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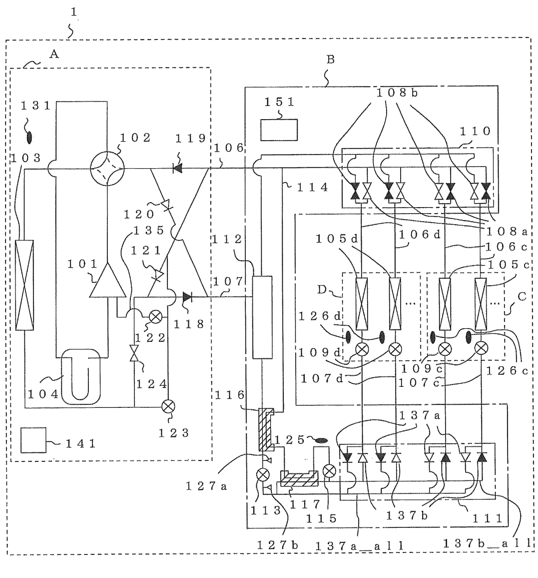
(54) AIR CONDITIONING DEVICE

(57) An air-conditioning apparatus 1 that includes a compressor 101, a heat-source-side heat exchanger 103, a plurality of use-side heat exchangers 105, and a relay unit B which switches part of the plurality of use-side heat exchangers 105 to the cooling operation side and which switches part of the plurality of use-side heat exchangers 105 to the heating operation side and that performs a cooling and heating simultaneous operation by switching each of the plurality of use-side heat exchangers 105 to the cooling operation side or the heating operation side in accordance with a control instruction, includes a second flow rate control device 122 which adjusts the flow rate of the refrigerant flowing into the compressor 101, a third flow rate control device 123 which is connected in parallel to the third flow rate control device 123 and which adjusts the flow rate of the refrigerant flowing into the heat-source-side heat exchanger 103, and a controller 141 which adjusts the second flow rate control device 122 and the third flow rate control device 123. The controller 141 adjusts the opening degree of the second flow rate control device 122 and the opening degree of the third flow rate control device 123 in accordance with the outside air temperature.

F I G. 1



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Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus.

Background Art

[0002] A known air-conditioning apparatus includes a high-stage-side compressor and a low-stage-side compressor and causes a liquid refrigerant to flow through an injection pipe to the high-stage-side compressor (see, for example, Patent Literature 1). Furthermore, a known air-conditioning apparatus includes a flow rate control device provided between a heat-source-side heat exchanger and pressure detection means and controls the opening degree of the flow rate control device in accordance with a detection value of the pressure detection means (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 4675810 (Paragraph [0018])

Summary of Invention

Technical Problem

[0004] However, in the known air-conditioning apparatus (Patent Literature 1), in the case where the outside air temperature drops during a cooling and heating simultaneous operation, in order to maintain the heating capacity, it is necessary to provide a plurality of compressors, and in order to continue the cooling operation, it is necessary to control the opening degree of the flow rate control device in accordance with the pressure detection means.

[0005] Accordingly, an expensive air-conditioning apparatus is necessary in order to continue the cooling operation while maintaining the heating capacity in the case where the outside air temperature drops during a cooling and heating simultaneous operation.

[0006] Thus, there is a problem in that the known air-conditioning apparatus (Patent Literature 1) cannot continue the cooling operation while maintaining the heating capacity with low cost in the case where the outside air temperature drops during a cooling and heating simultaneous operation.

[0007] The present invention has been made to solve the above problem. An object of the present invention is to provide an air-conditioning apparatus with low cost which is able to continue the cooling operation while maintaining the heating capacity even in the case where the outside air temperature drops during a cooling and heating simultaneous operation.

Solution to Problem

[0008] An air-conditioning apparatus according to the present invention including a single compressor which compresses a refrigerant and discharges the compressed refrigerant, a heat-source-side heat exchanger which exchanges heat between the refrigerant and an ambient heat source medium, a plurality of use-side heat exchangers which exchanges heat between the refrigerant and an ambient use medium, and a relay unit which is provided between the heat-source-side heat exchanger and the plurality of use-side heat exchangers, which switches part of the plurality of use-side heat exchangers to the cooling operation side, and which switches part of the plurality of use-side heat exchangers to the heating operation side and that performs a cooling and heating simultaneous operation by switching each of the plurality of use-side heat exchangers to the cooling operation side or the heating operation side in accordance with a control instruction, includes an injection pipe which is provided between the relay unit and the heat-source-side heat exchanger and which allows the refrigerant flowing into the heat-source-side heat exchanger to be supplied to the single compressor; a compressor flow rate control device which is provided at the injection pipe and which adjusts a flow rate of the refrigerant flowing into the single compressor; a heat-source-side heat exchanger flow rate control device which is connected in parallel to the compressor flow rate control device and which adjusts a flow rate of the refrigerant flowing into the heat-source-side heat exchanger; and a controller which adjusts the compressor flow rate control device and the heat-source-side heat exchanger flow rate control device. The controller adjusts an opening degree of the compressor flow rate control device and an opening degree of the heat-source-side heat exchanger flow rate control device in accordance with an outside air temperature.

Advantageous Effects of Invention

[0009] In the present invention, by reducing the flow rate of a refrigerant to a heat-source-side heat exchanger while increasing the amount of injection to the single compressor in accordance with the outside air temperature, even if the outside air temperature drops during a cooling and heating simultaneous operation, it is possible to continue the cooling operation while maintaining the heating capacity with low cost. With this configuration, an effect of being able to perform a high-efficiency cooling and heating simultaneous operation can be achieved.

Brief Description of Drawings

[0010]

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

[Fig. 2] Fig. 2 is a diagram illustrating a modeled connection relationship between a second flow rate control device 122, a third flow rate control device 123, and a third flow rate control unit 115 of a relay unit B according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a diagram illustrating an example of the configuration of the air-conditioning apparatus 1 for explaining a cooling main operation state in a cooling and heating simultaneous operation according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a diagram illustrating an example of the configuration of the air-conditioning apparatus 1 for explaining a heating main operation state in a cooling and heating simultaneous operation according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the opening degree of the second flow rate control device 122 according to Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a diagram for explaining an example of the correlation between the outside air temperature and the flow rate ratio in accordance with the opening degree of the second flow rate control device 122 and the opening degree of the third flow rate control device 123 according to Embodiment 1 of the present invention.

[Fig. 7] Fig. 7 is a diagram for explaining an example of the correlation between the outside air temperature and the flow rate ratio in accordance with the opening degree of the second flow rate control device 122, the opening degree of the third flow rate control device 123, and the opening degree of the third flow rate control unit 115 according to Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the case where the second flow rate control device 122 is properly controlled and the case where second flow rate control device 122 is not properly controlled according to Embodiment 1 of the present invention.

[Fig. 9] Fig. 9 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the case where a fourth flow rate control valve 124 is properly controlled and the case where fourth flow rate control valve 124 is not properly controlled according to Embodiment 1 of the present invention.

[Fig. 10] Fig. 10 is a flowchart for explaining an operation example of a controller 141 provided in a heat source unit A according to Embodiment 1 of the present invention.

[Fig. 11] Fig. 11 is a flowchart for explaining an operation example of a controller 151 provided in the relay unit B according to Embodiment 1 of the present invention.

Description of Embodiments

[0011] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

Embodiment 1.

[0012] Fig. 1 is a diagram illustrating an example of the configuration of an air-conditioning apparatus 1 according to Embodiment 1 of the present invention. As illustrated in Fig. 1, the air-conditioning apparatus 1 forms a refrigeration cycle for cooling and a refrigeration cycle for heating within the air-conditioning apparatus 1 using an indoor unit C, an indoor unit D, a relay unit B, check valves 118 to 121, a four-way valve 102, and the like to perform a cooling and heating simultaneous operation. In the case where the outside air temperature drops during the cooling and heating simultaneous operation, as described in detail later, the amount of refrigerant flowing to a compressor 101 is adjusted by a second flow rate control device, and the amount of refrigerant flowing to a heat-source-side heat exchanger 103 is adjusted by a third flow rate control device 123. By this operation, regarding the amount of refrigerant flowing from the relay unit B to a heat source unit A, distribution between the amount of refrigerant flowing to the compressor 101 and the amount of refrigerant flowing to the heat-source-side heat exchanger 103 is performed. Consequently, even in the case where the outside air temperature drops during the cooling and heating simultaneous operation, a high-efficiency cooling and heating simultaneous operation can be performed while continuing the cooling operation and maintaining the heating capacity, with low cost.

[0013] Hereinafter, the above details will be explained in order.

[0014] The air-conditioning apparatus 1 includes the heat source unit A, the relay unit B, the indoor unit C, the indoor unit D, and the like. The relay unit B is provided between the heat source unit A and each of the indoor unit C and the indoor unit D. The heat source unit A and the relay unit B are connected to each other by a first connection pipe 106 and a second connection pipe 107 which has a pipe diameter smaller than the first connection pipe 106. The relay unit B and the indoor unit C are connected to each other by first connection pipes 106c and second connection pipes 107c. The relay unit B and the indoor unit D are connected to each other by first connection pipes 106d and second connection pipes 107d.

[0015] With this connection configuration, the relay unit B relays a refrigerant flowing between the heat source unit A and each of the indoor unit C and the indoor unit D.

[0016] An example in which one heat source unit and two indoor units are provided will be explained below. However, the present invention is not limited to this. For example, two or more indoor units may be provided. Furthermore, for example, a plurality of heat source units may be provided. Moreover, for example, a plurality of relay units B may be provided.

[0017] The heat source unit A includes the compressor 101, the four-way valve 102, the heat-source-side heat exchanger 103, and an accumulator 104. The heat source unit A also includes the check valve 118, the check valve 119, the check valve 120, and the check valve 121. The heat source unit A also includes a second flow rate control device 122, the third flow rate control device 123, a fourth flow rate control valve 124, and a controller 141. The heat source unit A also includes an outside air temperature detection means 131 that measures the outside air temperature and supplies a measurement result to the controller 141.

[0018] The compressor 101 is provided between the four-way valve 102, the accumulator 104, and the second flow rate control device 122. The compressor 101 compresses the refrigerant and discharges the compressed refrigerant. The discharge side of the compressor 101 is connected to the four-way valve 102, and the suction side of the compressor 101 is connected to the accumulator 104 and the second flow rate control device 122.

[0019] The four-way valve 102 includes four ports which are connected to the discharge side of the compressor 101, the heat-source-side heat exchanger 103, the accumulator 104, and the outlet side of the check valve 119 and the inlet side of the check valve 120, so that switching of the flow passage of the refrigerant can be performed.

[0020] The heat-source-side heat exchanger 103 is provided between the four-way valve 102, the third flow rate control device 123, and the fourth flow rate control valve 124. The heat-source-side heat exchanger 103 is connected to a pipe whose one end is connected to the four-way valve 102 and whose other end is connected to the third flow rate control device 123 and the fourth flow rate control valve 124. The heat-source-side heat exchanger 103 exchanges heat between the refrigerant flowing inside the heat-source-side heat exchanger 103 and the ambient air of the heat-source-side heat exchanger 103.

[0021] The accumulator 104 is connected between the four-way valve 102 and the suction side of the compressor 101, performs separation of a liquid refrigerant, and supplies a gas refrigerant to the compressor 101.

[0022] The compressor 101, the four-way valve 102, and the heat-source-side heat exchanger 103 mentioned above constitute part of a refrigerant circuit.

[0023] The check valve 118 is connected between the fourth flow rate control valve 124, which is connected to the heat-source-side heat exchanger 103, and the outlet side of the check valve 121; and the second connection pipe 107 and the outlet side of the check valve 120. The inlet side of the check valve 118 is connected to a pipe connected to the fourth flow rate control valve 124 and the outlet side of the check valve 121. The outlet side of the check valve 118 is connected to a pipe connected to the second connection pipe 107 and the outlet side of the check valve 120. The check valve 118 allows the refrigerant to circulate only in one direction from the heat-source-side heat exchanger 103 through the fourth flow rate control valve 124 to the second connection pipe 107.

[0024] The check valve 119 is provided between the four-way valve 102 and the inlet side of the check valve 120; and the first connection pipe 106 and the inlet side of the check valve 121. The inlet side of the check valve 119 is connected to a pipe connected to the first connection pipe 106 and the inlet side of the check valve 121. The outlet side of the check valve 119 is connected to a pipe connected to the four-way valve 102 and the inlet side of the check valve 120. The check valve 119 allows the refrigerant to circulate only in one direction from the first connection pipe 106 to the four-way valve 102.

[0025] The check valve 120 is provided between the four-way valve 102 and the outlet side of the check valve 119; and the outlet side of the check valve 118 and the second connection pipe 107. The inlet side of the check valve 120 is connected to a pipe connected to the four-way valve 102 and the outlet side of the check valve 119. The outlet side of the check valve 120 is connected to a pipe connected to the outlet side of the check valve 118 and the second connection pipe 107. The check valve 120 allows the refrigerant to circulate only in one direction from the four-way valve 102 to the second connection pipe 107.

