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(54) **AIR CONDITIONING DEVICE**

(57) In an air-conditioning apparatus 100, a controller 50 performs a pressure variation suppressing operation for suppressing a pressure variation on the side of a refrigerant circuit A by controlling a heat medium flow control device 34b to be slightly opened so as to allow a certain amount of heat medium to flow through a use-side heat exchanger 35b before the use-side heat exchanger 35b starts operation or performs switching of an operation mode.

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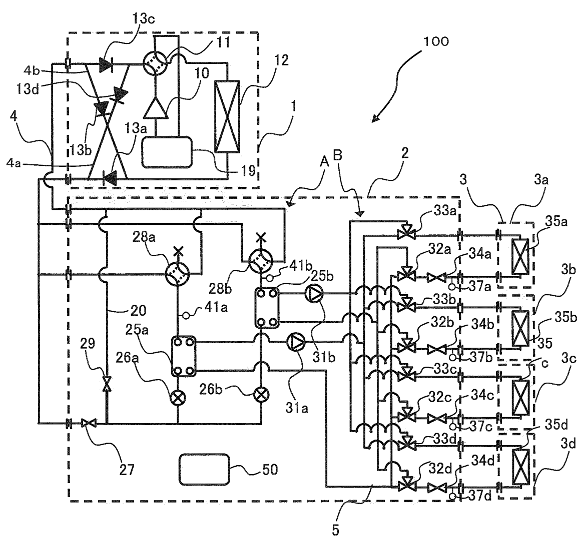

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Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus applied to, for example, a multi-air-conditioning apparatus for buildings, and more particularly, to an air-conditioning apparatus that is capable of efficiently supplying heating energy, cooling energy, or both the heating energy and cooling energy generated by a heat source unit to a plurality of loads.

Background Art

[0002] As a related art, air-conditioning apparatuses that perform heat exchange using a heat medium (cold liquid or hot liquid) from a heat source apparatus (heat source equipment) and that perform precooling or preheating of a heat medium that circulates between a heat source unit and an indoor unit (air-conditioning unit) are available. Regarding the above-mentioned air-conditioning apparatus, a precooling/preheating control method for air-conditioning equipment configured such that "after the liquid temperature inside pipes is measured during a night time when electricity rate is low and heat source equipment is activated at the time calculated on the basis of data obtained by leaning and calculation, a valve of a cold liquid coil or hot liquid coil of an air-conditioning unit that is scheduled to operate on that day is forced to be fully opened without an air-sending fan of the air-conditioning unit being operated and the precooling/preheating for a portion from the heat source equipment to the coil of the air-conditioning unit is performed within the minimum time by the time when the air-conditioning unit actually starts to be used so that a reduction in power consumption and an elimination of wasteful supply of heat by liquid can be achieved" has been suggested (for example, see Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-227242 (Abstract, Fig. 1).

Summary of Invention

Technical Problem

[0004] For the method described in Patent Literature 1, in the case where many air-conditioning units are scheduled to operate and the scheduled operation time differs from unit to unit, a heat medium during operation and a heat medium during stopping are mixed together when an indoor unit whose scheduled operation time is later is activated. Thus, the temperature of the heat medium during operation suddenly changes. This sudden change causes a pressure variation to occur on a refrigerant side, which becomes a factor of inducing pressure anomaly. Furthermore, in the case where a simultaneous cooling and heating operation in which both an indoor unit that performs cooling and an indoor unit that performs heating exist is performed, such a situation also occurs at the time when the operation mode of an indoor unit is switched from heating to cooling (or from cooling to heating).

[0005] The present invention has been designed to solve the problems described above. An object of the present invention is to provide a highly reliable air-conditioning apparatus that is capable of performing a simultaneous cooling and heating operation, suppressing a pressure variation on a refrigerant even at the time when an indoor unit is activated or when switching of the operation mode of an indoor unit is performed, and efficiently supplying heating energy, cooling energy, or both the heating energy and cooling energy generated by a heat source unit to a plurality of loads.

Solution to Problem

[0006] An air-conditioning apparatus according to the present invention includes a refrigerant circuit in which a compressor, a heat-source-side heat exchanger, a plurality of expansion devices, refrigerant-side flows of a plurality of intermediate heat exchangers, and a plurality of refrigerant flow switching devices that perform switching of circulation paths are connected with refrigerant pipes and through which a heat-source-side refrigerant circulates, a heat medium circuit in which pumps, a plurality of use-side heat exchangers, heat medium flow control devices, and heat-medium-side flows of the intermediate heat exchangers are connected with heat medium pipes and through which a heat medium circulates, and a controller that controls an opening degree of at least one of the heat medium flow control devices to adjust a flow rate of the heat medium. The controller performs a pressure variation suppressing operation for suppressing a refrigerant pressure variation on a side of the refrigerant circuit by controlling the at least one of the heat medium flow control devices to have a first opening degree so as to allow a certain amount of heat medium to flow through the use-side heat exchangers, before at least one of the use-side heat exchangers starts operation or performs switching of an operation mode.

Advantageous Effects of Invention

[0007] With an air-conditioning apparatus according to the present invention, a pressure variation on a refrigerant side can be suppressed even in a system that is capable of performing a simultaneous cooling and heating operation by adjusting the flow rate of a heat medium that is caused to circulate in a target indoor unit at the time when an indoor unit is activated or when switching of the operation mode of an indoor unit is performed, and the reliability can thus be improved.

Brief Description of Drawings

[0008]

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

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

[Fig. 3] Fig. 3 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus according to Embodiment 1 of the present invention is in a heating only operation mode.

[Fig. 4] Fig. 4 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus according to Embodiment 1 of the present invention is in a heating main operation mode.

[Fig. 5] Fig. 5 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus according to Embodiment 1 of the present invention is in a cooling only operation mode.

[Fig. 6] Fig. 6 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus according to Embodiment 1 of the present invention is in the cooling main operation mode.

[Fig. 7] Fig. 7 is a flowchart illustrating an example of the flow of a process of a pressure variation suppressing operation performed by the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a flowchart illustrating another example of the flow of the process of the pressure variation suppressing operation performed by the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 9] Fig. 9 is an explanatory diagram for explaining a method for increasing the opening degree of a heat medium flow control device.

[Fig. 10] Fig. 10 is a flowchart illustrating an example of the flow of a process of a pressure variation suppressing operation performed by an air-conditioning apparatus according to Embodiment 2 of the present invention.

[Fig. 11] Fig. 11 is a flowchart illustrating an example of the flow of a process of a pressure variation suppressing operation performed by an air-conditioning apparatus according to Embodiment 3 of the present invention.

Description of Embodiments

[0009] Hereinafter, embodiments of the present invention will be explained with reference to the drawings.

Embodiment 1

[0010] Fig. 1 is a schematic diagram illustrating an example of the installation of an air-conditioning apparatus according to an embodiment of the present invention. The example of the installation of the air-conditioning apparatus will be explained with reference to Fig. 1. In the air-conditioning apparatus, with the use of refrigeration cycles (a refrigerant circuit A and a heat medium circuit B) for allowing refrigerants (a heat-source-side refrigerant and a heat medium) to circulate, indoor units can freely select between a cooling mode and a heating mode as an operation mode. Fig. 1 schematically illustrates the entire air-conditioning apparatus in which a plurality of indoor units 3 are connected. In the drawings provided below including Fig. 1, the size relationship of individual component parts may differ from the actual size relationship.

[0011] In Fig. 1, the air-conditioning apparatus according to Embodiment 1 includes an outdoor unit (heat source unit) 1, a plurality of indoor units 3, and a relay unit 2 that is arranged between the outdoor unit 1 and the indoor units 3. The relay unit 2 exchanges heat between a heat-source-side refrigerant and a heat medium. The outdoor unit 1 and the relay unit 2 are connected by refrigerant pipes 4 through which the heat-source side refrigerant flows. The relay unit 2 and each of the indoor units 3 are connected by pipes (heat medium pipes) 5 through which the heat medium flows. Cooling energy or heating energy generated by the outdoor unit 1 is sent through the relay unit 2 to the indoor units 3.

[0012] Normally, the outdoor unit 1 is arranged in an outdoor space 6, which is a space (for example, a rooftop or the like) outside a structure 9 such as a building, and supplies cooling energy or heating energy through the relay unit 2 to the indoor units 3. The indoor units 3 are arranged at positions from which cooling air or heating air can be supplied to an indoor space 7, which is a space (for example, a living room or the like) inside the structure 9, and supplies cooling air or heating air to the indoor space 7 serving as a space to be air-conditioned. The relay unit 2 is configured so as to be installed, as a housing different from the outdoor unit 1 and the indoor units 3, at a position (for example, a shared space in the structure 9 or a space above the ceiling) that is different from the outdoor space 6 and the indoor space 7. The relay unit 2 is connected to the outdoor unit 1 and the indoor units 3 by the refrigerant pipes 4 and the pipes 5, respectively, and transmits to cooling energy or heating energy supplied from the outdoor unit 1 the indoor units 3.

[0013] The operation of the air-conditioning apparatus according to an embodiment of the present invention will be briefly explained. A heat-source-side refrigerant is conveyed from the outdoor unit 1 to the relay unit 2 through the refrigerant pipes 4. The conveyed heat-source-side refrigerant exchanges heat with a heat medium in an intermediate heat exchanger (will be described later) in the relay unit 2 to heat or to cool the heat medium. That is, the intermediate heat exchanger generates hot water or cold water. The hot water or cold water generated by the relay unit 2 is conveyed, by a heat medium conveyance device (will be described later), through the pipes 5 to the indoor units 3 and is used by the indoor units 3 for a heating operation or a cooling operation for the indoor space 7.

[0014] As the heat-source side refrigerant flowing through the refrigerant pipes 4, for example, a single refrigerant, such as R-22 or R-134a, a near-azeotropic refrigerant mixture, such as R-410A or R-404A, a non-azeotropic refrigerant mixture, such as R-407C, a refrigerant, such as $CF_3CF = CH_2$, containing a double bond in its chemical formula and having a relatively low global warming potential, a mixture containing the refrigerant, or a natural refrigerant, such as CO_2 or propane, can be used.

[0015] In contrast, as a heat medium flowing through the pipes 5, for example, water, antifreeze, a mixed solution of water and antifreeze, a mixed solution of water and an additive with high anticorrosive effect, or the like can be used.

[0016] As illustrated in Fig. 1, in the air-conditioning apparatus according to Embodiment 1, the outdoor unit 1 and the relay unit 2 are connected by the two refrigerant pipes 4, and the relay unit 2 and each of the indoor units 3 are connected by the two pipes 5. As described above, in the air-conditioning apparatus according to Embodiment 1, since individual units (the outdoor unit 1, the indoor units 3, and the relay unit 2) are connected using two pipes (the refrigerant pipes 4 and the pipes 5), simple construction can be achieved.

[0017] In Fig. 1, the state is illustrated as an example in which the relay unit 2 is installed in a space above the ceiling or the like (for example, simply referred to as a space 8), such as a space that is inside the structure 9 but is different from the indoor space 7. The relay unit 2 may be installed in a shared space or the like where an elevator or the like is located. Furthermore, although the case where the indoor units 3 are of a ceiling cassette type is illustrated as an example in Fig. 1, the type of the indoor units 3 is not necessarily of a ceiling cassette type. The indoor units 3 may be of any type, such as a ceiling-concealed type or a ceiling-hung type, as long as they are capable of blowing heating air or cooling air to the indoor space 7 directly or via ducts or the like.

[0018] Although the case where the outdoor unit 1 is installed in the outdoor space 6 is illustrated as an example in Fig. 1, the outdoor unit 1 is not necessarily installed in the outdoor space 6. For example, the outdoor unit 1 may be installed in a surrounded space such as a machine room provided with a ventilating opening. The outdoor unit 1 may be installed inside the structure 9 as long as waste heat can be discharged outside the structure 9 through an exhaust duct, or the outdoor unit 1 of a water-cooled type may be installed inside the structure 9. Even in the case where the outdoor unit 1 is installed in the above-mentioned place, a particular problem does not occur.

[0019] Furthermore, the relay unit 2 may be installed in the vicinity of the outdoor unit 1. However, if the distance from the relay unit 2 to each of the indoor units 3 is too long, the conveyance power for a heat medium is significantly increased. Accordingly, it is necessary to heed that the energy-saving effect is reduced. Furthermore, the number of the outdoor unit 1, the indoor units 3, and the relay unit 2 that are connected is not necessarily equal to the number illustrated in Fig. 1. The number of the outdoor unit 1, the indoor units 3, and the relay unit 2 that are connected can be determined in accordance with the structure 9 for which the air-conditioning apparatus according to Embodiment 1 is installed.

[0020] A plurality of relay units 2 may be connected to a single outdoor unit 1. In this case, the plurality of relay units 2 may be installed in different places in a shared space or a space above the ceiling in a structure such as a building. With this installation, the air-conditioning load can be compensated by intermediate heat exchangers in the individual relay units 2. Furthermore, the indoor units 3 can be installed at a distance or a height within a conveyance allowable range of the heat medium conveyance devices of the individual relay units 2, and the indoor units 3 can be arranged for the entire structure such as a building.

[0021] Fig. 2 is a schematic circuit diagram illustrating an example of the circuit configuration of the air-conditioning apparatus (hereinafter, referred to as the air-conditioning apparatus 100) according to Embodiment 1. The configuration of the air-conditioning apparatus 100, that is, operation of individual actuators configuring a refrigerant circuit, will be explained in detail with reference to Fig. 2. As illustrated in Fig. 2, the outdoor unit 1 and the relay unit 2 are connected by the refrigerant pipes 4 through an intermediate heat exchanger (refrigerant/water heat exchanger) 25a and an intermediate heat exchanger (refrigerant/water heat exchanger) 25b that are provided in the relay unit 2. In addition, the relay unit 2 and each of the indoor units 3 are connected by the pipes 5 through the intermediate heat exchanger 25a and the intermediate heat exchanger 25b.

[Outdoor unit 1]

[0022] A compressor 10, a first refrigerant flow switching device 11 having a four-way valve or the like, a heat-source-side heat exchanger 12, and an accumulator 19 are connected in series by the refrigerant pipes 4 and are mounted in the outdoor unit 1. Furthermore, a refrigerant connecting pipe 4a, a refrigerant connecting pipe 4b, a check valve 13a, a check valve 13b, a check valve 13c, and a check valve 13d are provided in the outdoor unit 1. With the provision of the refrigerant connecting pipe 4a, the refrigerant connecting pipe 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d, the flow of the heat-source side refrigerant caused to be flowed into the relay unit 2 can be maintained in a constant direction, irrespective of operation required by the indoor units 3.

[0023] The compressor 10 sucks the heat-source side refrigerant, compresses the heat-source side refrigerant into a high-temperature and high-pressure state, and conveys the heat-source side refrigerant in that state to the refrigerant circuit A. The compressor 10 includes, for example, an inverter compressor or the like for which capacity control can be performed. The first refrigerant flow switching device 11 performs switching between the flow of the heat-source side refrigerant at the time of a heating operation (at the time in a heating only operation mode and in a heating main operation mode) and the flow of the heat-source side refrigerant at the time of a cooling operation (at the time in a cooling only operation mode and in a cooling main operation mode).

[0024] The heat-source-side heat exchanger 12 functions as an evaporator at the time of a heating operation and functions as a condenser (or a radiator) at the time of a cooling operation. The heat-source-side heat exchanger 12 performs heat exchange between air fluid supplied from an air-sending device such as a fan or the like, which is not illustrated, and the heat-source side refrigerant, and evaporates and gasifies or condenses and liquefies the heat-source side refrigerant. The accumulator 19 is arranged on the suction side of the compressor 10. The accumulator 19 accumulates a surplus refrigerant caused by a difference between the time of a heating operation and the time of a cooling operation or a surplus refrigerant for a transient operation change.

[0025] The check valve 13c is arranged at the refrigerant pipe 4 between the relay unit 2 and the first refrigerant flow switching device 11 and allows the heat-source side refrigerant to flow only in a specific direction (the direction from the relay unit 2 to the outdoor unit 1). The check valve 13a is arranged at the refrigerant pipe 4 between the heat-source-side heat exchanger 12 and the relay unit 2 and allows the heat-source side refrigerant to flow only in a specific direction (the direction from the outdoor unit 1 to the relay unit 2). The check valve 13d is arranged at the refrigerant connecting pipe 4a and allows the heat-source side refrigerant discharged from the compressor 10 at the time of a heating operation to flow to the relay unit 2. The checked valve 13b is arranged at the refrigerant connecting pipe 4b and allows the heat-source side refrigerant returned from the relay unit 2 at the time of a heating operation to flow to the suction side of the compressor 10.

[0026] The refrigerant connecting pipe 4a connects the refrigerant pipe 4 between the first refrigerant flow switching device 11 and the check valve 13c to the refrigerant pipe 4 between the check valve 13a and the relay unit 2 in the outdoor unit 1. The refrigerant connecting pipe 4b connects the refrigerant pipe 4 between the check valve 13c and the relay unit 2 to the refrigerant pipe 4 between the heat-source-side heat exchanger 12 and the check valve 13a in the outdoor unit 1. In Fig. 2, the case where the refrigerant connecting pipe 4a, the refrigerant connecting pipe 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d are provided is illustrated as an example. However, the configuration is not limited to this. The refrigerant connecting pipe 4a, the refrigerant connecting pipe 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d are not necessarily provided.

