 50 of the units 2, 3, 4, and 5 are linked with each other, whereby the operations of the units 2, 3, 4, and 5 are started (S01). For example, the controllers 20, 30, 40, and 50 respectively start the operations of the outdoor unit 2, heat exchange unit 3, valve unit 4, and indoor unit 5. It should be noted that the fact that the air conditioner 1 is in operation is the prerequisite for the operation mode selection processing (S0). It is sufficient if the controller 20 executes the operation mode selection processing (S0) by utilizing the above state as a trigger. Accordingly, when the air conditioner 1 is not in operation, the operation mode selection processing (S0) is not executed.

[0074] In the state where the air conditioner 1 is actually operated, the controller 20 makes the outdoor air temperature sensor 21 detect the outdoor air temperature (TO) (S02). The outdoor air temperature (TO) is a temperature outside the air-conditioning object space and, as an example, is the ambient temperature of the outdoor unit 2. The outdoor air temperature sensor 21 transmits the detection data (detection value of TO) to the controller 20.

[0075] Upon receipt of the detection data, the controller 20 carries out determination as to the summer season condition and winter season condition. The summer season condition is the condition of determination whether or not the outdoor air temperature (TO) is higher than or equal to a predetermined specified temperature (TH). The winter season condition is the condition of determination whether or not the outdoor air temperature (TO) is lower than or equal to a predetermined specified temperature (TL). Each of the values TH and TL is a temperature (threshold temperature) specifying the range of the outdoor air temperature (TO), TH is a first specified temperature, and TL is a second specified temperature lower than TH. Although as an example, TH is about 28°C, and TL is about 18°C, TH and TL can be set arbitrarily and are not limited to these values. The values of the first specified temperature (TH) and second specified temperature (TL) are stored in, for example, a storage device of the controller 20, and are read into the memory as parameters at the time of determination of the summer season condition or winter season condition.

[0076] In this example, first the controller 20 determines the summer season condition ($TO \geq TH$) (S03). In determining the summer season condition, the controller 20 compares the value of the outdoor air temperature (TO) with the value of the first specified temperature (TH).

[0077] When the summer season condition is satisfied, the controller 20 executes the summer season operation mode selection processing (S1) (S04). The summer season operation mode selection processing (S1) is processing of selecting (switching) the operation mode of the outdoor unit 2 in the summer season according to the percentages of the cooling demand and heating demand on the indoor unit 5. Details will be described later.

[0078] Conversely, when the summer season condition is not satisfied in step S03, the controller 20 determines the winter season condition ($TO \leq TL$) (S05). In determining the winter season condition, the controller 20 compares the value of the outdoor air temperature (TO) with the value of the second specified temperature (TL).

[0079] When the winter season condition is satisfied, the controller 20 executes the winter season operation mode selection processing of the outdoor unit 2 (S2) (S06). The winter season operation mode selection processing (S2) is processing of selecting (switching) the operation mode of the outdoor unit 2 in the winter season according to the percentages of the cooling demand and heating demand on the indoor unit 5. Details will be described later.

[0080] Conversely, when the winter season condition is not satisfied in S05, the controller 20 executes the intermediate stage operation mode selection processing (S3) (S07). The intermediate stage operation mode selection processing (S3) is processing of selecting (switching) the operation mode of the outdoor unit 2 in the period other than the summer season and winter season ($TL < TO < TH$) according to the percentages of the cooling demand and heating demand on the indoor unit 5. Details will be described later.

[0081] The controller 20 executes as described above one of the summer season operation mode selection processing (S1), winter season operation mode selection processing (S2), and intermediate stage operation mode selection processing (S3) according to the outdoor air temperature. Further, on completion of the selection processing (S1, S2, S3), the operation mode selection processing (S0) is terminated. Next, the selection processing (S1, S2, S3) will be described.

[0082] In FIG. 8, the control flow of the controller 20 in the summer season operation mode selection processing (S1) is shown. As shown in FIG. 8, the controller 20 calculates the percentage of each of the cooling demand and heating demand (hereinafter referred to as the cooling/heating demand percentage) on the indoor unit 5 (S101). In calculating the percentages, the controller 20 acquires information (data) about the demand (cooling demand or heating demand) for the operation mode in each indoor unit 5 from the controller 50 of each indoor unit 5. The cooling demand and heating demand are set according to the operation mode selected by the user from, for example, the operating panel of the information acquisition device 5d, and signals of the demands are transmitted to the controller 50.

[0083] Upon calculation of the cooling/heating demand percentages, the controller 20 compares the cooling/heating demand percentages with a predetermined threshold, selects the operation mode of the outdoor unit 2 in the following manner according to the comparison result to thereby appropriately switch the operation mode. As the predetermined threshold, in addition to 0 (%) and 100 (%), in this embodiment, two thresholds (A1, A2) are used. The threshold A1 is a first threshold of the percentages of the cooling demand and heating demand on the indoor unit 5. For example, the first threshold is a majority, e.g., about 51%. The threshold A2 is a second threshold of the percentage of the heating

demand on the indoor unit 5. In other words, the value "100-A2" is also the second threshold of the percentage of the cooling demand on the indoor unit 5. The threshold A2 is an arbitrary value greater than A1 and less than 100% and is, for example, a value within the range of 90% to 70%, as an example, about 75%.

[0084] The controller 20 determines whether or not the percentage of the heating demand is zero, i.e., whether or not the percentage of the cooling demand is 100% (S102).

[0085] When the percentage of the heating demand is zero, the controller 20 makes the outdoor unit 2 carry out the cooling operation (S103).

[0086] Conversely, when the percentage of the heating demand is not zero, the controller 20 determines whether or not the percentage of the heating demand is less than the first threshold (S104).

[0087] When the percentage of the heating demand is less than the first threshold, the controller 20 makes the outdoor unit 2 carry out the cooling-prioritized cooling/heating-mixed operation (S105).

[0088] Conversely, when the percentage of the heating demand is greater than or equal to the first threshold, the controller 20 determines whether or not the percentage of the heating demand is less than the second threshold (S106).

[0089] When the percentage of the heating demand is less than the second threshold, the controller 20 suspends the heating demand made on the indoor unit 5 during such a period (S107).

[0090] Then, the controller 20 makes the outdoor unit 2 carry out the cooling-prioritized cooling/heating-mixed operation (S105). Accordingly, when the outdoor unit 2 is carrying out the cooling-prioritized cooling/heating-mixed operation, this mixed operation is continued. That is, in this case, the operation mode of the outdoor unit 2 is left maintained as it is as the cooling-prioritized cooling/heating-mixed operation without being switched.

[0091] Conversely, when the percentage of the heating demand is greater than or equal to the second threshold, the controller 20 determines whether or not the percentage of the heating demand is less than 100% (S108).

[0092] When the percentage of the heating demand is less than 100%, the controller 20 makes the outdoor unit 2 carry out the heating-prioritized cooling/heating-mixed operation (S109). Accordingly, when the outdoor unit 2 is carrying out the cooling-prioritized cooling/heating-mixed operation, the controller 20 releases the suspension of the heating demand (S107) and switches the operation mode from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation.

[0093] Conversely, when the percentage of the heating demand is 100%, the controller 20 makes the outdoor unit 2 carry out the heating operation (S110).

[0094] While the air conditioner 1 is operated, the controller 20 repetitively carries out the summer season operation mode selection processing on the outdoor unit 2 which is in such a state (S11). Thereby, in the outdoor unit 2, the operation mode is selected according to the cooling/heating demand percentages, and is appropriately switched.

[0095] Further, when the operation of the air conditioner 1 is stopped, the controller 20 terminates the summer season operation mode selection processing.

[0096] In FIG. 9, the control flow of the controller 20 in the winter season operation mode selection processing (S2) is shown. As shown in FIG. 9, the controller 20 calculates the cooling/heating demand percentages (S201). Calculation of the cooling/heating demand percentages is identical to step S101 in the summer season operation mode selection processing (S1).

[0097] Upon calculation of the cooling/heating demand percentages, the controller 20 compares the cooling/heating demand percentages with a predetermined threshold, selects the operation mode of the outdoor unit 2 in the following manner according to the comparison result to thereby appropriately switch the operation mode. As the predetermined threshold, in addition to 0 (%) and 100 (%), in this embodiment, two thresholds (A1, A3) are used. The threshold A1 is a first threshold of the percentages of the cooling demand and heating demand on the indoor unit 5, and is common to (as an example, about 51%) the summer season operation mode selection processing (S1). The threshold A3 is a third threshold of the percentage of the heating demand on the indoor unit 5. In other words, the value "100-A3" is also the third threshold of the percentage of the cooling demand on the indoor unit 5. The threshold A3 is an arbitrary value less than A1 and greater than 0% and is, for example, a value within the range of 10% to 30%, as an example, about 25%.

[0098] The controller 20 determines whether or not the percentage of the cooling demand is zero, i.e., whether or not the percentage of the heating demand is 100% (S202).

[0099] When the percentage of the cooling demand is zero, the controller 20 makes the outdoor unit 2 carry out the heating operation (S203).

[0100] Conversely, when the percentage of the cooling demand is not zero, the controller 20 determines whether or not the percentage of the cooling demand is less than the first threshold (S204).

[0101] When the percentage of the cooling demand is less than the first threshold, the controller 20 makes the outdoor unit 2 carry out the heating-prioritized cooling/heating-mixed operation (S205).

[0102] Conversely, when the percentage of the cooling demand is greater than or equal to the first threshold, the controller 20 determines whether or not the percentage of the cooling demand is less than the third threshold (S206).

[0103] When the percentage of the cooling demand is less than the third threshold, the controller 20 suspends the cooling demand on the indoor unit 5 during such a period (S207).

[0104] Then, the controller 20 makes the outdoor unit 2 carry out the heating-prioritized cooling/heating-mixed operation (S205). Accordingly, when the outdoor unit 2 is carrying out the heating-prioritized cooling/heating-mixed operation, this mixed operation is continued. That is, in this case, the operation mode of the outdoor unit 2 is left maintained as it is as the heating-prioritized cooling/heating-mixed operation without being switched.

[0105] Conversely, when the percentage of the cooling demand is greater than or equal to the third threshold, the controller 20 determines whether or not the percentage of the cooling demand is less than 100% (S208).

[0106] When the percentage of the cooling demand is less than 100%, the controller 20 makes the outdoor unit 2 carry out the cooling-prioritized cooling/heating-mixed operation (S209). Accordingly, when the outdoor unit 2 is carrying out the heating-prioritized cooling/heating-mixed operation, the controller 20 releases the suspension of the cooling demand (S207) and switches the operation mode from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation.

[0107] Conversely, when the percentage of the cooling demand is 100%, the controller 20 makes the outdoor unit 2 carry out the cooling operation (S210).

[0108] While the air conditioner 1 is operated, the controller 20 repetitively carries out the winter season operation mode selection processing on the outdoor unit 2 which is in such a state (S211). Thereby, in the outdoor unit 2, the operation mode is selected according to the cooling/heating demand percentages, and is appropriately switched.

[0109] Further, when the operation of the air conditioner 1 is stopped, the controller 20 terminates the winter season operation mode selection processing.

[0110] In FIG. 10, the control flow of the controller 20 in the intermediate stage operation mode selection processing (S3) is shown. As shown in FIG. 10, the controller 20 calculates the cooling/heating demand percentages (S301). Calculation of the cooling/heating demand percentages is identical to step S101 in the summer season operation mode selection processing (S1) and winter season operation mode selection processing (S2).

[0111] Upon calculation of the cooling/heating demand percentages, the controller 20 compares the cooling/heating demand percentages with a predetermined threshold, selects the operation mode of the outdoor unit 2 in the following manner according to the comparison result to thereby appropriately switch the operation mode. As the predetermined threshold, in addition to 0 (%) and 100 (%), in this embodiment, the first threshold (A1) is used. The threshold A1 is the first threshold of the percentages of the cooling demand and heating demand on the indoor unit 5, and is common to (as an example, about 51%) the summer season operation mode selection processing (S1) and winter season operation mode selection processing (S2).

[0112] The controller 20 determines whether or not the percentage of the heating demand is zero, i.e., whether or not the percentage of the cooling demand is 100% (S302).

[0113] When the percentage of the heating demand is zero, the controller 20 makes the outdoor unit 2 carry out the cooling operation (S303).

[0114] Conversely, when the percentage of the heating demand is not zero, the controller 20 determines whether or not the percentage of the heating demand is less than the first threshold (S304).

[0115] When the percentage of the heating demand is less than the first threshold, the controller 20 makes the outdoor unit 2 carry out the cooling-prioritized cooling/heating-mixed operation (S305).

[0116] Conversely, when the percentage of the heating demand is greater than or equal to the first threshold, the controller 20 determines whether or not the percentage of the heating demand is less than 100% (S306).