[0026] The check valve 121 is provided between the inlet side of the check valve 119 and the first connection pipe 106; and the inlet side of the check valve 118 and the fourth flow rate control valve 124 connected to the heat-source-side heat exchanger 103. The inlet side of the check valve 121 is connected to a pipe connected to the inlet side of the check valve 119 and the first connection pipe 106. The outlet side of the check valve 121 is connected to a pipe connected to the inlet side of the check valve 118 and the fourth flow rate control valve 124. The check valve 121 allows the refrigerant to circulate only in one direction from the first connection pipe 106 through the fourth flow rate control valve 124 to the heat-source-side heat exchanger 103.

[0027] The check valves 118 to 121 explained above form a flow passage switching valve of the refrigerant circuit. The flow passage switching valve and the relay unit B, the indoor unit C, and the indoor unit D, which will be described in detail later, form a refrigeration cycle for the cooling operation and a refrigeration cycle for the heating operation in the refrigerant circuit during the cooling and heating simultaneous operation.

[0028] One end of the second flow rate control device 122 is connected to the inlet side of the check valve 121 and the other end of the second flow rate control device 122 is connected to the suction side of the compressor 101. The inlet side of the check valve 121 is connected to one end of the first connection pipe 106. The other end of the first connection pipe 106 is connected to the relay unit B.

[0029] With this connection configuration, the second flow rate control device 122 is connected in series to the relay unit B, so that the refrigerant is supplied from the relay unit B. Furthermore, the second flow rate control device 122 is a flow rate control device whose opening degree is variable.

[0030] Therefore, the second flow rate control device 122 adjusts the opening degree thereof to control the amount of refrigerant which has flowed from the relay unit B and which has been separated into gas and liquid, and supplies the controlled amount of refrigerant to the suction side of the compressor 101.

[0031] The second flow rate control device 122 corresponds to a compressor flow rate control device according to the present invention.

[0032] The third flow rate control device 123 is provided between the second flow rate control device 122 and the heat-source-side heat exchanger 103 and is connected in parallel to the second flow rate control device 122. More specifically, the third flow rate control device 123 is connected to one of end portions of the second flow rate control device 122 that is connected to the inlet side of the check valve 121.

[0033] With this connection configuration, the third flow rate control device 123 is connected in series to the relay unit B, so that the refrigerant is supplied from the relay unit B. Furthermore, the third flow rate control device 123 is a flow rate control device whose opening degree is variable.

[0034] Therefore, the third flow rate control device 123 adjusts the opening degree thereof to control the amount of refrigerant which has flowed from the relay unit B, and supplies the controlled amount of refrigerant to the heat-source-side heat exchanger 103.

[0035] The third flow rate control device 123 corresponds to a heat-source-side heat exchanger flow rate control device according to the present invention.

[0036] Furthermore, with the connection configuration described above, the third flow rate control device 123 is connected in parallel to the second flow rate control device 122 and is connected in series to the relay unit B.

[0037] Therefore, the refrigerant flowing from the relay unit B is distributed and supplied to the second flow rate control device 122 and the third flow rate control device 123 in accordance with the opening degree of the second flow rate control device 122 and the opening degree of the third flow rate control device 123.

[0038] The fourth flow rate control valve 124 is provided between the outlet side of the check valve 121, the inlet side of the check valve 118, and the heat-source-side heat exchanger 103, and is connected in parallel to the third flow rate control device 123. More specifically, one end of the fourth flow rate control valve 124 is connected to a pipe connected to the outlet side of the check valve 121 and the inlet side of the check valve 118. The other end of the fourth flow rate control valve 124 is connected to a pipe on a side of one of end portions of the third flow rate control device 123 that is connected to the heat-source-side heat exchanger 103.

[0039] With this connection configuration, the fourth flow rate control valve 124 is connected in series to the relay unit B via the check valve 121, so that the refrigerant is supplied from the relay unit B. Furthermore, the fourth flow rate control valve 124 is a flow rate control valve whose opening degree is variable.

[0040] Therefore, the fourth flow rate control valve 124 adjusts the opening degree thereof to control the amount of refrigerant which has flowed from the relay unit B, and supplies the controlled amount of refrigerant to the heat-source-side heat exchanger 103.

[0041] With such a connection configuration, the fourth flow rate control valve 124 is connected in parallel to the second flow rate control device 122 and the third flow rate control device 123 via the check valve 121, and is connected in series to the relay unit B.

[0042] Therefore, the refrigerant flowing from the relay unit B is distributed and supplied to the second flow rate control device 122, the third flow rate control device 123, and the fourth flow rate control valve 124 in accordance with the opening degree of the second flow rate control device 122, the opening degree of the third flow rate control device 123, and the opening degree of the fourth flow rate control valve 124.

[0043] The controller 141 includes, for example, a microprocessor unit as a main element, and performs the integrated control of the entire heat source unit A, communication with an external device, such as the relay unit B, and various arithmetic operations.

[0044] The outside air temperature detection means 131 is, for example, a thermistor. The outside air temperature detection means 131 supplies a measurement result of the outside air temperature to the controller 141. The outside air temperature detection means 131 may supply the measurement result directly to the controller 141 or may accumulate measurement results for a certain period of time and then supply the accumulated measurement results to the controller 141 with predetermined time intervals.

[0045] An example in which the outside air temperature detection means 131 is a thermistor has been explained above, the present invention is not particularly limited to this.

[0046] The relay unit B includes a first branch part 110, a second branch part 111, a gas/liquid separator 112, a second flow rate control unit 113, a third flow rate control unit 115, a first heat exchanger 116, a second heat exchanger 117, temperature detection means 125, pressure detection means 127a, pressure detection means 127b, a controller 151, and the like.

[0047] The relay unit B is connected to the heat source unit A via the first connection pipe 106 and the second connection pipe 107. The relay unit B is connected to the indoor unit C via the first connection pipes 106c and the second connection pipes 107c. The relay unit B is connected to the indoor unit D via the first connection pipes 106d and the second connection pipes 107d.

[0048] The first branch part 110 includes solenoid valves 108a and solenoid valves 108b. The solenoid valves 108a and the solenoid valves 108b are connected to the indoor unit C via the first connection pipes 106c. The solenoid valves 108a and the solenoid valves 108b are connected to the indoor unit D via the first connection pipes 106d.

[0049] The solenoid valves 108a are valves that can be opened and closed. One end of each of the solenoid valves 108a is connected to the first connection pipe 106, and the other end of each of the solenoid valves 108a is connected to the corresponding first connection pipe 106c, the corresponding first connection pipe 106d, and one terminal of the corresponding solenoid valve 108b. The solenoid valves 108b are valves that can be opened and closed. One end of each of the solenoid valves 108b is connected to the second connection pipe 107, and the other end of each of the solenoid valves 108b is connected to the corresponding first connection pipe 106c, the corresponding first connection pipe 106d, and one terminal of the corresponding solenoid valve 108a.

[0050] The first branch part 110 is connected to the indoor unit C via the first connection pipes 106c. The first branch part 110 is connected to the indoor unit D via the first connection pipes 106d. The first branch part 110 is connected to the heat source unit A via the first connection pipe 106 and the second connection pipe 107. The first branch part 110 is connected to the first connection pipes 106c and either the first connection pipe 106 or the second connection pipe 107 using the solenoid valves 108a and the solenoid valves 108b. The first branch part 110 is connected to the first connection pipes 106d and either the first connection pipe 106 or the second connection pipe 107 using the solenoid valves 108a and the solenoid valves 108b.

[0051] The second branch part 111 includes check valves 137a and check valves 137b. The check valves 137a and the check valves 137b are connected in antiparallel to each other. The input sides of the check valves 137a and the output sides of the check valves 137b are connected to the indoor unit C via the second connection pipes 107c and are connected to the indoor unit D via the second connection pipes 107d. The output sides of the check valves 137a are connected to a junction part 137a_all. The input sides of the check valves 137b are connected to a junction part 137b_all.

[0052] The second branch part 111 is connected to the indoor unit C via the second connection pipes 107c. The second branch part 111 is connected to the indoor unit D via the second connection pipes 107d. The second branch part 111 is connected to the second flow rate control unit 113 and the first heat exchanger 116 via the junction part 137a_all. The second branch part 111 is connected to the third flow rate control unit 115 and the first heat exchanger 116 via the junction part 137b_all.

[0053] The gas/liquid separator 112 is provided in the middle of the second connection pipe 107. A gas-phase portion of the gas/liquid separator 112 is connected to the solenoid valves 108b of the first branch part 110, and a liquid-phase portion of the gas/liquid separator 112 is connected to the second branch part 111 via the first heat exchanger 116, the second flow rate control unit 113, the second heat exchanger 117, and the third flow rate control unit 115.

[0054] One end of the second flow rate control unit 113 is connected to the first heat exchanger 116, and the other end is connected to one end of the second heat exchanger 117 and the junction part 137a_all of the second branch part 111. At a pipe connecting the first heat exchanger 116 and the second flow rate control unit 113, the pressure detection means 127a, which will be described in detail later, is provided. At a pipe connecting the second flow rate control unit 113, the second heat exchanger 117, and the junction part 137a_all, the pressure detection means 127b, which will be described in detail later, is provided.

[0055] The second flow rate control unit 113 is a flow rate control unit whose opening degree is adjustable. The opening degree of the second flow rate control unit 113 is adjusted so that a difference between a pressure value detected by the pressure detection means 127a and a pressure value detected by the pressure detection means 127b is maintained constant.

[0056] One end of the third flow rate control unit 115 is connected to a bypass pipe 114 side of the second heat exchanger 117, and the other end of the third flow rate control unit 115 is connected to a side of a pipe connecting the junction part 137b_all and the second heat exchanger 117. The third flow rate control unit 115 is a flow rate control unit whose opening degree is adjustable. The opening degree of the third flow rate control unit 115 is adjusted in accordance with any one of the outside air temperature detection means 131, the temperature detection means 125, the pressure detection means 127a, and the pressure detection means 127b or a combination thereof.

[0057] One end of the bypass pipe 114 is connected to the first connection pipe 106, and the other end of the bypass pipe 114 is connected to the third flow rate control unit 115.

[0058] Accordingly, the amount of refrigerant to be supplied to the heat source unit A varies according to the opening degree of the third flow rate control unit 115.

[0059] The first heat exchanger 116 is provided between the gas/liquid separator 112, the second heat exchanger 117, and the second flow rate control unit 113, and exchanges heat between the bypass pipe 114 and a pipe provided between the gas/liquid separator 112 and the second flow rate control unit 113.

[0060] The second heat exchanger 117 is provided between the first heat exchanger 116 and the second flow rate control unit 113; and one end of the third flow rate control unit 115 and the other end of the third flow rate control unit 115. In this case, the other end of the third flow rate control unit 115 is connected to the junction part 137b_all. The second heat exchanger 117 exchanges heat between the bypass pipe 114 and a pipe provided between the second flow rate control unit 113 and the third flow rate control unit 115.

[0061] The temperature detection means 125 is, for example, a thermistor. The temperature detection means 125 measures the temperature of the refrigerant flowing inside a pipe provided between the third flow rate control unit 115 and the second heat exchanger 117, and supplies a measurement result to the controller 151. The temperature detection means 125 may supply the measurement result directly to the controller 151 or may accumulate measurement results for a certain period of time and then supply the accumulated measurement results to the controller 151 with predetermined time intervals.

[0062] An example in which the temperature detection means 125 is a thermistor has been explained above, the present invention is not particularly limited to this.

[0063] The pressure detection means 127a measures the pressure of the refrigerant flowing inside a pipe provided between the first heat exchanger 116 and the second flow rate control unit 113, and supplies a measurement result to the controller 151.

[0064] The pressure detection means 127b measures the pressure of the refrigerant flowing inside a pipe provided between the second flow rate control unit 113, the second heat exchanger 117, and the second branch part 111, and supplies a measurement result to the controller 151.

[0065] The pressure detection means 127a and the pressure detection means 127b are collectively referred to as pressure detection means 127. The pressure detection means 127 may supply a measurement result directly to the controller 151 or may accumulate measurement results for a certain period of time and then supply the accumulated measurement results to the controller 151 with predetermined time intervals.

[0066] The controller 151 includes, for example, a microprocessor unit as a main element, and performs the integrated control of the entire relay unit B, communication with an external device, such as the heat source unit A, and various arithmetic operations.

[0067] The indoor unit C includes use-side heat exchangers 105c, liquid pipe temperature detection means 126c, first flow rate control units 109c, and the like. A plurality of use-side heat exchangers 105c are provided. The liquid pipe temperature detection means 126c for detecting the temperature of pipes are provided between the use-side heat exchangers 105c and the first flow rate control units 109c.

[0068] The use-side heat exchangers 105c and the first flow rate control units 109c explained above constitute part of the refrigerant circuit.

[0069] The indoor unit D includes use-side heat exchangers 105d, liquid pipe temperature detection means 126d, first flow rate control units 109d, and the like. A plurality of use-side heat exchangers 105d are provided. The liquid pipe temperature detection means 126d for detecting the temperature of pipes are provided between the use-side heat exchangers 105d and the first flow rate control units 109d.