[Indoor unit 3]

[0027] Use-side heat exchangers 35 are mounted in the indoor units 3. The use-side heat exchangers 35 are connected to heat medium flow control devices 34 and second heat medium flow switching devices 33 in the relay unit 2 by the pipes 5. The use-side heat exchangers 35 perform heat exchange between air supplied from an air-sending device such as a fan, which is not illustrated, and a heat medium supplied from the relay unit 2, and generate heating air or cooling air to be supplied to the indoor space 7.

[0028] In Fig. 2, the case where four indoor units 3 are connected to the relay unit 2 is illustrated as an example, and an indoor unit 3a, an indoor unit 3b, an indoor unit 3c, and an indoor unit 3d are illustrated in that order from the top side in the drawing. Furthermore, regarding the use-side heat exchangers 35, a use-side heat exchanger 35a, a use-side heat exchanger 35b, a use-side heat exchanger 35c, and a use-side heat exchanger 35d are illustrated in that order from the top side in the drawing, in accordance with the indoor units 3a to 3d. As in Fig. 1, the number of indoor units 3 connected is not necessarily limited to four, which is illustrated in Fig. 2.

[Relay unit 2]

[0029] The relay unit 2 includes two or more intermediate heat exchangers 25. The intermediate heat exchangers 25 perform heat exchange between the heat-source side refrigerant and the heat medium and transmit cooling energy or heating energy generated by the outdoor unit 1 and stored in the heat-source side refrigerant to the heat medium. In the relay unit 2, two expansion devices 26, two opening/closing devices (an opening/closing device 27 and an opening/closing device 29), two second refrigerant flow switching devices 28, two pumps (heat medium conveyance devices) 31, four first heat medium flow switching devices 32, four second heat medium flow switching devices 33, and four heat medium flow control devices 34 are mounted.

[0030] The two intermediate heat exchangers 25 (the intermediate heat exchanger 25a and the intermediate heat exchanger 25b) function as condensers (radiators) at the time when supplying heating energy to an indoor unit 3 that is performing a heating operation, function as evaporators at the time when supplying cooling energy to an indoor unit 3 that is performing a cooling operation, perform heat exchange between the heat-source side refrigerant and the heat medium, and transmit cooling energy or heating energy generated by the outdoor unit 1 and stored in the heat-source side refrigerant to the heat medium. The intermediate heat exchanger 25a is arranged between an expansion device 26a and a second refrigerant flow switching device 28a in the refrigerant circuit A and is used for cooling the heat medium at the time of a cooling only operation or in a cooling and heating mixed operation mode. The intermediate heat exchanger 25b is arranged between an expansion device 26b and a second refrigerant flow switching device 28b in the refrigerant circuit A and is used for heating the heat medium at the time of a heating only operation and in the cooling and heating mixed operation mode.

[0031] The two expansion devices 26 (the expansion devices 26a and 26b) each has a function of a pressure reducing valve and an expansion valve and reduce the pressure of the heat-source side refrigerant to expand the heat-source side refrigerant. The expansion device 26a is arranged on the upstream side of the intermediate heat exchanger 25a in the flow of the heat-source side refrigerant at the time of a cooling operation. The expansion device 26b is arranged on the upstream side of the intermediate heat exchanger 25b in the flow of the heat-source side refrigerant at the time of a cooling operation. The two expansion devices 26 may be devices for which the opening degree can be variably controlled, for example, such as electronic expansion valves or the like.

[0032] The two opening/closing devices (the opening/closing device 27 and the opening/closing device 29) each include a solenoid valve that is capable of performing opening and closing operations by electrification, and open and close the refrigerant pipes 4. That is, opening and closing of the two opening/closing devices is controlled in accordance with an operation mode, and the two opening/closing devices perform switching of the flow of the heat-source side refrigerant, together with the second refrigerant flow switching devices 28. The opening/closing device 27 is arranged at the refrigerant pipe 4 on the inlet side of the heat-source side refrigerant (the refrigerant pipe 4 located at the lowest portion of the drawing of the refrigerant pipes 4 that connect the outdoor unit 1 to the relay unit 2). The opening/closing device 29 is arranged at a pipe (a bypass pipe 20) that connects the refrigerant pipe 4 on the inlet side of the heat-source side refrigerant to the refrigerant pipe 4 on the outlet side of the heat-source side refrigerant. The opening/closing devices 27 and 29 need to be capable of performing switching of a refrigerant flow, and for example, devices, such as electronic expansion valves, for which the opening degree can be variably controlled, may be used.

[0033] The two second refrigerant flow switching devices 28 (the second refrigerant flow switching device 28a and the second refrigerant flow switching device 28b) each include, for example, a four-way valve, and perform switching of the flow of the heat-source side refrigerant in such a manner that the intermediate heat exchangers 25 operate as condensers or evaporators in accordance with an operation mode. The second refrigerant flow switching device 28a is arranged on the downstream side of the intermediate heat exchanger 25a in the flow of the heat-source side refrigerant at the time of a cooling operation. The second refrigerant flow switching device 28b is arranged on the downstream side of the intermediate heat exchanger 25b in the flow of the heat-source side refrigerant in the cooling only operation mode.

[0034] The two pumps 31 (pumps 31 a and 31 b) allow the heat medium which flows through the pipes 5 to circulate in the heat medium circuit B. The pump 31 a is arranged for the pipes 5 between the intermediate heat exchanger 25a and the second heat medium flow switching devices 33. The pump 31 b is arranged for the pipes 5 between the intermediate heat exchanger 25b and the second heat medium flow switching devices 33. The two pumps 31 may be, for example, pumps for which capacity control can be performed, and the flow rate of the pumps 31 may be adjusted on the basis of the size of the load in the indoor units 3. Although the state in which the two pumps 31 are installed on the heat-medium outlet side of the intermediate heat exchangers 25 is illustrated as an example, it is obvious that the pumps 31 may be installed on the heat-medium inlet side of the intermediate heat exchangers 25.

[0035] The four first heat medium flow switching devices 32 (first heat medium flow switching devices 32a to 32d) each include a three-way valve or the like and perform switching of the flow of the heat medium between the intermediate heat exchanger 25a and the intermediate heat exchanger 25b. The number of the installed first heat medium flow switching devices 32 corresponds to the number of the installed indoor units 3 (here, four). One of the three ways of each of the first heat medium flow switching devices 32 is connected to the intermediate heat exchanger 25a, another one of the three ways is connected to the intermediate heat exchanger 25b, and the other one of the three ways is connected to the corresponding one of the heat medium flow control devices 34. The first heat medium flow switching devices 32 are arranged on the outlet side of the heat medium flows of the use-side heat exchangers 35. The first heat medium flow switching device 32a, the first heat medium flow switching device 32b, the first heat medium flow switching device 32c, and the first heat medium flow switching device 32d are illustrated in that order from the top side in the drawing, in accordance with the indoor units 3. Furthermore, the switching of the heat medium flow includes partial switching from one to another way as well as complete switching from one to another way.

[0036] The four second heat medium flow switching devices 33 (second heat medium flow switching devices 33a to 33d) each include a three-way valve or the like and perform switching of the flow of the heat medium between the intermediate heat exchanger 25a and the intermediate heat exchanger 25b. The number of the installed second heat medium flow switching devices 33 corresponds to the number of the installed indoor units 3 (here, four). One of the three ways of each of the second heat medium flow switching devices 33 is connected to the intermediate heat exchanger 25a, another one of the three ways is connected to the intermediate heat exchanger 25b, and the other one of the three ways is connected to the corresponding one of the use-side heat exchangers 35. The second heat medium flow switching devices 33 are arranged on the inlet side of the heat medium flows of the use-side heat exchangers 35. The second heat medium flow switching device 33a, the second heat medium flow switching device 33b, the second heat medium flow switching device 33c, and the second heat medium flow switching device 33d are illustrated in that order from the top side in the drawing, in accordance with the indoor units 3. Furthermore, the switching of the heat medium flow includes partial switching from one to another way as well as complete switching from one to another way.

[0037] The four heat medium flow control devices 34 (heat medium flow control devices 34a to 34d) each include a device for which the opening area can be controlled (for example, a two-way valve or a three-way valve whose one end is closed which is capable of controlling the flow rate in a flow by a stepping motor driving method) and control the flow rate of the heat medium flowing to the pipe 5. The number of the installed heat medium flow control devices 34 corresponds to the number of the installed indoor units 3 (here, four). One of the two ways of each of the heat medium flow control devices 34 is connected to the corresponding one of the use-side heat exchangers 35 and the other one of the two ways is connected to the corresponding one of the first heat medium flow switching devices 32. The heat medium flow control devices 34 are arranged on the outlet side of the heat medium flows of the use-side heat exchangers 35. That is, the heat medium flow control devices 34 adjust the amount of heat medium flowing into the indoor units 3 on the basis of the temperature of the heat medium flowing into the indoor units 3 and the temperature of the heat medium flowing out of the indoor units 3, and are capable of supplying an optimal amount of heat medium corresponding to the indoor load to the indoor units 3.

[0038] Here, the heat medium flow control device 34a, the heat medium flow control device 34b, the heat medium flow control device 34c, and the heat medium flow control device 34d are illustrated in that order from the top side in the drawing, in accordance with the indoor units 3. The heat medium flow control devices 34 may be arranged on the inlet side of the heat medium flows of the use-side heat exchangers 35. Furthermore, the heat medium flow control devices 34 may be arranged at positions on the inlet side of the heat medium flows of the use-side heat exchangers 35 and between the second heat medium flow switching devices 33 and the use-side heat exchangers 35. Furthermore, in the case of stopping, thermo-off, or the like, which does not require load, in the indoor units 3, by fully-closing the heat medium flow control devices 34, heat medium supply to the indoor units 3 can be stopped.

[0039] Here, in the case where devices having the function of the heat medium flow control devices 34 added thereto are used as the first heat medium flow switching devices 32 or the second heat medium flow switching devices 33, the heat medium flow control devices 34 may be omitted.

[0040] Furthermore, pressure sensors 41 (a pressure sensor 41 a and a pressure sensor 41 b) that detect the pressure of the heat-source side refrigerant flowing in the refrigerant pipes 4 are provided in the relay unit 2. Furthermore, temperature sensors 37 (temperature sensors 37a to 37d) are provided on the inlet side of heat medium flows in the relay unit 2. Information detected by such detecting devices (for example, pressure information and temperature information) is transmitted to a controller 50 that performs integrated control of the operation of the air-conditioning apparatus 100, and is used for controlling the driving frequency of the compressor 10, the rotation speed of air-sending devices, which are not illustrated, switching of the first refrigerant flow switching device 11, the driving frequency of the pumps 31, switching of the second refrigerant flow switching devices 28, switching of the flow of the heat medium, adjustment of the flow rate of the heat medium in the indoor units 3, and the like.

[0041] Furthermore, the controller 50 includes a microcomputer or the like. The controller 50 controls the individual actuators (driving components such as the pumps 31, the first heat medium flow switching devices 32, the second heat medium flow switching devices 33, the expansion devices 26, the second refrigerant flow switching devices 28, and the like) for the driving frequency of the compressor 10, the rotation speed (including ON/OFF) of the air-sending devices, switching of the first refrigerant flow switching device 11, driving of the pumps 31, the opening degree of the expansion devices 26, opening and closing of the opening/closing devices, switching of the second refrigerant flow switching devices 28, switching of the first heat medium flow switching devices 32, switching of the second heat medium flow switching devices 33, driving of the heat medium flow control devices 34, and the like, on the basis of detection information by the various detecting devices and instructions from a remote control, and executes various operation modes, which will be described later. The above-mentioned control may be performed by a controller mounted in the outdoor unit 1. In this case, the controller 50 may be configured to be mounted in the outdoor unit 1.

[0042] The pipes 5 through which the heat medium flows include pipes connected to the intermediate heat exchanger 25a and pipes connected to the intermediate heat exchanger 25b. The pipes 5 are branched out in accordance with the number of the indoor units 3 connected to the relay unit 2 (here, four branches for each pipe). The pipes 5 are connected through the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33. By controlling the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33, determination as to whether the heat medium from the intermediate heat exchanger 25a is to be flowed into the use-side heat exchangers 35 or the heat medium from the intermediate heat exchanger 25b is to be flowed into the use-side heat exchangers 35 is made.

[0043] In the air-conditioning apparatus 100, the compressor 10, the first refrigerant flow switching device 11, the heat-source-side heat exchanger 12, the opening/closing device 27, the opening/closing device 29, the second refrigerant flow switching devices 28, the refrigerant flows for the intermediate heat exchangers 25, the expansion devices 26, and the accumulator 19 are connected through the refrigerant pipes 4 to configure the refrigerant circuit A. Furthermore, the heat medium flows for the intermediate heat exchangers 25, the pumps 31, the first heat medium flow switching devices 32, the heat medium flow control devices 34, the use-side heat exchangers 35, and the second heat medium flow switching devices 33 are connected through the pipes 5 to configure a heat medium circuit B. That is, the plurality of use-side heat exchangers 35 are connected in parallel to each of the intermediate heat exchangers 25, so that the heat medium circuit B is formed as plural systems.

[0044] Accordingly, in the air-conditioning apparatus 100, the outdoor unit 1 and the relay unit 2 are connected through the intermediate heat exchanger 25a and the intermediate heat exchanger 25b provided in the relay unit 2, and the relay unit 2 and the indoor units 3 are connected through the intermediate heat exchanger 25a and the intermediate heat exchanger 25b. That is, in the air-conditioning apparatus 100, heat exchange is performed, in the intermediate heat exchanger 25a and the intermediate heat exchanger 25b, between the heat-source side refrigerant circulating in the refrigerant circuit A and the heat medium circulating in the heat medium circuit B. With this configuration, the air-conditioning apparatus 100 is capable of achieving an optimal cooling operation or heating operation corresponding to the indoor load.

[Operation mode]

[0045] Various operation modes executed by the air-conditioning apparatus 100 will be explained. The air-conditioning apparatus 100 enables each of the indoor units 3 to perform a cooling operation or a heating operation on the basis of an instruction from the indoor unit 3. That is, the air-conditioning apparatus 100 is capable of allowing all the indoor units 3 to perform the same operations and allowing the individual indoor units 3 to perform different operations.

[0046] The operation modes executed by the air-conditioning apparatus 100 include a heating only operation mode in which all of the operating indoor units 3 perform heating operations, a cooling only operation mode in which all of the operating indoor units 3 perform cooling operations, a cooling main operation mode, which is a cooling and heating mixed operation mode in which the cooling load is larger than heating load, and a heating main operation, which is a cooling and heating mixed operation mode in which the heating load is larger than the cooling load. Hereinafter, the various operation modes with respect to the flows of the heat-source side refrigerant and the heat medium will be explained.

[Heating only operation mode]

[0047] Fig. 3 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus 100 is in the heating only operation mode. With reference to Fig. 3, the heating only operation mode will be explained by way of an example of the case where heating load is generated in all the use-side heat exchangers 35a to 35d. In Fig. 3, pipes expressed by thick lines represent pipes through which the heat-source side refrigerant flows. Furthermore, in Fig. 3, the direction of the flow of the heat-source side refrigerant is expressed by solid-line arrows, and the direction of the flow of a heat medium is expressed by broken-line arrows.

[0048] In the case of the heating only operation mode illustrated in Fig. 3, the outdoor unit 1 performs switching for the first refrigerant flow switching device 11 in such a manner that the heat-source side refrigerant discharged from the compressor 10 flows into the relay unit 2 without passing through the heat-source-side heat exchanger 12. In the relay unit 2, the pump 31 a and the pump 31 b are driven and the heat medium flow control devices 34a to 34d are opened, so that the heat medium circulates between the intermediate heat exchanger 25a and each of the use-side heat exchangers 35a to 35d and between the intermediate heat exchanger 25b and each of the use-side heat exchangers 35a to 35d. Furthermore, the second refrigerant flow switching device 28a and the second refrigerant flow switching device 28b are switched to the heating side, the opening/closing device 27 is closed, and the opening/closing device 29 is opened.

[0049] First, the flow of the heat-source side refrigerant in the refrigerant circuit A will be explained.

[0050] A low-temperature and low-pressure refrigerant is compressed by the compressor 10, and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the first refrigerant flow switching device 11, flows through the refrigerant connecting pipe 4a, passes through the check valve 13d, and flows out of the outdoor unit 1. The high-temperature and high-pressure gas refrigerant that has flowed out of the outdoor unit 1 passes through the refrigerant pipe 4 and flows into the relay unit 2. The high-temperature and high-pressure gas refrigerant that has flowed into the relay unit 2 is split out, and the split flows of gas refrigerant pass through the second refrigerant flow switching device 28a and the second refrigerant flow switching device 28b and flow into the intermediate heat exchanger 25a and the intermediate heat exchanger 25b.

[0051] The flows of high-temperature and high-pressure gas refrigerant that have flowed into the intermediate heat exchanger 25a and the intermediate heat exchanger 25b are condensed and liquefied into flows of high-pressure liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit B. The flows of liquid refrigerant that have flowed out of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b are expanded by the expansion device 26a and the expansion device 26b and turn into flows of low-temperature and low-pressure two-phase refrigerant. The flows of two-phase refrigerant are merged into one and pass through the opening/closing device 29 to flow in the bypass pipe 20. The merged refrigerant flows out of the relay unit 2, passes through the refrigerant pipe 4, and flows into the outdoor unit 1 again. The refrigerant that has flowed into to the outdoor unit 1 flows through the refrigerant connecting pipe 4b, passes through the check valve 13b, and flows into the heat-source-side heat exchanger 12 operating as an evaporator.