[0117] When the percentage of the heating demand is less than 100%, the controller 20 makes the outdoor unit 2 carry out the heating-prioritized cooling/heating-mixed operation (S307). Accordingly, when the outdoor unit 2 is carrying out the cooling-prioritized cooling/heating-mixed operation, the controller 20 switches the operation mode from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation. That is, in the intermediate stage operation mode selection processing (S3), the operation mode is switched from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation without suspension of the heating demand on the indoor unit 5 unlike in the case of the summer season operation mode selection processing (S1).

[0118] Conversely, when the percentage of the heating demand is 100%, the controller 20 makes the outdoor unit 2 carry out the heating operation (S308).

[0119] While the air conditioner 1 is operated, the controller 20 repetitively carries out the intermediate stage operation mode selection processing on the outdoor unit 2 which is in such a state (S309). Thereby, in the outdoor unit 2, the operation mode is selected according to the cooling/heating demand percentages, and is appropriately switched.

[0120] Further, when the operation of the air conditioner 1 is stopped, the controller 20 terminates the intermediate stage operation mode selection processing.

[0121] It should be noted that conversely, in the intermediate stage operation mode selection processing (S3), the controller 20 switches the operation mode of the outdoor unit 2 to the heating operation when the percentage of the cooling demand is zero, to heating-prioritized cooling/heating-mixed operation when the percentage is greater than or equal to zero and less than the first threshold, to cooling-prioritized cooling/heating-mixed operation when the percentage

is greater than or equal to the first threshold and less than 100%, and to cooling operation when the percentage is 100%. As described above, when the percentage of the cooling demand is greater than or equal to the first threshold and less than 100%, the controller 20 switches the operation mode of the outdoor unit 2 from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation. That is, in the intermediate stage operation mode selection processing (S3), the operation mode of the outdoor unit 2 is switched from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation without suspension of the cooling demand on the indoor unit 5 unlike in the case of the winter season operation mode selection processing (S2).

[0122] FIG. 11 is a view showing examples of a temporal change in each of the percentages of the cooling demand and heating demand on the indoor unit 5. In the examples, the total of the percentages of each of the cooling demand and heating demand on the four indoor units 5 is shown. The cooling demand and heating demand are set according to the operation mode or the like of the indoor unit selected by the user from, for example, the operating panel of the information acquisition device 5d.

[0123] In FIG. 12, examples of a change in the operation mode of the outdoor unit 2 corresponding to the outdoor air temperature in the case where the percentages of the cooling demand and heating demand on the indoor unit 5 change as shown in FIG. 11 are shown for each of the seasons. FIG. 10(a), FIG. 10(b), and FIG. 10(c) are views showing examples of a change in the operation mode respectively in the intermediate stage ($TL < TO < TH$), summer season ($TO \geq TH$), and winter season ($TO \leq TL$).

[0124] As shown in FIG. 11, at, for example, time t_0 , the operation start control is carried out in the state where the cooling demand is made on all the indoor units 5 and, thereafter this state is maintained until time t_1 . At time t_1 , the heating demand is made on a part of the indoor units 5, and control of switching the operation mode from the cooling operation to the heating operation is carried out in such indoor units 5. Then, until time t_5 , the operation of the indoor units 5 is carried out in the state of the operation mode in which the cooling operations of a part of the indoor units 5 and heating operations of the remaining indoor units 5 are carried out in a coexisting manner. During the abovementioned period, with the elapse of the time through time t_2 , t_3 , and t_4 , the percentage (percentage by which the operation mode is the heating mode) of the heating demand on the indoor units 5 gradually increases. Then, at time t_5 and thereafter, the state where the heating demand is made on all the indoor units 5 (operation modes of all the indoor units 5 are heating modes) is brought about. The portion L11 shown in FIG. 11 is the locus indicating changes in the percentage of the heating demand made on the indoor units 5, and is the borderline between the percentages of the cooling demand and heating demand. It should be noted that the time series is not limited to the order of "time t_0 , t_1 , t_2 , t_3 , t_4 , t_5 , and t_6 (ascending order)". The time series may be a time series of the descending order from time t_6 to time t_0 opposite to the above order or may be a time series in which the time points are lined in a random order.

[0125] In FIG. 11, each of A1, A2, and A3 is a threshold of the percentages of the cooling/heating demands on the indoor units, and A1, A2, and A3 respectively correspond to the aforementioned first threshold, second threshold, and third threshold.

[0126] In FIG. 12A, the control aspect of the operation mode of the outdoor unit 2 in the intermediate stage ($TL < TO < TH$) is shown. In the intermediate stage, for example, from time t_0 to time t_1 , there is a state where the operation mode in all the indoor units 5 is the cooling mode, i.e., where the percentage of the cooling demand on the indoor units 5 is 100%. Accordingly, the outdoor unit 2 is made to carry out the cooling operation.

[0127] At time t_1 , the heating demand is made on a part of the indoor units 5, the percentage of the heating demand on the indoor units 5 rises from 0% and the percentage of the cooling demand lowers from 100%. At this time, in the outdoor unit 2, the operation mode is switched from the cooling operation to the cooling-prioritized cooling/heating-mixed operation.

[0128] At time t_2 , although the percentage of the heating demand on the indoor units 5 becomes A3%, and percentage of the cooling demand becomes "(100-A3)%", the percentage of the cooling demand still exceeds "(100-A1)%". Accordingly, the outdoor unit 2 continues the cooling-prioritized cooling/heating-mixed operation.

[0129] At time t_3 , the percentage of the heating demand on the indoor units 5 becomes A1% and percent of the cooling demand becomes "(100-A1)%", and thus both the percentages become approximately equal to each other (as an example, the percentage of the heating demand is the majority). At this time, in the outdoor unit 2, the operation mode is switched from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation.

[0130] At time t_4 , although the percentage of the heating demand on the indoor units 5 increases to A2% and percentage of the cooling demand lowers to "(100-A2)%", the percentage of the heating demand does not yet reach 100%. Accordingly, the outdoor unit 2 continues the heating-prioritized cooling/heating-mixed operation.

[0131] At time t_5 , the state where the operation mode of all the indoor units 5 is the heating mode is brought about, i.e., the percentage of the heating demand on all the indoor units 5 becomes 100%. Accordingly, in the outdoor unit 2, the operation mode is switched from the heating-prioritized cooling/heating-mixed operation to the heating operation. Further, at t_5 and thereafter, even when it becomes time t_6 , the outdoor unit 2 continues the heating operation.

[0132] It should be noted that when the control aspect of the operation mode of the outdoor unit 2 at the intermediate

stage shown in FIG. 12A is perceived as a time series of the descending order from time t_6 to time t_0 , in the outdoor unit 2, the operation mode is switched in the following manner opposite to the abovementioned control aspect. That is, at time t_5 , the operation mode is switched from the heating operation to the heating-prioritized cooling/heating-mixed operation. Subsequently, at time t_3 , the operation mode is switched from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation. Then, at time t_1 , the operation mode is switched from the cooling-prioritized cooling/heating-mixed operation to the cooling operation.

[0133] By switching the operation mode of the outdoor unit 2 on the basis of the percentage of the demand for the operation mode on indoor units 5 in the manner described above, it is possible to make the outdoor unit 2 carry out the operation in the appropriate operation mode. However, in, for example, the summer season in which great cooling demand is expected to be made on the indoor units 5 or winter season or the like in which great heating demand is expected to be made, there is a possibility of the capability in the outdoor unit 2 being lowered or hunting of the cycle state concomitant with switching of the operation mode being caused.

[0134] Therefore, in this embodiment, the operation mode of the outdoor unit 2 is switched in the following manner on the basis of the outdoor air temperature in addition to the percentage of the demand for the operation mode to be made on the indoor units 5.

[0135] For example, in the summer season, the outdoor unit 2 is operated in a control aspect of the operation mode shown in FIG. 12B. As an example, it is assumed that the summer season is the season of the case where the outdoor air temperature (TO) is higher than or equal to the predetermined specified temperature (TH) ($TO \geq TH$).

[0136] As shown in FIG. 12B, for example, from time t_0 to time t_3 , the outdoor unit 2 is operated in the control aspect of the operation mode identical to the intermediate stage shown in FIG. 12A. That is, during the period from time t_0 to time t_1 when the percentage of the cooling demand is 100%, the outdoor unit 2 is made to carry out the cooling operation. During the period from time t_1 to time t_3 when the percentage of the cooling demand lowers from 100%, the outdoor unit 2 is made to carry out the cooling-prioritized cooling/heating-mixed operation.

[0137] Even when the percentage of the cooling demand further lowers to " $(100-A1)\%$ " at time t_3 to thereby become approximately equal to (as an example, the percentage of the heating demand is the majority) the percentage ($A1\%$) of the heating demand, the indoor unit 2 continues the cooling-prioritized cooling/heating-mixed operation. At this time, switching of the operation mode from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation is not carried out unlike in the case of the intermediate stage (FIG. 12A).

[0138] When the percentage of the cooling demand lowers to " $(100-A2)\%$ " at time t_4 and percentage of the heating demand rises to $A2\%$, in the outdoor unit 2, the operation mode is switched from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation. That is, after the operation mode is switched from the cooling operation at time t_1 , during the period from time t_1 to time t_4 , in the outdoor unit 2, the cooling-prioritized cooling/heating-mixed operation is continued. During this period, the heating demand is suspended and cooling-prioritized cooling/heating-mixed operation is maintained.

[0139] In this embodiment, as a threshold of the percentage of the heating demand of the case where the heating demand is suspended and cooling-prioritized cooling/heating-mixed operation is maintained as described above, $A2$ is set as the second threshold and, as a threshold of the percentage of the cooling demand of the above case, " $(100-A2)\%$ " is set as the second threshold.

[0140] Thereafter, at time t_5 , when the percentage of the cooling demand becomes 0% and percentage of the heating demand becomes 100%, in the outdoor unit 2, the operation mode is switched from the heating-prioritized cooling/heating-mixed operation to the heating operation. Then, at time t_5 and thereafter, even when it becomes time t_6 , the outdoor unit 2 continues the heating operation. The control aspect of the operation mode of the outdoor unit 2 during the above period is identical to the intermediate stage shown in FIG. 12A.

[0141] For example, in the winter season, the outdoor unit 2 is operated in the control aspect of the operation mode shown in FIG. 12C. As an example, it is assumed that the winter season is the season of the case where the outdoor air temperature (TO) is lower than or equal to the second specified temperature (TL) ($TO \leq TL$). In FIG. 12C, a time series of the descending order is set from time t_6 to time t_0 .

[0142] As shown in FIG. 12C, for example, from time t_6 to time t_3 , the outdoor unit 2 is operated in the control aspect of the operation mode identical to the intermediate stage shown in FIG. 12A. That is, during the period from time t_6 to time t_5 when the percentage of the heating demand is 100%, the indoor unit 2 is made to carry out the heating operation. During the period from time t_5 to time t_3 when the percentage of the heating demand lowers from 100%, the outdoor unit 2 is made to carry out the heating-prioritized cooling/heating-mixed operation.

[0143] Even when the percentage of the heating demand further lowers to " $(100-A1)\%$ " at time t_3 to thereby become approximately equal to (as an example, the percentage of the cooling demand is the majority) the percentage ($A1\%$) of the cooling demand, the indoor unit 2 continues the heating-prioritized cooling/heating-mixed operation. At this time, switching of the operation mode from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation is not carried out.

[0144] When the percentage of the heating demand lowers to $A3\%$ at time t_2 and percentage of the cooling demand

5 rises to "(100-A3)%", in the outdoor unit 2, the operation mode is switched from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation. That is, after the operation mode is switched from the heating operation at time t5, during the period from time t5 to time t2, in the outdoor unit 2, the heating-prioritized cooling/heating-mixed operation is continued. During this period, the cooling demand is suspended and heating-prioritized cooling/heating-mixed operation is maintained.

[0145] In this embodiment, as a threshold of the percentage of the cooling demand of the case where the cooling demand is suspended and heating-prioritized cooling/heating-mixed operation is maintained as described above, "100-A3" is set as the third threshold and, as a threshold of the percentage of the heating demand of the above case, A3 is set as the third threshold.

10 [0146] Thereafter, at time t1, when the percentage of the heating demand becomes 0% and percentage of the cooling demand becomes 100%, in the outdoor unit 2, the operation mode is switched from the cooling-prioritized cooling/heating-mixed operation to the cooling operation. Then, at time t1 and thereafter, even when it becomes time t0, the outdoor unit 2 continues the cooling operation. The control aspect of the operation mode of the outdoor unit 2 during the above period is identical to the intermediate stage shown in FIG. 12A.

15 [0147] The operation mode of the outdoor unit 2 is switched on the basis of the outdoor air temperature in addition to the percentage of the demand for the operation mode made on the indoor units 5, whereby it is possible to shift (delay) the timing for switching the operation mode from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation. Thereby, for example, in the summer season ($TO \geq TH$), even when the heating demand is made, it is possible to suspend the heating demand, and maintain the cooling-prioritized cooling/heating-mixed operation for which much demand is expected without switching the operation mode of the outdoor unit 2. On the other hand, in the winter season ($TO \leq TL$), even when the cooling demand is made, it is possible to suspend the cooling demand, and maintain the heating-prioritized cooling/heating-mixed operation for which much demand is expected without switching the operation mode of the outdoor unit 2.