[0070] The use-side heat exchangers 105d and the first flow rate control units 109d explained above constitute part of the refrigerant circuit.

[0071] Fig. 2 is a diagram illustrating a modeled connection relationship between the second flow rate control device 122, the third flow rate control device 123, and the third flow rate control unit 115 of the relay unit B according to Embodiment 1 of the present invention. As illustrated in Fig. 2, the second flow rate control device 122 is provided between the relay unit B and the compressor 101. Furthermore, the third flow rate control device 123 and the fourth flow rate control valve 124 are provided between the relay unit B and the heat-source-side heat exchanger 103. The third flow rate control device 123 and the fourth flow rate control valve 124 are connected in parallel to each other, and the third flow rate control device 123 and the second flow rate control device 122 are connected in parallel to each other. Accordingly, the second flow rate control device 122, the third flow rate control device 123, and the fourth flow rate control valve 124 are connected in parallel to one another and are connected in series to the relay unit B.

[0072] As described above, the relay unit B includes the third flow rate control unit 115, and adjusts the amount of refrigerant to the heat source unit A side.

[0073] Therefore, the third flow rate control unit 115 determines the amount of refrigerant flowing in the second flow rate control device 122, the third flow rate control device 123, and the fourth flow rate control valve 124.

[0074] The controller 141 adjusts the opening degree of the second flow rate control device 122, the third flow rate control device 123, and the fourth flow rate control valve 124. The controller 151 adjusts the opening degree of the third flow rate control unit 115. The controller 141 and the controller 151 transmit and receive various signals to supply control contents to each other.

[0075] Fig. 3 is a diagram illustrating an example of the configuration of the air-conditioning apparatus 1 for explaining a cooling main operation state in the cooling and heating simultaneous operation according to Embodiment 1 of the present invention.

[0076] As a prerequisite, it is assumed that the cooling operation and the heating operation are set for the indoor unit C and the indoor unit D, respectively, and the operation of the air-conditioning apparatus 1 is performed based on the cooling main operation.

[0077] The solenoid valves 108a on the indoor unit C side are opened, and the solenoid valves 108a on the indoor unit D side are closed. The solenoid valves 108b on the indoor unit C side are closed, and the solenoid valves 108b on the indoor unit D side are opened.

[0078] The opening degree of the second flow rate control unit 113 is controlled so that the pressure difference between the pressure detection means 127a and the pressure detection means 127b has an appropriate value.

[0079] The flow of the refrigerant will be explained. As expressed by thick solid arrows, a high-temperature and high-pressure gas refrigerant which has been compressed by and discharged from the compressor 101 passes through the four-way valve 102 and flows into the heat-source-side heat exchanger 103.

[0080] The heat-source-side heat exchanger 103 exchanges heat with a heat source medium such as air or water. The high-temperature and high-pressure refrigerant which has been subjected to heat exchange turns into a two-phase gas-liquid, high-temperature and high-pressure refrigerant. Next, the two-phase gas-liquid, high-temperature and high-pressure refrigerant passes through the fourth flow rate control valve 124, the check valve 118, and the second connection pipe 107, and is supplied to the gas/liquid separator 112 of the relay unit B.

[0081] The gas/liquid separator 112 separates the two-phase gas-liquid, high-temperature and high-pressure refrigerant into a gas-state refrigerant and a liquid-state refrigerant.

[0082] The separated gas-state refrigerant flows into the first branch part 110. The gas-state refrigerant which has flowed into the first branch part 110 passes through the opened solenoid valves 108b and the first connection pipes 106d, and is supplied to the indoor unit D, for which the heating operation is set.

[0083] In the indoor unit D, the use-side heat exchangers 105d perform heat exchange with a use side medium such as air, and condense and liquefy the supplied gas-state refrigerant.

[0084] Furthermore, the use-side heat exchangers 105d are controlled by the first flow rate control units 109d on the basis of the degree of subcooling at the outlet of the use-side heat exchangers 105d.

[0085] The first flow rate control units 109d decompress the liquid refrigerant, which has been condensed and liquefied by the use-side heat exchangers 105d, into a two-phase gas-liquid refrigerant having an intermediate pressure, which is between a high pressure and a low pressure.

[0086] The two-phase gas-liquid refrigerant, which has the intermediate pressure, is caused to flow into the second branch part 111.

[0087] The gas refrigerant of the two-phase gas-liquid refrigerant which has flowed into the second branch part 111 flows into the indoor unit D. The liquid refrigerant of the two-phase gas-liquid refrigerant which has flowed into the second branch part 111 flows out of the second branch part 111, is merged with a liquid refrigerant which has passed through the second flow rate control unit 113, is subjected to heat exchange at the first heat exchanger 116 as described later, returns to the second branch part 111, and flows into the indoor unit C and the indoor unit D.

[0088] At this time, the first connection pipe 106 has a low pressure, and the second connection pipe 107 has a high pressure. Therefore, due to the pressure difference between the first connection pipe 106 and the second connection pipe 107, the refrigerant flows to the check valve 118 and the check valve 119, while the refrigerant does not flow to the check valve 120 or the check valve 121.

[0089] Meanwhile, the liquid-state refrigerant which has been separated by the gas/liquid separator 112 passes through the second flow rate control unit 113, which controls the pressure difference between the high pressure and the intermediate pressure to be maintained constant, and flows into the second branch part 111.

[0090] Next, in the second branch part 111, the supplied liquid-state refrigerant passes through check valves 108d which are connected to the indoor unit C side, and flows into the indoor unit C.

[0091] Next, the liquid-state refrigerant which has flowed into the indoor unit C is decompressed into a low pressure using the first flow rate control units 109c which are controlled in accordance with the degree of superheat at the outlet of the use-side heat exchangers 105c of the indoor unit C, and is supplied to the use-side heat exchangers 105c.

[0092] In the use-side heat exchangers 105c, the supplied liquid-state refrigerant evaporates and gasifies by heat exchange with a use side medium such as air.

[0093] The refrigerant, which has been gasified into a gas refrigerant, passes through the first connection pipes 106c and flows into the first branch part 110. In the first branch part 110, the solenoid valves 108a on a side connected to the indoor unit C are opened. Thus, the gas refrigerant which has flowed into the first branch part 110 passes through the solenoid valves 108a on a side connected to the indoor unit C, and flows into the first connection pipe 106.

[0094] Next, the gas refrigerant flows into the check valve 119 side at a lower pressure than the check valve 121, passes through the four-way valve 102 and the accumulator 104, and is sucked into the compressor 101.

[0095] By the above operation, a refrigeration cycle is formed, and the cooling main operation is performed.

[0096] Some of the liquid-state refrigerant which has been separated by the gas/liquid separator 112 and has flowed into the second branch part 111 does not flow into the indoor unit C. Such a liquid-state refrigerant flows into the second branch part 111, passes through the first heat exchanger 116, and flows into the third flow rate control unit 115. The third flow rate control unit 115 decompresses the liquid-state refrigerant which has flowed into the third flow rate control unit 115 into a low pressure to lower the evaporating temperature of the refrigerant. In the course of passage through the bypass pipe 114, the liquid-state refrigerant whose evaporating temperature has been lowered turns into a two-phase gas-liquid refrigerant by heat exchange at the first heat exchanger 116 mainly with a liquid refrigerant supplied from the second flow rate control unit 113, turns into a gas refrigerant by heat exchange at the second heat exchanger 117 with a liquid refrigerant supplied from the gas/liquid separator 112, and flows into the first connection pipe 106.

[0097] Fig. 4 is a diagram illustrating an example of the configuration of the air-conditioning apparatus 1 for explaining the heating main operation state in the cooling and heating simultaneous operation according to Embodiment 1 of the present invention.

[0098] As a prerequisite, it is assumed that the heating operation and the cooling operation are set for the indoor unit C and the indoor unit D, respectively, and the operation of the air-conditioning apparatus 1 is performed based on the heating main operation.

[0099] The solenoid valves 108a on the indoor unit C side are closed, and the solenoid valves 108a on the indoor unit D side are opened. The solenoid valves 108b on the indoor unit C side are opened, and the solenoid valves 108b on the indoor unit D side are closed.

[0100] The opening degree of the second flow rate control unit 113 is controlled so that the pressure difference between the pressure detection means 127a and the pressure detection means 127b has an appropriate value.

[0101] The flow of the refrigerant will be explained. As expressed by thick solid arrows, a high-temperature and high-pressure gas refrigerant which has been compressed by and discharged from the compressor 101 passes through the four-way valve 102, the check valve 120, and the second connection pipe 107, and is supplied to the gas/liquid separator 112 of the relay unit B.

[0102] The gas/liquid separator 112 supplies the high-temperature and high-pressure gas refrigerant to the first branch part 110. The gas refrigerant which has been supplied to the first branch part 110 passes through the opened solenoid valves 108b and the first connection pipes 106c, and is supplied to the indoor unit C, for which the heating operation is set.

[0103] In the indoor unit C, the use-side heat exchangers 105c perform heat exchange with a use side medium such as air, and condense and liquefy the supplied gas refrigerant.

[0104] Furthermore, the use-side heat exchangers 105c are controlled by the first flow rate control units 109c on the basis of the degree of subcooling at the outlet of the use-side heat exchangers 105c.

[0105] The first flow rate control units 109c decompress a liquid refrigerant, which has been condensed and liquefied by the use-side heat exchangers 105c, into a two-phase gas-liquid refrigerant having an intermediate pressure, which is between a high pressure and a low pressure.

[0106] The two-phase gas-liquid refrigerant, which has the intermediate pressure, is caused to flow into the second branch part 111.

[0107] The two-phase gas-liquid refrigerant which has flowed into the second branch part 111 merges together at the junction part 137a_all. The two-phase gas-liquid refrigerant merged at the junction part 137a_all passes through the first heat exchanger 116, turns into a liquid-state refrigerant, reaches the junction part 137b_all, passes through the check valves 137b which are connected to the indoor unit D, passes through the second connection pipes 107d, and flows into the indoor unit D.

[0108] Next, the liquid-state refrigerant which has flowed into the indoor unit D is decompressed into a low pressure using the first flow rate control units 109d which are controlled in accordance with the degree of superheat at the outlet of the use-side heat exchangers 105d of the indoor unit D, and is supplied to the use-side heat exchangers 105d.

[0109] In the use-side heat exchangers 105d, the supplied liquid-state refrigerant evaporates and gasifies by heat exchange with a use side medium such as air.

[0110] The refrigerant, which has been gasified into a gas refrigerant, passes through the first connection pipes 106d and flows into first branch part 110. In the first branch part 110, the solenoid valves 108a on a side connected to the indoor unit D are opened. Thus, the gas refrigerant which has flowed into the first branch part 110 passes through the solenoid valves 108a on a side connected to the indoor unit D, and flows into the first connection pipe 106.

[0111] Next, the gas refrigerant flows into the check valve 121 side at a lower pressure than the check valve 119, flows into the fourth flow rate control valve 124 and the heat-source-side heat exchanger 103, and is evaporated and gasified into a gas state. Next, the refrigerant passes through the four-way valve 102 and the accumulator 104, and is sucked into the compressor 101.

[0112] By the above operation, a refrigeration cycle is formed, and the heating main operation is performed.

[0113] At this time, the first connection pipe 106 has a low pressure, and the second connection pipe 107 has a high pressure. Therefore, due to the pressure difference between the first connection pipe 106 and the second connection pipe 107, the refrigerant flows to the check valve 120 and the check valve 121, while the refrigerant does not flow to the check valve 118 or the check valve 119.

[0114] Here, if the outside air temperature is low at the time of the heating main operation during the cooling and heating simultaneous operation, the heat-source-side heat exchanger 103, the second flow rate control device 122, and the third flow rate control device 123 correlate with one another.

[0115] More specifically, as the outside air temperature decreases, it becomes more difficult for the air-conditioning apparatus 1 to maintain the high pressure high and the heating capacity degrades. Furthermore, lowering the low pressure causes the indoor unit D that is currently performing the cooling operation not to continue the operation. Therefore, a problem occurs both in the cooling operation and the heating operation.

[0116] Fig. 5 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the opening degree of the second flow rate control device 122 according to Embodiment 1 of the present invention.

[0117] In Fig. 5, it is assumed that the reference temperature on the horizontal axis is represented by α, and the reference heating capacity ratio on the vertical axis is represented by β.

[0118] As illustrated in Fig. 5, in the case where the outside air temperature is at a certain value or below, the heating capacity ratio is low when the opening degree of the second flow rate control device 122 is small, while the heating capacity ratio increases when the opening degree of the second flow rate control device 122 increases.

[0119] In other words, in order to increase the heating capacity, by increasing the opening degree of the second flow rate control device 122, a high pressure can be maintained high.

[0120] More specifically, by increasing the flow rate from the second flow rate control device 122 to the compressor 101 through a bypass, that is, the amount of injection, the high pressure increases, and the heating capacity is thus increased. For example, at an outside air temperature of α-30 degrees Centigrade, when the amount of injection is increased by 30 percent to 40 percent, the heating capacity is increased by about 8 percent.