[0052] Then, the heat-source side refrigerant that has flowed into the heat-source-side heat exchanger 12 removes heat from air in the outdoor space 6 (hereinafter, referred to as outdoor air) by the heat-source-side heat exchanger 12 and turns into a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant that has flowed out of the heat-source-side heat exchanger 12 passes through the first refrigerant flow switching device 11 and the accumulator 19, and is sucked into the compressor 10 again.

[0053] Next, the flow of the heat medium in the heat medium circuit B will be explained. In the heating only operation mode, each of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b transmits the heating energy of the heat-source side refrigerant to the heat medium, and each of the pump 31 a and the pump 31 b allows the heated heat medium to flow through the pipes 5. The flows of heat medium that have been pressurized by and that have flowed out of the pump 31 a and the pump 31 b pass through the second heat medium flow switching devices 33a to 33d, and flow into the use-side heat exchangers 35a to 35d. Then, when the heat medium transfers heat to indoor air by the use-side heat exchangers 35a to 35d, thereby heating of the indoor space 7 is performed.

[0054] Then, the heat medium flows out of the use-side heat exchangers 35a to 35d and flows into the heat medium flow control devices 34a to 34d. At this time, the heat medium flows into the use-side heat exchanges 35a to 35d in such a manner that the flow rate of the heat medium is controlled, with the operation of the heat medium flow control devices 34a to 34d, to a flow rate required for the air - conditioning load necessary for inside the room. The heat medium that has flowed out of the heat medium flow control devices 34a to 34d passes through the first heat medium flow switching devices 32a to 32d, flows into the intermediate heat exchanger 25a and the intermediate heat exchanger 25b, receives from the refrigerant side the heat quantity that corresponds to the amount supplied through the indoor units 3 to the indoor space 7, and is sucked into the pump 31 a and the pump 31 b again.

[0055] At this time, the opening degree of the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33 is set to an intermediate opening degree or an opening degree corresponding to the heat medium temperature at the exit of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b so that flows to both the intermediate heat exchanger 25a and the intermediate heat exchanger 25b can be secured. In the pipes 5 for the use-side heat exchangers 35, the heat medium flows in the direction in which the heat medium from the second heat medium flow switching devices 33 passes through the heat medium flow control devices 34 and flows into the first heat medium flow switching devices 32.

[0056] For execution of the heating only operation mode, since it is not necessary to cause the heat medium to be flowed into a use-side heat exchanger 35 in which heat load is not generated (including thermo-off), the passage is closed by the corresponding heat medium flow control device 34 so that the heat medium is not flowed into the use-side heat exchanger 35. In Fig. 3, the heat medium flows into all the use-side heat exchangers 35a to 35d due to the presence of the heat load in all the use-side heat exchangers 35a to 35d. However, when no heat load exists, the corresponding heat medium flow control device 34 is fully closed. In the case where heat load is generated again, the corresponding heat medium flow control device 34 can be opened so that the heat medium can circulate. This aspect is similarly applied to different operation modes described later.

[Heating main operation mode]

[0057] Fig. 4 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus 100 is in the heating main operation mode. With reference to Fig. 4, the heating main operation mode will be explained by way of an example of the case where heating load is generated in any of the use-side heat exchangers 35 and cooling load is generated in the other use-side heat exchangers 35. In Fig. 4, pipes expressed by thick lines represent pipes through which the heat-source side refrigerant circulates. Furthermore, in Fig. 4, the direction of the flow of the heat-source side refrigerant is expressed by solid-line arrows, and the direction of the flow of the heat medium is expressed by broken-line arrows.

[0058] In the case of the heating main operation mode illustrated in Fig. 4, the outdoor unit 1 performs switching for the first refrigerant flow switching device 11 in such a manner that the heat-source side refrigerant discharged from the compressor 10 flows into the relay unit 2 without passing through the heat-source-side heat exchanger 12. In the relay unit 2, the pump 31 a and the pump 31 b are driven and the heat medium flow control devices 34a to 34d are opened, so that the heat medium circulates between the intermediate heat exchanger 25a and a use-side heat exchanger 35 in which cooling load is generated and between the intermediate heat exchanger 25b and a use-side heat exchanger 35 in which heating load is generated. Furthermore, the second refrigerant flow switching device 28a is switched to the cooling side, the second refrigerant flow switching device 28b is switched to the heating side, the expansion device 26a is fully opened, the opening/closing device 27 is closed, and the opening/closing device 29 is closed.

[0059] First, the flow of the heat-source side refrigerant in the refrigerant circuit A will be explained.

[0060] A low-temperature and low-pressure refrigerant is compressed by the compressor 10, and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the first refrigerant flow switching device 11, flows through the refrigerant connecting pipe 4a, passes through the check valve 13d, and flows out of the outdoor unit 1. The high-temperature and high-pressure gas refrigerant that has flowed out of the outdoor unit 1 passes through the refrigerant pipe 4 and flows into the relay unit 2. The high-temperature and high-pressure gas refrigerant that has flowed into the relay unit 2 passes through the second refrigerant flow switching device 28b and flows into the intermediate heat exchanger 25b operating as a condenser.

[0061] The gas refrigerant that has flowed into the intermediate heat exchanger 25b is condensed and liquefied into a liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit B. The liquid refrigerant that has flowed out of the intermediate heat exchanger 25b is expanded by the expansion device 26b and turns into a low -pressure two-phase refrigerant. The low-pressure two-phase refrigerant passes through the expansion device 26a and flows into the intermediate heat exchanger 25a operating as an evaporator. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 25a evaporates by receiving heat from the heat medium circulating in the heat medium circuit B and thus cools the heat medium. The low-pressure two-phase refrigerant flows out of the intermediate heat exchanger 25a, passes through the second refrigerant flow switching device 28a, flows out of the relay unit 2, passes through the refrigerant pipe 4, and flows into the outdoor unit 1 again.

[0062] The low-temperature and low-pressure two-phase refrigerant that has flowed into the outdoor unit 1 passes through the refrigerant connecting pipe 4b and the check valve 13b, and flows into the heat-source-side heat exchanger 12 operating as an evaporator. Then, the refrigerant that has flowed into the heat-source-side heat exchanger 12 removes heat from outdoor air by the heat-source-side heat exchanger 12 and turns into a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant that has flowed out of the heat-source-side heat exchanger 12 passes through the first refrigerant flow switching device 11 and the accumulator 19, and is sucked into the compressor 10 again.

[0063] Here, the opening degree of the expansion device 26b is controlled such that the subcool (degree of supercooling) of a refrigerant at the exit of the intermediate heat exchanger 25b exhibits a target value. Here, the expansion device 26b may be fully opened, and the subcool may be controlled using the expansion device 26a.

[0064] Next, the flow of the heat medium in the heat medium circuit B will be explained.

[0065] In the heating main operation mode, the intermediate heat exchanger 25b transmits the heating energy of the heat-source side refrigerant to the heat medium, and the pump 31 b allows the heated heat medium to flow through the pipes 5. Furthermore, in the heating main operation mode, the intermediate heat exchanger 25a transmits the cooling energy of the heat-source side refrigerant to the heat medium, and the pump 31 a allows the cooled heat medium to flow through the pipes 5. The cooled heat medium that has been pressurized by and that has flowed out of the pump 31 a passes through a corresponding second heat medium flow switching device 33 and flows into a use-side heat exchanger 35 in which cooling load is generated, and the heat medium that has been pressurized by and that has flowed out of the pump 31 b passes through a corresponding second heat medium flow switching device 33 and flows into a use-side heat exchanger 35 in which heating load is generated.

[0066] Here, when the indoor unit 3 connected to a second heat medium flow switching device 33 is in the heating operation mode, the second heat medium flow switching device 33 is switched to the direction in which the intermediate heat exchanger 25b and the pump 31 b are connected. When the indoor unit 3 connected to a second heat medium flow switching device 33 is in the cooling operation mode, the second heat medium flow switching device 33 is switched to the direction in which the intermediate heat exchanger 25a and the pump 31 a are connected. That is, with the second heat medium flow switching device 33, the heat medium supplied to the indoor unit 3 is switched between use for heating and use for cooling.

[0067] In the use-side heat exchangers 35, when the heat medium removes heat from indoor air, a cooling operation for the indoor space 7 is performed. In the use-side heat exchangers 35, when the heat medium transfers heat to indoor air, a heating operation for the indoor space 7 is performed. At this time, the heat medium flows into the use-side heat exchangers 35 in such a manner that the flow rate of the heat medium is controlled, with the operation of the heat medium flow control devices

34, to be a flow rate required for the air conditioning load necessary for inside the room.

[0068] The heat medium which has been used for a cooling operation, which has passed through a use-side heat exchanger 35, and whose temperature has been increased passes through a corresponding heat medium flow control device 34 and a corresponding first heat medium flow switching device 32, flows into the intermediate heat exchanger 25a, and is sucked into the pump 31 a again. The heat medium which has been used for a heating operation, which has passed through a use-side heat exchanger 35, and whose temperature has been reduced passes through a corresponding heat medium flow control device 34 and a corresponding first heat medium flow switching device 32, flows into the intermediate heat exchanger 25b, and is sucked into the pump 31 b again. At this time, when the indoor unit 3 connected to a first heat medium flow switching device 32 is in the heating operation mode, the first heat medium flow switching device 32 is switched to the direction in which the intermediate heat exchanger 25b and the pump 31 b are connected. When the indoor unit 3 connected to a first heat medium flow switching device 32 is in the cooling operation mode, the first heat medium flow switching device 32 is switched to the direction in which the intermediate heat exchanger 25a and the pump 31 a are connected.

[0069] During this processing, with the operation of the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33, the heated heat medium and the cooled heat medium are not mixed together and are individually introduced into the corresponding use-side heat exchangers 35 in which the heating load and the cooling load are generated. Accordingly, the heat medium used in the heating operation mode flows into the intermediate heat exchanger 25b in which a refrigerant supplies heat as use for heating, and the heat medium used in the cooling operation mode flows into the intermediate heat exchanger 25a in which a refrigerant receives heat for use for cooling. After heat exchange is performed between each flow of the heat medium and a refrigerant, the heat medium is conveyed to the pumps 31 a and 31 b.

[0070] Here, in the pipes 5 for the use-side heat exchangers 35, for both the heating side and cooling side, the heat medium flow in the direction in which the heat medium from the second heat medium flow switching devices 33 passes through the heat medium flow control devices 34 and flow into the first heat medium flow switching devices 32.

[Cooling only operation mode]

[0071] Fig. 5 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus 100 is in the cooling only operation mode. With reference to Fig. 5, the cooling only operation mode will be explained by way of an example of the case where cooling load is generated in all the use-side heat exchangers 35a to 35d. In Fig. 5, pipes expressed by thick lines represent pipes through which the heat-source side refrigerant flows. In addition, in Fig. 5, the direction of the flow of the heat-source side refrigerant is expressed by solid-line arrows and the direction of the flow of the heat medium is expressed by broken-line arrows.

[0072] In the case of the cooling only operation mode illustrated in Fig. 5, the outdoor unit 1 performs switching for the first refrigerant flow switching device 11 in such a manner that the heat-source side refrigerant discharged from the compressor 10 flows into the heat-source-side heat exchanger 12. In the relay unit 2, the pump 31a and the pump 31 b are driven and the heat medium flow control devices 34a to 34d are opened, so that the heat medium circulates between the intermediate heat exchanger 25a and each of the use-side heat exchangers 35a to 35d and between the intermediate heat exchanger 25b and each of the use-side heat exchangers 35a to 35d. Furthermore, the second refrigerant flow switching device 28a and the second refrigerant flow switching device 28b are switched to the cooling side, the opening/closing device 27 is opened, and the opening/closing device 29 is closed.

[0073] First, the flow of the heat-source side refrigerant in the refrigerant circuit A will be explained.

[0074] A low-temperature and low-pressure refrigerant is compressed by the compressor 10 and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the first refrigerant flow switching device 11 and flows into the heat-source-side heat exchanger 12. Then, the gas refrigerant is condensed and liquefied into a high-pressure liquid refrigerant while transferring heat to outdoor air by the heat-source-side heat exchanger 12. The high-pressure liquid refrigerant that has flowed out of the heat-source-side heat exchanger 12 passes through the check valve 13a, flows out of the outdoor unit 1, passes through the refrigerant pipe 4, and flows into the relay unit 2. The high-pressure liquid refrigerant that has flowed into the relay unit 2 passes through the opening/closing device 27, is split out and expanded by the expansion device 26a and the expansion device 26b into flows of low-temperature and low-pressure two-phase refrigerant.

[0075] The flows of two-phase refrigerant flow into the intermediate heat exchanger 25a and the intermediate heat exchanger 25b operating as evaporators, and turn into low-temperature and low-pressure gas refrigerant while cooling the heat medium by removing heat from the heat medium circulating in the heat medium circuit B. The flows of gas refrigerant discharged from the intermediate heat exchanger 25a and the intermediate heat exchanger 25b pass through the second refrigerant flow switching device 28a and the second refrigerant flow switching device 28b, are merged into one. The merged gas refrigerant flows out of the relay unit 2, passes through the refrigerant pipe 4, and flows into the outdoor unit 1 again. The refrigerant that has flowed into the outdoor unit 1 passes through the check valve 13c, passes through the first refrigerant flow switching device 11 and the accumulator 19, and is sucked into the compressor 10 again.

[0076] At this time, the opening degree of the expansion devices 26 is controlled such that the superheat (degree of superheat) obtained as a difference between the temperature of the heat-source side refrigerant that flows into the intermediate heat exchangers 25 and the temperature of the heat-source side refrigerant that flows out of the intermediate heat exchangers 25 is made constant.

[0077] Next, the flow of the heat medium in the heat medium circuit B will be explained.

[0078] In the cooling only operation mode, each of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b transmits the cooling energy of the heat-source side refrigerant to the heat medium, and each of the pump 31 a and the pump 31 b allows the cooled heat medium to flow through the pipes 5. The flows of heat medium that have been pressurized by and have flowed out of the pump 31 a and the pump 31 b pass through the second heat medium flow switching devices 33a to 33d, and flow into the use-side heat exchangers 35a to 35d. When the heat medium removes heat from indoor air by the use-side heat exchangers 35a to 35d, thereby cooling of the indoor space 7 is performed.

[0079] Then, the heat medium flow out of the use-side heat exchangers 35a to 35b, and flow into the heat medium flow control devices 34a to 34d. At this time, the heat medium flow into the use-side heat exchangers 35a to 35d in such a manner that the flow rate of the heat medium is controlled, with the operation of the heat medium flow control devices 34a to 34d, to a flow rate required for the air conditioning load necessary for inside the room. The heat medium that has flowed out of the heat medium flow control devices 34a to 34d passes through the first heat medium flow switching device 32a to 32d, flows into the intermediate heat exchanger 25a and the intermediate heat exchanger 25b, provides the refrigerant side with the heat quantity that corresponds to the amount received through the indoor units 3 from air in the indoor space 7, and is sucked into the pump 31 a and the pump 31 b again.

[0080] At this time, the opening degree of the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33 is set to an intermediate opening degree or to an opening degree corresponding to the heat medium temperature at the exit of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b so that flows to both the intermediate heat exchanger 25a and the intermediate heat exchanger 25b can be secured. Here, in the pipes 5 for the use-side heat exchangers 35, the heat medium flows in the direction in which the heat medium from the second heat medium flow switching devices 33 passes through the heat medium flow control devices 34 and flows into the first heat medium flow switching devices 32.

[Cooling main operation mode]

[0081] Fig. 6 is a refrigerant circuit diagram illustrating the flow of a refrigerant when the air-conditioning apparatus 100 is in the cooling main operation mode. With reference to Fig. 6, a first cooling main operation mode will be explained by way of an example of the case where cooling load is generated in any of the use-side heat exchangers 35 and heating load is generated in the other use-side heat exchangers 35. In Fig. 6, pipes expressed by thick lines represent pipes through which the heat-source side refrigerant circulates. Furthermore, in Fig. 6, the direction of the flow of the heat-source side refrigerant is expressed by solid-line arrows and the direction of the flow of the heat medium is expressed by broken-line arrows.

[0082] In the case of the cooling main operation mode illustrated in Fig. 6, the outdoor unit 1 performs switching for the first refrigerant flow switching device 11 in such a manner that the heat-source side refrigerant discharged from the compressor 10 flows into the heat-source-side heat exchanger 12. In the relay unit 2, the pump 31a and the pump 31 b are driven and the heat medium flow control devices 34a to 34d are opened, so that the heat medium circulates between the intermediate heat exchanger 25a and a use-side heat exchanger 35 in which cooling load is generated and between the intermediate heat exchanger 25b and a use-side heat exchanger 35 in which heating load is generated. Furthermore, the second refrigerant flow switching device 28a is switched to the cooling side, the second refrigerant flow switching device 28b is switched to the heating side, the expansion device 26a is fully opened, the opening/closing device 27 is closed, and the opening/closing device 29 is closed.

[0083] First, the flow of the heat-source side refrigerant in the refrigerant circuit A will be explained.

[0084] A low-temperature and low-pressure refrigerant is compressed by the compressor 10, and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the first refrigerant flow switching device 11, and flows into the heat-source-side heat exchanger 12. Then, the gas refrigerant is condensed while transferring heat to outdoor air by the heat-source-side heat exchanger 12 and turns into a high-pressure two-phase refrigerant. The two-phase refrigerant that has flowed out of the heat-source-side heat exchanger 12 passes through the check valve 13a, flows out of the outdoor unit 1, flows through the refrigerant pipe 4, and flows into the relay unit 2. The two-phase refrigerant that has flowed into the relay unit 2 passes through the second refrigerant flow switching device 28b, and flows into the intermediate heat exchanger 25b operating as a condenser.