25 [0148] Accordingly, it is possible to suppress frequent occurrence of the operation mode switching of the outdoor unit 2. As a result, it becomes possible to prevent lowering of the capability in the operation mode for which much demand is expected and hunting of the cycle state from occurring. Further, even in an operation mode of the indoor unit 5 for which small demand is expected, e.g., the heating mode in the summer season and cooling mode in the winter season, when the demand exceeds a certain fixed demand percentage (second threshold or third threshold), the operation mode of the outdoor unit 2 is switched. Accordingly, suspension of the demand for the operation mode for which small demand is expected is released, and the operation mode of the outdoor unit 2 is switched according to the operation mode of the indoor unit 5 actually demanded by the user. Accordingly, it becomes possible to appropriately switch the operation mode of the outdoor unit 2 to the heating-prioritized cooling/heating-mixed operation even in the summer season, and to the cooling-prioritized cooling/heating-mixed operation even in the winter season. That is, it is possible to appropriately supply the capability of the operation mode actually demanded by the user, and efficiently reduce the switching loss of the operation mode of the outdoor unit 2 concomitant with the variation in the demand percentage.

35 [0149] It should be noted that although in the embodiment described above, as the thresholds for specifying the range of the outdoor air temperature, the second threshold and third threshold are set in addition to the first threshold, thresholds to be added to the first threshold may further be increased. Thereby, it becomes possible to switch the operation mode of the outdoor unit 2 in more stages, and supply the capability of the operation mode actually demanded by the user more finely.

(Second Embodiment)

45 [0150] Next, a second embodiment will be described below. The configuration itself of an air conditioner according to the second embodiment is identical to the configuration of the air conditioner according to the first embodiment shown in FIG. 1 and FIG. 2.

[0151] Hereinafter, switching control of the operation mode (first mode, second mode) at the time of each of the cooling operation and heating operation in the air conditioner 1 according to this embodiment will be described.

50 [0152] In FIG. 13, relationships between the operation mode (first mode, second mode) and target temperature of the heat medium at the time of each of the cooling operation and heating operation are shown. The relationships are stored in the memory of the controller 30 as setting values. At the time of the cooling operation of the air conditioner 1, when the target temperature of the first mode (normal operation mode) is a target temperature TA1, the target temperature of the second mode (energy-saving operation mode) is a target temperature TA2 ($>TA1$). That is, the target temperature of the second mode at the time of the cooling operation is set higher than the target temperature of the first mode.

55 [0153] Further, at the time of the heating operation of the air conditioner 1, when the target temperature of the first mode (normal operation mode) is a target temperature TB1, the target temperature of the second mode (energy-saving operation mode) is a target temperature TB2 ($<TB1$). That is, the target temperature of the second mode at the time of the heating operation is set lower than the target temperature of the first mode. Here, the target temperatures TA1, TA2,

TB1, and TB2 of the heat medium are made settable from, for example, the control panel 100.

[0154] Next, the switching processing of the operation mode to be executed by the control unit will be described. In FIG. 14, a flowchart which is an example of the switching processing of the operation mode is shown. In this embodiment, a description will be given of a case where the main control is executed by the controller 30 of the heat exchange unit 3, and rotation control of the compressor 2a is executed by the controller 20.

[0155] The controller 30 determines whether the operation of the air conditioner 1 is the cooling operation or heating operation on the basis of, for example, an instruction of the control panel 100 (ST101). Upon determination that the operation is the cooling operation, the controller 30 then makes a determination as to the mode (ST102). In this embodiment, regarding determination of the mode, the determination is carried out on the basis of the instruction from the control panel 100 as described above. Upon determination that the mode is the first mode (normal operation mode), the controller 30 sets TA1 as the target temperature of the heat medium (ST103). That is, the current operational state is continued. Further, upon determination that the mode is the second mode (energy-saving operation mode), the controller 30 sets TA2 (>TA1) as the target temperature of the heat medium (ST104). Thereby, the target temperature of the heat medium at the time of the cooling operation is changed.

[0156] On the other hand, upon determination that the operation is the heating operation in step ST101, the controller 30 makes a determination as to the mode (ST105). The determination of the mode is carried out on the basis of the instruction from the control panel 100, this being identical to the case of the cooling operation. Upon determination that the mode is the first mode (normal operation mode), the controller 30 sets TB1 as the target temperature of the heat medium (ST106). That is, the current operational state is continued. Upon determination that the mode is the second mode (energy-saving operation mode), the controller 30 sets TB2 (<TB1) as the target temperature of the heat medium (ST107). Thereby, the target temperature of the heat medium at the time of the heating operation is changed. After each target temperature of the heat medium is set in this way, the controller 20 carries out the operation of the air conditioner 1 at each set target temperature (ST108). That is, the controller 20 controls the rotational speed of the compressor 2a in such a manner that the temperature currently acquired from the heat medium becomes the target temperature set to the heat medium.

[0157] Next, the function and advantageous effects of the air conditioner 1 will be described.

[0158] When each of the indoor units 5 carries out the cooling operation, the rotational speed of the compressor 2a of the outdoor unit 2 is controlled according to the target temperature of the heat medium set to the cooling intermediate heat exchanger 31b. Accordingly, the lower the target temperature of the heat medium, the higher the rotational speed of the compressor 2a becomes. For example, in the first mode (normal operation mode), the outlet setting temperature of the cooling intermediate heat exchanger 31b, i.e., the target temperature of the heat medium is set at 7°C and, in the energy-saving operation mode, the outlet setting temperature of the cooling intermediate heat exchanger 31b, i.e., the target temperature of heat medium is set at 12°C. The target temperature of the heat medium is set higher in the second mode as compared with the first mode as described above, whereby it is possible to suppress the rotational speed of the compressor 2a of the outdoor unit 2 at the time of setting of the second mode, and realize energy saving.

[0159] Further, for example, when each of the indoor units 5 carries out the heating operation, the rotational speed of the compressor 2a of the outdoor unit 2 is controlled according to the target temperature of the heat medium set to the heating intermediate heat exchanger 32b. Accordingly, the higher the target temperature of the heat medium, the higher the rotational speed of the compressor 2a becomes. For example, in the first mode (normal operation mode), the outlet setting temperature of the heating intermediate heat exchanger 32b, i.e., the target temperature of the heat medium is set at 45°C and, in the second mode (energy-saving operation mode), the outlet setting temperature of the heating intermediate heat exchanger 32b, i.e., the target temperature of heat medium is set at 40°C. The target temperature of the heat medium is set lower in the second mode as compared with the first mode, whereby it is possible to suppress the rotational speed of the compressor 2a of the outdoor unit 2 at the time of setting of the second mode, and realize energy saving.

[0160] Further, in this embodiment, it is possible, from the control panel, to change the operation mode, i.e., to change the operation mode from the first mode (normal operation mode) to the second mode (energy-saving operation mode). Accordingly, for example, at the time of power peak, the manager of the air conditioner 1 operates the control panel 100 to change the operation mode of the air conditioner 1 from the first mode to the second mode, whereby it is possible to suppress the power consumption amount at the peak time. That is, the air conditioner 1 can realize energy saving.

[0161] It should be noted that although in this embodiment, the description has been given of the case where the operation mode of the air conditioner 1 is changed by the manager by operating the control panel 100, the method of changing the operation mode is not limited to this. For example, the configuration may be contrived in such a manner that the controller 30 changes the operation mode of the air conditioner 1 from the first mode to the second mode according to the operating states of the indoor units 5. More specifically, the controller 40 of the valve unit 4 carries out communication with the controller 50 of each of the indoor units 5 connected to the valve unit 4 and acquires the operating state of each of the indoor units 5. Furthermore, the controller 30 carries out communication with the controller 40 of the valve unit 4, acquires the operating state of each of the indoor units 5 and, upon acquisition of information indicating

that each of all the indoor units 5 operates at the minimum capacity, the controller 30 changes the operation mode of the air conditioner 1 from the first mode (normal operation mode) to the second mode (energy-saving operation mode). In this manner too, it is possible to suppress the rotational speed of the compressor 2a of the outdoor unit 2, and realize energy saving of the air conditioner 1. Further, it is possible for the air conditioner 1 to automatically realize energy saving without receiving an instruction from the control panel 100.

[0162] It should be noted that although in this embodiment, the description has been given of the case where a pump 5a is provided in each of the indoor units 5, the position of the pump may not be provided in each of the indoor units 5 and, it is sufficient if the position is provided in the vicinity of each of the indoor units 5. For example, as in the case of a third modified example shown in FIG. 15, the configuration may be contrived in such a manner that a pump Pa configured to adjust the flow rate of the cooling heat medium, and pump Pb configured to adjust the flow rate of the heating heat medium are provided between the heat exchange unit 3 and valve unit 4 without providing a pump in each of the indoor units 5. In FIG. 15, an air conditioner 1c according to the third modified example is shown. The fundamental configuration of the air conditioner 1c is identical to the configuration of the air conditioner 1 according to the first embodiment described above. Accordingly, configurations identical to the air conditioner 1 are denoted by reference symbols identical to the first embodiment on the drawings and descriptions of the configurations are omitted.

(Third Embodiment)

[0163] Next, a third embodiment will be described. The fundamental configuration of an air conditioner according to the third embodiment is identical to the configuration of the air conditioner 1 according to the first embodiment shown in FIG. 1 and FIG. 2. Accordingly, configurations identical to the air conditioner 1 are denoted by reference symbols identical to the air conditioner 1 on the drawings and descriptions of the configurations are omitted.

[0164] The third embodiment differs from the first embodiment in that arrangement of a cooling intermediate heat exchanger 31b and heating intermediate heat exchanger 32b is contrived. Accordingly, arrangement of the cooling intermediate heat exchanger 31b and heating intermediate heat exchanger 32b will be described in detail.

[0165] In this embodiment, as the cooling intermediate heat exchanger 31b and heating intermediate heat exchanger 32b, compact plate heat exchangers are used. In general, the plate heat exchanger is designed in such a manner that the longitudinal direction is the vertical direction and lateral direction is the horizontal direction, and is configured in such a manner that the refrigerant flows in the longitudinal direction. The reason for this is that by making the longitudinal direction the vertical direction, it is possible to make the flow path cross-sectional area smaller, improve the flow velocity, and improve the thermal conductivity. In comparison with the case where the lateral direction is made the vertical direction, it becomes possible to improve the performance with respect to the same volume.

[0166] It is assumed that the heat exchange unit 3 is installed in a small and confined space such as a ceiling cavity or the like. Accordingly, it is desirable that the dimension of the casing in the height direction (vertical direction) be designed small to the extent possible. Accordingly, the cooling intermediate heat exchanger 31b and heating intermediate heat exchanger 32b are respectively installed as shown in FIG. 16 and FIG. 17. It should be noted that in each of FIG. 16 and FIG. 17, the underside in the figure is the installation surface G of the plate heat exchanger. In this embodiment, it is assumed that the heat exchange unit 3 includes three small-sized cooling intermediate heat exchangers 31b and one large-sized heating intermediate heat exchanger 32b.

[0167] As shown in FIG. 16, in the heat exchange unit 3, the cooling intermediate heat exchanger 31b is installed in such a manner that the refrigerant flows upwardly from below in the direction perpendicular to the installation surface G. That is, the cooling intermediate heat exchanger 31b is installed on the installation surface G in such a manner that the entrance E11 of the refrigerant is located at a lower position and exit E12 of the refrigerant is located at an upper position, and the refrigerant flows in from the entrance E11 as indicated by an arrow R1 shown in FIG. 16 and thereafter flows out from the exit E12 in a gaseous phase (gas). A two-phase refrigerant (gaseous phase, liquid phase) flows into the cooling intermediate heat exchanger 31b, and hence if the cooling intermediate heat exchanger 31b is installed to be laid in the horizontal direction (as in the case of the heating intermediate heat exchanger 32b of FIG. 17) relatively to the installation surface G, the refrigerant liquid goes too far to the underside, and thus the plate inside the cooling intermediate heat exchanger 31b becomes unable to be effectively used, the performance of the heat exchanger largely lowers, and there is a possibility of a trouble such as freezing or the like due to lowering of the evaporation temperature being caused. Accordingly, the cooling intermediate heat exchanger 31b is installed as shown in FIG. 16.