[0121] The opening degree of the third flow rate control device 123 will now be discussed. In the case where the opening degree of the third flow rate control device 123 is opened at a certain value or more, since the second flow rate control device 122 and the third flow rate control device 123 are connected in parallel to each other, the flow rate to the second flow rate control device 122 decreases.

[0122] When the above explanation is taken into consideration, in the case where the outside air temperature is decreased from a certain value at the time of the heating main operation during the cooling and heating simultaneous operation, the liquid pipe temperature detection means 126 in the indoor unit D measures a value lower than or equal to a certain value, and therefore the cooling operation cannot be maintained. For the above reason, by reducing the opening degree of the third flow rate control device 123, the liquid pipe temperature of the indoor unit D is increased, and at the same time, the amount of injection to the compressor 101 is prioritized.

[0123] By this operation, a comfortable operation can be achieved both in the cooling operation and the heating operation.

[0124] By taking such correlation characteristics into consideration, the opening degree of the second flow rate control device 122 and the opening degree of third flow rate control device 123 will be described below.

[0125] Fig. 6 is a diagram for explaining an example of the correlation between the outside air temperature and the flow rate ratio in accordance with the opening degree of the second flow rate control device 122 and the opening degree of the third flow rate control device 123 according to Embodiment 1 of the present invention.

[0126] In Fig. 6, it is assumed that the reference temperature on the horizontal axis is represented by α, and the reference flow rate ratio on the vertical axis is represented by β.

[0127] As illustrated in Fig. 6, when the outside air temperature is α-20 degrees Centigrade, the flow rate of the third flow rate control device 123 is decreased, and the flow rate of the second flow rate control device 122 is increased.

[0128] By this operation, the heating capacity can be increased. At this time, a low pressure also decreases, and therefore the cooling capacity is not affected.

[0129] Next, the correlation with the relay unit B will also be discussed.

[0130] Fig. 7 is a diagram for explaining an example of the correlation between the outside air temperature and the flow rate ratio in accordance with the opening degree of the second flow rate control device 122, the opening degree of the third flow rate control device 123, and the opening degree of the third flow rate control unit 115 according to Embodiment 1 of the present invention.

[0131] In Fig. 7, the third flow rate control unit 115 provided in the relay unit B for controlling the pressure differences between the high pressure and the intermediate pressure before and after the pressure detection means 127a and 127b to be maintained constant, decreases the opening degree thereof as the outside air temperature decreases, in a manner similar to the operation of the third flow rate control device 123.

[0132] By this operation, the pressure difference between the high pressure and the intermediate pressure is maintained constant, and at the same time, the liquid pipe temperature of the indoor unit D can be increased.

[0133] Consequently, the cooling operation can be maintained.

[0134] Fig. 8 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the case where the second flow rate control device 122 is properly controlled and the case where second flow rate control device 122 is not properly controlled according to Embodiment 1 of the present invention.

[0135] As illustrated in Fig. 8, in the case where the outside air temperature has reached a certain value or more, by adjusting the proper opening degree of the second flow rate control device 122, it is possible to reduce the influence on the cooling capacity and thus maintain a stable cooling capacity.

[0136] Fig. 9 is a diagram for explaining an example of the correlation between the outside air temperature and the heating capacity ratio in accordance with the case where the fourth flow rate control valve 124 is properly controlled and the case where fourth flow rate control valve 124 is not properly controlled according to Embodiment 1 of the present invention.

[0137] As illustrated in Fig. 9, by adjusting the opening degree of the fourth flow rate control valve 124, it is possible to reduce the influence on the cooling capacity and thus maintain a stable cooling capacity. For example, when the outside air temperature is lower than a certain value, the opening degree of the fourth flow rate control valve 124 is reduced. Meanwhile, when the outside air temperature is higher than the certain value, the opening degree of the fourth flow rate control valve 124 is increased.

[0138] By this operation, it is possible to reduce the influence on the cooling capacity and thus maintain a stable cooling capacity.

[0139] As described above, by properly controlling the opening degrees of the second flow rate control device 122, the third flow rate control device 123, and the third flow rate control unit 115 of the relay unit B in accordance with the outside air temperature, it is possible to continue a stable cooling operation while maintaining the heating capacity.

[0140] Thus, a high-efficiency cooling and heating simultaneous operation can be achieved.

[0141] Although the cooling main operation and the heating main operation have been explained in Embodiment 1, the present invention is not particularly limited to this. For example, only the heating operation may be performed.

[0142] Furthermore, similar effects can be achieved in the case where some or all of the number of heat source units A, the number of relay units B, and the number of indoor units are different from those in Embodiment 1 described above.

[0143] Furthermore, similar effects can be achieved in the case where an ice thermal storage tank or a water thermal storage tank (including hot water) is installed in series or parallel to the heat-source-side heat exchanger 103.

[0144] Although a configuration including the heat source unit A, the relay unit B, and two connection pipes: the first connection pipe 106 and the second connection pipe 107, has been explained, similar effects can be achieved with a configuration in which the total number of connection pipes is three.

[0145] Next, an operation example will be explained with reference to figures, based on the assumption of the above explanation.

[0146] Fig. 10 is a flowchart for explaining an operation example of the controller 141 provided in the heat source unit A according to Embodiment 1 of the present invention.

(Step S11)

[0147] The controller 141 of the heat source unit A determines whether or not the cooling and heating simultaneous operation is being performed. When it is determined that the cooling and heating simultaneous operation is being performed, the controller 141 of the heat source unit A proceeds to step S12. When it is determined that the cooling and heating simultaneous operation is not being performed, the controller 141 of the heat source unit A proceeds to step S16.

(Step S12)

[0148] The controller 141 of the heat source unit A acquires outside air temperature. For example, outside air temperature data detected by the outside air temperature detection means 131 is acquired.

(Step S13)

[0149] The controller 141 of the heat source unit A determines whether or not the outside air temperature corresponds to any of a plurality of predetermined thresholds.

[0150] For example, when the outside air temperature is lower than or equal to an injection start threshold (WB degrees Centigrade), the controller 141 of the heat source unit A proceeds to step S14. The injection start threshold (WB degrees Centigrade) corresponds to, for example, α-5 (WB degrees Centigrade) which is a start temperature at which the opening degree of the second flow rate control device 122 gradually increases, as illustrated in Fig. 6. It is assumed that α-5 (WB degrees Centigrade) is, for example, 0 degrees Centigrade.

[0151] Although an example in which α-5 (WB degrees Centigrade) is 0 degrees Centigrade has been explained above, the present invention is not particularly limited to this. A specific value of α-5 (WB degrees Centigrade) may be varied according to circumstances in accordance with the ambient environment and the operation status of the air-conditioning apparatus 1.

[0152] For example, when the outside air temperature is lower than or equal to an opening degree reduction threshold (WB degrees Centigrade), the controller 141 of the heat source unit A proceeds to step S15. The opening degree reduction threshold (WB degrees Centigrade) corresponds to, for example, α-20 (WB degrees Centigrade) which is a start temperature at which the opening degree of the third flow rate control device 123 gradually decreases, as illustrated in Fig. 6. It is assumed that α-20 (WB degrees Centigrade) is, for example, -15 degrees Centigrade.

[0153] More specifically, when the outside air temperature has reached -15 degrees Centigrade while either the indoor unit C or the indoor unit D is performing the cooling operation, the liquid pipe temperature of a pipe between the indoor unit that is performing the cooling operation and the second branch part 111 decreases. Therefore, the cooling operation cannot be continued. In the case where the outside air temperature is -15 degrees Centigrade, by reducing the opening degree of the third flow rate control device 123, the liquid pipe temperature of the pipe is increased, so that the cooling operation can be continued.

[0154] Although an example in which α-20 (WB degrees Centigrade) is -15 degrees Centigrade has been explained above, the present invention is not particularly limited to this. A specific value of α-20 (WB degrees Centigrade) may be varied according to circumstances in accordance with the ambient environment and the operation status of the air-conditioning apparatus 1.

[0155] For example, when the outside air temperature is not as described above (the injection start threshold or the opening degree reduction threshold), the controller 141 of the heat source unit A proceeds to step S16.

(Step S14)

[0156] The controller 141 of the heat source unit A increases the opening degree of the second flow rate control device 122 at a predetermined ratio. For example, the ratio at which the opening degree is gradually reduced is changed in accordance with the outside air temperature, as illustrated in Fig. 6.

(Step S15)

[0157] The controller 141 of the heat source unit A reduces the opening degree of the third flow rate control device 123. For example, as illustrated in Fig. 6, the opening degree of the third flow rate control device 123 is fully opened when the outside air temperature is within a range from α to α-20, while the opening degree of the third flow rate control device 123 is reduced when the outside air temperature is at α-20 or below.

(Step S16)

[0158] The controller 141 of the heat source unit A determines whether or not a termination instruction exists. When a termination instruction exists, the controller 141 of the heat source unit A ends the process. When a termination instruction does not exist, the controller 141 of the heat source unit A returns to step S12, and repeats processing of steps S12 to S15.

[0159] Fig. 11 is a flowchart for explaining an operation example of the controller 151 provided in the relay unit B according to Embodiment 1 of the present invention.

(Step S51)

[0160] The controller 151 of the relay unit B sets a first ratio. The first ratio represents a ratio at which the opening degree of the third flow rate control unit 115 is reduced when the outside air temperature is higher than α-20 and equal to or lower than α, as illustrated in Fig. 7.

(Step S52)

[0161] The controller 151 of the relay unit B sets a second ratio which satisfies a condition: the second ratio > the first ratio. The second ratio represents a ratio at which the opening degree of the third flow rate control unit 115 is reduced when the outside air temperature is lower than or equal to α-20, as illustrated in Fig. 7. As described above, on the assumption that the cooling operation cannot be continued at an outside air temperature of α-20, when the outside air temperature is α-20 or below, the cooling operation cannot be continued unless the liquid pipe temperature of the indoor unit that is performing the cooling operation is increased. Thus, a large reducing ratio is set.

(Step S53)

[0162] The controller 151 of the relay unit B determines whether or not the cooling and heating simultaneous operation is being performed. When the cooling and heating simultaneous operation is being performed, the controller 151 of the relay unit B proceeds to step S54. When the cooling and heating simultaneous operation is not being performed, the controller 151 of the relay unit B ends the process.

(Step S54)

[0163] The controller 151 of the relay unit B determines whether or not a termination instruction exists. When a termination instruction exists, the controller 151 of the relay unit B ends the process. When a termination instruction does not exist, the controller 151 of the relay unit B proceeds to step S55.

(Step S55)

[0164] The controller 151 of the relay unit B acquires a high-pressure-side pressure value. For example, the controller 151 of the relay unit B acquires a pressure value of a high-pressure side of the pressure detection means 127a or 127b. The determination as to which one of the pressure detection means 127a and 127b is on a high-pressure side is performed based on a correspondence table held by the controller 151 of the relay unit B in which information indicating which one of the pressure detection means 127a and 127b corresponds to a high-pressure side is registered in advance in accordance with the operation state.

(Step S56)

[0165] The controller 151 of the relay unit B acquires an intermediate-pressure-side pressure value. For example, the controller 151 of the relay unit B acquires a pressure value of an intermediate-pressure side of the pressure detection means 127a or 127b. The determination as to which one of the pressure detection means 127a and 127b is on an intermediate-pressure side is performed based on a correspondence table held by the controller 151 of the relay unit B in which information indicating which one of the pressure detection means 127a and 127b corresponds to an intermediate-pressure side is registered in advance in accordance with the operation state.

(Step S57)

[0166] The controller 151 of the relay unit B obtains a pressure difference between the high-pressure-side pressure value and the intermediate-pressure-side pressure value.

(Step S58)

[0167] The controller 151 of the relay unit B determines whether or not the pressure difference is constant. When the pressure difference is constant, the controller 151 of the relay unit B proceeds to step S59. When the pressure difference is not constant, the controller 151 of the relay unit B proceeds to step S60.

(Step S59)

[0168] The controller 151 of the relay unit B acquires outside air temperature.

(Step S60)

[0169] The controller 151 of the relay unit B makes the pressure difference constant by the third flow rate control unit 115.

(Step S61)

[0170] The controller 151 of the relay unit B determines whether or not the outside air temperature corresponds to any of a plurality of predetermined thresholds.

[0171] For example, when the outside air temperature is higher than a second threshold (WB degrees Centigrade) and equal to or lower than a first threshold (WB degrees Centigrade), the process proceeds to step S62.

[0172] For example, when the outside air temperature is lower than or equal to the second threshold (WB degrees Centigrade), the process proceeds to step S63.

[0173] For example, when the outside air temperature is not as described above (higher than the first threshold (WB degrees Centigrade)), the process returns to step S54.

(Step S62)

[0174] The controller 151 of the relay unit B reduces the opening degree of the third flow rate control unit 115 at the first ratio, and returns to step S54.

(Step S63)

[0175] The controller 151 of the relay unit B reduces the opening degree of the third flow rate control unit 115 at the second ratio, and returns to step S54.