[0085] The two-phase refrigerant that has flowed into the intermediate heat exchanger 25b is condensed and liquefied into a liquid refrigerant while transferring heat to the heat medium circulating in the heat medium circuit

B. The liquid refrigerant that has flowed out of the intermediate heat exchanger 25b is expanded by the expansion device 26b, and turns into a low-pressure two-phase refrigerant. The low-pressure two-phase refrigerant passes through the expansion device 26a, and flows into the intermediate heat exchanger 25a operating as an evaporator. The low-pressure two-phase refrigerant that has flowed into the intermediate heat exchanger 25a turns into a low-pressure gas refrigerant while cooling the heat medium by removing heat from the heat medium circulating in the heat medium circuit B. The gas refrigerant flows out of the intermediate heat exchanger 25a, passes through the second refrigerant flow switching device 28a, flows out of the relay unit 2, passes through the refrigerant pipe 4, and flows into the outdoor unit 1 again. The heat-source side refrigerant that has flowed into the outdoor unit 1 passes through the check valve 13c, the first refrigerant flow switching device 11, and the accumulator 19, and is sucked into the compressor 10 again.

[0086] Here, the opening degree of the expansion device 26b is controlled such that the subcool (degree of supercooling) of a refrigerant at the exit of the intermediate heat exchanger 25b exhibits a target value. Here, the expansion device 26b may be fully opened, and the subcool may be controlled using the expansion device 26a.

[0087] Next, the flow of the heat medium in the heat medium circuit B will be explained. In the cooling main operation mode, the intermediate heat exchanger 25b transmits the heating energy of the heat-source side refrigerant to the heat medium, and the pump 31 b allows the heated heat medium to flow through the pipes 5. Furthermore, in the cooling main operation mode, the intermediate heat exchanger 25a transmits the cooling energy of the heat-source side refrigerant to the heat medium, and the pump 31 a allows the cooled heat medium to flow through the pipes 5. The heat medium that has been pressurized by and has flowed out of the pump 31 a and the pump 31 b passes through the second heat medium flow switching device 33a and the second heat medium flow switching device 33b, and flows into the use-side heat exchanger 35a and the use-side heat exchanger 35b.

[0088] At this time, when the indoor unit 3 connected to a second heat medium flow switching device 33 is in the heating operation mode, the second heat medium flow switching device 33 is switched to the direction in which the intermediate heat exchanger 25b and the pump 31 b are connected. When the indoor unit 3 connected to a second heat medium flow switching device 33 is in the cooling operation mode, the second heat medium flow switching device 33 is switched to the direction in which the intermediate heat exchanger 25a and the pump 31 a are connected. That is, with the second heat medium flow switching devices 33, heat medium supplied to the indoor units 3 can be switched between use for heating and use for cooling.

[0089] In the use-side heat exchangers 35, when the heat medium transfers heat to indoor air, a heating operation for the indoor space 7 is performed. In the use-side heat exchanger 35, when the heat medium removes heat from indoor air, a cooling operation for the indoor space 7 is performed. At this time, the heat medium flows into the use-side heat exchangers 35 in such a manner that the flow rate of the heat medium is controlled, with the operation of the heat medium flow control devices 34, to be a flow rate required for the air conditioning load necessary for inside the room.

[0090] The heat medium which has been used for a heating operation, which has passed through a use-side heat exchanger 35, and whose temperature has been reduced passes through a corresponding heat medium flow control device 34 and a corresponding first heat medium flow switching device 32, flows into the intermediate heat exchanger 25b, and is sucked into the pump 31 b again. The heat medium which has been used for a cooling operation, which has passed through a use-side heat exchanger 35, and whose temperature has been increased passes through a corresponding heat medium flow control device 34 and a corresponding first heat medium flow switching device 32, flows into the intermediate heat exchanger 25a, and is sucked into the pump 31 a again. At this time, when the indoor unit 3 connected to a first heat medium flow switching device 32 is in the heating operation mode, the first heat medium flow switching device 32 is switched to the direction in which the intermediate heat exchanger 25b and the pump 31 b are connected. When the indoor unit 3 connected to a first heat medium flow switching device 32 is in the cooling operation mode, the first heat medium flow switching device 32 is switched to the direction in which the intermediate heat exchanger 25a and the pump 31 a are connected.

[0091] During this processing, with the operation of the first heat medium flow switching devices 32 and the second heat medium flow switching devices 33, the heated heat medium and the cooled heat medium are not mixed together and are individually introduced into the corresponding use-side heat exchangers 35 in which the heating load and the cooling load are generated. Accordingly, the heat medium used in the heating operation mode flows into the intermediate heat exchanger 25b in which a refrigerant supplies heat as use for heating, and the heat medium used in the cooling operation flows into the intermediate heat exchanger 25a in which a refrigerant receives heat as use for cooling. After heat exchange is performed between each flow of the heat medium and a refrigerant, the heat medium is conveyed to the pumps 31 a and 31 b.

[0092] Here, in the pipes 5 for the use-side heat exchangers 35, for both the heating side and the cooling side, the heat medium flows in the direction in which the heat medium from the second heat medium flow switching devices 33 passes through the heat medium flow control devices 34 and flows into the first heat medium flow switching devices 32.

[Regarding pressure variation of refrigerant circuit A]

[0093] The air-conditioning apparatus 100 according to Embodiment 1 causes the heat medium to circulate between the relay unit 2 and the indoor units 3 (more specifically, the use-side heat exchangers 35). The pipes 5 which connect the relay unit 2 to the indoor units 3 may be about 50 meters in one way as in the case for the use in, for example, a multi-air-conditioning apparatus for buildings.

[0094] A large amount of heat medium remains in the pipes 5 for the stopped indoor units 3. Thus, for example, during the execution of operation, when a stopped indoor unit 3 is activated, the heat medium that has been supplied to an indoor unit 3 that has been operating and the heat medium that has remained during the stopping are mixed together. Accordingly, the temperature of the heat medium that passes through the intermediate heat exchanger 25a and the intermediate heat exchanger 25b suddenly changes. The sudden temperature change causes a pressure variation to occur on the refrigerant side, which may become a factor of inducing pressure anomaly.

[0095] Furthermore, regarding switching of the operation of the indoor units 3, at the time when an indoor unit 3 that has been performing a cooling operation is switched to perform a heating operation, a cooled heat medium that has been supplied to the indoor unit 3 and a heated heat medium that has been supplied to an indoor unit 3 that has been performing a heating operation are mixed together. Thus, a similar phenomenon occurs.

[0096] When some of the indoor units 3 being in operation are to stop, merely separating the heat medium having the same temperature by closing down the heat medium flow control devices 34. Accordingly, although a load variation for the amount corresponding to the stopped indoor units 3 occurs, it is predicted that the variation does not reach the degree of variation which occurs at the time when an indoor unit 3 is activated or performs switching of operation.

[0097] The above-mentioned pressure variation may occur in all the operation modes. It can be considered that the degree of influence increases in the order of the heating only operation mode, the mixed operation mode (the heating main operation mode, the cooling main operation mode), and the cooling only operation mode.

[0098] Here, the case where it is assumed that the heat medium temperature at the time of a heating operation is between 35 degrees C and 50 degrees C and the heat medium temperature at the time of a cooling operation is between 5 degrees C and 15 degrees C will be considered. In the heating only operation mode, since the temperature of the heat medium remaining in the pipes 5 of the stopped indoor units 3 reduces to a value corresponding to the outdoor temperature, the temperature difference of heat medium to be mixed together is about 50 degrees C at the largest in the case where the outdoor temperature is 0 degrees C or lower. In the mixed operation mode, when switching of the operation mode of the indoor units 3 is assumed, the temperature difference of heat medium to be mixed together is about 45 degrees C at the largest, on the basis of the temperature difference between the heat medium at the time of a heating operation and the heat medium at the time of a cooling operation. In the cooling only operation mode, when the outdoor temperature is about 35 degrees C at the highest, the temperature difference of heat medium to be mixed together is about 30 degrees C at the largest.

[0099] Here, regarding the mixed operation mode, an example of switching of the operation mode between heating and cooling has been explained. However, in the case where a stopped indoor unit 3 is activated, a result similar to the case of the heating only operation mode or the cooling only operation mode is obtained. Furthermore, the outdoor temperature represents the ambient temperature of a space in which the pipes 5 are installed, and the temperature of a space that is different from a space above the ceiling or the like (the space 8 illustrated in Fig. 1) and an indoor space (the indoor space 7 illustrated in Fig. 1) is assumed as the outdoor temperature.

[0100] In the air-conditioning apparatus 100, suppression of a pressure variation on the refrigerant side is achieved by the method described below. More specifically, the pressure variation suppressing operation is performed in such a manner that the pressure variation of the heat-source side refrigerant can be reduced by causing the heat medium to circulate in an indoor unit 3 that is scheduled to start operation and adjusting the opening degree of the corresponding heat medium flow control device 34 on the basis of the refrigerant pressure of the refrigerant pipe 4 (pressure detected by the pressure sensor 41) and the heat medium temperature of the pipe 5 connected to the indoor unit 3 that is scheduled to start operation (temperature detected by the corresponding temperature sensor 37). The pressure variation suppressing operation is performed at the time when switching of the operation mode is performed or when a stopped indoor unit 3 is activated. Although the state in which two pressure sensors 41 are installed is illustrated as an example in the drawing, two pressure sensors are not necessarily provided.

[0101] Fig. 7 is a flowchart illustrating an example of the flow of the process of a pressure variation suppressing operation performed by the air-conditioning apparatus 100. With reference to Fig. 7, the example of the flow of the process of the pressure variation suppressing operation on a heat-source-side refrigerant side performed by the air-conditioning apparatus 100 will be explained. Here, the case where a pressure variation suppressing operation is performed at the time when the use-side heat exchanger 35b is newly activated in order to perform a heating operation while the use-side heat exchanger 35a is performing a heating operation will be explained. That is, the use-side heat exchanger 35b of the indoor unit 3b is a target for a pressure variation suppressing operation.

[0102] The controller 50 configures a heating heat medium circuit that causes the heat medium to circulate in the use-side heat exchanger 35b, which is a target for a pressure variation suppressing operation, when the pressure variation suppressing operation starts. That is, the controller 50 determines the use-side heat exchanger 35b as a target for the pressure variation suppressing operation, and configures the heating heat medium circuit that causes the heat medium to circulate in the use-side heat exchanger 35b.

[0103] More specifically, the controller 50 slightly opens the heat medium flow control device 34b (step S101), and switches the first heat medium flow switching device 32b and the second heat medium flow switching device 33b to the heating side (steps S102 and S103). Here, setting the opening degree of the heat medium flow control device 34b to be slightly opened means that the opening degree is set to the minimum opening degree (a first opening degree) at which the heat medium can flow. Setting the opening degree of the heat medium flow control device 34b to the minimum opening degree allows the heat medium remaining in the use-side heat exchanger 35b and the pipe 5 to circulate. Here, heating of the heat medium may be performed by either the intermediate heat exchanger 25a or the intermediate heat exchanger 25b.

[0104] After allowing the remaining heat medium to circulate, the controller 50 compares the pressure difference Pa between before and after the indoor unit 3b is activated (pressure difference detected by the pressure sensor 41) with a predetermined specific pressure P0 (step S104). When Pa is lower than P0 (step S104; YES), the controller 50 increases the opening degree of the heat medium flow control device 34b (to a second opening degree) (step S105). Meanwhile, when Pa is equal to P0 or higher (step S104; NO), the controller 50 keeps the opening degree of the heat medium flow control device 34b the minimum opening degree. That is, the controller 50 controls the opening degree of the heat medium flow control device 34 on the basis of Pa, and reduces the pressure variation on the heat-source side refrigerant side to the minimum.

[0105] Then, the controller 50 compares the heat medium temperature Ta at the pipe 5 connected to the use-side heat exchanger 35b in the newly activated indoor unit 3b (temperature detected by the temperature sensor 37b) with a predetermined specific temperature T0 (step S106). When Ta is lower than T0 (step S106; YES), the process returns to step S104 to continue to perform the process. Meanwhile, when Ta is equal to or higher than T0 (step S106; NO), the controller 50 determines that a further pressure variation suppressing operation is not required, and terminates the pressure variation suppressing operation. Accordingly, the series of processing is terminated.

[0106] Here, in order not to greatly affect over the control of the expansion device 26, P0 is desirably set within a range up to, for example, about 6 kgf/cm^2, and more preferably, set to about 1 kgf/cm^2. Accordingly, highly-accurate suppression of a high-pressure variation for the heat-source side refrigerant that avoids the pressure variation at the time of a normal operation can be achieved. Furthermore, T0 may be set to, for example, a value similar to the heat medium return temperature at the use-side heat exchanger 35a during heating (temperature detected by the temperature sensor 37a). By setting the target temperature (T0) of the heat medium not to be higher than the heat medium return temperature at the use-side heat exchanger 35a during heating, excessive heating of the heat medium can be suppressed, and the start-up time of the newly activated indoor unit 3b can be shortened.

[0107] As described above, with the air-conditioning apparatus 100, by performing the control processing mentioned above, a pressure variation on the refrigerant side can be suppressed at the time when a heating operation of the indoor unit 3b starts. Thus, with the air-conditioning apparatus 100, system construction with high reliability without occurrence of pressure anomaly at the time of starting a heating operation can be achieved. Furthermore, with the air-conditioning apparatus 100, owing to the control processing mentioned above, a reduction in the air-outlet temperature at the indoor unit 3a that is performing a heating operation can be prevented, and an effect of not losing the comfort of a user can also be achieved. Although pressure variation suppression on the refrigerant side at the time when the indoor unit 3b starts a heating operation has been explained with reference to Fig. 7, pressure variation suppression on the refrigerant side at the time when the indoor unit 3b that is performing a cooling operation in the mixed mode is switched to perform a heating operation can be similarly dealt with.

[0108] Fig. 8 is a flowchart illustrating a different example of the flow of the process of a pressure variation suppressing operation performed by the air-conditioning apparatus 100. The different example of the flow of the process of the pressure variation suppressing operation on the heat-source side refrigerant side performed by the air-conditioning apparatus 100 will be explained with reference to Fig. 8. Here, the case where a pressure variation suppressing operation is performed when the use-side heat exchanger 35b is newly activated in order to perform a cooling operation while the use-side heat exchanger 35a is performing a cooling operation will be explained. That is, the use-side heat exchanger 35b of the indoor unit 3b is a target for a pressure variation suppressing operation. Since steps S201 to S205 illustrated in Fig. 8 are similar to steps S101 to S105 illustrated in Fig. 7, the explanation of steps S201 to S205 will be omitted.

[0109] In step S206, the controller 50 compares the heat medium temperature Ta at the pipe 5 connected to the use-side heat exchanger 35b of the newly activated indoor unit 3b (temperature detected by the temperature sensor 37b) with a predetermined specific temperature

T10. When Ta is higher than T10 (step S206; YES), the process returns to step S204 to continue to perform the process. Meanwhile, when Ta is lower than or equal to T10 (step S206; NO), the controller 50 determines that a further pressure variation suppressing operation is not required, and terminates the pressure variation suppressing operation. Accordingly, the series of processing is terminated.

[0110] Here, in order not to greatly affect the control of the expansion device 26, P0 is desirably set within a range up to, for example, about 6 kgf/cm^2, and more preferably, set to about 1 kgf/cm^2. Accordingly, highly-accurate suppression of a high-pressure variation for the heat-source side refrigerant that avoids the pressure variation at the time of a normal operation can be achieved. Furthermore, T10 may be set to, for example, a value similar to the heat medium return temperature at the use-side heat exchanger 35a during cooling (temperature detected by the temperature sensor 37a). By setting the target temperature of the heat medium (T10) not to be lower than the heat medium return temperature of the use-side heat exchanger 35a during cooling, excessive cooling of the heat medium can be suppressed, and the start-up time of the newly activated indoor unit 3b can be shortened.

[0111] As described above, the air-conditioning apparatus 100 can suppress a pressure variation on the refrigerant side, by performing the control processing mentioned above, at the time when a cooling operation of the indoor unit 3b starts. Thus, the air-conditioning apparatus 100 not only prevents pressure anomaly from occurring at the time when a heating operation starts but also prevents pressure anomaly on the refrigerant side from occurring even at the time of starting a cooling operation owing to execution of activation of the indoor unit 3, or switching of the operation mode while managing the refrigerant pressure of the refrigerant circuit A. Accordingly, system construction with high reliability without occurrence of pressure anomaly on the refrigerant side even at the time of starting a cooling operation can be achieved. Furthermore, with the air-conditioning apparatus 100, owing to the control processing mentioned above, a reduction in the air-outlet temperature at the indoor unit 3a that is performing a cooling operation can be prevented, and an effect of not losing the comfort of a user can also be achieved. Although pressure variation suppression on the refrigerant side at the time when the indoor unit 3b starts a cooling operation has been explained with reference to Fig. 8, pressure variation suppression on the refrigerant side at the time when the indoor unit 3b that is performing a heating operation in the mixed mode is switched to perform a cooling operation can be similarly dealt with.

[Method for increasing opening degree of heat medium flow control device 34]

[0112] Fig. 9 is an explanatory diagram for explaining a method for increasing the opening degree of the heat medium flow control devices 34. A method for increasing the opening degree of the heat medium flow control devices 34 performed by the air-conditioning apparatus 100, and more specifically, a method for increasing the opening degree when the opening degree is increased from a first opening degree to a second opening degree will be explained with reference to Fig. 9. In Fig. 9, six patterns of the method for increasing the opening degree of the heat medium flow control devices 34 are illustrated in a table format. Although any of the patterns illustrated in Fig. 9 may be adopted as the method for increasing the opening degree of the heat medium flow control devices 34, the pattern may be determined comprehensively based on the control structure, the influence on the system, the time to termination of a pressure variation suppressing operation, the possibility of a large variation, and the like.