[0168] On the other hand, as shown in FIG. 17, in the heat exchange unit 3, the heating intermediate heat exchanger 32b is installed in such a manner that the refrigerant flows in the horizontal direction relatively to the installation surface G. That is, the refrigerant flows in from the entrance E21 as indicated by the arrow R2 in FIG. 17 and thereafter flows out from the exit E22. The refrigerant flows into the heating intermediate heat exchanger 32b in the gaseous phase (gas) and flows out in the form of the refrigerant liquid (condensate liquid), and hence even when the heat exchanger 32b is installed in such a manner that the refrigerant flows in the horizontal direction, it is possible to effectively use the plate inside the heating intermediate heat exchanger 32b and it is also possible to suppress lowering of the performance of

the heat exchanger as compared with the cooling intermediate heat exchanger 31b. Accordingly, the heating intermediate heat exchanger 32b is installed as shown in FIG. 17.

[0169] Accordingly, by installing the cooling intermediate heat exchangers 31b and heating intermediate heat exchanger 32b as shown in FIG. 16 and FIG. 17, it is possible to, although the plurality of cooling intermediate heat exchangers 31b become necessary, make the number of the heating intermediate heat exchanger 32b one, and hence it is possible to suppress an increase in the manufacturing cost due to an increase in the number of brazed parts and increase in the parts count in addition to it is possible to reduce the cost of the intermediate heat exchangers while suppressing lowering of the performance of the air conditioner 1.

[0170] It should be noted that although in this embodiment, the description has been given of the case where the number of the cooling intermediate heat exchangers 31b is three, the number of the cooling intermediate heat exchangers 31b is not limited to this. The number of the cooling intermediate heat exchangers 31b and number of the heating intermediate heat exchanger 32b may be increased/decreased according to the environment such as the installation area of the installation location, height of the installation location, and the like within the range in which an increase in the number of brazed parts and increase in the parts count are decreased to the extent possible.

[0171] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

Reference Signs List

[0172] 1, 1a, 1b, 1c ... air conditioner, 2 ... outdoor unit, 21 ... outdoor air temperature sensor, 3 ... heat exchange unit, 3b ... intermediate heat exchanger, 4 ... valve unit, 4a ... flow path change-over valve, 5 ... indoor unit, 5a ... circulating pump, 5b ... indoor side heat exchanger, 5d ... information acquisition device, 6 ... refrigerant piping, 6a ... liquid pipe, 6b ... suction gas pipe, 6c ... discharged gas pipe, 7, 8 ... heat medium piping, 7a ... cooling heat medium supply pipe, 7b ... cooling heat medium reflux pipe, 8a ... heating heat medium supply pipe, 8b ... heating heat medium reflux pipe, 9 ... distribution pipe, 9a ... water advancing pipe, 9b ... water returning pipe, 20, 30, 40, 50 ... controller, 21, 31, 41, 51 ... housing, 31b ... cooling intermediate heat exchanger, 32b ... heating intermediate heat exchanger, 31d, 32d, 34 ... temperature sensor, 35 ... pressure sensor, 41a ... water advancing valve, 42a ... water returning valve, E11, E21 ... entrance, E12, E22 ... exit.

Claims

1. An air conditioner comprising:

an outdoor unit including a compressor which circulates a refrigerant, an outdoor side heat exchanger, and a first expansion valve;

a heat exchange unit including a plurality of intermediate heat exchangers which carry out heat exchange between the refrigerant and a heat medium, and second expansion valves corresponding to the plurality of intermediate heat exchangers;

indoor units each of which includes an indoor side heat exchanger which carries out heat exchange between the heat medium and room air;

a valve unit including flow path change-over valves each of which makes one of the heat medium cooled by the intermediate heat exchanger and the heat medium heated by the intermediate heat exchanger flow into the indoor side heat exchanger; and

a control unit including controllers each of which controls each of the units, wherein

the outdoor unit, the heat exchange unit, the indoor units, and the valve unit are individually cased separately from each other,

the outdoor unit and the heat exchange unit are connected to each other by a liquid pipe which sends a condensate liquid condensed by the outdoor side heat exchanger to the heat exchange unit or sends a condensate liquid condensed by the intermediate heat exchanger to the outdoor unit, a suction gas pipe which sends the refrigerant evaporated by the intermediate heat exchanger to the outdoor unit, and a discharged gas pipe which sends a discharged gas compressed by the compressor to the heat exchange unit,

the control unit

carries out a heating operation by making the discharged gas flow into the intermediate heat exchanger,

carries out a cooling operation by condensing the discharged gas in the outdoor side heat exchanger and making the condensed condensate liquid flow into the intermediate heat exchanger through the second expansion valve, carries out a cooling-prioritized cooling/heating-mixed operation by making part of the discharged gas flow into one of the plurality of intermediate heat exchangers to thereby condense the part of the discharged gas, condensing the remainder of the discharged gas in the outdoor side heat exchanger, mixing the condensed condensate liquid with the refrigerant condensed in the intermediate heat exchanger through the liquid pipe, and making the mixed condensate liquid flow into the other of the intermediate heat exchangers through the second expansion valve to thereby evaporate the mixed condensate liquid, and carries out a heating-prioritized cooling/heating-mixed operation by making the discharged gas flow into one of the plurality of intermediate heat exchangers to thereby condense the discharged gas, making part of the discharged gas flow into the outdoor side heat exchanger through the liquid pipe to thereby evaporate the part of the discharged gas, and making the remainder of the condensate liquid flow into the other of the intermediate heat exchangers through the second expansion valve to thereby evaporate the remainder of the condensate liquid.

2. The air conditioner of claim 1, wherein regarding a piping diameter of piping connecting the outdoor unit and the heat exchange unit to each other, a relationship "the suction gas pipe > the discharged gas pipe > the liquid pipe" is established.

3. The air conditioner of claim 2, wherein

at least one of the plurality of intermediate heat exchangers is a cooling intermediate heat exchanger which cools the refrigerant at the time of the cooling operation, and the other of the intermediate heat exchangers is a heating intermediate heat exchanger which heats the refrigerant at the time of the heating operation, the discharged gas pipe is connected to the heating intermediate heat exchanger, the suction gas pipe is connected to the cooling intermediate heat exchanger, and the liquid pipe is connected to the heating intermediate heat exchanger and the cooling intermediate heat exchanger.

4. The air conditioner of claim 3, further comprising a third expansion valve in the heat exchange unit, wherein the third expansion valve is provided between the suction gas pipe and the cooling intermediate heat exchanger.

5. The air conditioner of claim 4, wherein

the third expansion valve operates on the basis of one of an inlet temperature of the cooling intermediate heat exchanger and an evaporation gas saturation temperature obtained by converting the outlet pressure of the cooling intermediate heat exchanger into a saturation temperature.

6. The air conditioner of claim 1, wherein

the intermediate heat exchanger is a plate heat exchanger formed by laminating plates, the plurality of plate heat exchangers include a plurality of cooling intermediate heat exchangers which cool the heat medium and a heating intermediate heat exchanger of a number less than the number of the plurality of cooling intermediate heat exchangers, each of the cooling intermediate heat exchangers is installed in such a manner that the refrigerant flows upwardly in a direction perpendicular to an installation surface, and the heating intermediate heat exchanger is installed in such a manner that the refrigerant flows in a horizontal direction relatively to the installation surface.

7. The air conditioner of claim 1, wherein

the outdoor unit includes an outdoor air temperature sensor which detects an outdoor air temperature, and the controller selects one of the heating operation, the cooling operation, the cooling-prioritized cooling/heating-mixed operation, and the heating-prioritized cooling/heating-mixed operation on the basis of a percentage of cooling demand or heating demand on the indoor units and the outdoor air temperature detected by the outdoor air temperature sensor to thereby operate the outdoor unit.

8. The air conditioner of claim 7, wherein

when it is assumed that the outdoor air temperature detected by the outdoor air temperature sensor is TO, and a first specified temperature and a second specified temperature each specifying a range of the outdoor air temperature are TH and TL, respectively,

in a case where a condition " $TL < TO < TH$ " is given, while the outdoor unit is made to carry out the cooling-prioritized cooling/heating-mixed operation, when the percentage of the heating demand on the indoor units becomes greater than or equal to a first threshold, the controller switches the operation of the outdoor unit from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation, while the outdoor unit is made to carry out the heating-prioritized cooling/heating-mixed operation, when the percentage of the cooling demand on the indoor units becomes greater than or equal to the first threshold, switches the operation of the outdoor unit from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation,

in a case where a condition " $TO \geq TH$ " is given, when the outdoor unit is made to carry out the cooling-prioritized cooling/heating-mixed operation, even if the percentage of the heating demand on the indoor units becomes greater than or equal to the first threshold, makes the outdoor unit continuously carry out the cooling-prioritized cooling/heating-mixed operation, and

in a case where a condition " $TO \leq TL$ " is given, when the outdoor unit is made to carry out the heating-prioritized cooling/heating-mixed operation, even if the percentage of the cooling demand on the indoor units becomes greater than or equal to the first threshold, makes the outdoor unit continuously carry out the heating-prioritized cooling/heating-mixed operation.

9. The air conditioner of claim 8, wherein

in the case where the condition " $TO \geq TH$ " is given, when the percentage of the heating demand on the indoor units becomes greater than or equal to a second threshold greater than the first threshold, the controller switches the operation of the outdoor unit from the cooling-prioritized cooling/heating-mixed operation to the heating-prioritized cooling/heating-mixed operation, and

in the case where the condition " $TO \leq TL$ " is given, when the percentage of the cooling demand becomes greater than or equal to a third threshold greater than the first threshold, switches the operation of the outdoor unit from the heating-prioritized cooling/heating-mixed operation to the cooling-prioritized cooling/heating-mixed operation.

10. The air conditioner of claim 1, wherein

the heat exchange unit includes a temperature sensor which detects a temperature of the heat medium on the downstream side of the intermediate heat exchanger,

the control unit stores therein setting of a target temperature of the heat medium for each of operation modes at the time of the cooling operation and at the time of the heating operation, acquires the temperature of the heat medium detected by the temperature sensor, and controls a rotational speed of the compressor on the basis of the acquired temperature and the target temperature,

the operation modes include a first mode and a second mode in which an operation is carried out with a higher degree of power saving than the first mode, and

the target temperature of the second mode at the time of the cooling operation is set higher than the target temperature of the first mode, and the target temperature of the second mode at the time of the heating operation is set lower than the target temperature of the first mode.

11. The air conditioner of claim 10, wherein

the outdoor unit is connected to a control panel, and

the air conditioner makes a transition from the first mode to the second mode on the basis of an instruction of the control panel.

12. The air conditioner of claim 10, wherein

the valve unit includes communication means for carrying out communication with each of the plurality of indoor units connected thereto, and

the control unit acquires an operating state of each of the plurality of indoor units through the valve unit, and makes the air conditioner make a transition from the first mode to the second mode on the basis of the acquired operating state of each of the plurality of indoor units.