[0176] As described above, by reducing the flow rate of the refrigerant to the heat-source-side heat exchanger while increasing the amount of injection to the single compressor in accordance with the outside air temperature, even if the outside air temperature drops during the cooling and heating simultaneous operation, the cooling operation can be continued while maintaining the heating capacity, with low cost. With this configuration, a high-efficiency cooling and heating simultaneous operation can be achieved.

[0177] As described above, in Embodiment 1, the air-conditioning apparatus 1 that includes the single compressor 101 which compresses the refrigerant and discharges the compressed refrigerant, the heat-source-side heat exchanger 103 which exchanges heat between the refrigerant and an ambient heat source medium, the plurality of use-side heat exchangers 105 which perform heat exchange between the refrigerant and an ambient use medium, and a relay unit B which is provided between the heat-source-side heat exchanger 103 and the plurality of use-side heat exchangers 105, which switches some of the plurality of use-side heat exchangers 105 to the cooling operation side, and which switches some of the plurality of use-side heat exchangers 105 to the heating operation side and that performs the cooling and heating simultaneous operation by switching each of the plurality of use-side heat exchangers 105 to the cooling operation side or the heating operation side in accordance with a control instruction, includes the injection pipe 135 which is provided between the relay unit B and the heat-source-side heat exchanger 103 and which allows the refrigerant that is to flow into the heat-source-side heat exchanger 103 to be supplied to the single compressor 101, the second flow rate control device 122 which is provided at the injection pipe 135 and which adjusts the flow rate of the refrigerant that is to flow into the single compressor 101, the third flow rate control device 123 which is connected in parallel to the third flow rate control device 123 and which adjusts the flow rate of the refrigerant that is to flow into the heat-source-side heat exchanger 103, and the controller 141 which adjusts the second flow rate control device 122 and the third flow rate control device 123. By adjusting the opening degree of the second flow rate control device 122 and the opening degree of the third flow rate control device 123 in accordance with the outside air temperature, the controller 141 is able to continue the cooling operation while maintaining the heating capacity with low cost even when the outside air temperature drops during the cooling and heating simultaneous operation. With this configuration, a high-efficiency cooling and heating simultaneous operation can be achieved.

Reference Signs List

[0178] A: heat source unit, B: relay unit, C, D: indoor unit, 1: air-conditioning apparatus, 101: compressor, 102: four-way valve, 103: heat-source-side heat exchanger, 104: accumulator, 105, 105c, 105d: use-side heat exchanger, 106, 106c, 106d: first connection pipe, 107, 107c, 107d: second connection pipe, 108, 108a, 108b: solenoid valve, 109, 109c, 109d: first flow rate control unit, 110: first branch part, 111: second branch part, 112: gas/liquid separator, 113: second flow rate control unit, 114: bypass pipe, 115: third flow rate control unit, 116: first heat exchanger, 117: second heat exchanger, 118 to 121, 137a, 137b: check valve, 122: second flow rate control device, 123: third flow rate control device, 124: fourth flow rate control valve, 125: temperature detection means, 126, 126c, 126d: liquid pipe temperature detection means, 127, 127a, 127b: pressure detection means, 131: outside air temperature detection means, 135: injection pipe, 137a_all, 137b_all: junction part, 141, 151: controller

Claims

1. An air-conditioning apparatus including a single compressor configured to compress a refrigerant and discharges the compressed refrigerant, a heat-source-side heat exchanger configured to exchange heat between the refrigerant and an ambient heat source medium, a plurality of use-side heat exchangers configured to exchange heat between the refrigerant and an ambient use medium, and a relay unit provided between the heat-source-side heat exchanger and the plurality of use-side heat exchangers, which switches part of the plurality of use-side heat exchangers to the cooling operation side, and which switches part of the plurality of use-side heat exchangers to the heating operation side, wherein the air-conditioning apparatus performs a cooling and heating simultaneous operation by switching each of the plurality of use-side heat exchangers to the cooling operation side or the heating operation side in accordance with a control instruction, the apparatus comprising:

an injection pipe provided between the relay unit and the heat-source-side heat exchanger and configured to allow the refrigerant flowing into the heat-source-side heat exchanger to be supplied to the single compressor;
a compressor flow rate control device provided at the injection pipe and which adjusts a flow rate of the refrigerant flowing into the single compressor;
a heat-source-side heat exchanger flow rate control device connected in parallel to the compressor flow rate control device and configured to adjust a flow rate of the refrigerant flowing into the heat-source-side heat exchanger; and
a controller configured to adjust the compressor flow rate control device and the heat-source-side heat exchanger flow rate control device,
wherein the controller
adjusts an opening degree of the compressor flow rate control device and an opening degree of the heat-source-side heat exchanger flow rate control device in accordance with an outside air temperature.

2. The air-conditioning apparatus of claim 1, wherein the controller
sets an injection start threshold at which the refrigerant starts to be supplied from the injection pipe,
sets an opening degree reduction threshold at which a flow rate of the refrigerant passing through the heat-source-side heat exchanger flow rate control device decreases,
increases an opening degree of the compressor flow rate control device at a predetermined ratio when the outside air temperature is lower than or equal to the injection start threshold, and
reduces an opening degree of the heat-source-side heat exchanger flow rate control device when the outside air temperature is lower than or equal to the opening degree reduction threshold.

3. The air-conditioning apparatus of claim 2, wherein the relay unit
includes a flow rate control unit which is connected in series to the compressor flow rate control device and the heat-source-side heat exchanger flow rate control device and which adjusts a flow rate of the refrigerant flowing in the relay unit, and
adjusts an opening degree of the flow rate control unit in accordance with the outside air temperature.

4. The air-conditioning apparatus of claim 3, wherein the relay unit
sets a first ratio and a first threshold corresponding to the first ratio,
sets a second ratio which is larger than the first ratio and a second threshold which corresponds to the second ratio,
reduces the opening degree of the flow rate control unit at the first ratio when the outside air temperature is lower than or equal to the first threshold, and
reduces the opening degree of the flow rate control unit at the second ratio when the outside air temperature is lower than or equal to the second threshold.

5. The air-conditioning apparatus of claim 4, further comprising:

a flow rate control valve provided between the relay unit and the heat-source-side heat exchanger, connected in parallel to the heat-source-side heat exchanger flow rate control device, and configured to adjust the flow rate of the refrigerant, wherein
the controller

adjusts an opening degree of the flow rate control valve in accordance with the outside air temperature.

6. The air-conditioning apparatus of claim 5, wherein the controller
increases an amount of refrigerant supplied from the relay unit and flowing to the compressor by adjusting the opening degree of the compressor flow rate control device when the outside air temperature is lower than or equal to the injection start threshold, and
reduces an amount of refrigerant supplied from the relay unit and flowing to the heat-source-side heat exchanger by adjusting the opening degree of the heat-source-side heat exchanger flow rate control device and the opening degree of the flow rate control valve when the outside air temperature is lower than or equal to the opening degree reduction threshold.

FIG. 1

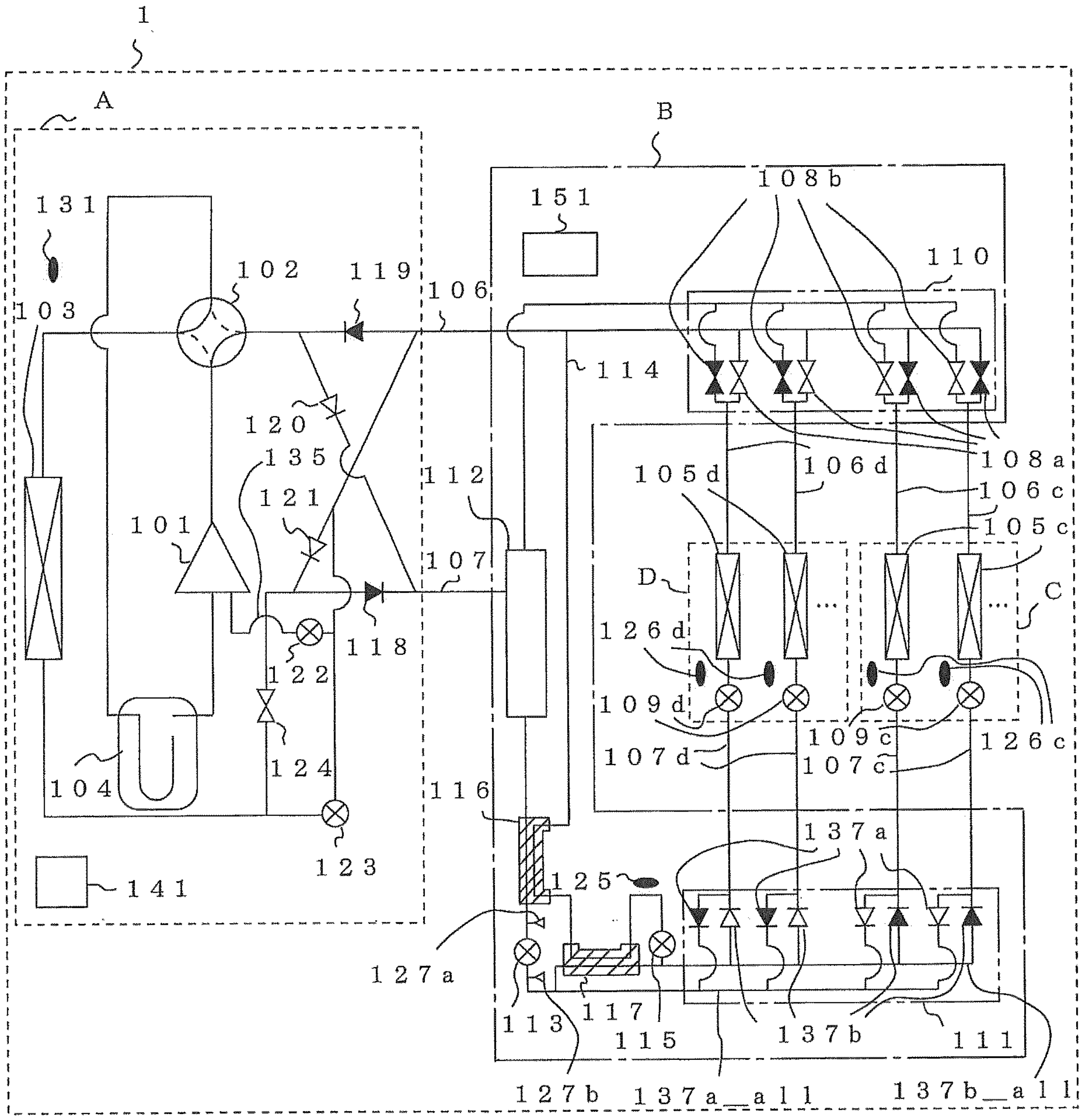
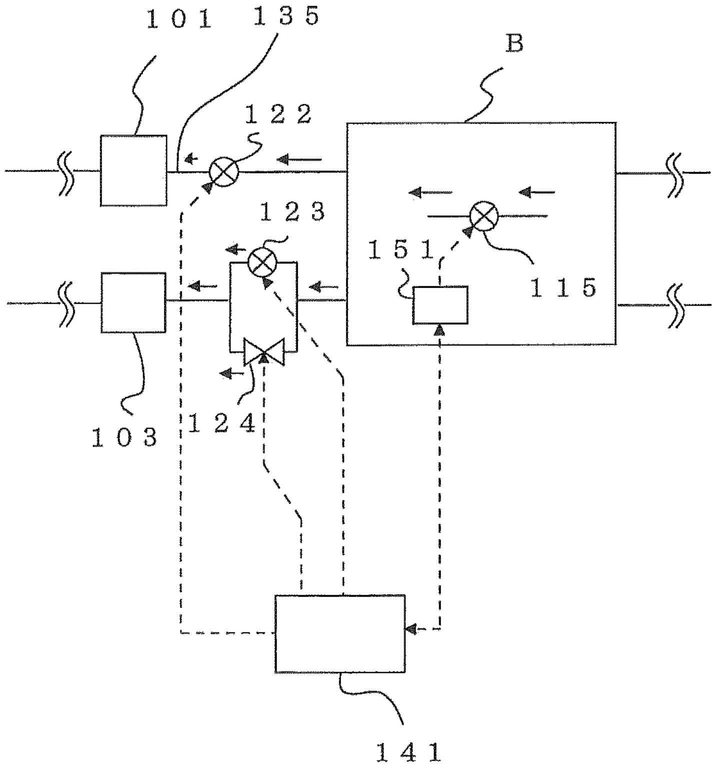
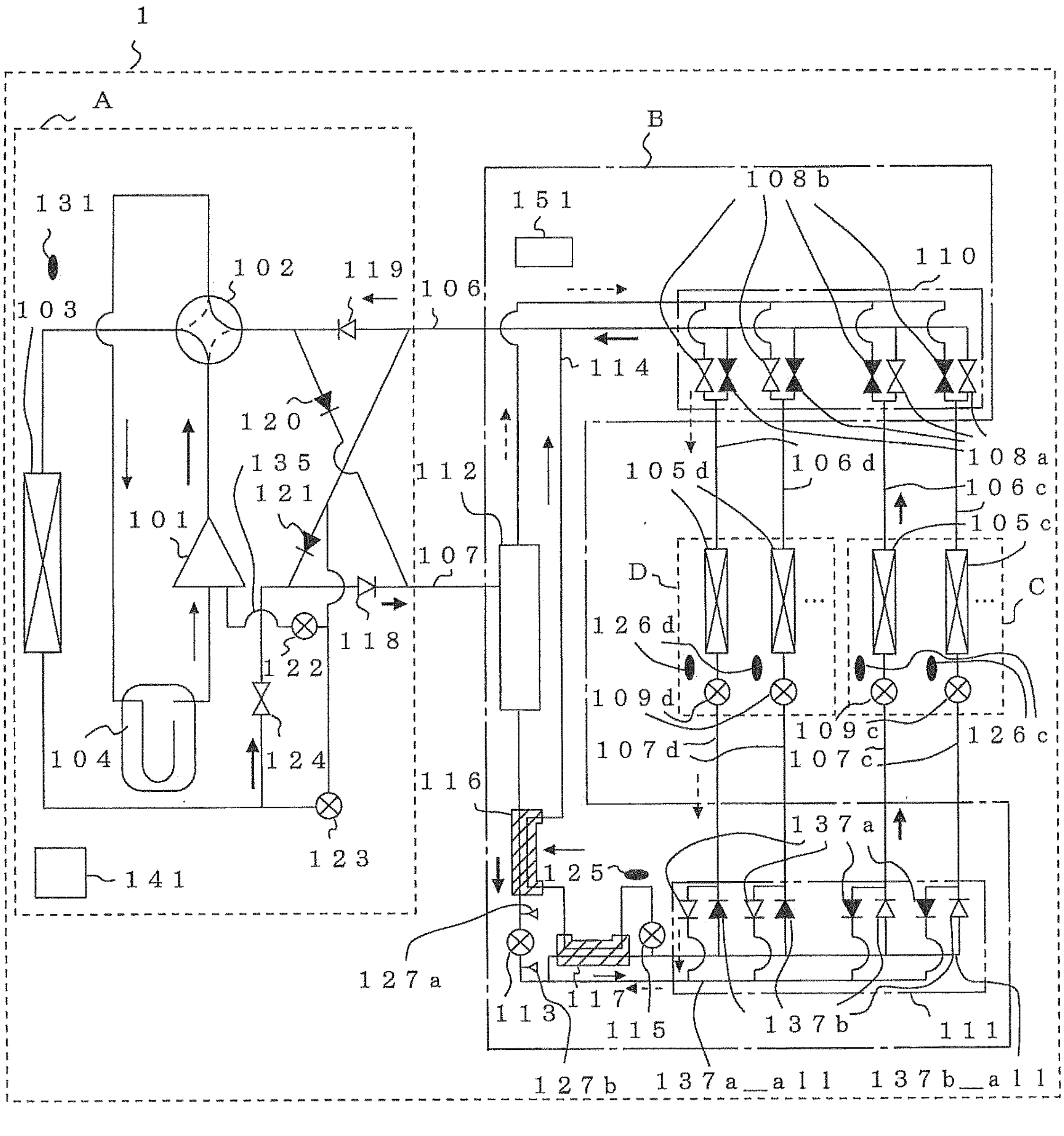