(First pattern)

[0113] A first pattern is a fixed opening degree control pattern in which the speed is focused on. The first pattern is summarized in that the opening degree is fixed constant at the timing when the opening degree of the heat medium flow control devices 34 is increased and the same opening degree is maintained until a pressure variation suppressing operation ends. Regarding the details of the first pattern, the fixed opening degree of the heat medium flow control devices 34 is set to be relatively large. The first pattern has an effect in that the control structure is simple, the influence on the system is large, the time to the termination of a pressure variation suppressing operation is short, and the possibility of the occurrence of a large pressure variation is high.

(Second pattern)

[0114] A second pattern is a fixed opening degree control pattern in which the influence on the system is focused on. The second pattern is summarized in that, similar to the first pattern, the opening degree is fixed constant at the timing when the opening degree of the heat medium flow control devices 34 is increased and the same opening degree is maintained until the termination of a pressure variation suppressing operation. However, regarding the details of the second pattern, the fixed opening degree of the heat medium flow control devices 34 is set to be relatively small. The second pattern has an effect in that the control structure is simple, the influence on the system is small, the time to the termination of a pressure variation suppressing operation is long, and the possibility of the occurrence of a large pressure variation is low.

(Third pattern)

[0115] A third pattern is an inching opening degree control pattern in which the speed is focused on. The third pattern is summarized in that the opening degree is increased by a certain opening degree at the timing when the opening degree of the heat medium flow control devices 34 is increased. Regarding the details of the third pattern, the inching width of the heat medium flow control devices 34 is set to be relatively large. The third pattern has an effect in that the control structure is at an intermediate level, the influence on the system is large, the time to the termination of a pressure variation suppressing operation is short, and the possibility of the occurrence of a large pressure variation is high.

(Fourth pattern)

[0116] A fourth pattern is an inching opening degree control pattern in which the influence on the system is focused on. The fourth pattern is summarized in that, similar to the third pattern, the opening degree is increased by a certain opening degree at the timing when the opening degree of the heat medium flow control devices 34 is increased. However, regarding the details of the fourth pattern, the inching width of the heat medium flow control devices 34 is set to be relatively small. The fourth pattern has an effect in that the control structure is at the intermediate level, the influence on the system is small, the time to the termination of a pressure variation suppressing operation is long, and the possibility of the occurrence of a large pressure variation is low.

(Fifth pattern)

[0117] A fifth pattern is a target opening degree control pattern in which the speed is focused on. The fifth pattern is based on the start of a heating operation of the indoor unit 3b when T0 is used as the reference temperature. The fifth pattern is summarized in that the opening degree of the heat medium flow control devices 34 is determined on the basis of the difference between the reference temperature and a detected temperature and the target opening degree is determined at the timing when the opening degree of the heat medium flow control devices 34 is increased. Regarding the details of the fifth pattern, first, the amount of the increase of the opening degree is determined using a conversion formula $\Delta pulse = f(Am - A1)$ for converting the opening area of the heat medium flow control devices 34 into the pulse number. Here, Am represents the target opening area, and A1 represents the current opening area. In addition, based on the relationship $Am = A1 \times \Delta T1 / \Delta Tm$, $(Am - A1) = (\Delta T1 / \Delta Tm - 1) \times A1$ can be expressed. Here, ΔTm represents the target temperature difference (> 0 degrees C) from the reference temperature T0, and ΔPT represents (reference temperature (target temperature) T0 - detected temperature Ta). The fifth pattern has an effect in that the control structure is complicated, the influence on the system is at the intermediate level, the time to the termination of a pressure variation suppressing operation is short, and the possibility of the occurrence of a large pressure variation is high. Here, for a cooling operation starting pattern for the indoor unit 3b, the reference temperature is represented by T10, and the details of the formula of AT are opposite (ΔT = (detected temperature Ta - reference temperature (target temperature) T10).

(Sixth pattern)

[0118] A sixth pattern is a target opening degree control pattern in which the influence on the system is focused on. The sixth pattern is summarized in that, similar to the fifth pattern, the opening degree of the heat medium flow control devices 34 is determined on the basis of the difference between the reference temperature and the detected temperature, and the target opening degree is determined at the timing when the opening degree of the heat medium flow control devices 34 is increased. However, regarding the details of the sixth pattern, the amount of the increase of the opening degree is determined in inverse-proportion to the difference between a target temperature difference and the current temperature difference from the reference temperature. As a formula, $\Delta pulse = f(Am - A1) / (\Delta T1 - \Delta Tm)$ is expressed. The sixth pattern has an effect in that the control structure is complicated, the influence on the system is small, the time to the termination of a pressure variation suppressing operation is at the intermediate level, and the possibility of the occurrence of a large pressure variation is low.

Embodiment 2

[0119] Fig. 10 is a flowchart illustrating an example of the flow of the process of a pressure variation suppressing operation performed by an air-conditioning apparatus according to Embodiment 2 of the present invention. The example of the flow of the process of the pressure variation suppressing operation on the heat-source side refrigerant side performed by the air-conditioning apparatus according to Embodiment 2 will be explained with reference to Fig. 10. In Embodiment 2, differences from Embodiment 1 described above will be mainly explained, and the same parts as those in Embodiment 1 will be assigned with the same reference signs. Furthermore, the circuit configuration and operation modes of the air-conditioning apparatus according to Embodiment 2 are similar to those in the air-conditioning apparatus 100 according to Embodiment 1.

[0120] In Embodiment 1, the case where a pressure variation suppressing operation using the heat medium flow control devices 34 is performed on the basis of the refrigerant pressure of the refrigerant pipes 4 (pressure detected by the pressure sensors 41) has been explained as an example. Whereas, in Embodiment 2, the case where a pressure variation suppressing operation using the heat medium flow control devices 34 is performed not on the basis of the refrigerant pressure of the refrigerant pipes 4 (pressure detected by the pressure sensors

41) but on the basis of the heat medium temperature that has been flowing in the pipes 5 (temperature detected by the temperature sensors 37) will be explained as an example.

[0121] More specifically, the pressure variation suppressing operation for the air-conditioning apparatus according to Embodiment 2 is performed in such a manner that a pressure variation of a heat-source side refrigerant is suppressed by causing a heat medium to circulate in an indoor unit 3 that is scheduled to start operation and adjusting the opening degree of a corresponding heat medium flow control device 34 on the basis of the heat medium temperature of a pipe 5 connected to the operating indoor unit 3 (temperature detected by a corresponding temperature sensor 37). The pressure variation suppressing operation is performed at the time when switching of an operation mode is performed or when a stopped indoor unit 3 is activated.

[0122] Here, the case where a pressure variation suppressing operation is performed when the use-side heat exchanger 35b is newly activated in order to perform a heating operation while the use-side heat exchanger 35a is performing a heating operation will be explained. That is, the use-side heat exchanger 35b of the indoor unit 3b is a target for a pressure variation suppressing operation. The controller 50 configures a heating heat medium circuit that causes a heart medium to circulate in the use-side heat exchanger 35b, which is a target for a pressure variation suppressing operation, when the pressure variation suppressing operation starts. That is, the controller 50 determines the use-side heat exchanger 35b as a target for a pressure variation suppressing operation, and configures the heating heat medium circuit that causes the heat medium to circulate in the use-side heat exchanger 35b.

[0123] More specifically, the controller 50 slightly opens the heat medium flow control device 34b (step S301), and switches the first heat medium flow switching device 32b and the second heat medium flow switching device 33b to the heating side (steps S302 and S303). Here, setting the opening degree of the heat medium flow control device 34b to be slightly opened means that the opening degree is set to the minimum opening degree (the first opening degree) at which the heat medium can flow. Setting the opening degree of the heat medium flow control device 34b to the minimum opening degree allows the heat medium remaining in the use-side heat exchanger 35b and the pipe 5 to circulate. Here, heating of the heat medium may be performed by any of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b.

[0124] After allowing the remaining heat medium to circulate, the controller 50 compares the temperature difference Tb of heat medium flowing in the pipe 5 connected to the indoor unit 3a that is performing a heating operation before and after the indoor unit 3b is activated (the difference between heat medium temperatures detected by the temperature sensor 37) with a predetermined specific temperature T1 (step S304). When Tb is lower than T1 (step S304; YES), the controller 50 increases the opening degree of the heat medium flow control device 34b (to the second opening degree) (step S305). Meanwhile, when Tb is equal to or higher than T1 (step S304; NO), the controller 50 keeps the opening degree of the heat medium flow control device 34b the minimum opening degree. That is, the controller 50 controls the opening degree of the heat medium flow control device 34 on the basis of Tb, and reduces the pressure variation on the heat-source side refrigerant side to the minimum.

[0125] Then, the controller 50 compares the heat medium temperature Ta at the pipe 5 connected to the use-side heat exchanger 35b of the newly activated indoor unit 3b (temperature detected by the temperature sensor 37b) with a predetermined specific temperature T0 (step S306). When Ta is lower than T0 (step S306; YES), the controller 50 returns to step S304 to continue to perform the process. Meanwhile, when Ta is equal to or higher than T0 (step S306; NO), the controller 50 determines that a further pressure variation suppressing operation is not required, and terminates the pressure variation suppressing operation. Accordingly, the series of processing is terminated.

[0126] Here, in order not to greatly affect the control of the expansion device 26, T1 is desirably set within a range up to, for example, about 10 degrees C, and more preferably, set to about 1.5 degrees C. Accordingly, highly-accurate suppression of a high-pressure variation for a refrigerant that avoids a temperature variation at the time of a normal operation can be achieved. Furthermore, T0 may be set to, for example, a value similar to the heat medium return temperature at the use-side heat exchanger 35a during heating (temperature detected by the temperature sensor 37a). By setting the target temperature (T0) of the heat medium not to be higher than the heat medium return temperature at the use-side heat exchanger 35a during heating, excessive heating of the heat medium can be suppressed, and the start-up time of the newly activated indoor unit 3b can be shortened.

[0127] As described above, the air-conditioning apparatus according to Embodiment 2, by performing the control processing mentioned above, a pressure variation on the refrigerant side can be suppressed at the time when a heating operation of the indoor unit 3b starts. In other words, the air-conditioning apparatus according to Embodiment 2 executes activation of the indoor unit 3, or switching of the operation mode while managing the refrigerant pressure of the refrigerant circuit A. Accordingly, system construction with high reliability without occurrence of pressure anomaly on the refrigerant side can be achieved. Furthermore, in the air-conditioning apparatus according to Embodiment 2, the control processing mentioned above prevents a reduction in the air-outlet temperature at the indoor unit 3a that is performing a heating operation, and therefore, an effect of not losing the comfort of a user can be achieved. Although pressure variation suppression on the refrigerant side at the time when the indoor unit 3b starts a heating operation has been explained with reference to Fig. 10, pressure variation suppression on the refrigerant side at the time when the indoor unit 3b starts a cooling operation can be dealt with by changing the relationship of step S306 to the relationship of step S206 illustrated in Fig. 8.

Embodiment 3

[0128] Fig. 11 is a flowchart illustrating an example of the flow of the process of a pressure variation suppressing operation performed by an air-conditioning apparatus according to Embodiment 3 of the present invention. The example of the flow of the pressure variation suppressing operation on the heat-source side refrigerant side performed by the air-conditioning apparatus according to Embodiment 3 will be explained with reference to Fig. 11. In Embodiment 3, differences from Embodiment 1 described above will be mainly explained, and the same parts as those in Embodiment 1 will be assigned with the same reference signs. Furthermore, the circuit configuration and operation modes of the air-conditioning apparatus according to Embodiment 3 are similar to those of the air-conditioning apparatus 100 according to Embodiment 1.

[0129] In Embodiment 1, the case where a pressure variation suppressing operation using the heat medium flow control devices 34 is performed on the basis of the refrigerant pressure of the refrigerant pipes 4 (pressure detected by the pressure sensors 41) has been explained as an example. Whereas, in Embodiment 3, the case where a pressure variation suppressing operation using the heat medium flow control devices 34 is performed not on the basis of the refrigerant pressure of the refrigerant pipes 4 (pressure detected by the pressure sensors 41) but on the basis of the unit capacity of an additionally activated indoor unit 3 will be explained as an example. Here, a pressure variation suppressing operation is performed at the time when switching of an operation mode is performed or a stopped indoor unit 3 is activated.

[0130] Here, the case where a pressure variation suppressing operation is performed at the time when the use-side heat exchanger 35b is newly activated in order to perform a heating operation while the use-side heat exchanger 35a is performing a heating operation will be explained. That is, the use-side heat exchanger 35b of the indoor unit 3b is a target for a pressure variation suppressing operation. The controller 50 configures a heating heat medium circuit that causes a heat medium to circulate in the use-side heat exchanger 35b, which is a target for a pressure variation suppressing operation, when the pressure variation suppressing operation starts. That is, the controller 50 determines the use-side heat exchanger 35b as a target for a pressure variation suppressing operation, and configures the heating heat medium circuit that causes the heat medium to circulate in the use-side heat exchanger 35b.

[0131] More specifically, the controller 50 slightly opens the heat medium flow control device 34b (step S401), and switches the first heat medium flow switching device 32b and the second heat medium flow switching device 33b to the heating side (steps S402 and S403). Here, setting the opening degree of the heat medium flow control device 34b to be slightly opened means that the opening degree is set to the minimum opening degree (the first opening degree) at which the heat medium can flow. Setting the opening degree of the heat medium flow control device 34b to the minimum opening degree allows the heat medium remaining in the use-side heat exchanger 35b and the pipe 5 to circulate. Here, heating of the heat medium may be performed by any of the intermediate heat exchanger 25a and the intermediate heat exchanger 25b.

[0132] The controller 50 compares the heat medium temperature Ta at the pipe 5 connected to the use-side heat exchanger 35b of the newly activated indoor unit 3b (temperature detected by the temperature sensor 37b) with a predetermined specific temperature T0 (step S404). When Ta is lower than T0 (step S404; YES), the controller 50 increases the opening degree of the heat medium flow control device 34b (to the second opening degree) and fixes the opening degree, in proportion to the capacity of the newly activated indoor unit 3b (step S405). Meanwhile, when Ta is equal to or higher than T0 (step S404; NO), the controller 50 determines that a further pressure variation suppressing operation is not required, and terminates the pressure variation suppressing operation. Accordingly, the series of processing is terminated.

[0133] Here, regarding the fixed opening degree of a heat medium flow control device 34, for example, the opening degree at which a pressure variation on the refrigerant side can be suppressed may be deducted on the basis of the ratio of the capacity of an operating indoor unit 3 to the capacity of an indoor unit to be activated. Then, the opening degree of the heat medium flow control device 34 may be determined on the basis of the capacity ratio of the operating indoor unit 3/the indoor unit 3 to be activated. Furthermore, T0 may be set to a value similar to the heat medium return temperature at the use-side heat exchanger 35a during heating (temperature detected by the temperature sensor 37a). By setting the target temperature (T0) of the heat medium not to be higher than the heat medium return temperature at the use-side heat exchanger 35a during heating, excessive heating of the heat medium can be suppressed, and the start-up time of the newly activated indoor unit 3b can be shortened.

[0134] As described above, the air-conditioning apparatus according to Embodiment 3, by performing the control processing mentioned above, a pressure variation on the refrigerant side can be suppressed at the time when a heating operation of the indoor unit 3b starts. Thus, the air-conditioning apparatus according to Embodiment 3 executes activation of the indoor unit 3, or switching of the operation mode while managing the refrigerant pressure of the refrigerant circuit A. Accordingly, system construction with high reliability without occurrence of pressure anomaly on the refrigerant side can be achieved. Furthermore, with the air-conditioning apparatus according to Embodiment 3, owing to the control processing mentioned above, a reduction in the air-outlet temperature at the indoor unit 3a that is performing a heating operation can be prevented, and an effect of not losing the comfort of a user can also be achieved. Although pressure variation suppression on the refrigerant side at the time when the indoor unit 3b starts a heating operation has been explained with reference to Fig. 11, pressure variation suppression on the refrigerant side at the time when the indoor unit 3b performs a cooling operation can be dealt with by changing the relationship of step S404 into the relationship of step S206 illustrated in Fig. 8.

[0135] As described above, embodiments of the present invention have been individually explained. However, combining the features of the embodiments together is not denied.

[0136] Although the heat medium flow control devices 34 are used as means for adjusting the flow rate of the heat medium in Embodiments 1 to 3, the flow rate of the heat medium may be adjusted by directly inputting a control instruction to the pumps 31. Furthermore, although the second refrigerant flow switching devices 28 are illustrated as if they are four-way valves. However, the second refrigerant flow switching devices 28 are not necessarily four-way valves. The second refrigerant flow switching devices 28 may each include a plurality of two-way passage switching valves or three-way passage switching valves so that a refrigerant flows in the same manner as in the case where the second refrigerant flow switching devices 28 each includes a four-way valve.

[0137] Furthermore, it is needless to mention that the same applies to the case where only one use-side heat exchanger 35 and one heat medium flow control device 34 are connected. Furthermore, obviously, there is no problem in that as the intermediate heat exchangers 25 and the expansion devices 26, a plurality of devices that perform the same operations are provided. Furthermore, although the case where the heat medium flow control devices 34 are built in the relay unit 2 has been explained as an example, the heat medium flow control devices 34 are not necessarily built in the relay unit 2. The heat medium flow control devices 34 may be built in the indoor units 3 or may be configured independent of the relay unit 2 and the indoor units 3.