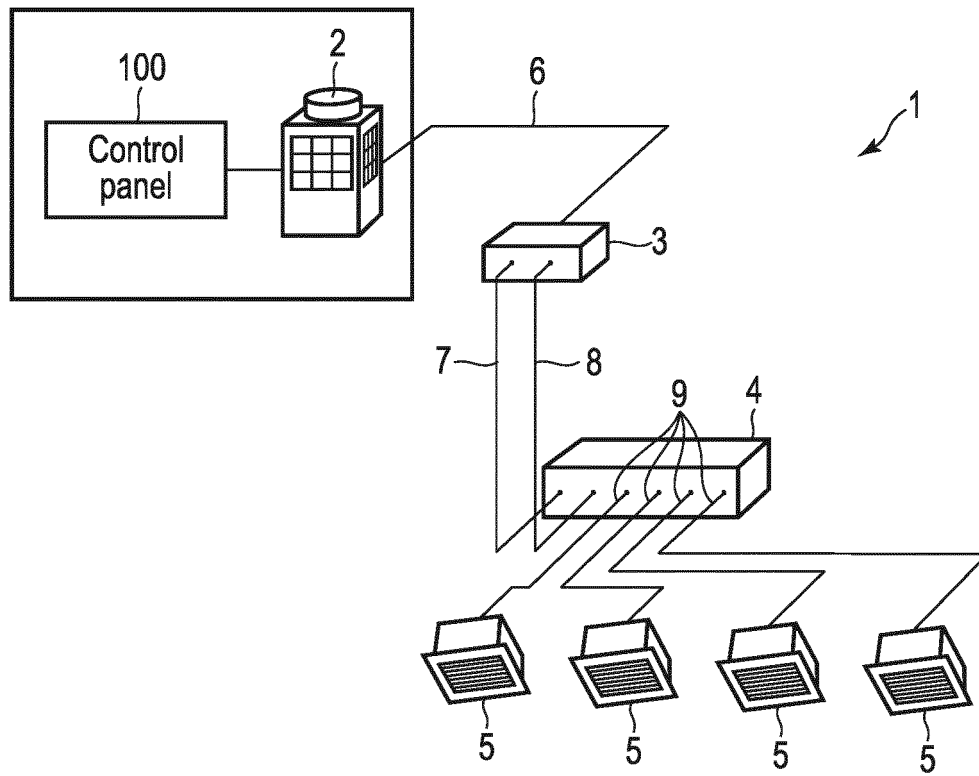
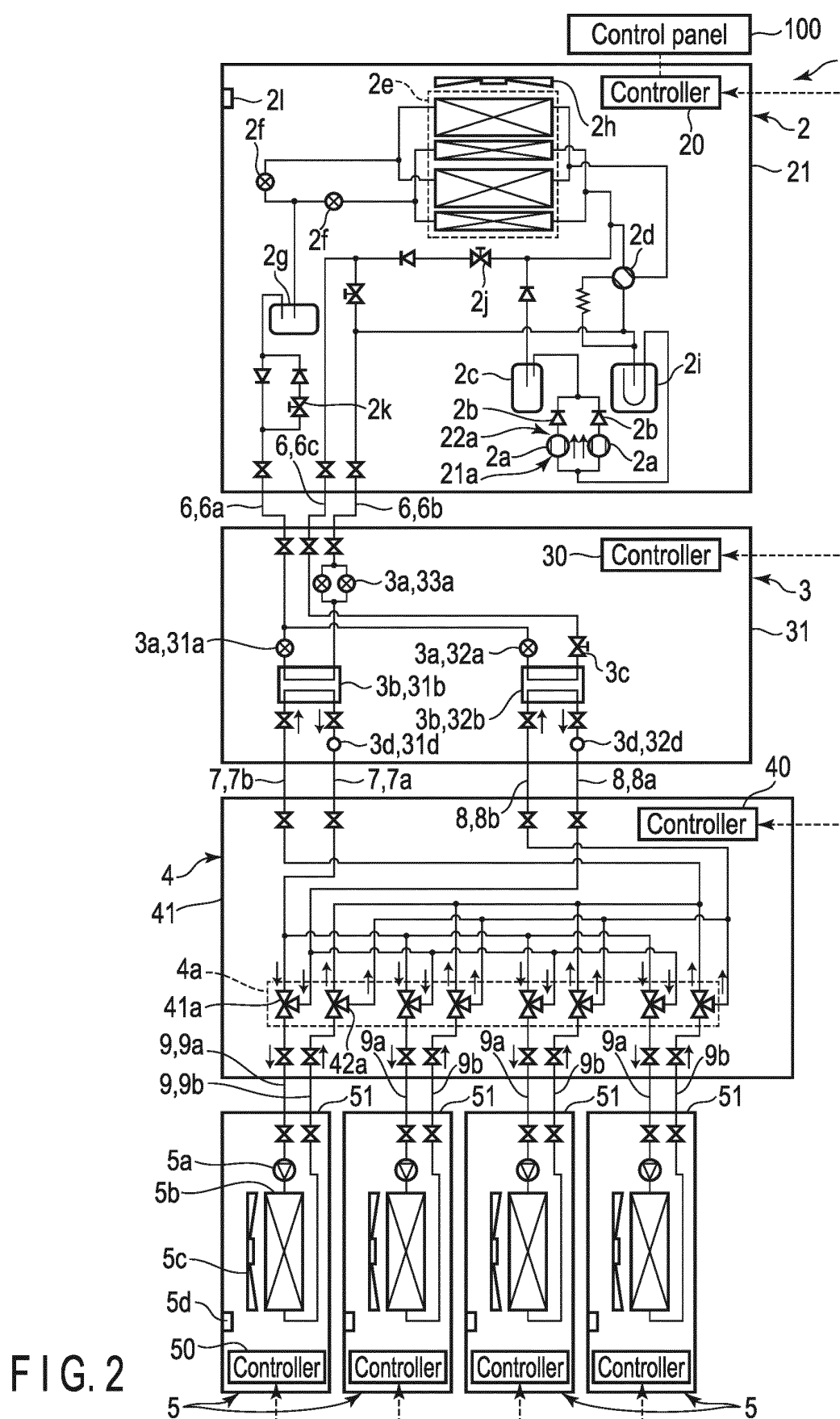


FIG. 1



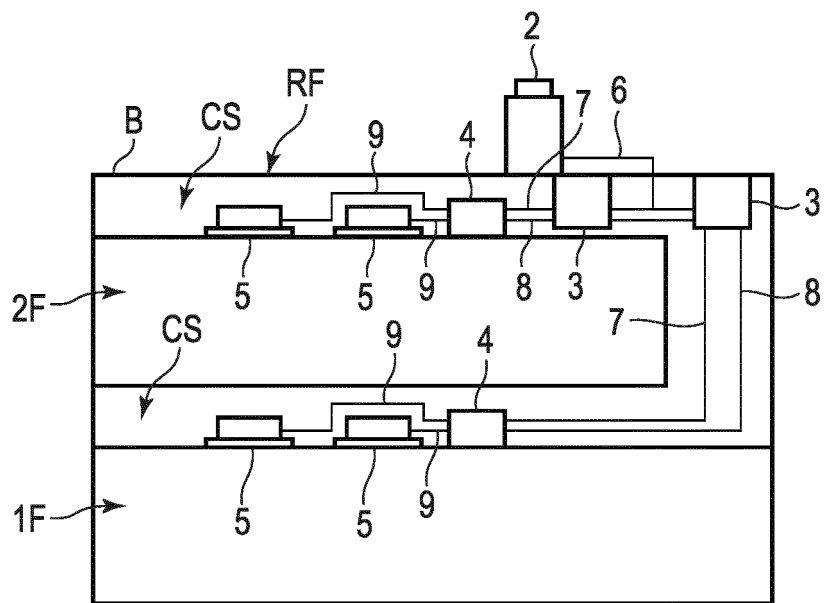


FIG. 3

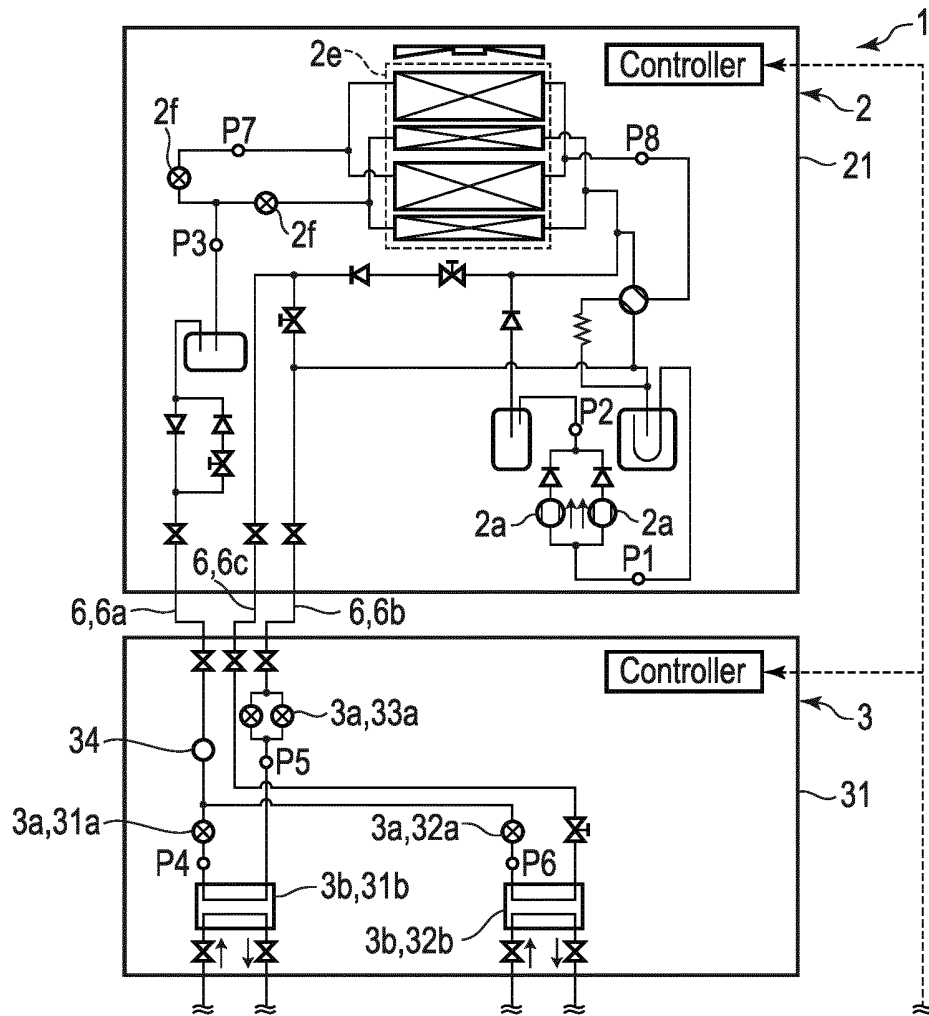


FIG. 4A

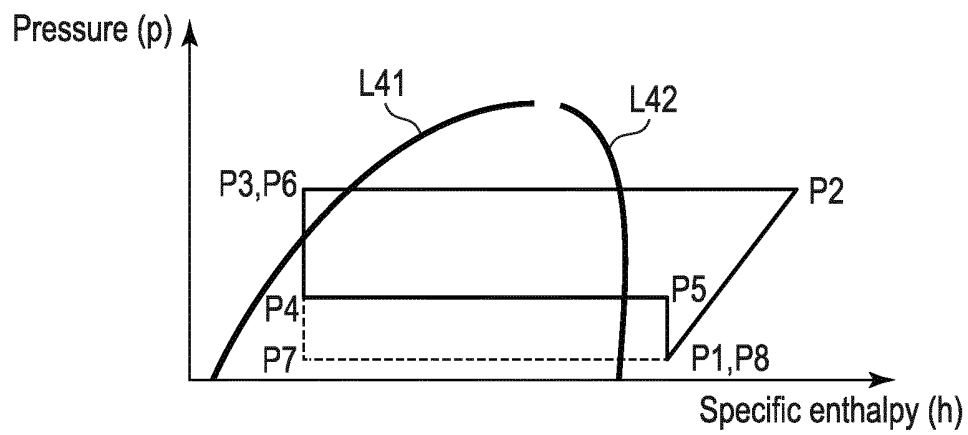


FIG. 4B

T1

		Discharged gas pipe	Liquid pipe	Suction gas pipe
Refrigerant density (Percentage)	kg/m3 %	94.2 100%	980.4 1041%	34.6 37%
Refrigerant flow velocity (Refrigerant flow velocity) ² (Percentage)	m/s – %	23.3 542.4 100%	2.2 5.0 1%	63.4 4025.7 742%
Pressure loss percentage	%	100%	10%	272%