1
A
B
131
102
119
106
103
151
108b
110
114
120
135
112
121
101
107
118
122
124
104
116
123
141
125
127a
113
117
115
127b
105d
106d
108a
106c
105c
D
C
126d
109d
109c
126c
107d
107c
137a
137b
111
137a_all
137b_all

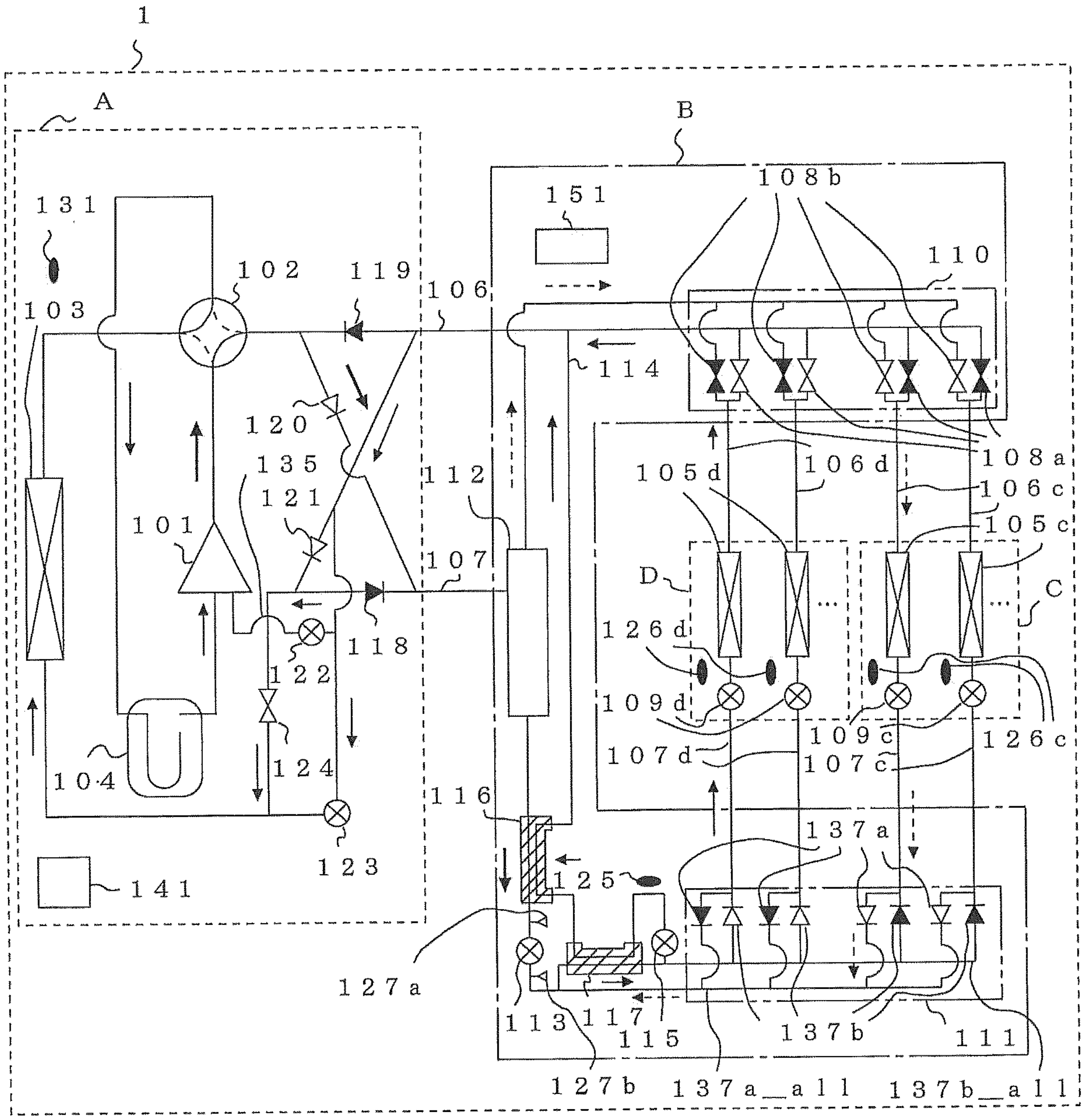
FIG. 2



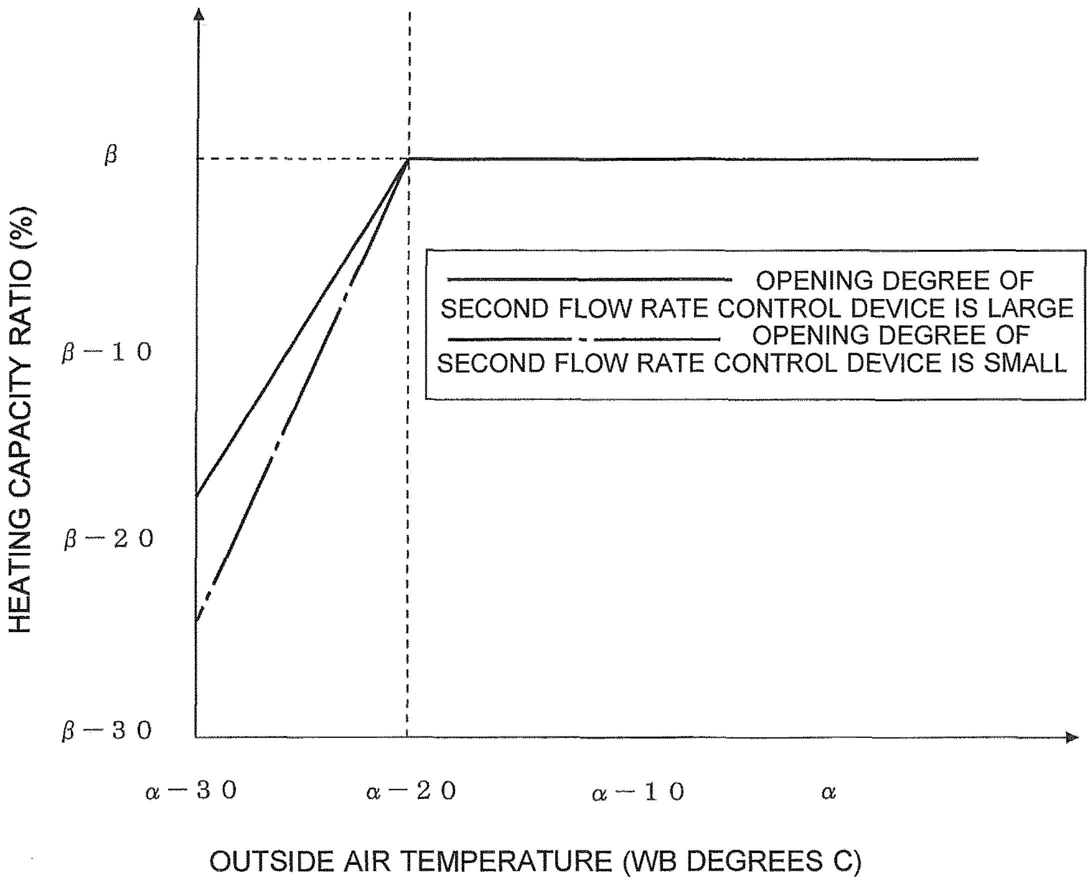
F I G. 3


1
A
B
131
102
119
106
103
108b
110
151
114
120
135
121
101
112
107
118
122
124
104
123
141
116
125
127a
113
117
115
127b
105d
106d
108a
106c
105c
D
C
126d
109d
109c
126c
107d
107c
137a
137b
111
137a_all
137b_all

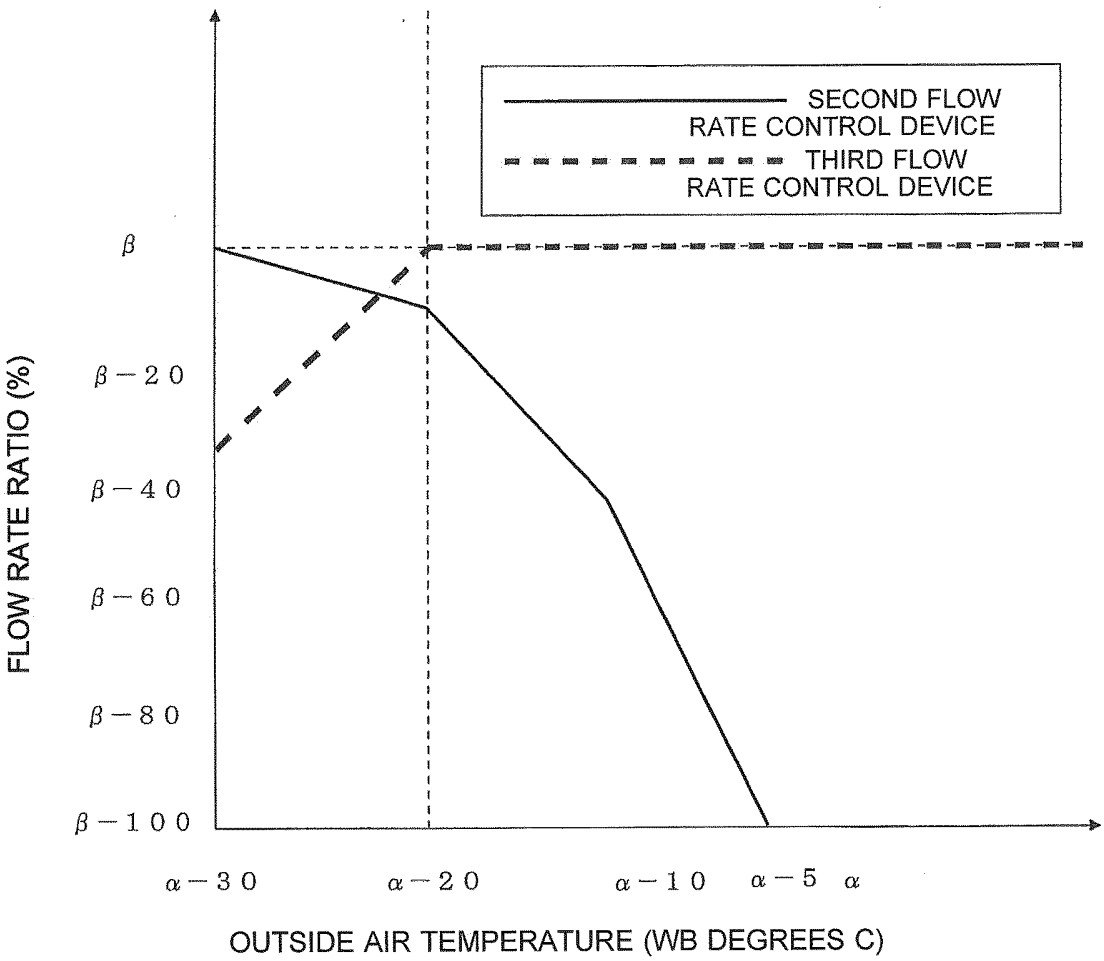
F I G. 4


1
A
B
131
102
119
106
103
151
108b
110
114
120
135
112
121
101
107
118
122
124
104
123
141
108a
105d
106d
106c
105c
D
C
126d
109d
109c
126c
107d
107c
116
125
137a
127a
113
117
115
137b
111
127b
137a_all
137b_all