[0138] As a heat medium, for example, brine (antifreeze), water, a liquid mixture of brine and water, a liquid mixture of water and an additive having a high anticorrosive effect, or the like may be used. Thus, in the air-conditioning apparatus 100, even if a heat medium leaks through the indoor units 3 to the indoor space 7, since a highly safe material is used for a heat medium, the use of the highly safe material contributes to improvement in the safety.

[0139] In the embodiments described above, the case where the air-conditioning apparatus 100 includes the accumulator 19 has been explained as an example. However, the accumulator 19 is not necessarily provided. Furthermore, in general, an air-sending device is often mounted in each of the heat-source-side heat exchanger 12 and the use-side heat exchangers 35 so that condensation or evaporation is promoted by air sending. However, an air-sending device is not necessarily mounted in each of the heat-source-side heat exchanger 12 and the use-side heat exchangers 35. For example, panel heaters or the like that use radiation may be used as the use-side heat exchangers 35, and a device of a water cooled type that transports heat with water or antifreeze may be used as the heat-source-side heat exchanger 12. That is, devices of any type may be used as the heat-source-side heat exchanger 12 and the use-side heat exchangers 35 as long as they have a configuration capable of transferring or removing heat.

[0140] In the embodiments described above, the case where four use-side heat exchangers 35 are provided has been explained as an example. However, the number of use-side heat exchangers 35 is not particularly limited. Furthermore, the case where two intermediate heat exchangers, the intermediate heat exchanger 25a and the intermediate heat exchanger 25b, are provided has been explained as an example. However, obviously, the two intermediate heat exchangers are not necessarily provided. Any number of intermediate heat exchangers can be provided as long as they are configured to be capable of cooling and/or heating a heat medium. Furthermore, the number of each of the pump 31 a and the pump 31 b to be provided
is not necessarily limited to one. A plurality of small-capacity pumps may be arranged in parallel to one another.

[0141] Furthermore, with the air-conditioning apparatuses according to Embodiments 1 to 3, not only can the safety be improved without causing the heat-source side refrigerant to circulate in the indoor units 3 or circulate near the indoor units 3, but system construction with high reliability can also be achieved, which ensures the improvement in the energy efficiency. Furthermore, with the air-conditioning apparatuses according to Embodiments 1 to 3, since the length of the pipes 5 can be shortened, energy saving can be achieved. Furthermore, with the air-conditioning apparatus according to Embodiments 1 to 3, the number of connecting pipes (refrigerant pipes 4, pipes 5) between the outdoor unit 1 and the relay unit 2 or the indoor units 3 can be reduced, thus improving the workability.

Reference Signs List

[0142] 1 outdoor unit, 2 relay unit, 3 indoor unit, 3a indoor unit, 3b indoor unit, 3c indoor unit, 3d indoor unit, 4 refrigerant pipe, 4a refrigerant connecting pipe, 4b refrigerant connecting pipe, 5 pipe, 6 outdoor space, 7 indoor space, 8 space, 9 structure, 10 compressor, 11 first refrigerant flow switching device, 12 heat-source-side heat exchanger, 13a check valve, 13b check valve, 13c check valve, 13d check valve, 19 accumulator, 20 bypass pipe, 25 intermediate heat exchanger, 25a intermediate heat exchanger, 25b intermediate heat exchanger, 26 expansion device, 26a expansion device, 26b expansion device, 27 opening/closing device, 28 second refrigerant flow switching device, 28a second refrigerant flow switching device, 28b second refrigerant flow switching device, 29 opening/closing device, 31 pump, 31 a pump, 31 b pump, 32 first heat medium flow switching device, 32a first heat medium flow switching device, 32b first heat medium flow switching device, 32c first heat medium flow switching device, 32d first heat medium flow switching device, 33 second heat medium flow switching device, 33a second heat medium flow switching device, 33b second heat medium flow switching device, 33c second heat medium flow switching device, 33d second heat medium flow switching device, 34 heat medium flow control device, 34a heat medium flow control device, 34b heat medium flow control device, 34c heat medium flow control device, 34d heat medium flow control device, 35 use-side heat exchanger, 35a use-side heat exchanger, 35b use-side heat exchanger, 35c use-side heat exchanger, 35d use-side heat exchanger, 37 temperature sensor, 37a temperature sensor, 37b temperature sensor, 37c temperature sensor, 37d temperature sensor,, 41 pressure sensor, 41 a pressure sensor, 41 b pressure sensor, 50 controller, 100 air-conditioning apparatus, A refrigerant circuit, B heat medium circuit

Claims

1. An air-conditioning apparatus comprising:

a refrigerant circuit in which a compressor, a heat-source-side heat exchanger, a plurality of expansion devices, refrigerant-side flows of a plurality of intermediate heat exchangers, and a plurality of refrigerant flow switching devices that perform switching of circulation paths are connected with refrigerant pipes, through which a heat-source-side refrigerant circulates;

a heat medium circuit in which pumps, a plurality of use-side heat exchangers, heat medium flow control devices, and heat-medium-side flows of the intermediate heat exchangers are connected with heat medium pipes, through which a heat medium circulates; and

a controller that controls an opening degree of at least one of the heat medium flow control devices to adjust a flow rate of the heat medium, wherein, the controller performs a pressure variation suppressing operation for suppressing a refrigerant pressure variation on a side of the refrigerant circuit by controlling the at least one of the heat medium flow control devices to have a first opening degree so as to allow a certain amount of heat medium to flow through at least one of the use-side heat exchangers of the plurality of the use-side heat exchangers, before the at least one of the use-side heat exchangers of the plurality of the use-side heat exchangers starts operation or performs switching of an operation mode.

2. The air-conditioning apparatus of claim 1, wherein the controller,
after controlling the at least one heat medium flow control devices to have the first opening degree, compares a preset predetermined pressure with a pressure difference between a pressure of the heat-source side refrigerant before the at least one of the heat medium flow control devices is set to have the first opening degree and a pressure of the heat-source side refrigerant after the at least one of the heat medium flow control devices is set to have the first opening degree, and
when the pressure difference is smaller than the predetermined pressure, the controller controls the at least one of the heat medium flow control devices whose opening degree has been controlled to the first opening degree to have a second opening degree that is greater than the first opening degree.

3. The air-conditioning apparatus of claim 2, wherein the predetermined pressure is set within a range up to 6 kgf/cm^2.

4. The air-conditioning apparatus of claim 1, wherein, the controller,
after controlling the at least one of the heat medium flow control devices to have the first opening degree, compares a preset predetermined temperature with a temperature difference between a temperature of the heat medium before the at least one of the heat medium flow control devices is set to have the first opening degree and a temperature of the heat medium after the at least one of the heat medium flow control devices is set to have the first opening degree and
when the temperature difference is lower than the predetermined temperature, controls the at least one of the heat medium flow control devices whose opening degree has been controlled to the first opening degree to have a second opening degree that is greater than the first opening degree.

5. The air-conditioning apparatus of claim 4, wherein the predetermined temperature is set within a range up to 10 degrees C.

6. The air-conditioning apparatus of any one of claims 2 to 5, wherein,
the controller,

when the pressure difference is equal to or greater than the predetermined pressure or after the at least one of the heat medium flow control devices is set to have the second opening degree,
compares a preset predetermined temperature with a temperature of the heat medium circulating in the at least one of the use-side heat exchangers to which the corresponding heat medium flow control device whose opening degree has been controlled to the second opening degree is connected, and
terminates the pressure variation suppressing operation in respective cases where the temperature of the heat medium is equal to or higher than the predetermined temperature at a time when the at least one of the use-side heat exchangers being in operation of the plurality of the use-side heat exchangers is performing a heating operation and where the temperature of the heat medium is lower than or equal to the predetermined temperature at a time when the at least one of the use-side heat exchangers being in operation of the plurality of the use-side heat exchangers is performing a cooling operation.

7. The air-conditioning apparatus of claim 1, wherein, the controller,
when a temperature of the heat medium circulating in the at least one of the use-side heat exchangers to which the corresponding heat medium flow control device whose opening degree has been controlled to the first opening degree is connected is lower than a preset predetermined temperature,
controls the at least one of the heat medium flow control devices whose opening degree has been controlled to the first opening degree to have a second opening degree that is greater than the first opening degree, in proportion to a capacity of an indoor unit including the at least one of the use-side heat exchangers to which the corresponding heat medium flow control device whose opening degree has been controlled to the first opening degree is connected.

8. The air-conditioning apparatus of claim 7, wherein, the controller,
compares the preset predetermined temperature with the temperature of the heat medium circulating in the at least one of the use-side heat exchangers to which the corresponding heat medium flow control device whose opening degree has been controlled to the first opening degree is connected, and
terminates the pressure variation suppressing operation in respective cases where the temperature of the heat medium is equal to or higher than the predetermined temperature at a time when the at least one of the use-side heat exchangers being in operation of the plurality of he use-side heat exchangers is performing a heating operation and where the temperature of the heat medium is lower than or equal to the predetermined temperature at a time when the at least one of the use-side heat exchangers being in operation of the plurality of the use-side heat exchangers is performing a cooling operation.

9. The air-conditioning apparatus of claim 2, 4, or 7, wherein the controller fixes the opening degree of the at least one of the heat medium flow control devices to the second opening degree.

10. The air-conditioning apparatus of claim 2, 4, or 7, wherein the controller increases the opening degree of the at least one of the heat medium flow control devices by a certain opening degree to the second opening degree.

11. The air-conditioning apparatus of claim 2, 4, or 7, wherein the controller determines a target opening degree of the second opening degree by calculation based on the predetermined temperature and the temperature difference.

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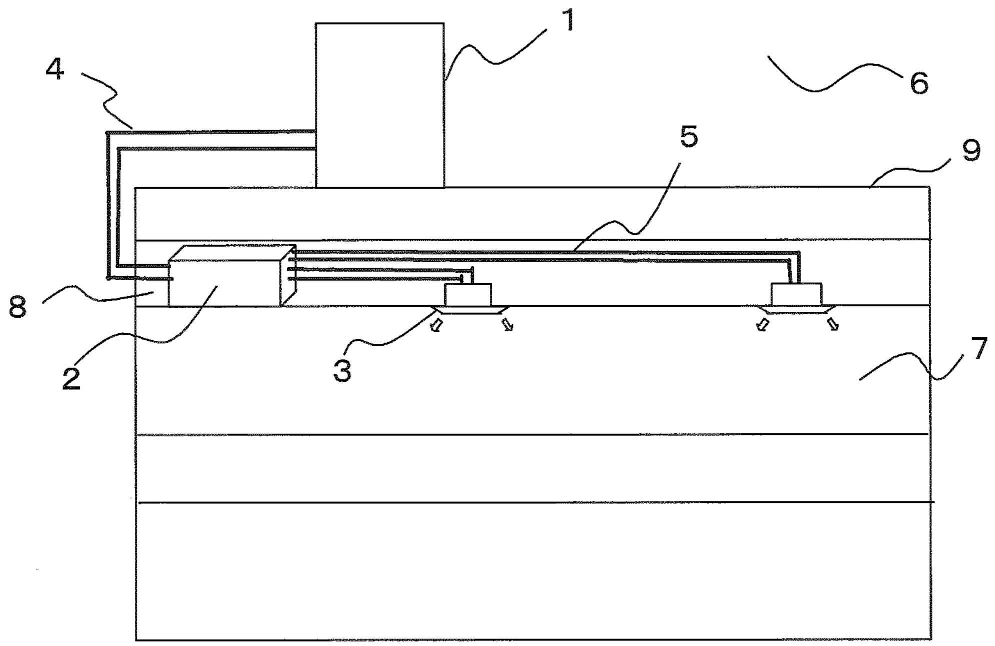
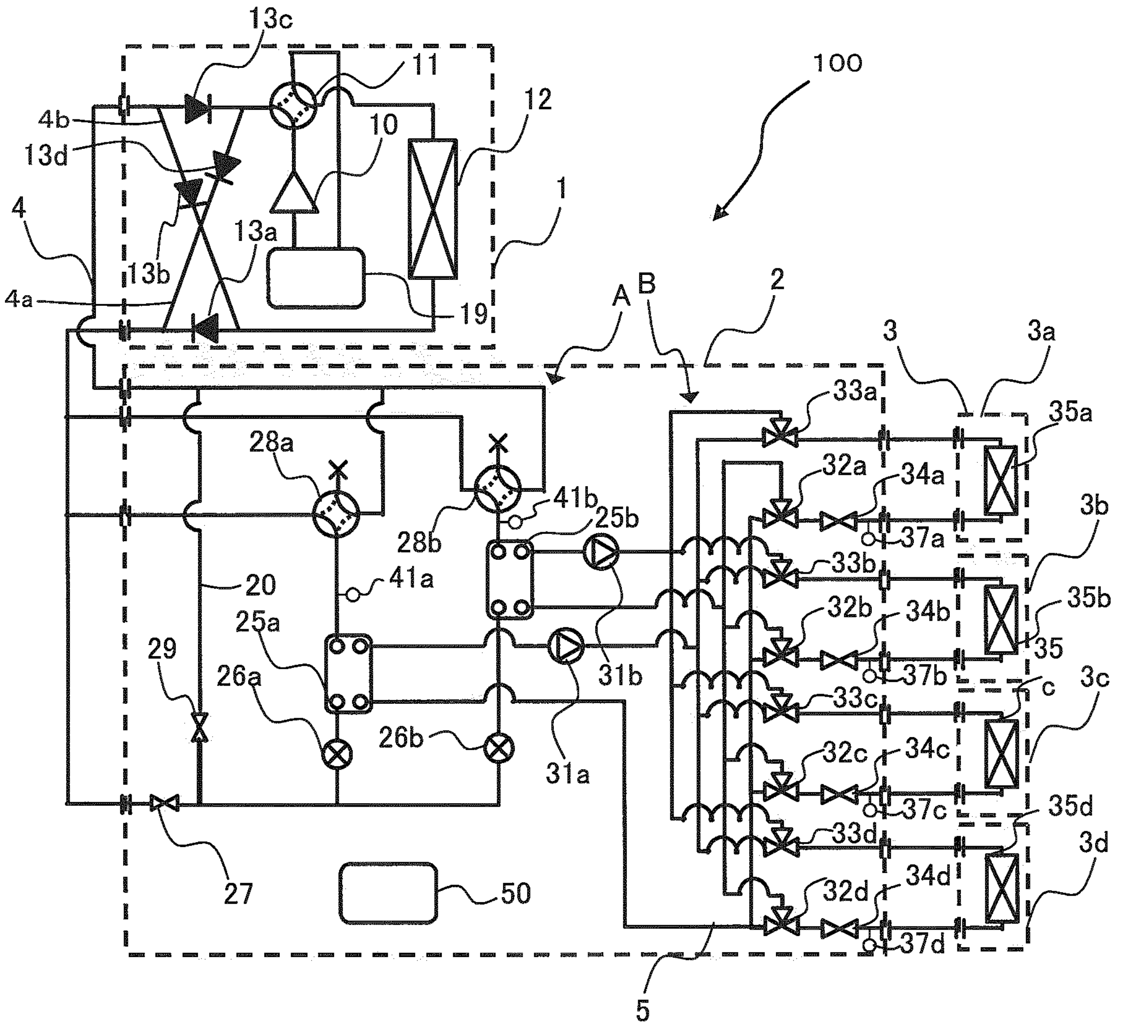


FIG. 2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25a
32b
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26a
31b
37b
33c
c
3c
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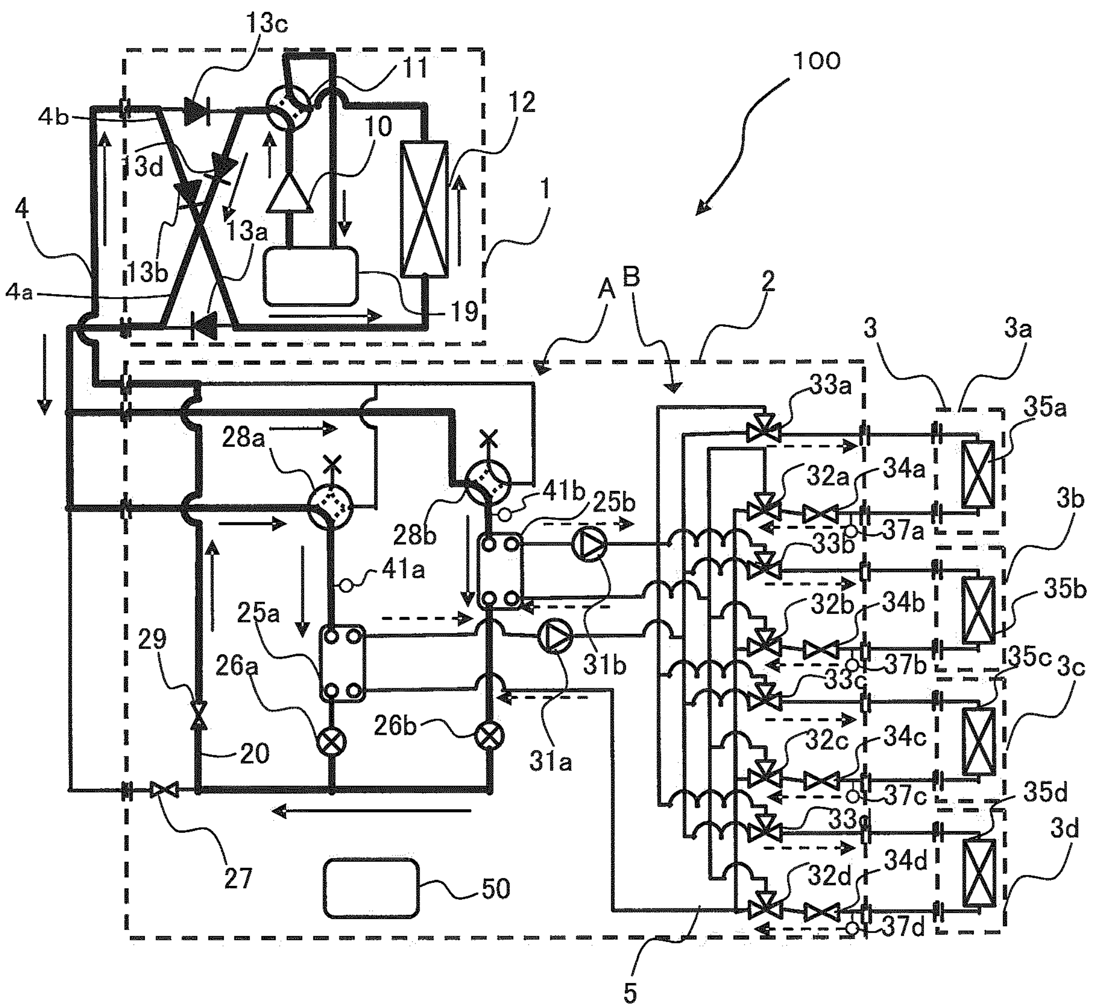
37d
5