FIG. 5

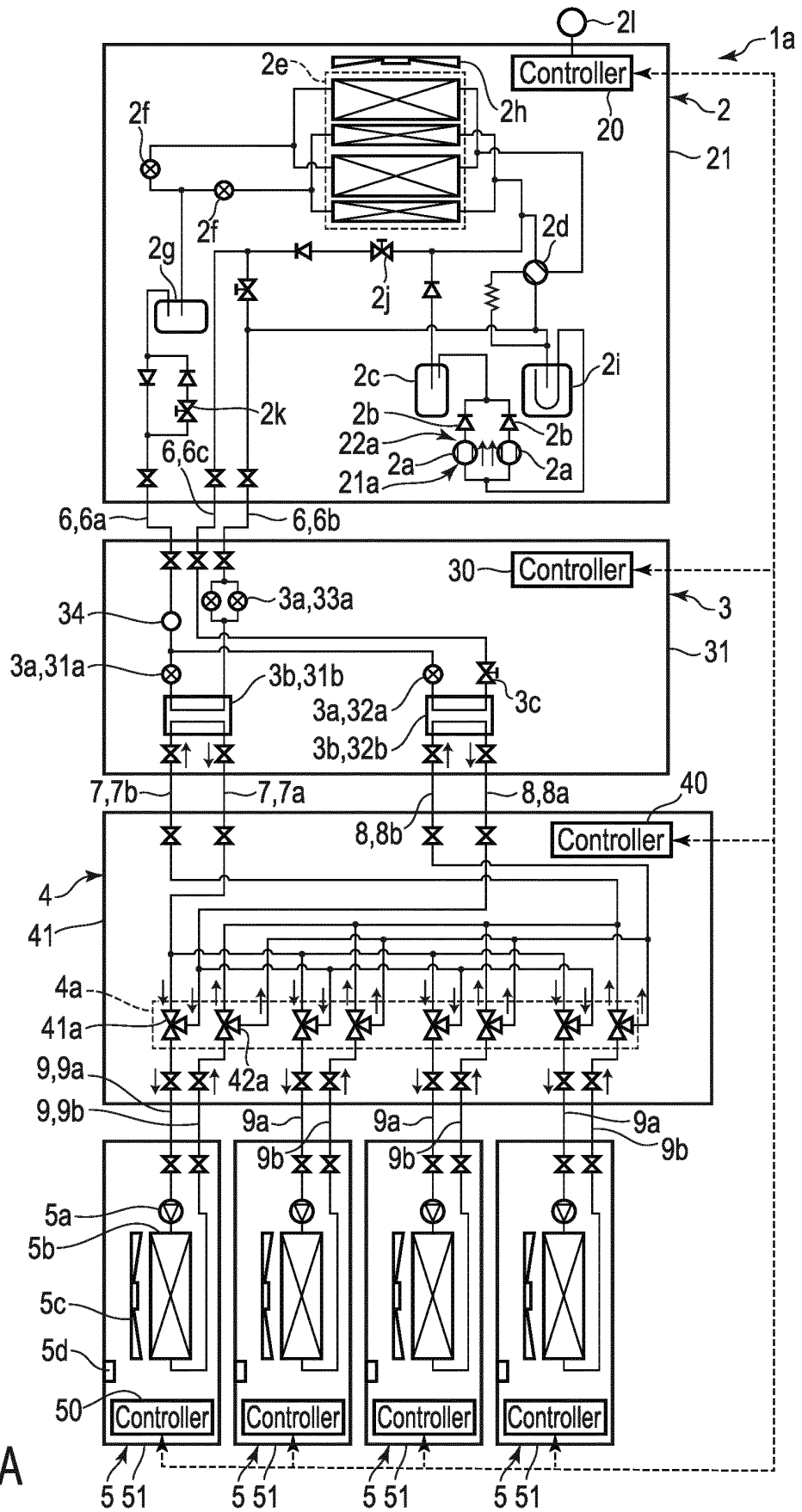
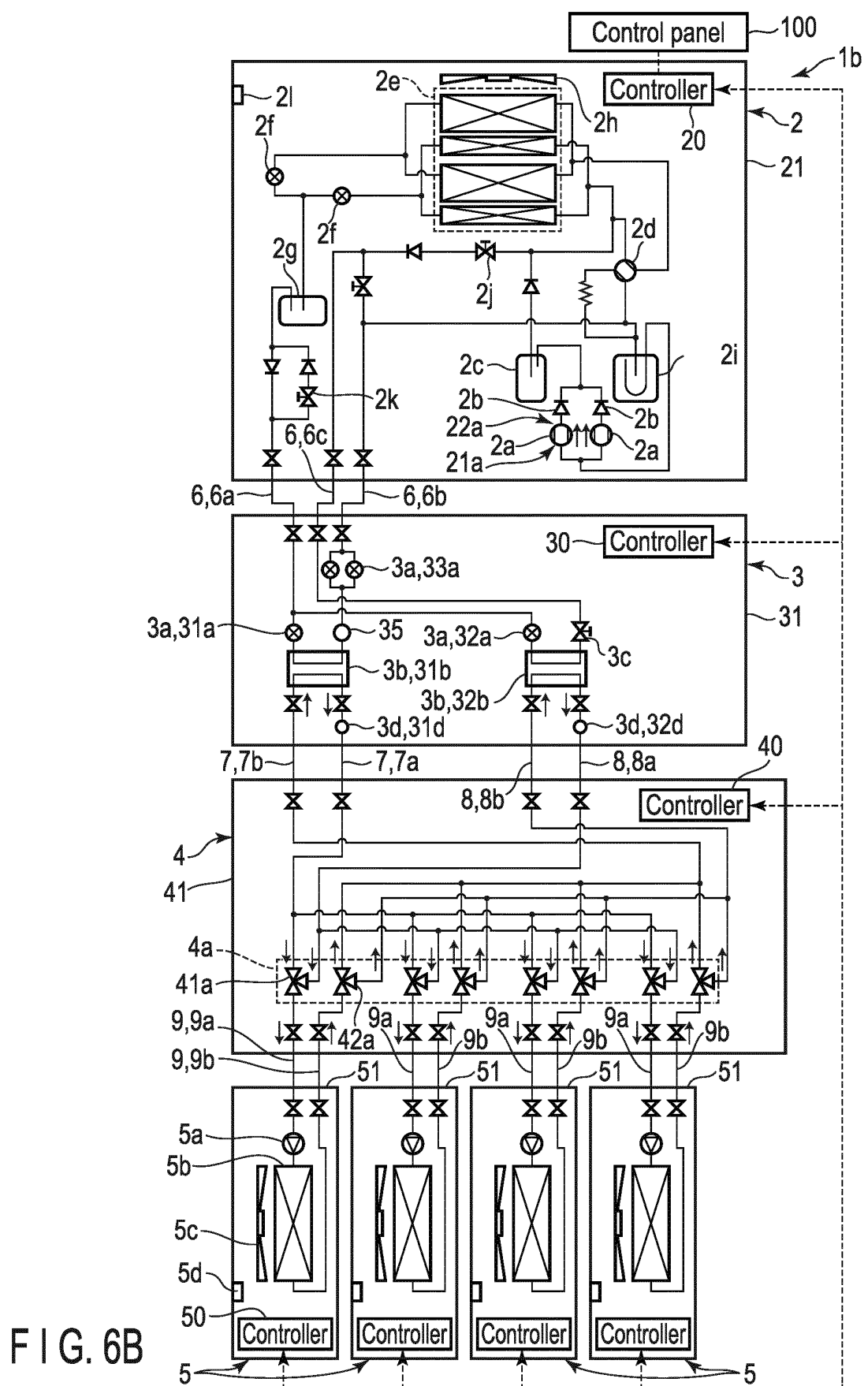