F I G. 5


HEATING CAPACITY RATIO (%)
β
β－10
β－20
β－30
OPENING DEGREE OF SECOND FLOW RATE CONTROL DEVICE IS LARGE
OPENING DEGREE OF SECOND FLOW RATE CONTROL DEVICE IS SMALL
α－30
α－20
α－10
α
OUTSIDE AIR TEMPERATURE (WB DEGREES C)

F I G. 6


SECOND FLOW RATE CONTROL DEVICE
THIRD FLOW RATE CONTROL DEVICE
β
β−20
β−40
β−60
β−80
β−100
FLOW RATE RATIO (%)
α−30
α−20
α−10
α−5
α
OUTSIDE AIR TEMPERATURE (WB DEGREES C)

F I G. 7

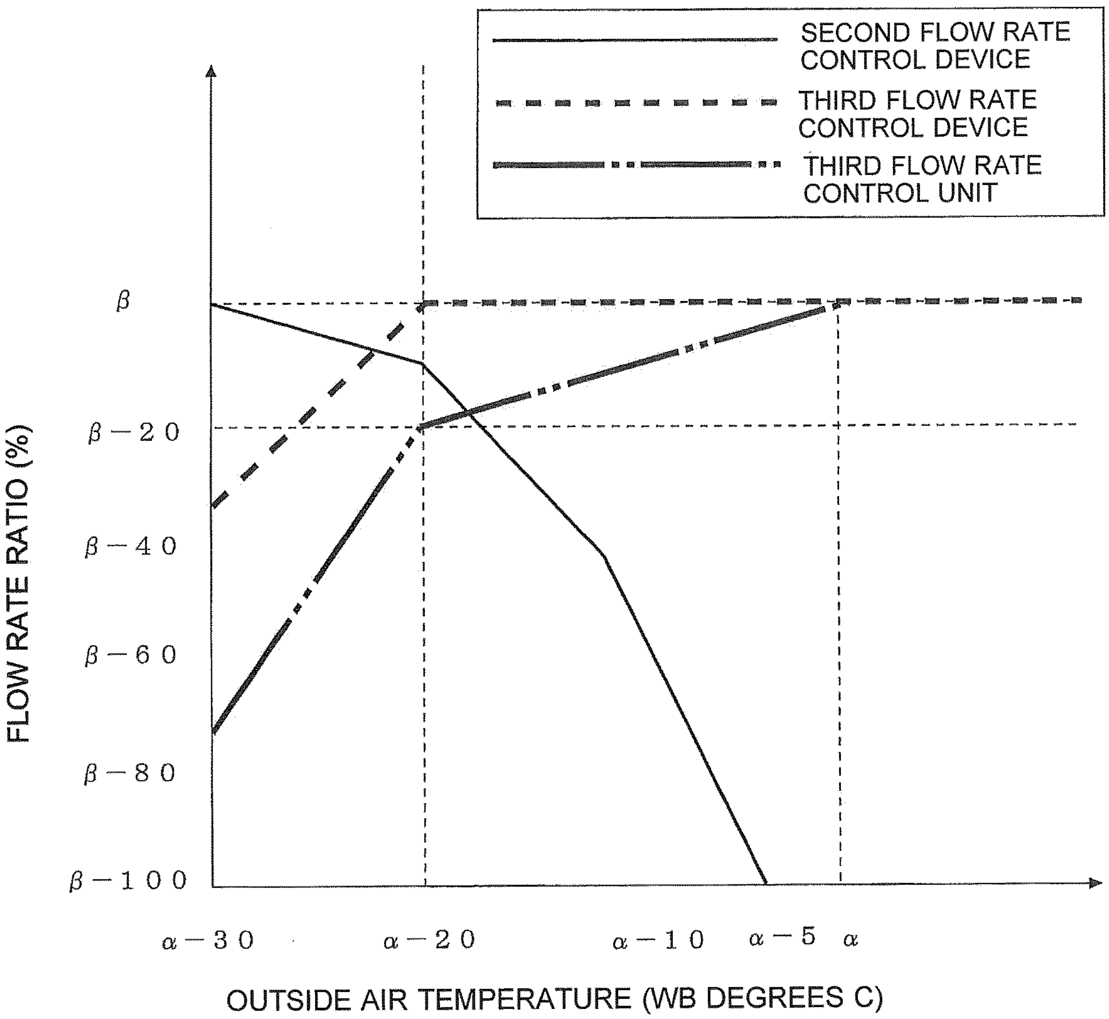

SECOND FLOW RATE CONTROL DEVICE
THIRD FLOW RATE CONTROL DEVICE
THIRD FLOW RATE CONTROL UNIT
FLOW RATE RATIO (%)
β
β－20
β－40
β－60
β－80
β－100
α－30
α－20
α－10
α－5
α
OUTSIDE AIR TEMPERATURE (WB DEGREES C)

FIG. 8

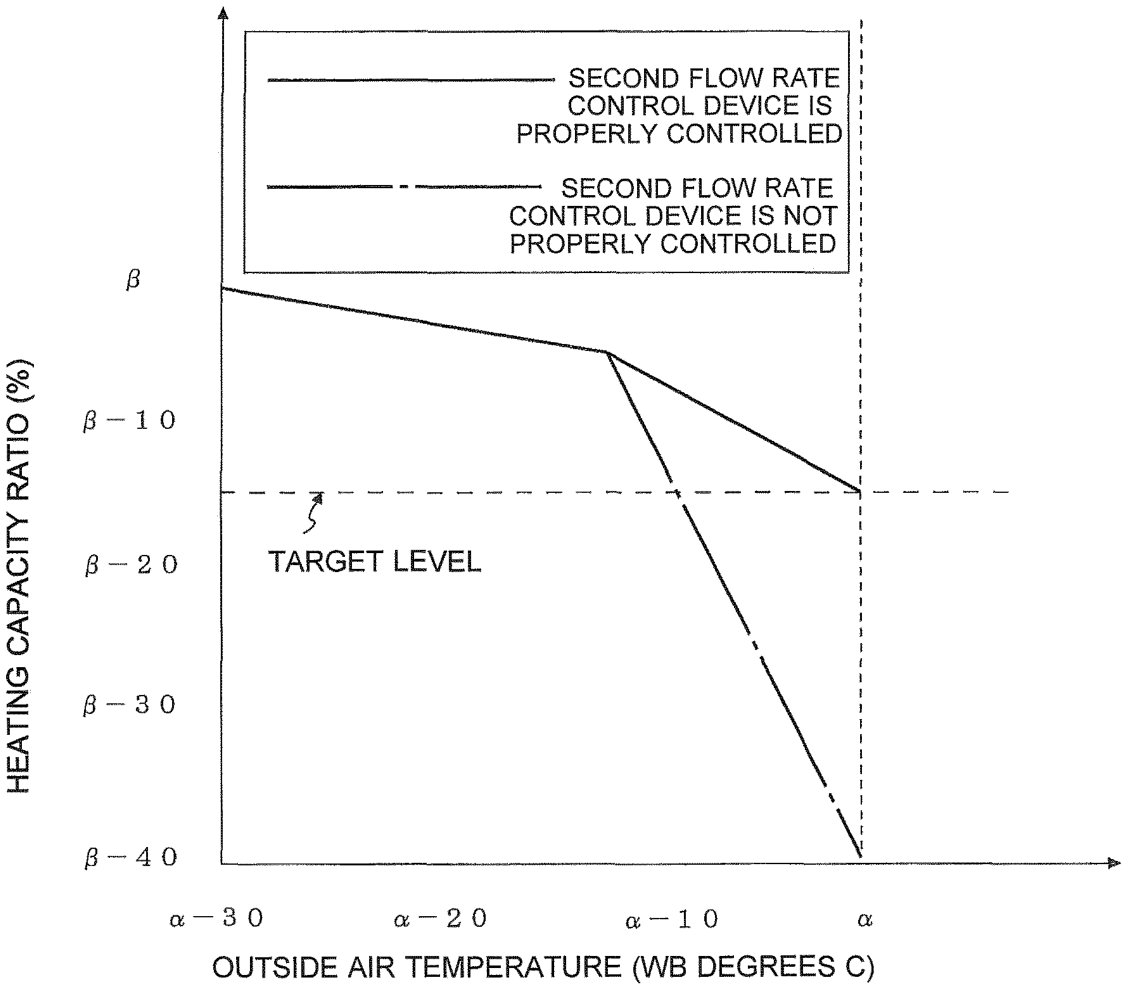

SECOND FLOW RATE CONTROL DEVICE IS PROPERLY CONTROLLED
SECOND FLOW RATE CONTROL DEVICE IS NOT PROPERLY CONTROLLED
β
β−10
β−20
β−30
β−40
HEATING CAPACITY RATIO (%)
TARGET LEVEL
α−30
α−20
α−10
α
OUTSIDE AIR TEMPERATURE (WB DEGREES C)

FIG. 9

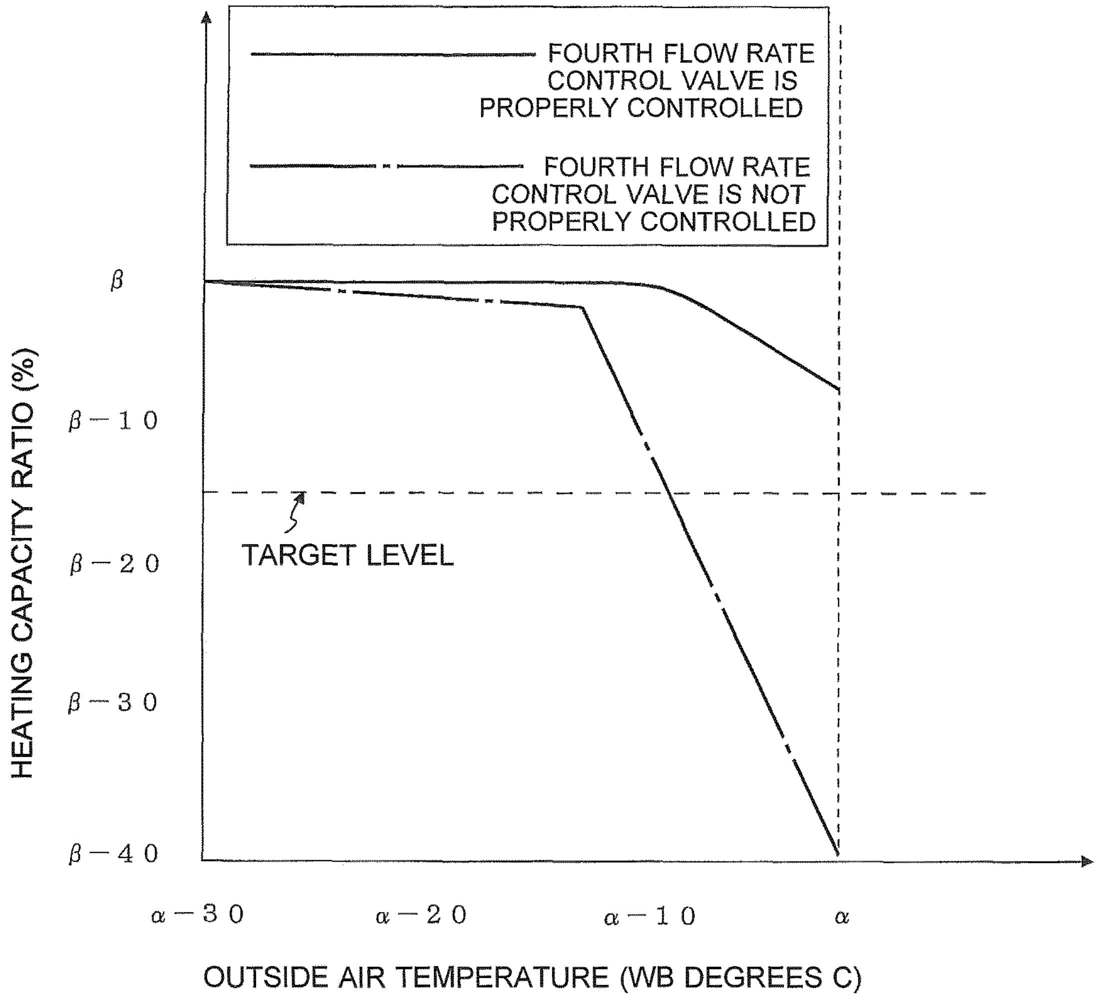

FOURTH FLOW RATE CONTROL VALVE IS PROPERLY CONTROLLED
FOURTH FLOW RATE CONTROL VALVE IS NOT PROPERLY CONTROLLED
HEATING CAPACITY RATIO (%)
β
β−10
β−20
β−30
β−40
TARGET LEVEL
α−30
α−20
α−10
α
OUTSIDE AIR TEMPERATURE (WB DEGREES C)