F I G. 3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F I G. 4

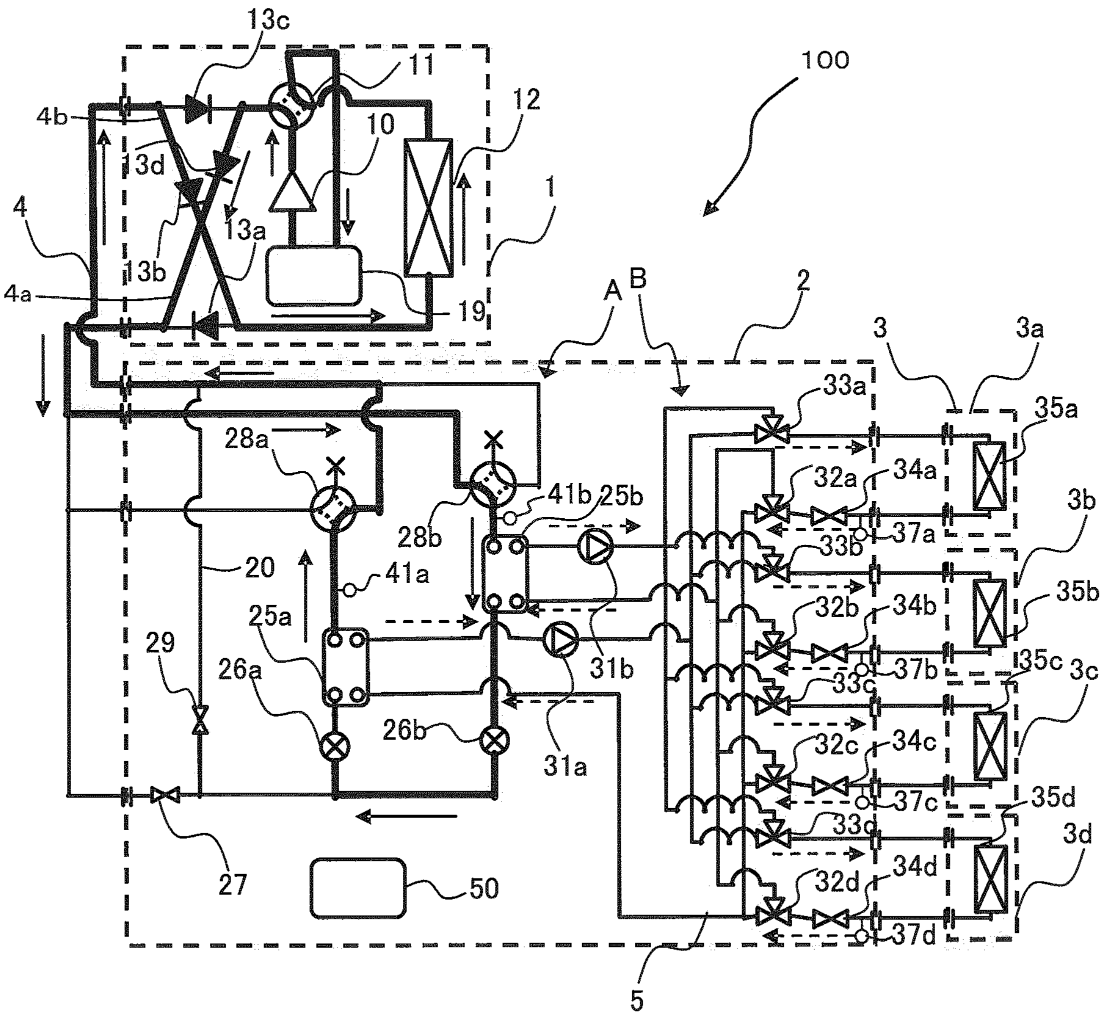
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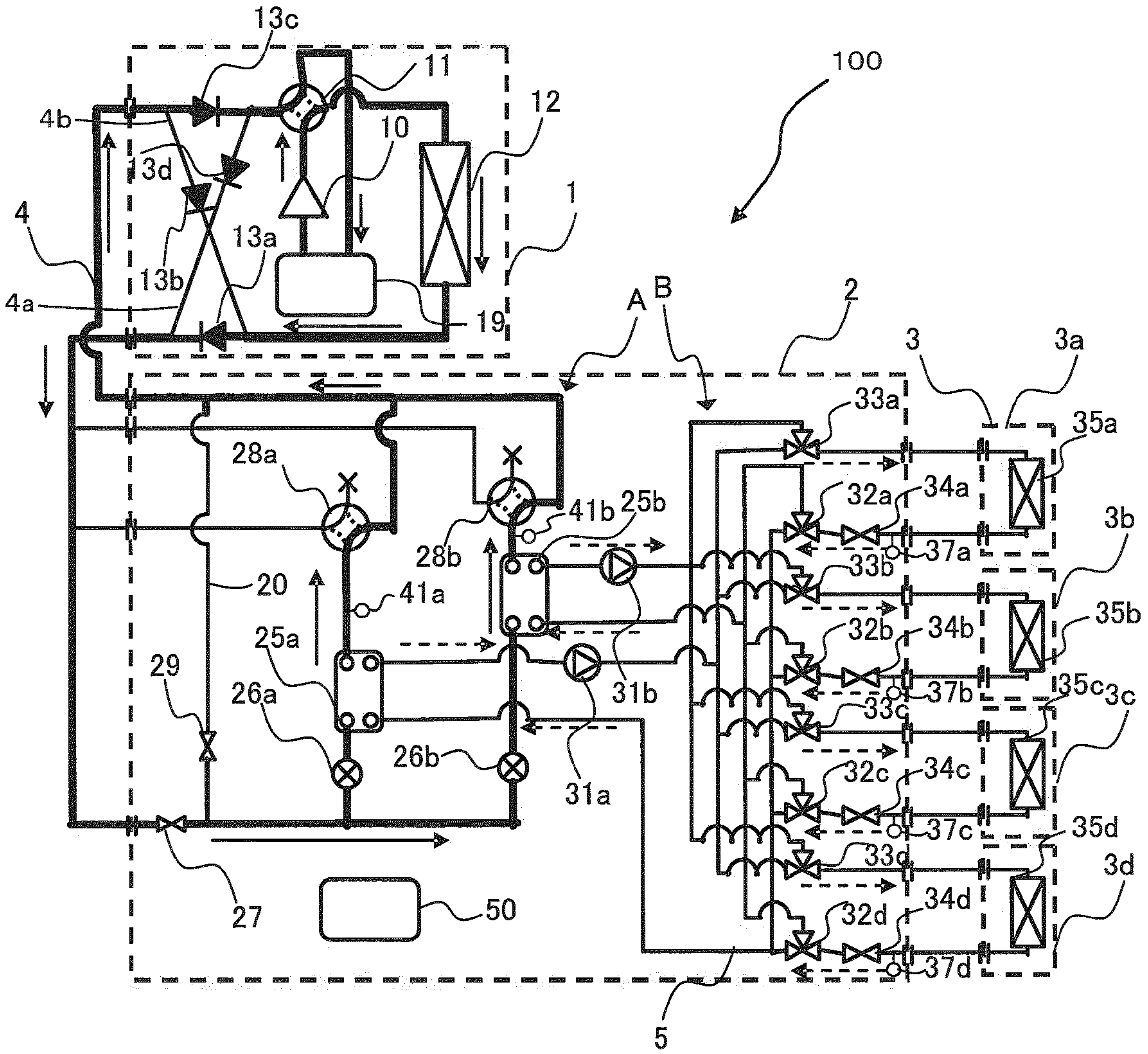
FIG. 5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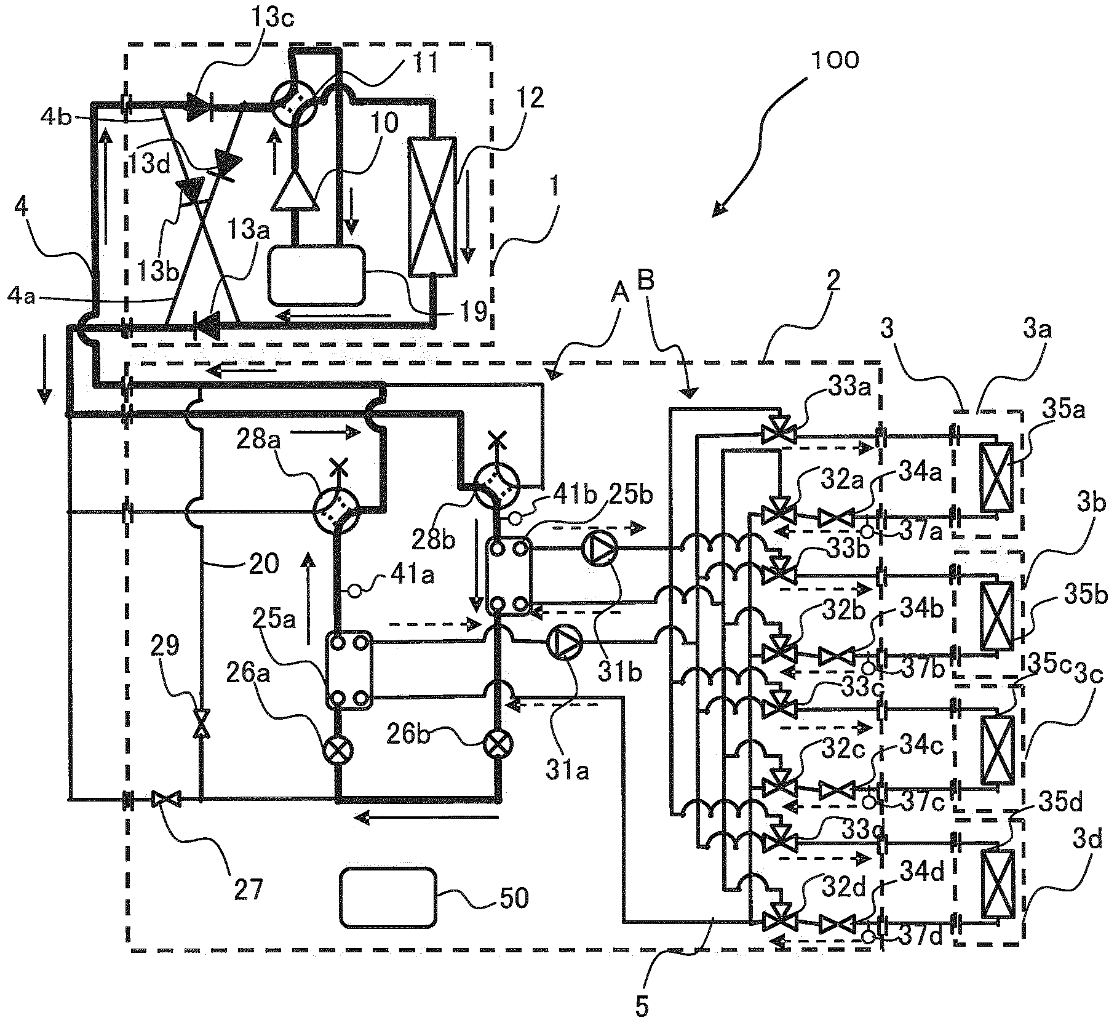
F I G. 6



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31b
37b
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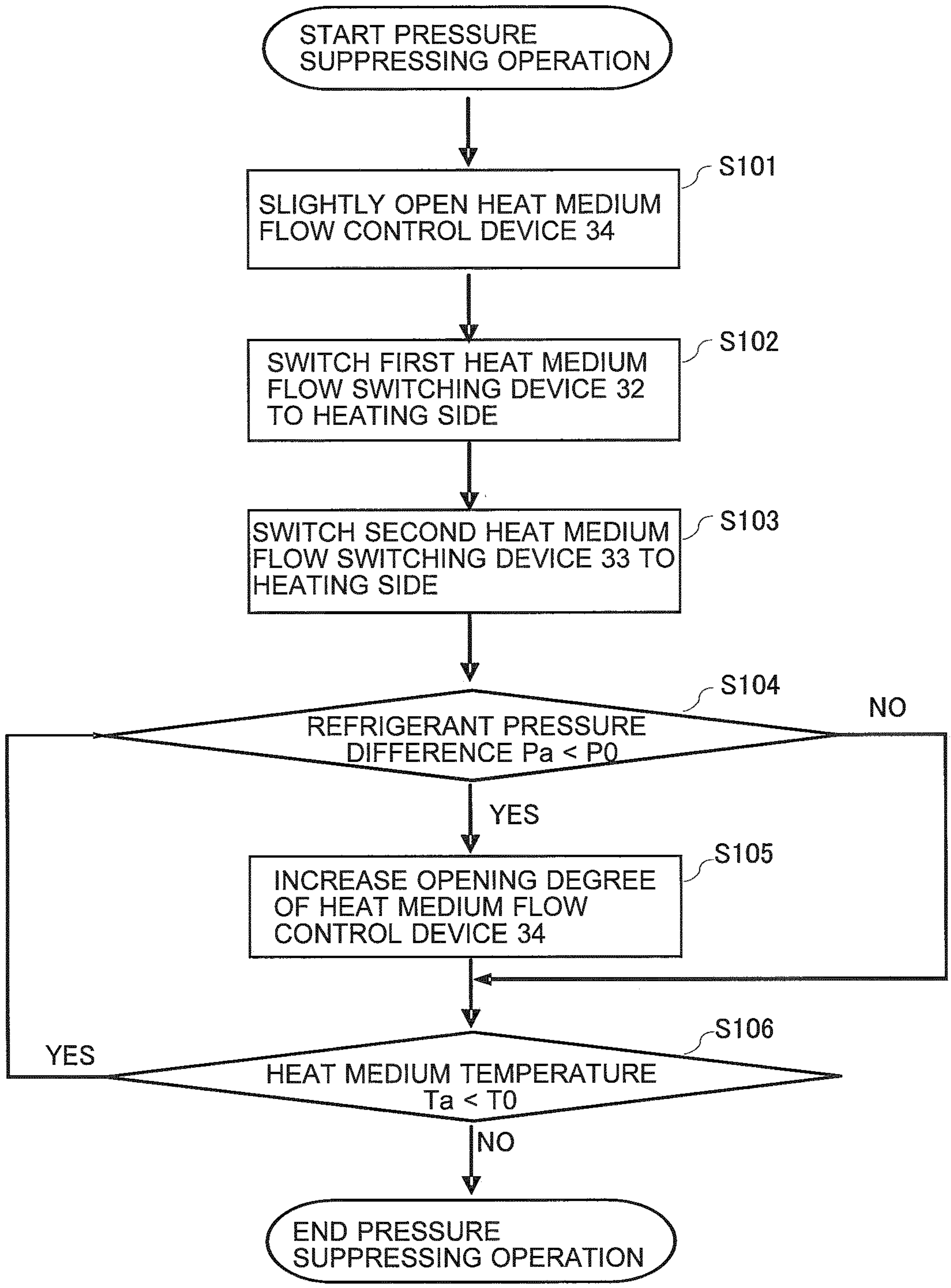
F I G. 7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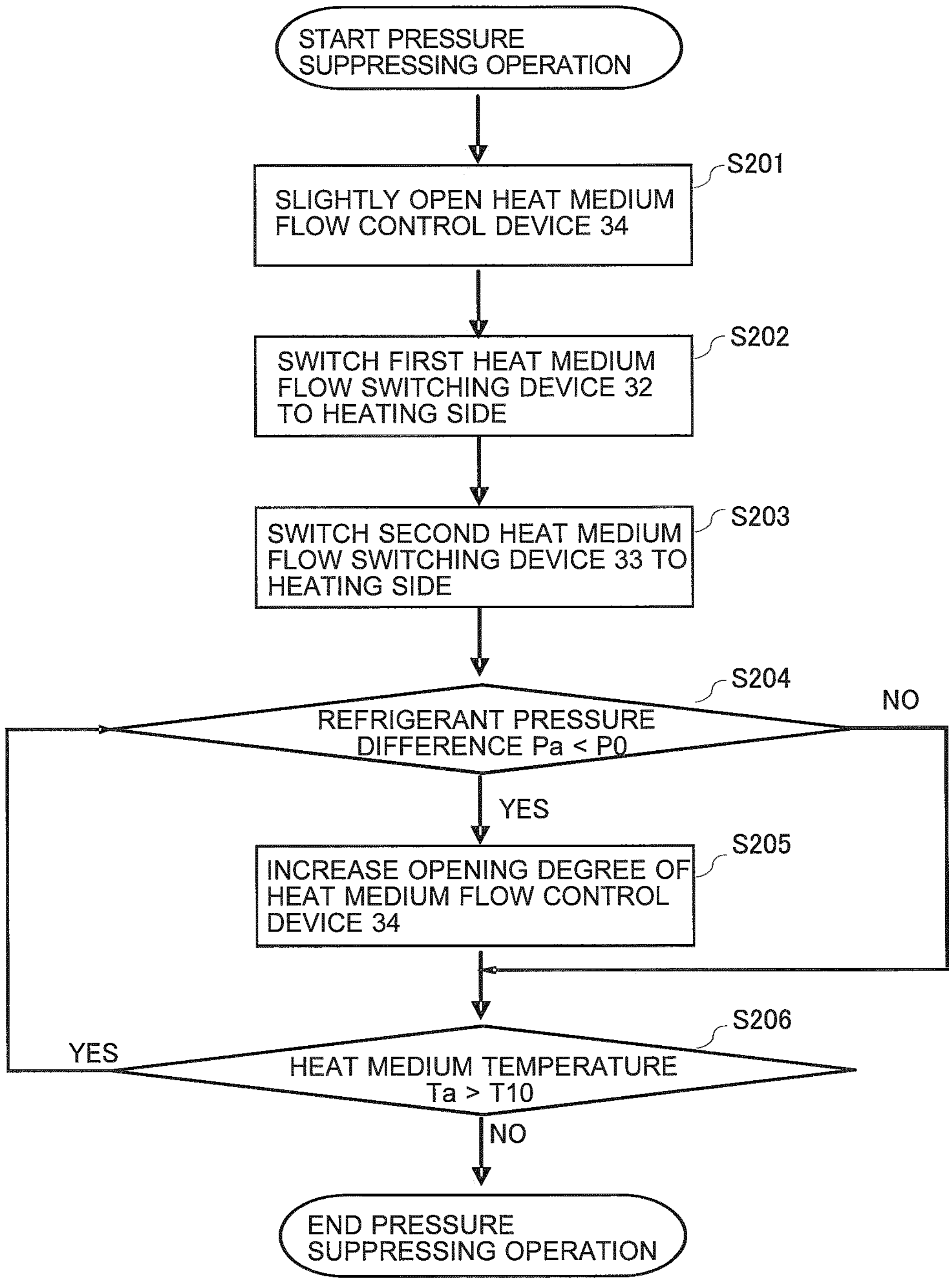
S102
SWITCH FIRST HEAT MEDIUM FLOW SWITCHING DEVICE 32 TO HEATING SIDE
S103
SWITCH SECOND HEAT MEDIUM FLOW SWITCHING DEVICE 33 TO HEATING SIDE
S104
REFRIGERANT PRESSURE DIFFERENCE Pa < P0
NO
YES
S105
INCREASE OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE 34
S106
YES
HEAT MEDIUM TEMPERATURE Ta < T0
NO
END PRESSURE SUPPRESSING OPERATION