FIG. 6A



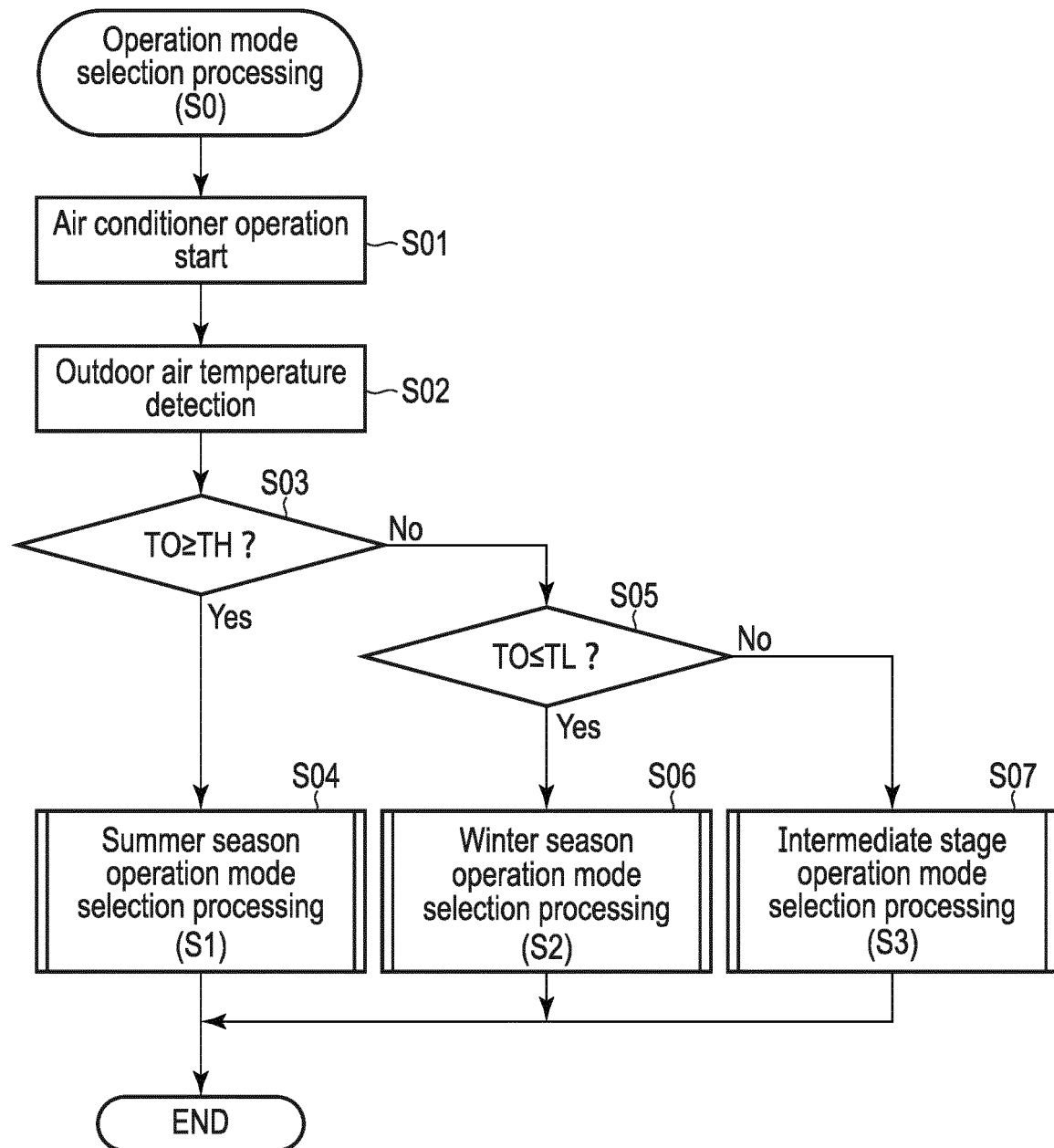


FIG. 7

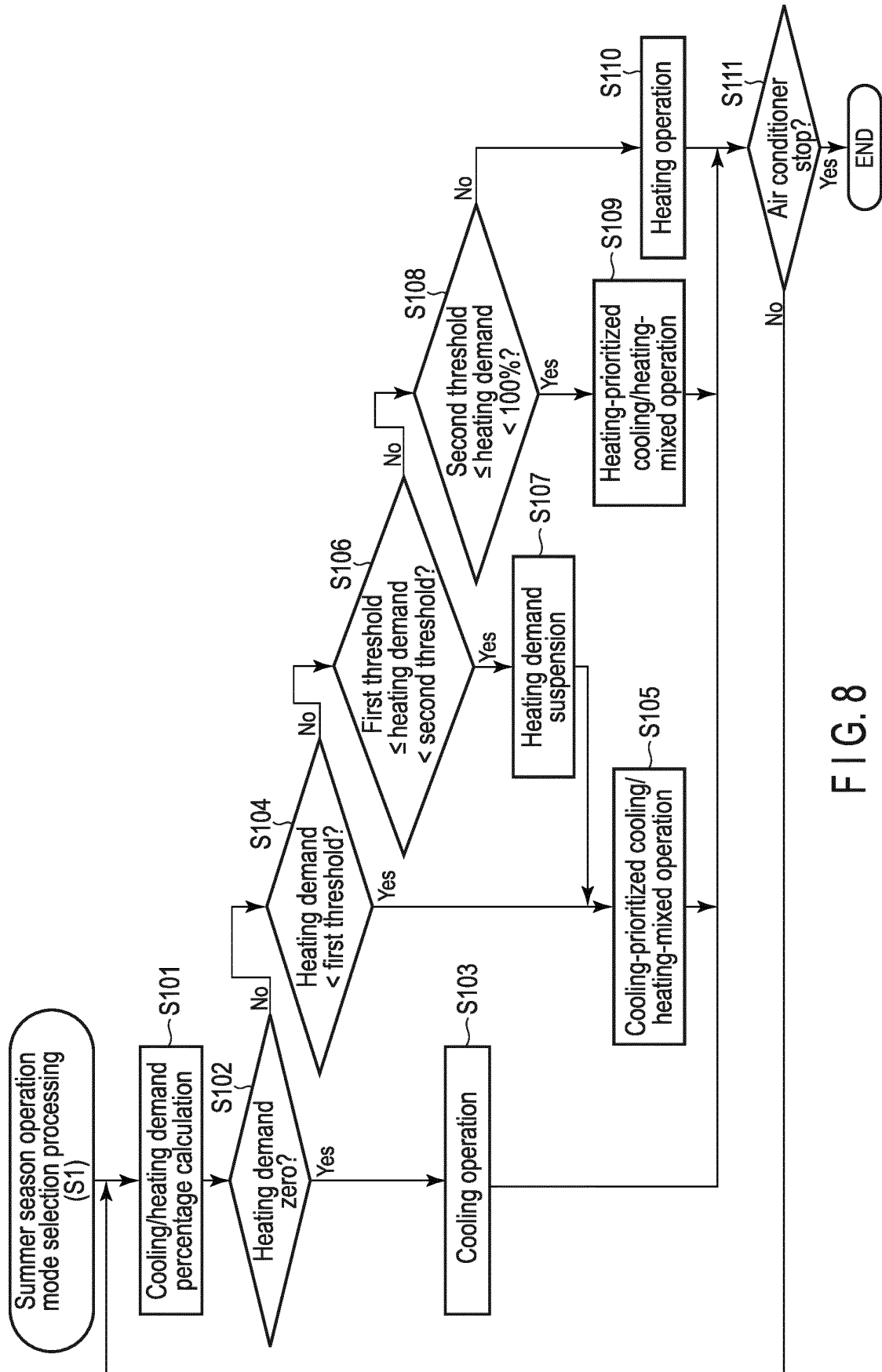


FIG. 8

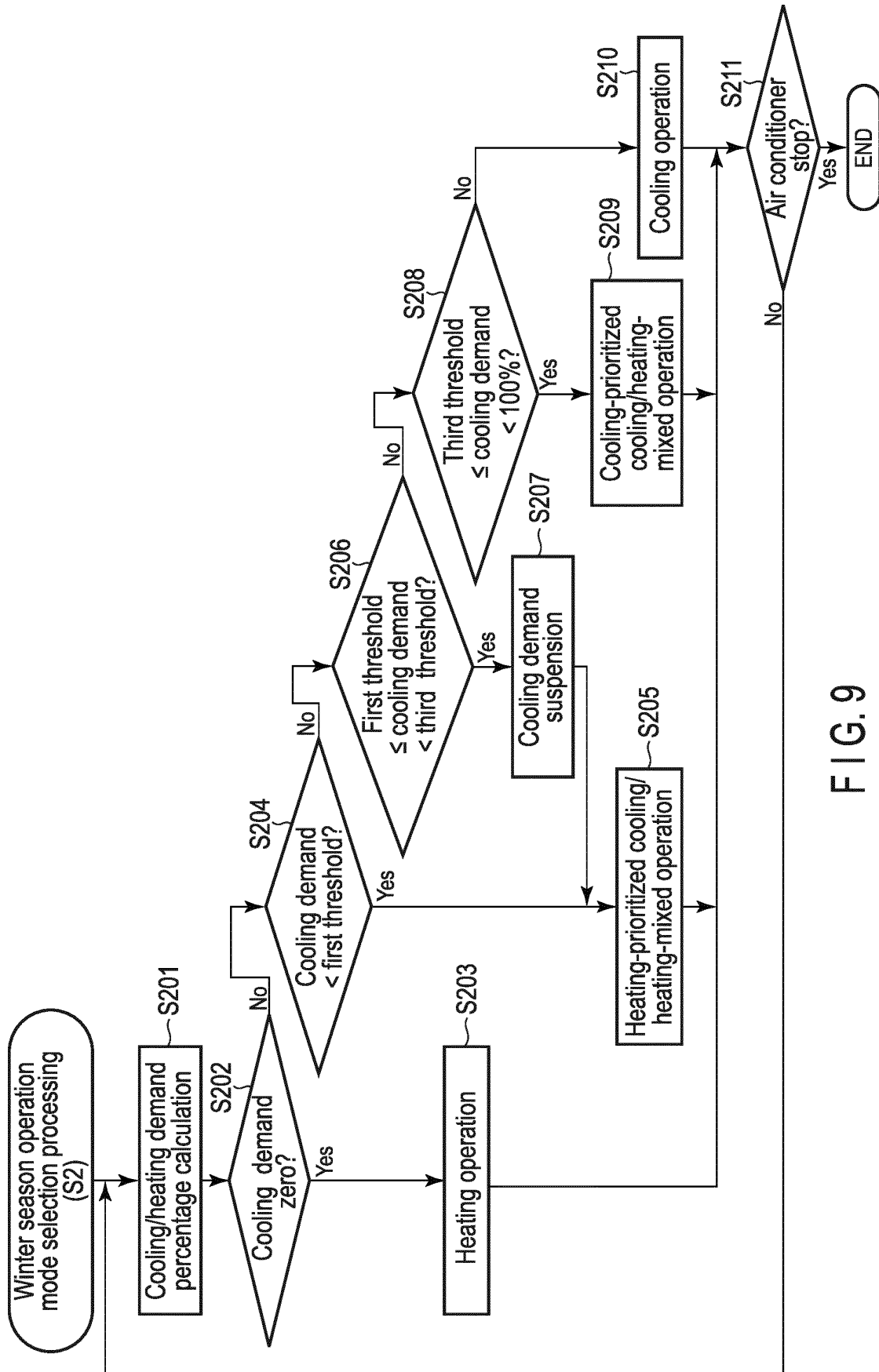


FIG. 9

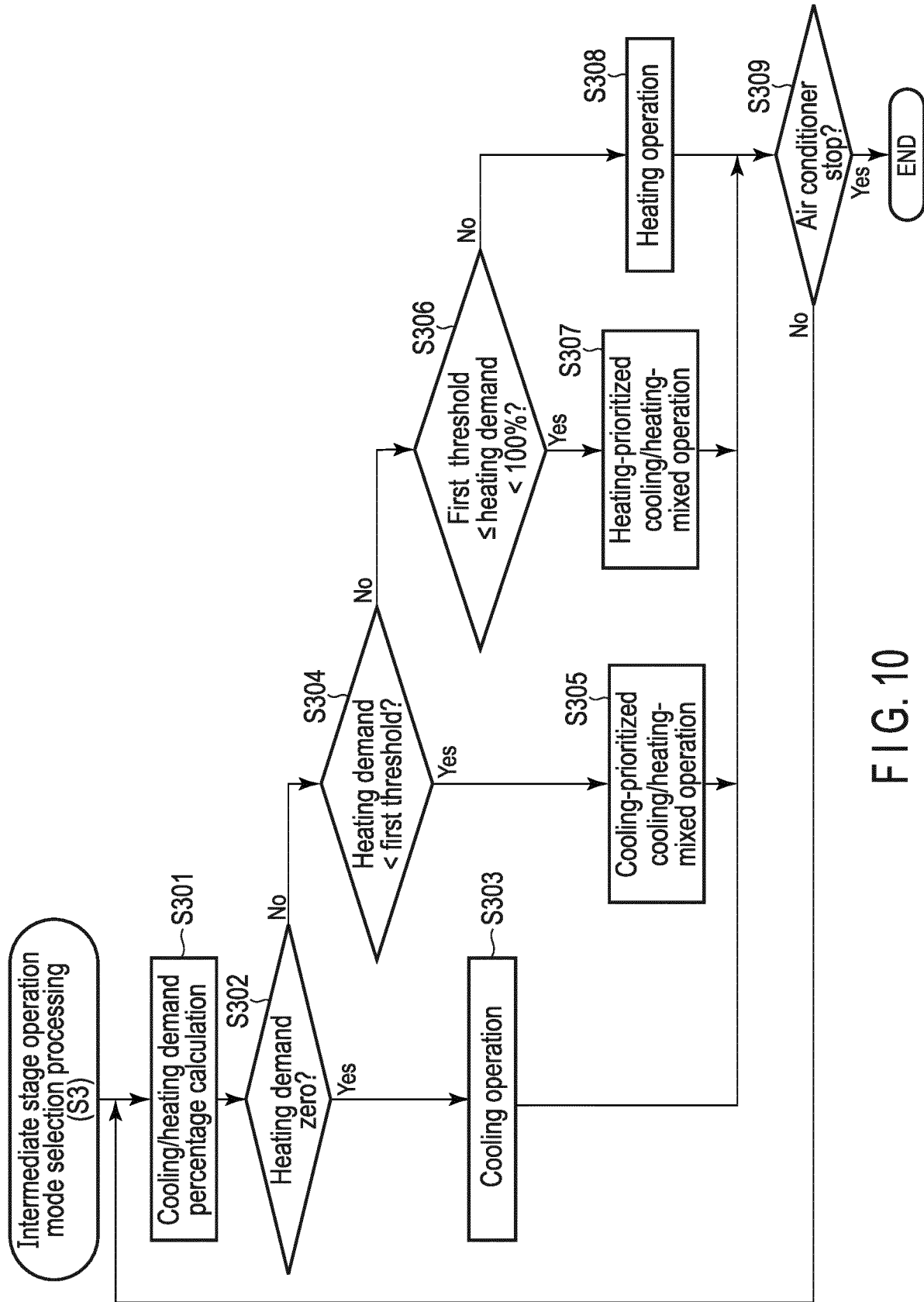


FIG. 10

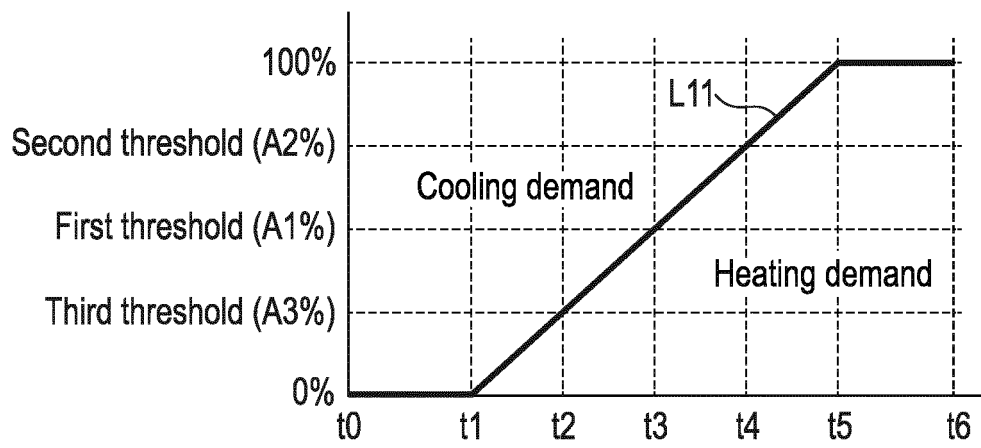


FIG. 11

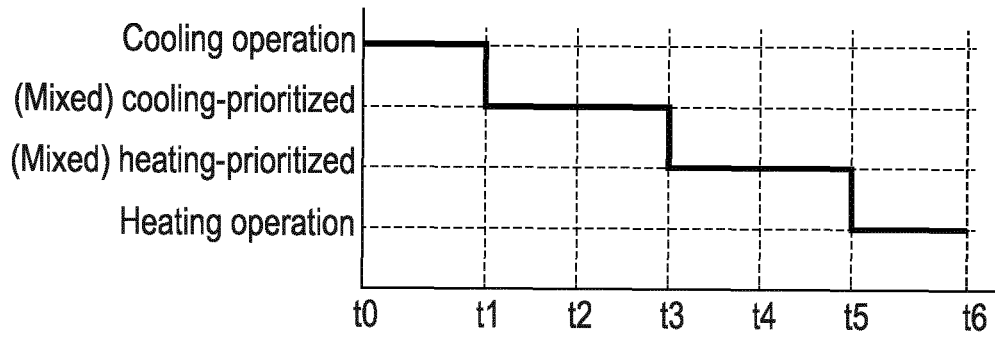


FIG. 12A

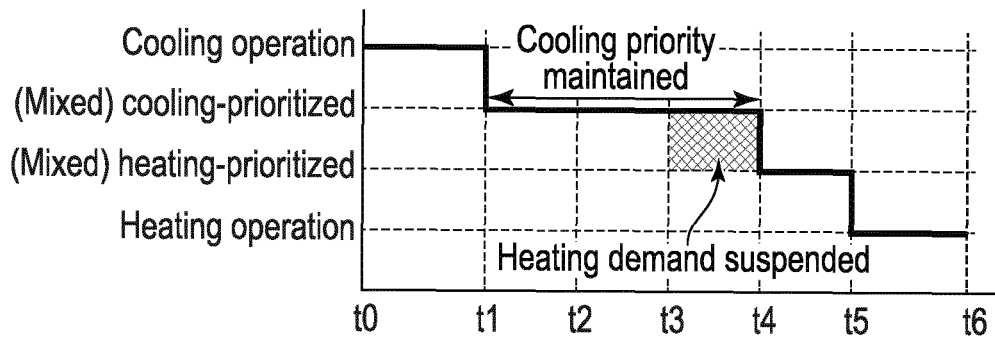


FIG. 12B

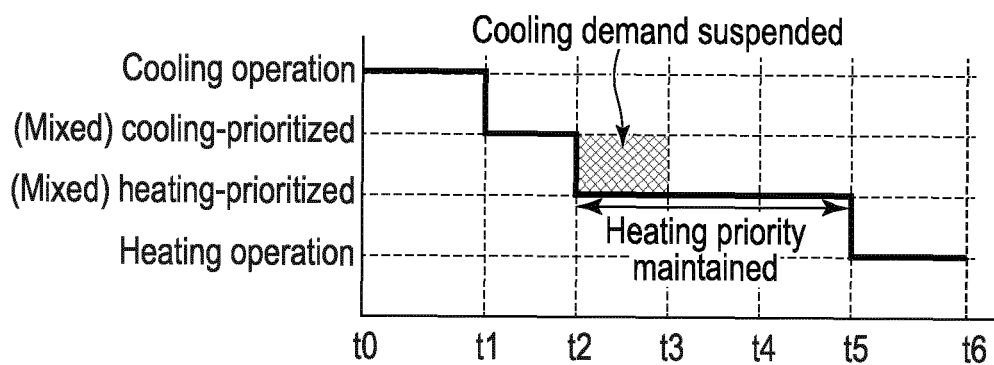


FIG. 12C


 T1

	Operation mode	Target temperature
At the time of cooling operation	First mode (normal operation mode)	TA1
	Second mode (energy-saving operation mode)	TA2(>TA1)
At the time of heating operation	First mode (normal operation mode)	TB1
	Second mode (energy-saving operation mode)	TB2(<TB1)