FIG. 10

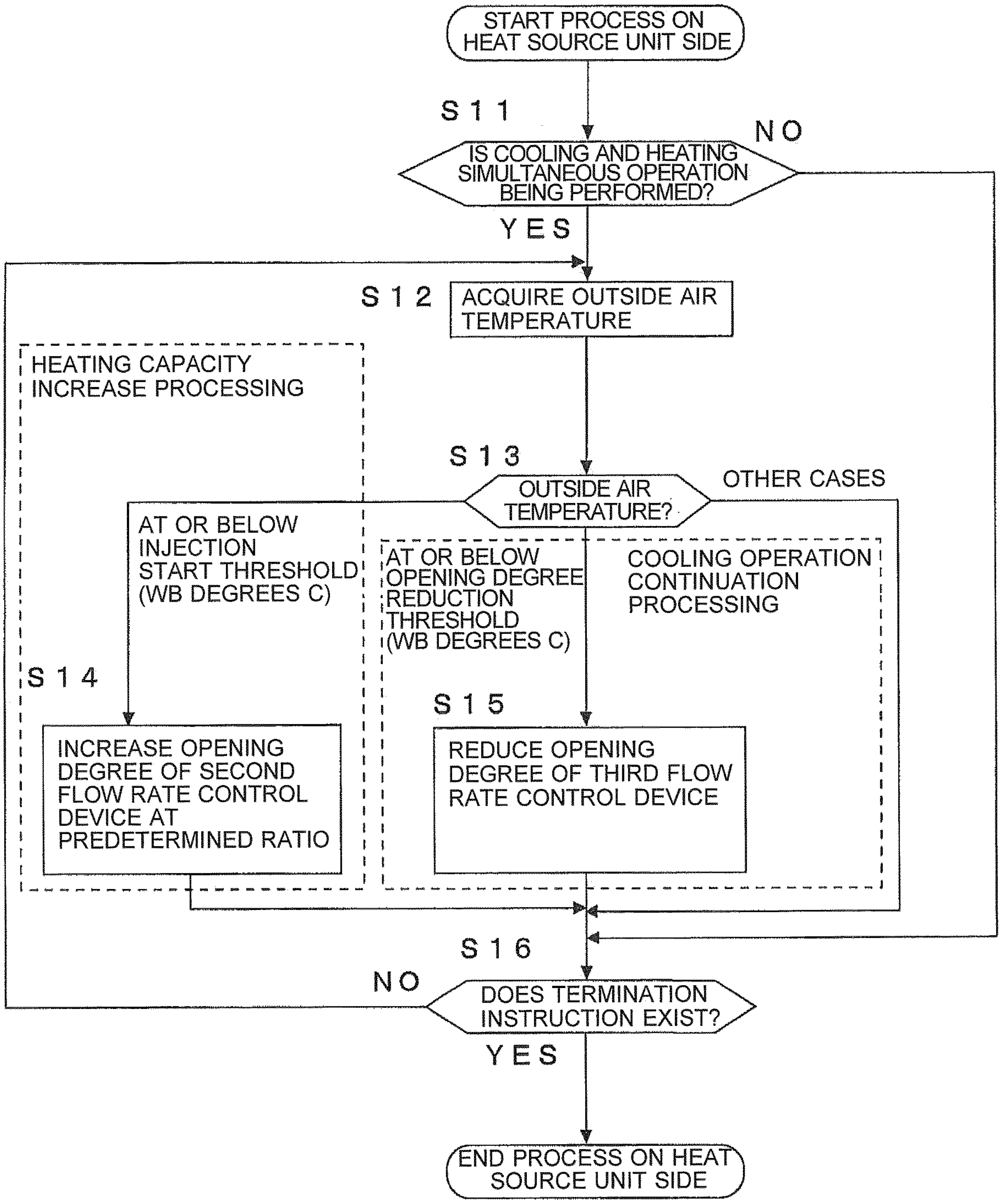
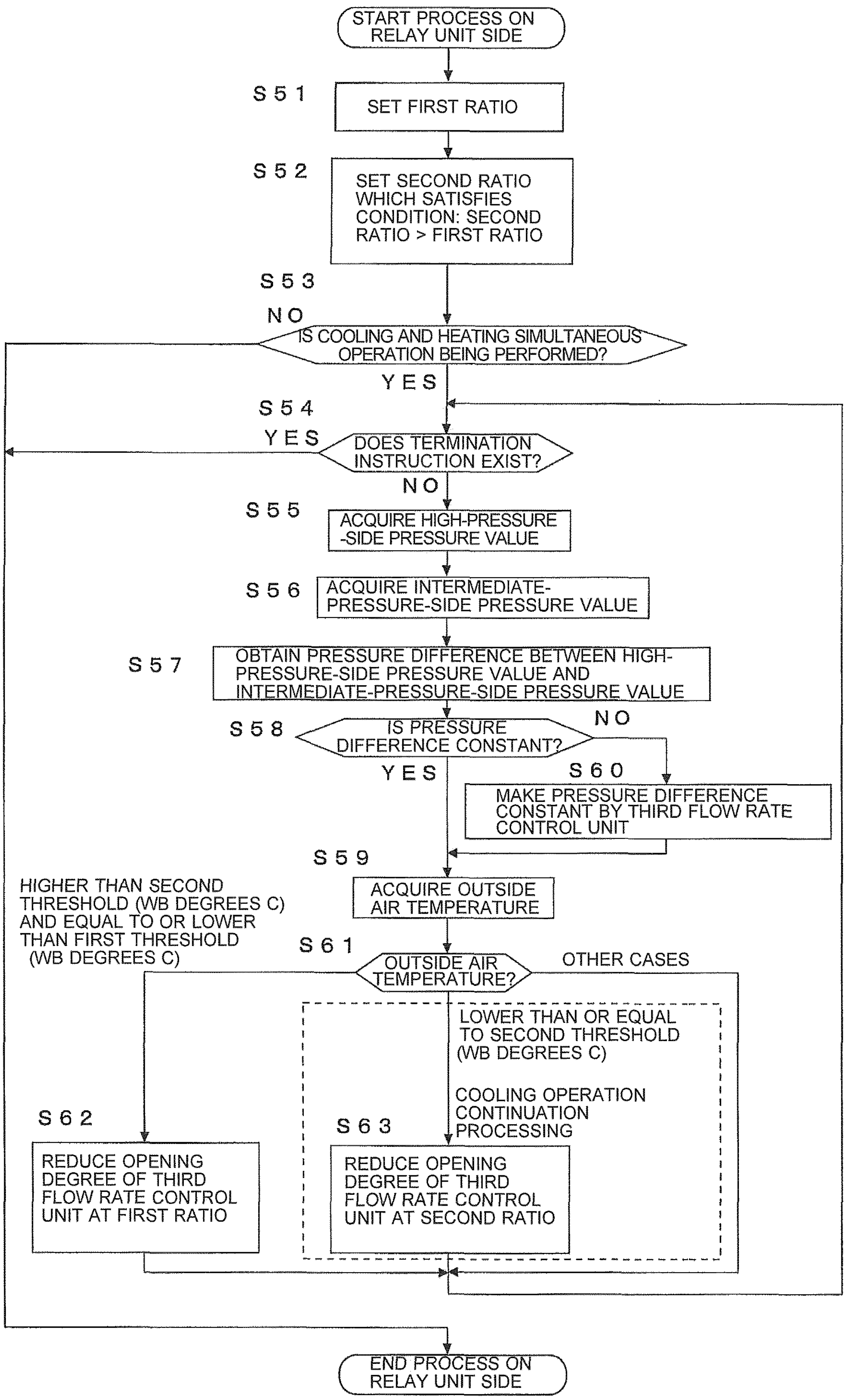

START PROCESS ON HEAT SOURCE UNIT SIDE
S11
IS COOLING AND HEATING SIMULTANEOUS OPERATION BEING PERFORMED?
NO
YES
S12
ACQUIRE OUTSIDE AIR TEMPERATURE
HEATING CAPACITY INCREASE PROCESSING
S13
OUTSIDE AIR TEMPERATURE?
OTHER CASES
AT OR BELOW INJECTION START THRESHOLD (WB DEGREES C)
AT OR BELOW OPENING DEGREE REDUCTION THRESHOLD (WB DEGREES C)
COOLING OPERATION CONTINUATION PROCESSING
S14
INCREASE OPENING DEGREE OF SECOND FLOW RATE CONTROL DEVICE AT PREDETERMINED RATIO
S15
REDUCE OPENING DEGREE OF THIRD FLOW RATE CONTROL DEVICE
S16
NO
DOES TERMINATION INSTRUCTION EXIST?
YES
END PROCESS ON HEAT SOURCE UNIT SIDE

FIG. 11


START PROCESS ON RELAY UNIT SIDE
S51
SET FIRST RATIO
S52
SET SECOND RATIO WHICH SATISFIES CONDITION: SECOND RATIO > FIRST RATIO
S53
NO
IS COOLING AND HEATING SIMULTANEOUS OPERATION BEING PERFORMED?
YES
S54
YES
DOES TERMINATION INSTRUCTION EXIST?
NO
S55
ACQUIRE HIGH-PRESSURE -SIDE PRESSURE VALUE
S56
ACQUIRE INTERMEDIATE-PRESSURE-SIDE PRESSURE VALUE
S57
OBTAIN PRESSURE DIFFERENCE BETWEEN HIGH-PRESSURE-SIDE PRESSURE VALUE AND INTERMEDIATE-PRESSURE-SIDE PRESSURE VALUE
S58
IS PRESSURE DIFFERENCE CONSTANT?
NO
YES
S60
MAKE PRESSURE DIFFERENCE CONSTANT BY THIRD FLOW RATE CONTROL UNIT
S59
ACQUIRE OUTSIDE AIR TEMPERATURE
HIGHER THAN SECOND THRESHOLD (WB DEGREES C) AND EQUAL TO OR LOWER THAN FIRST THRESHOLD (WB DEGREES C)
S61
OUTSIDE AIR TEMPERATURE?
OTHER CASES
LOWER THAN OR EQUAL TO SECOND THRESHOLD (WB DEGREES C)
COOLING OPERATION CONTINUATION PROCESSING
S62
REDUCE OPENING DEGREE OF THIRD FLOW RATE CONTROL UNIT AT FIRST RATIO
S63
REDUCE OPENING DEGREE OF THIRD FLOW RATE CONTROL UNIT AT SECOND RATIO
END PROCESS ON RELAY UNIT SIDE

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2012/075309

A. CLASSIFICATION OF SUBJECT MATTER
F25B29/00(2006.01)i, *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)
F25B29/00, 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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2010-139215 A (Mitsubishi Electric Corp.), 24 June 2010 (24.06.2010), paragraphs [0008] to [0017], [0100], [0131], [0132]; fig. 11 (Family: none)	1 2-6
Y A	JP 2009-186121 A (Mitsubishi Electric Corp.), 20 August 2009 (20.08.2009), paragraphs [0017] to [0019]; fig. 1 & US 2009/0199581 A1 & EP 2088390 A2	1 2-6
Y A	JP 4675810 B2 (Mitsubishi Electric Corp.), 27 April 2011 (27.04.2011), paragraph [0025]; fig. 5 (Family: none)	1 2-6

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

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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
14 December, 2012 (14.12.12)	25 December, 2012 (25.12.12)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/075309

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/104893 A1 (Mitsubishi Electric Corp.), 09 August 2012 (09.08.2012), paragraph [0023]; fig. 1 (Family: none)	1-6
A	WO 2010/128557 A1 (Mitsubishi Electric Corp.), 11 November 2010 (11.11.2010), fig. 1 & WO 2010/128557 A1 & CN 102422099 A	1-6

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Patent documents cited in the description

- JP 4675810 B **[0003]**