F I G. 8

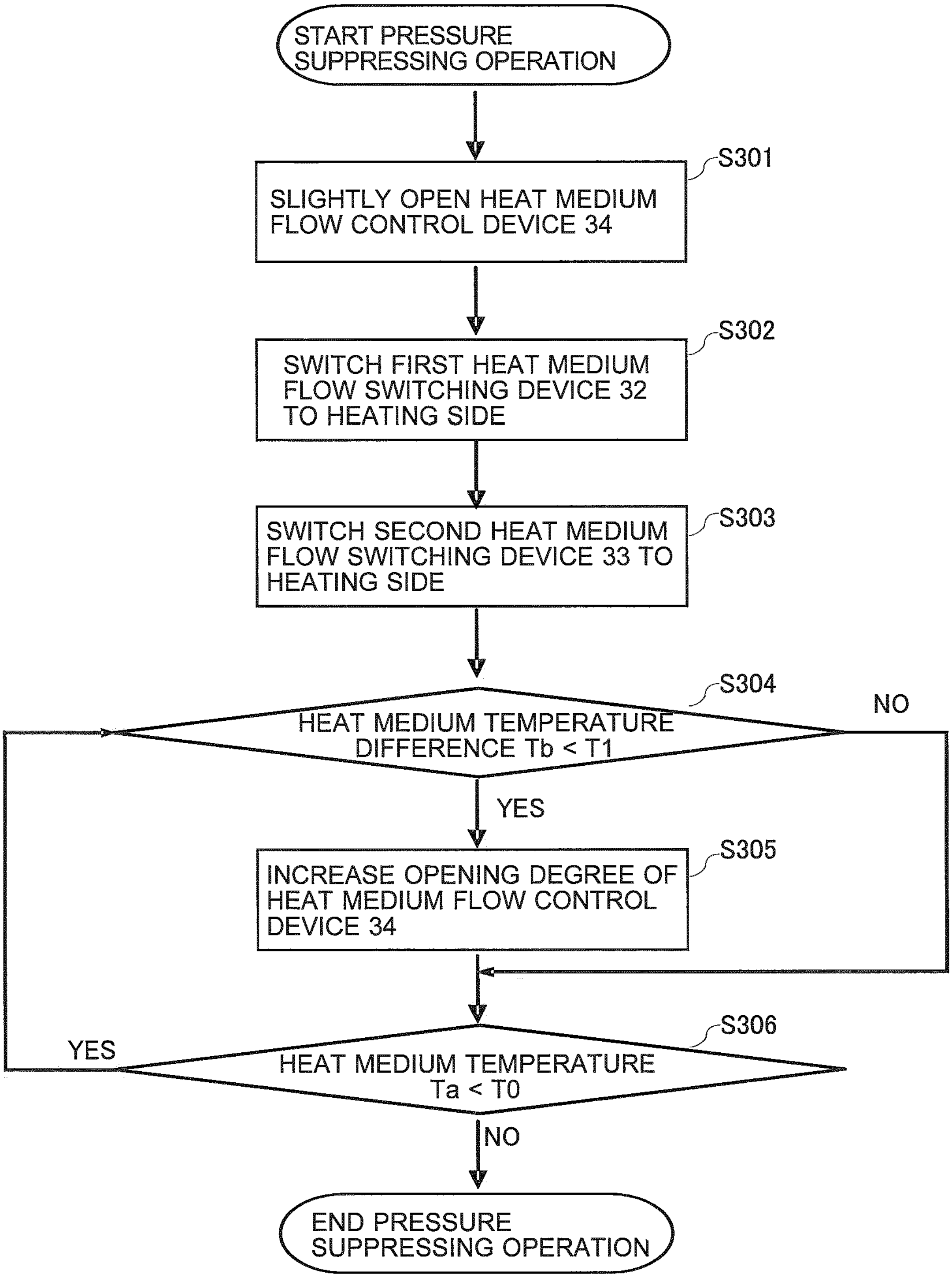

START PRESSURE SUPPRESSING OPERATION
S201
SLIGHTLY OPEN HEAT MEDIUM FLOW CONTROL DEVICE 34
S202
SWITCH FIRST HEAT MEDIUM FLOW SWITCHING DEVICE 32 TO HEATING SIDE
S203
SWITCH SECOND HEAT MEDIUM FLOW SWITCHING DEVICE 33 TO HEATING SIDE
S204
REFRIGERANT PRESSURE DIFFERENCE Pa < P0
NO
YES
S205
INCREASE OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE 34
S206
YES
HEAT MEDIUM TEMPERATURE Ta > T10
NO
END PRESSURE SUPPRESSING OPERATION

F I G. 9

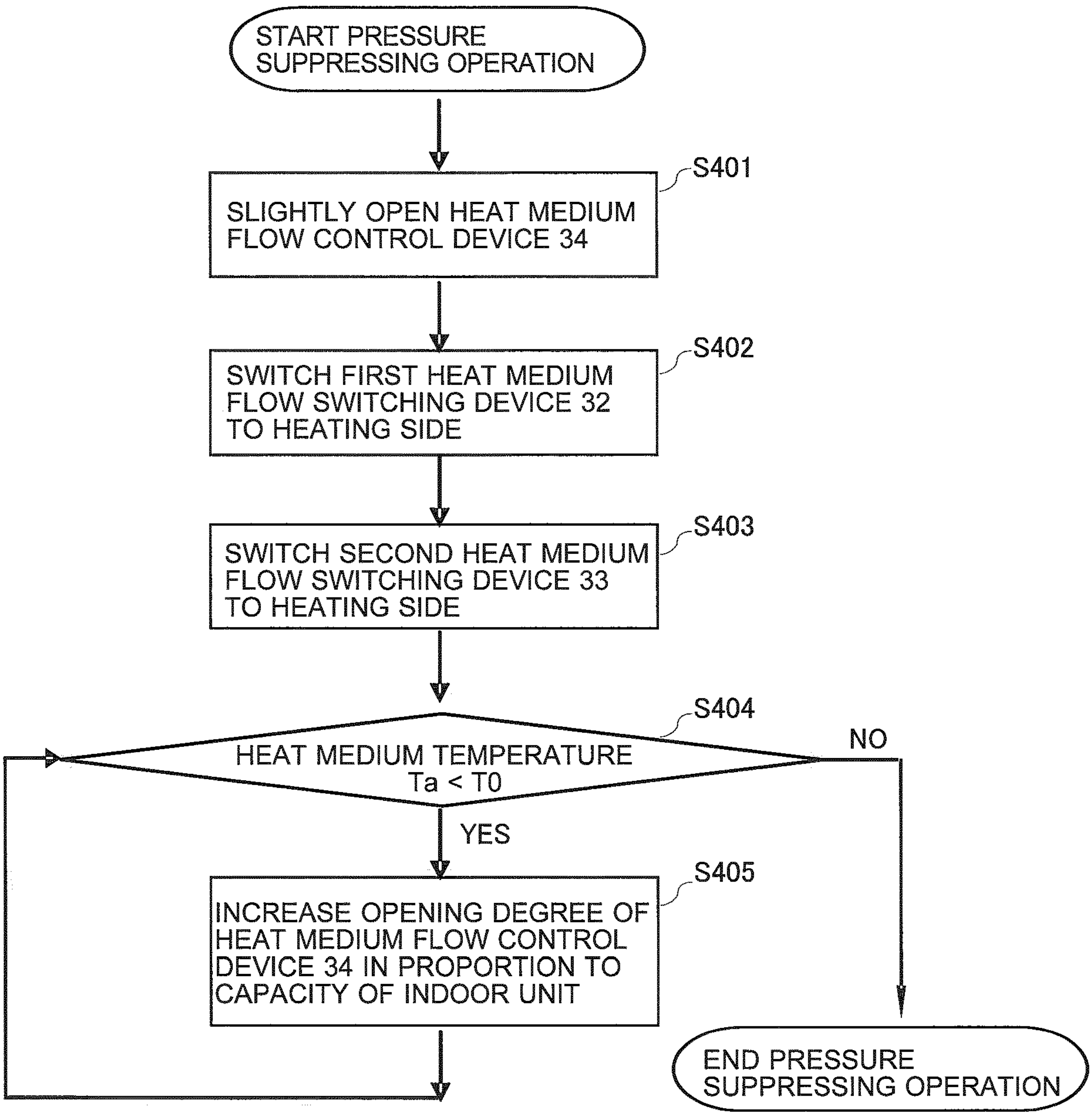
METHOD FOR INCREASING OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE

No.	MEANS	OPERATION		EFFECTS			
		SUMMARY	DETAILS	CONTROL STRUCTURE	INFLUENCE ON SYSTEM	TIME TO TERMINATION OF PRESSURE VARIATION SUPPRESSING OPERATION	POSSIBILITY OF OCCURRENCE OF LARGE PRESSURE FLUCTUATION
1	FIXED OPENING DEGREE CONTROL 1 (FOCUSED ON SPEED)	FIX OPENING DEGREE CONSTANT AT TIMING WHEN OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE IS INCREASED	LARGE FIXED OPENING DEGREE	O(SIMPLE)	×(LARGE)	O(SHORT)	×(LARGE)
2	FIXED OPENING DEGREE CONTROL 2 (FOCUSED ON INFLUENCE ON SYSTEM)	KEEP SAME OPENING DEGREE UNTIL TERMINATION PRESSURE VARIATION SUPPRESSING OPERATION	SMALL FIXED OPENING DEGREE	O(SIMPLE)	O(SMALL)	×(LONG)	O(SMALL)
3	INCHING OPENING DEGREE CONTROL 1 (FOCUSED ON SPEED)	INCREASE OPENING DEGREE BY A CERTAIN OPENING DEGREE AT TIMING WHEN OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE IS INCREASED	LARGE INCHING WIDTH	Δ(MEDIUM)	×(LARGE)	O(SHORT)	×(LARGE)
4	INCHING OPENING DEGREE CONTROL 2 (FOCUSED ON INFLUENCE ON SYSTEM)		SMALL INCHING WIDTH	Δ(MEDIUM)	O(SMALL)	×(LONG)	O(SMALL)
5	TARGET OPENING DEGREE CONTROL 1 (FOCUSED ON SPEED)	DETERMINE OPENING DEGREE OF HEAT MEDIUM FLOW DEVICE ON THE BASIS OF DIFFERENCE BETWEEN REFERENCE TEMPERATURE AND DETECTED TEMPERATURE DETERMINE TARGET OPENING DEGREE AT TIMING WHEN OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE IS INCREASED	Δpulse=f(Am- A1) DETERMINE AMOUNT OF INCREASE OF OPENING DEGREE BY USING CONVERSION FORMULA (f(x) FOR CONVERTING OPENING AREA OF FLOW CONTROL DEVICE INTO PULSE NUMBER. RELATIONSHIP OF "Am - A1" IS AS FOLLOWS. Am: TARGET OPENING AREA, A1: CURRENT OPENING AREA ΔTm = TARGET TEMPERATURE DIFFERENCE (> 0 DEGREES C) FROM REFERENCE TEMPERATURE T0 ΔT = REFERENCE TEMPERATURE T0 - DETECTED TEMPERATURE Ta BASED ON RELATIONSHIP OF Am =A1 × ΔT1/ΔTm, Am - A1 = (ΔT1/ΔTm-1) × A1 CAN BE REPRESENTED.	×(COMPLICATED)	Δ(MEDIUM)	O(SHORT)	×(LARGE)
6	TARGET OPENING DEGREE CONTROL 2 (FOCUSED ON INFLUENCE ON SYSTEM)		Δpulse=f(Am- A1)/ (ΔT1/ΔTm) DETERMINE AMOUNT OF INCREASE OF OPENING DEGREE IN INVERSE PROPORTION TO DIFFERENCE BETWEEN TARGET TEMPERATURE DIFFERENCE AND CURRENT TEMPERATURE DIFFERENCE FROM REFERENCE TEMPERATURE	×(COMPLICATED)	O(SMALL)	Δ(MEDIUM)	O(SMALL)

FIG. 10


START PRESSURE SUPPRESSING OPERATION
S301
SLIGHTLY OPEN HEAT MEDIUM FLOW CONTROL DEVICE 34
S302
SWITCH FIRST HEAT MEDIUM FLOW SWITCHING DEVICE 32 TO HEATING SIDE
S303
SWITCH SECOND HEAT MEDIUM FLOW SWITCHING DEVICE 33 TO HEATING SIDE
S304
HEAT MEDIUM TEMPERATURE DIFFERENCE Tb < T1
NO
YES
S305
INCREASE OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE 34
S306
YES
HEAT MEDIUM TEMPERATURE Ta < T0
NO
END PRESSURE SUPPRESSING OPERATION

F I G. 1 1


START PRESSURE SUPPRESSING OPERATION
S401
SLIGHTLY OPEN HEAT MEDIUM FLOW CONTROL DEVICE 34
S402
SWITCH FIRST HEAT MEDIUM FLOW SWITCHING DEVICE 32 TO HEATING SIDE
S403
SWITCH SECOND HEAT MEDIUM FLOW SWITCHING DEVICE 33 TO HEATING SIDE
S404
HEAT MEDIUM TEMPERATURE Ta < T0
NO
YES
S405
INCREASE OPENING DEGREE OF HEAT MEDIUM FLOW CONTROL DEVICE 34 IN PROPORTION TO CAPACITY OF INDOOR UNIT
END PRESSURE SUPPRESSING OPERATION

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/002932

A. CLASSIFICATION OF SUBJECT MATTER
F25B1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B1/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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 2011/052049 A1 (Mitsubishi Electric Corp.), 05 May 2011 (05.05.2011), fig. 2 to 6; paragraphs [0015] to [0122] (Family: none)	1,7-11 2-6
Y A	JP 5-71770 A (Matsushita Refrigeration Co.), 23 March 1993 (23.03.1993), claim 2; fig. 1 (Family: none)	1,7-11 2-6
A	JP 2004-60956 A (Sanyo Electric Co., Ltd.), 26 February 2004 (26.02.2004), claims 3, 8; fig. 1 (Family: none)	1-11

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"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	Date of mailing of the international search report
06 July, 2011 (06.07.11)	19 July, 2011 (19.07.11)

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

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

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Patent documents cited in the description

- JP 2000227242 A **[0003]**