FIG. 13

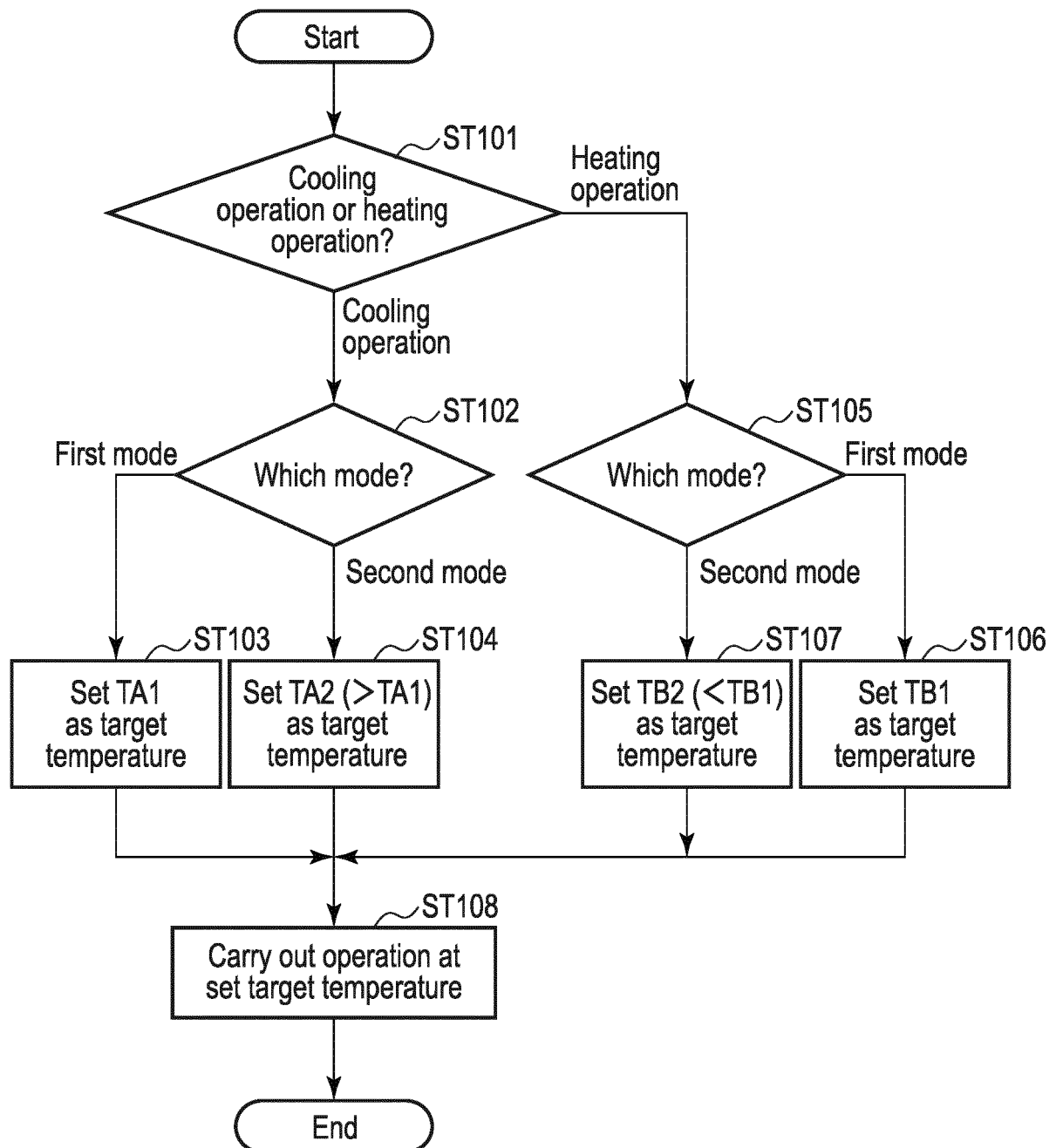
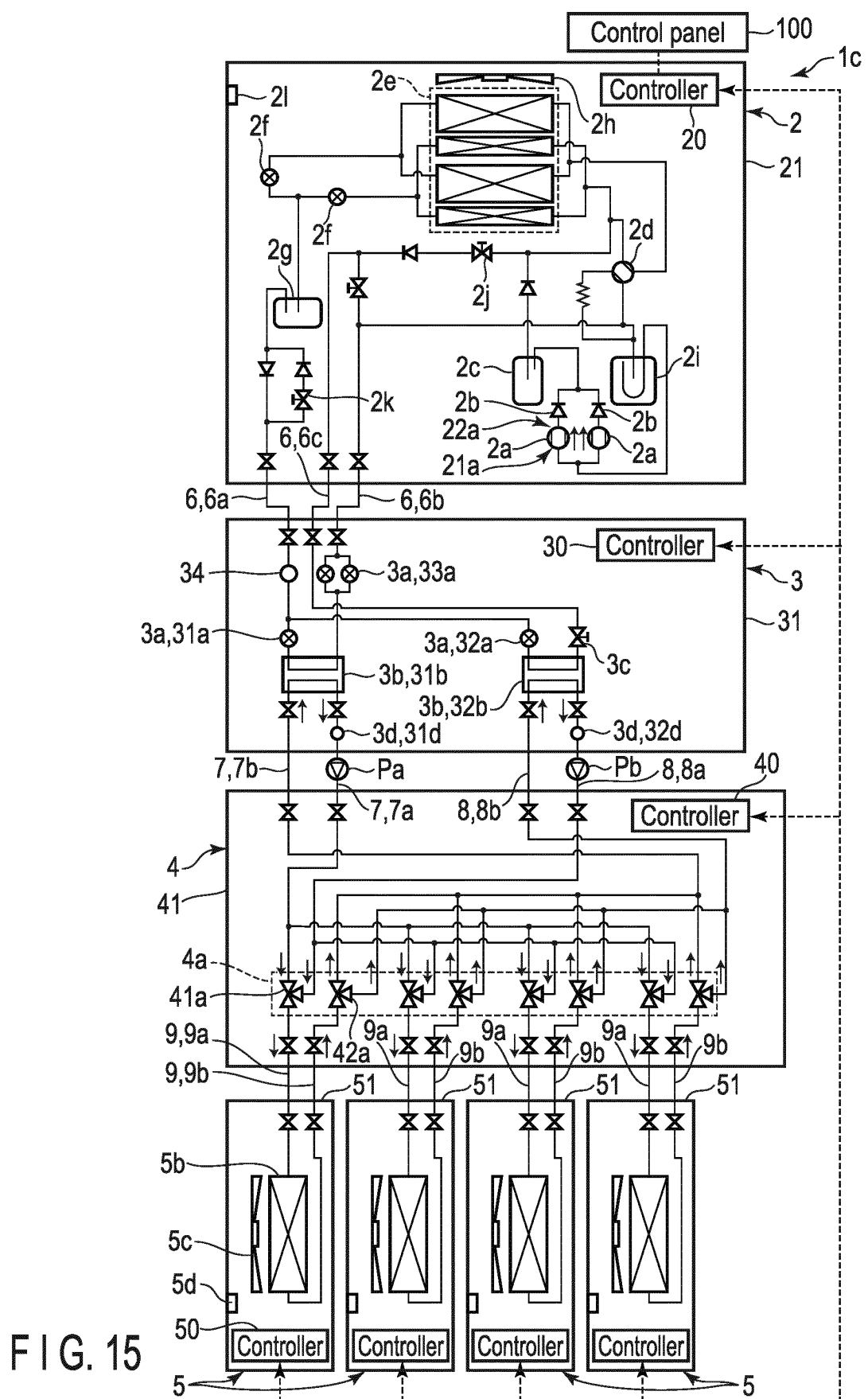


FIG. 14



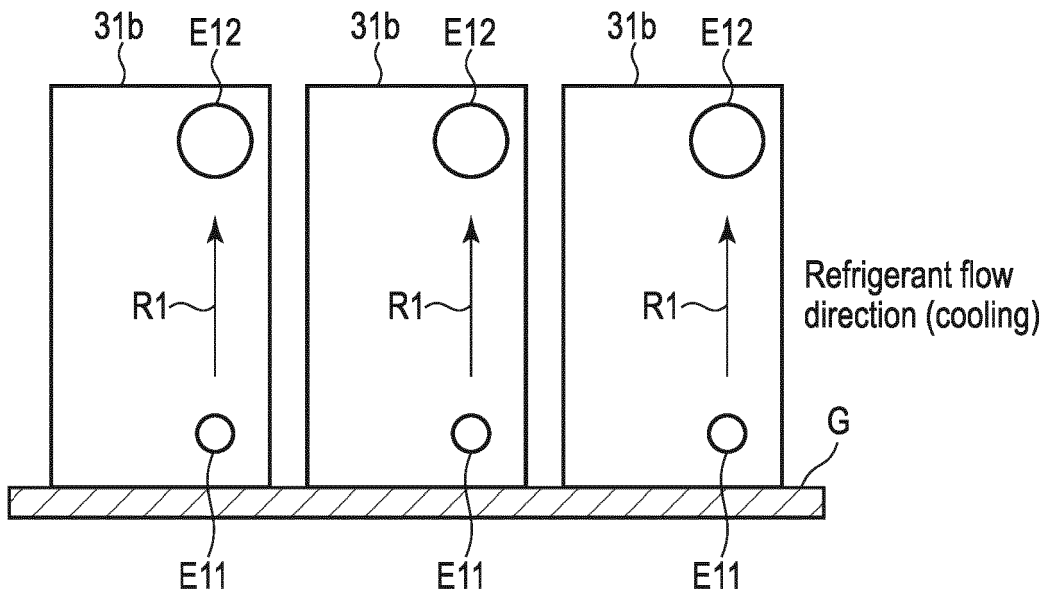


FIG. 16

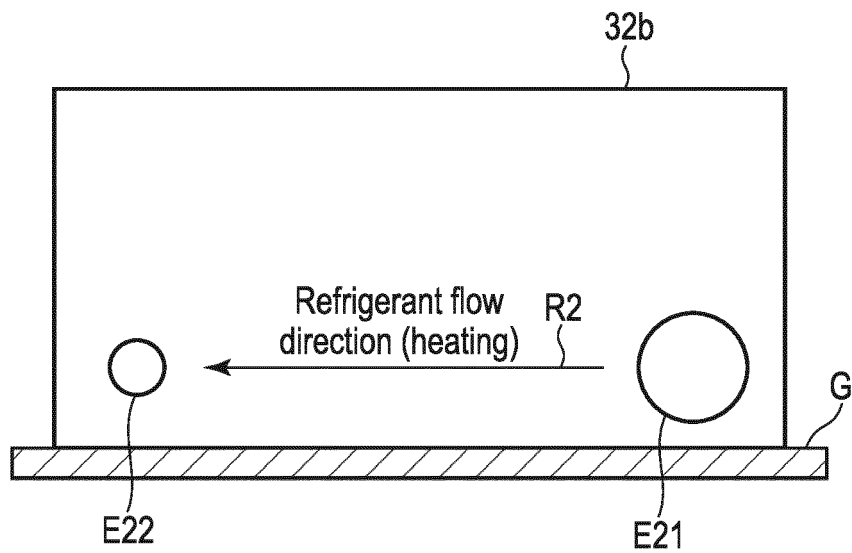


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/025338

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F25B13/00(2006.01)i, F25B1/00(2006.01)i, F24F5/00(2006.01)i,
F24F11/46(2018.01)i, F24F11/65(2018.01)i, F24F11/86(2018.01)i,
F24F110/12(2018.01)n, F24F140/20(2018.01)n
FI: F24F11/65, F25B1/00399Y, F24F5/00Z, F24F11/46, F24F11/86,
F24F5/00101Z, F25B13/00S, F24F110/12, F24F140/20

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F25B13/00, F25B1/00, F24F5/00, F24F11/46, F24F11/65, F24F11/86,
F24F110/12, F24F140/20

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2016/194145 A1 (MITSUBISHI ELECTRIC CORPORATION) 08.12.2016 (2016-12-08), paragraphs [0014]-[0071]	1-3, 7, 10-11 4-6, 8-9, 12
Y A	WO 2010/050006 A1 (MITSUBISHI ELECTRIC CORPORATION) 06.05.2010 (2010-05-06), paragraphs [0112]-[0169]	1-3, 7, 10-11 4-6, 8-9, 12
Y	WO 2018/105250 A1 (DAIKIN INDUSTRIES, LTD.) 14.06.2018 (2018-06-14), paragraphs [0056]-[0064]	10-11



Further documents are listed in the continuation of Box C.



See patent family annex.

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"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

05.08.2020

Date of mailing of the international search report

01.09.2020

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No. PCT/JP2020/025338
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WO 2010/050006 A1	06.05.2010	US 2011/0167865 A1	EP 2312229 A1
		paragraphs [0113]-[0170]	CN 102112816 A
WO 2018/105250 A1	14.06.2018	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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- JP 5236009 B [0004]